ECOLOGY

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ECOLOGICAL DISTRIBUTION OF THE PYGMY FILED MOUSE (APODEMUS URALENSIS) AND NICHE DIFFERENTIATION IN MICROMAMMALIA COMMUNITIES OF CONIFER-DECIDUOUS FORESTS OF THE VOLGA UPLAND

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Abstract

The results of fields studies and statistical analysis of patterns and mechanisms of spacial distribution of micromammalia faunal communities of conifer-deciduous forests of the Volga Upland are presented in this article. Using the methods of Cluster Analysis and correlation, patterns of spacial distribution of three rodent species, Apodemus uralensis, Clethrionomys glareolus and Apodemus flavicolis were shown. The Pygmy field mouse (A. uralensis) turned out to avoid semi-paludal plant associations with dominance of Vaccinium myrtillus, as well as forests with dominance of Carex pilosa, a species with hard evergreen leaves. With the help of Principal Component Analysis several cases of niche differentiation were discovered.

Keywords: ecological niche, vegetation, Apodemus uralensis, Clethrionomys glareolus, micromammalia, conifer-

deciduous forests

Introduction

Populations of micromammalia are important components of almost any forest ecosystem; but, their relation with the vegetation cover has not yet been fully understood. In this article the authors made an attempt to uncover ecological and phytosociological patterns of spatial distribution of micromammalia in conifer-deciduous forests of the Western part of the Volga Upland.

Study area and methods

The investigation was carried out in summer periods in 2008 and 2001 in the area of Pustyn National Park in the province of Nizhni Novgorod, Russia. 10 relevés were set up in the following forest types:

1. Piceeto-Tilietum stellarioso-oxalidosum 2. Tilieto-Piceetum aegopodiosum 3. Pineto-Piceetum oxalidosum 4. Tilietum pteridiosum 5. Tilietum aegopodioso-mercurialiosum 6. Tilietum oxalidoso-stellariosum 7. Tilietum caricoso pilosae-mercurialiosum 8. Tilietum caricoso pilosae- aegopodiosum 9. Tilietum caricosum pilosae 10. Pineto-Piceetum vacciniosum. – These numbers are used for the diagrams.

Trapping of micromammalia was fulfilled using a traditional method. Traps were located over standard relevés 20x20 m, in random order. 2600 trap-days were processed, 214 animals caught which turned out to belong to 2 genera and 3 species: Cletrionomys glareolus Scheber. (111 specimens), Apodemus flavicollis Melchior. (37 spec.), Apodemus uralensis L. (66 spec.). Series of 1x1m sample plots were set up in some relevés for more detailed vegetation investigation. Field records were stored using Ecodat scientific program [2]. Statistical analysis was fulfilled using Statistica 6.0 software suite. Statistical distribution of the primary data was not Gaussian in all cases since sample sizes were relatively small. Hence we had to use a nonparametric Spearman method for calculation of correlations [5].

Principal Component Analysis (PCA) was used to for detection of groups of similar objects, to reduce the number of dimensions and for visualization of the results.[1]

Estimation of environmental parameters by vegetation (phytoindication), was fulfilled using Ellenberg's ecological scales[8]. Values of the key factors, L, F, R and N, were calculated.

Types of plant communities were described using the dominant approach [4]. Associations were defined by up to three dominant species, as many authors do [3].

Results

The dominant species in the collected data are as follows: in associations of Tilietum aegopodioso-mercurialiosum, T. caricoso pilosae-aegopodiosum, T. caricosum pilosae Yellow-necked mouse was the dominant and Ural field mouse was a codominant.

Bank vole was the dominant in Piceeto-Tilietum stellarioso-oxalidosum, Tilieto-Piceetum aegopodiosum, Tilietum pteridiosum, T. aegopodioso-mercurialiosum and Pineto-Piceetum vacciniosum.

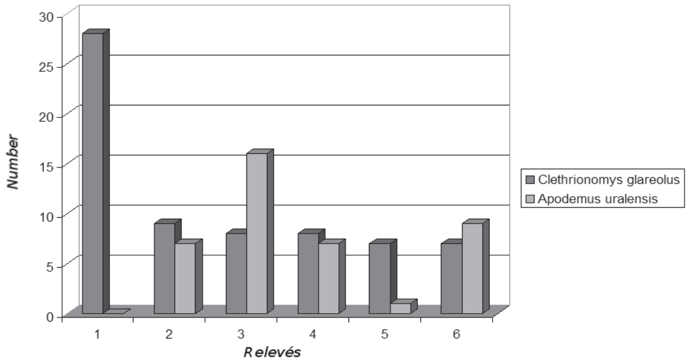


Fig. 1. Proportion of micromammalia by population density.

The Pygmy field mouse (A. uralensis) dominated in Tilietum oxalidoso-stellariosum and Pineto-Piceetum oxalidosum with Bank vole as a codominant (fig. 1, 2). On all figures quantity is shown in specimens, columns are species, relevés are specified on the horizontal axis.

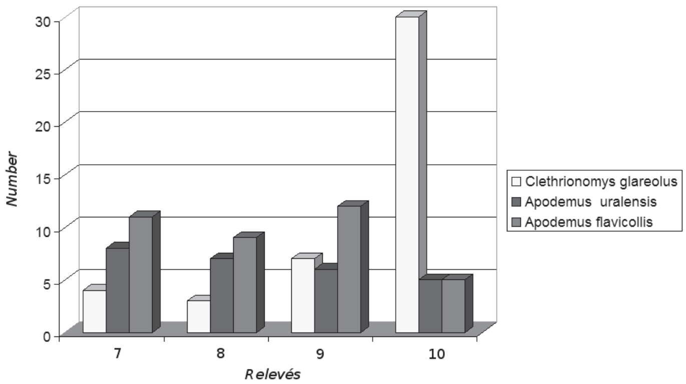
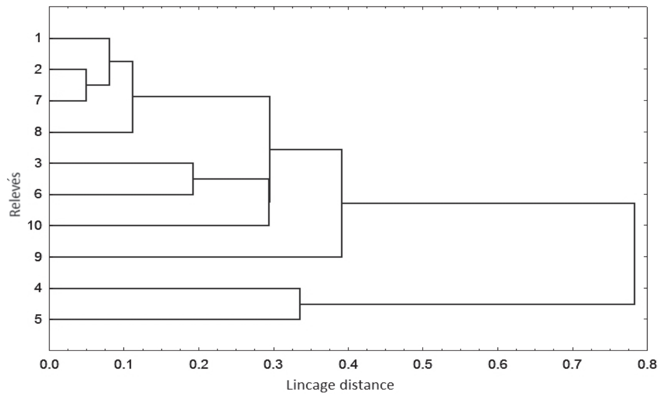


Fig. 2. Proportion of micromammalia by population density, for relevés 7-10 (different species composition).

To reveal another aspect of the ecological-spatial structure of the given set of communities, cluster analysis was used. Using method of single linkage by factors of light (L) and moisture (F) a diagram was made (Fig. 3).

For investigation the data set was separated for two subsets,



first (1-6) including conifer-deciduous forests and the second - deciduous sites (7-9). Tree chart of the similarity of plant communities (biotopes) was built using single linkage CA algorithm.

Fig 3. Cluster analysis of the terrestrial small mammal species based on quantitative data

Both samples (subsets) were investigated using the PCA method, it gave the following figures:

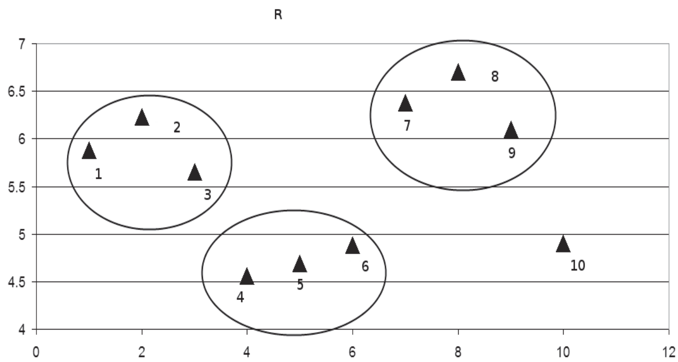


Fig. 4. Distribution in the space of ecological factors of reaction (R) and moisture (F)

Discussion and conclusions

On Fig. 3 we can see that there are three clusters (groups of relevés). First one (1,2,7) is the most condensed. It can be clearly characterized by presence of Tilia cordata in the tree layer. The second one has communities (3,6) with Oxalis acetosella, as dominant or co-dominant. It is a boreal species which marks another concrete set species of different ecological and sociological nature. This cluster has one more community close to it, which also has boreal, 'conifer' character, Pineto-Piceetum vaccinosum. Mention must be made that O. acetosella is also present there, though not as a dominant. In that way the two major clusters have clear ecologically-sociological color, representing nemoral and boreal components respectively.

Distribution of investigated plant associations on in the coordinate space of ecological factors is shown on Fig. 4.

It can be seen that the ecotops of faunal communities form three distinct groups. [A] is situated in the region of drought and good (above average) nutrition. [B] group lays in the ecological area of medium moisture and low nutrient. Finally, the third [C] group is the region of the best nutrition and high moisture. Also, there is a single 'fall away' value which belongs to the most wet range with poor soil. It is interesting that the third group, besides its uniform ecological character, is rather homogeneous phytosociologically. It includes communities with dominance of T. cordata in the tree layer and Carex pilosa in the grass layer. The other clusters are not so homogeneous.

Thus we can see that vegetation of the given sample (data set) is characterized by a distinct ecological structure. It's logical to surmise that it has its reflection in heterogeneity and structure of faunal communities of the area being investigated. The data set (field data of 2008 and 2011) was broken apart into several subsets (designated by relevé numbers) and studied separately. Method of Principal component analysis (PCA) was used.

Two major factors were revealed for the first subset. The results are represented on Tab. 1. Data processing showed that 30% of the variation is linked to the 1st factor. Let's examine the species correlations, with values more than 0.70 deemed significant. We can see that its nature is quite evident: this factor is linked to "boreal" vegetation. Indeed, it has the strongest positive correlation to Oxalis acetosella, which is one of the core boreal species of that region. More positive components: Dryopteris carthusiana, also a boreal 'ingredient' species, and Trientalis europaea, also boreal. On the other hand, the factor has the strongest negative correlation to the nemoral dominant of the grass layer of conifer-nemoral forests, Aegopodium podagraria. The 1st PCA factor also has lesser by value (but still significant) negative correlation to the second nemoral dominant, Mercurialis perennis. We called it second because, in the area discussed, it is "the most nemoral" species among the dominants of the grass cover, though being less frequent in plant communities than A.podagraria.

Table 1.

Results of the Principal Component Analysis, subset 1

Variable	Factor 1	Factor 2
Oxalis acetosella	0.95	0.20
Stellaria nemorum	0.41	-0.84
Convallaria majalis	0.60	0.20
Pulmonaria obscura	0.08	-0.41
Fragaria vesca	-0.01	0.28
Asarum europaeum	-0.10	-0.58
Solidago virgaurea	-0.37	0.47
Carex pilosa	0.44	0.79
Vaccinium myrtillus	0.32	0.77
Glechoma hederacea	-0.28	-0.56
Aegopodium podagraria	-0.85	0.35
Mercurialis perennis	-0.73	0.09
Trientalis europaea	0.72	0.55
Urtica dioica	-0.57	0.01
Viola mirabilis	-0.35	0.36
Chelidonium majus	0.56	-0.66
Dryopteris carthusiana	0.85	0.22
Maianthemum bifolium	0.28	-0.84
**Clethrionomys glareolus*	1.35	0.56
**Apodemus uralensis*	1.14	-0.74

The second factor has factor load of 25%. It does not show linear correlation to any phytosociological group in the narrow sense. Nevertheless, it's feasible to deduce its nature taking into consideration its major positive associate, Bilberry (Vaccinium myrtillus). Bilberry indicates rather high moisture (F=6 by the Ellenberg scale). The factor also correlates with Carex pilosa. Both species are dominants in the investigated types of conifer-deciduous forests. Another important thing for understanding the nature of factor #2 is the fact of high negative correlation with Chelidonium majus, which is an antropophyt and typical for peripheral parts of the forests, or gaps. There is also strong negative correlation with Maianthemum bifolium. This species is a regular associate to Oxalis acetosella, dominant of boreal group. Remembering that the 1st factor was specifically pro-boreal, now we see that the 2nd one shows distinctly negative link to the boreal group.

We can see that the key species for the two most significant factors are O. acetosella, V. myrtillus and M. bifolium. The question emerges, why do they have such a significance in this context, isn't it a mistake: after all, the first and the last of them are tiny plants, with no serious impact on the ecosystem? But if we take into consideration the classic works of V. Sukachev [4], fulfilled for forest vegetation of that very region, the question receives a definite answer. Sukachov showed that V. myrtillus is the characteristic species for a category of vegetation types (plant associations), and specifically intermediate stages to paludal forests. And O. acetosella, specifically with M. bifolium, are also characteristic species to another group ("myrtillosa" and "oxalidosa" respectively). In the investigated area, 'myrtillus' associations are typical for inner parts of the forest while oxalis-maianthemum types - for plots with more open canopy.

There are two more species which factor #2 shows significant correlation - negative. The first one is Stellaria nemorum. The factor's repulsion to it is very strong by its absolute value: -0.84, so it's crucial to give explanation to this fact. And knowledge of the phytosociological preferences of this species helps in this case. S. nemorum in the area of investigation is not a forest species (sylvant) in the narrow sense: it is typical for gaps in the canopy on ecotones. In that way it confirms "forest" character of the factor.

The last noteworthy species is Chelidonium majus. Factor #2 shows negative correlation with this ruderal antropophyt, and it also proves the hypothesis written above.

We can see that A. uralensis shows inclination to ecotones and moss types of conifer-deciduous forests, while avoiding semi-paludal forest types and also plant associations with C. pilosa, most probably for mechanical reasons: Carex-dominated grass cover with its rigid evergreen leaves is too hard for the tiny Pygmy mouse.

What does this mean in the application to mammalian component? We can see that one of the species, A. uralensis, shows negative relation to factor #2. Taking into account the facts revealed on the previous step, it means that the Pygmy field mouse is inclined (typical) to ecotones and plots with broken canopy. Other authors also pointed out that this species prefers ecotones [7].

The second subset was examined also using the PCA, and it revealed also two major factors (Tab. 2). Factor 1 (65%) demonstrates strong positive correlation with A. podagraria, A. europaeum and M. perennis. Also a little bit lesser but also strong: C. pilosa and V. mirabilis. Phytosocilogical characteristic of these species is very clear, they are classic nemoral species, and many of the are specifically dominants of conifer-deciduous forests. On the other hand, the strongest negative correlation is to Convallaria majalis, species typical (in the given area) for dry and mesophyt conifer forests with dominance of Pinus sylvestric.

Table 2.

Results of the Principal Component Analysis, subset 2

Variable	**Factor 1**	**Factor 2**
Carex pilosa	0.89	0.44
Aegopodium podagraria	0.96	-0.27
Pulmonaria obscura	0.87	-0.37
Mercurialis perennis	0.93	-0.34
Viola mirabilis	0.89	-0.36
Equisetum pratense	0.60	-0.70
Asarum europaeum	0.96	0.12
Lathyrus vernus	0.63	0.77
Stellaria holostea	0.86	0.33
Dryopteris filix-mas	0.66	0.50
Glechoma hederacea	0.66	-0.55
Convallaria majalis	-0.92	-0.06
Oxalis acetosella	-0.38	-0.90
Rubus saxatilis	0.67	-0.58
Paris quadrifolia	0.43	0.77
Melica nutans	0.10	0.96
Carex digitata	-0.71	0.66
**Apodemus flavicollis*	0.13	-1.20
**Apodemus uralensis*	1.78	-3.53
* *Clethrionomys glareolus*	-0.37	1.85

The factor's character is now known, let's take a look how the mammal's react on it. We can see that the Pygmy field mouse has positive correlation with it, and it means that A. uralensis has distinct correlation to nemoral group of species.

Factor 2 (factor load 24%) is positively correlated with M. nutans, which can be called a species of sparse forests in this context, and strongly negatively correlated with O. acetosella. A. uralensis is, in its turn, negatively correlated with the factor and, thus, shows ‘attraction’ to O. acetosella, the central species of the moss associations. Exactly the same law was discovered for the first relevé set as we remember, so the present result confirms it.

To figure out coherence of the micromammalian species to concrete plants, Spearman's correlation coefficient was used. Calculation was fulfilled on the whole dataset, without separation to subsets. The following correlations were found out:

Clethrionomys glareolus (Bank vole): Maianthemum bifolium (-0.78), Asarum europaeum (-0.75), Equisetum pratense (-0.69), Dryopteris filix-mas (-0.67), Viola mirabilis (-0.64).

Apodemus flavicollis (Yellow-necked mouse): Carex pilosa (0.69), Lathyrus vernus (0.72), Stellaria holostea (0.95), Dryopteris filix-mas (0.91).

Apodemus uralensis (Pygmy field mouse): Vaccinium myrtillus (-0.51).

Bank vole has many statistically significant negative correlations to M. bifolium and some nemoral plants. The Yellow-necked mouse, on the contrary, showed positive correlation to some nemoral species. Apodemus uralensis avoids moist myrtillus-associations (the same thing was shown by PCA). And negative correlation of Bank vole to M. bifolium can be explained by competition of A. uralensis - we remember that the latter showed attraction to Oxalis/Maianthemum associations.

Thus the results show that micromammalia species have distinct preferences in the investigated vegetation. Moreover, they obviously show ecological niche segregation, for example it is statistically proven that the Bank vole avoids associations with D. filix-mas, while Yellow-necked mouse specifically prefers them. Another case for niche differentiation, as it is clear from the figures provided above, is “green-moss” forest type (with Oxalis and Maianthemum). A. uralensis typically populates such associations while the Bank vole avoids them.

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