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SMALL TERRESTRIAL MAMMALS' (Eulipotyphla, Rodentia) SYNUSIA OF SELECTED LOCALITIES IN WESTERN SLOVAKIA

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Abstract

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We carried out the small terrestrial mammals trapping on 16 localities of intensively used agricultural land biotopes between 2005 and 2007. Localities are situated the Podunajská nížina lowland, 10 of them are in the Podunajská pahorkatina hillock and 6 in the Podunajská rovina plain. We caught and teriologicaly examined 1642 individual of small terrestrial mammals, 16 species of insectivores and rodents. Small mammals were examined by cluster analysis and ordinal analysis (DCA, PCA a RDA) to determine their habitat preference.

Key words: insectivore, rodent, Podunajská pahorkatina hillock, Podunajská rovina plain, ecological evaluation

Introduction

Basic information about small terrestrial mammals in the Nitra region are discussed in Soviš (1958, 1962) that was based on agricultural land survey. The research of small terrestrial mammals fauna in the Tribeč mountains was carried out by Ligač (1970; 1985). The populations of small mammals in Báb in Nitra pahorkatina hillock were searched by Pachinger (1984), Ambros et al. (1986). Teriological survey in the Nitra district was summarized by Dudich et al. (1993) and Ambros et al. (2006). The research of small terrestrial mammals of Tribeč mountains was done by Jančová, Baláž (2004). In the Zálužianska pahorkatina hillock the research was carried out by Baláž (2002) and Baláž, Áč (2002). The survey of small mammals in the Podunajská nížina lowland was recorded by Dudich et al. (1985).

Material and methods

For fauna of small terrestrial mammals research we used methods according to Pucek, Olszewski (1971), Morris (1968). Small mammals were caught in collapsible traps of small type that were set by the line method (50 traps in one line) and exposed for 1–3 nights.

We determined somatic characteristics (body weight, body length, tail length and hind foot length), sex, sexual condition and reproduction potential. Before the material processing the hosts were deparazited. The species determination was based on Gaisler et al. (1962). The material of small terrestrial mammals' catchment consists of 1642 individuals (leg. et det. M. Ambros, I. Baláž, A. Jančová, A. Dudich, A. Stollmann, Z. Bridišová). The bigger part of the material (mostly osteologic material) is stored with I. Baláž (Faculty of Natural Sciences, UKF in Nitra).

The structure of species data was analyzed by descriptive statistics in program STATISTIKA StatSoft, Inc. (2004). The variables were evaluated by: arithmetic mean, median, modus, standard deviation, skewness (the rate of distribution of variables symmetry), kurtosis. The information reduction was reached by rotation of coordinate system of mutual factors. We used common rotation method Varimax that minimize the number of variables highly correlated with individual factors (Rimarčík, 2007; Cigáňová, 2006; Harman, 1974; Überla, 1975; Jackson, 1991). The factor analysis was used as first step of analysis with the aim to figure out the strength of the correlation of species data. Following the analysis we evaluated the data using ordinal and cluster analyses. The multivariate ordinal analysis of the material was performed in programs CANOCO and CanoDraw (Ter Brak, Šmilauer, 2002) from species matrix of small terrestrial mammals. We used the type of habitat as environmental factor. The aim of direct line redundant analysis (RDA) is to figure out the correlation between small terrestrial mammals and their habitats (environmental variables). The data structure was analyzed by hierarchic Ward cluster procedure (Johnson, Wichan, 2001; Ward, 1963). For calculation of the distance between objects we used Euclidean distance. The results were graphically projected as tree diagram (dendrogram) in program STATISTIKA StatSoft, Inc. (2004).

Study area

The small mammals catchment was carried out on 16 localities in the Padunajská nížina lowland, 10 of them are in the Podunajská pahoraktina hillock and 6 in the Podunajská rovina plain. The register of research localities consists of the locality name, abbreviation, cadastral area, biotope code according to Ružičková et al. (1996) and Stanová, Valachovič (2002), biotope name and DFS code. Research localities: Nitrianska pahorkatina hillock: DVL Dvorčiansky forest (cadastral area Dolné Krškany I., biotopes: 2111200 *Ulmenion-Querceto-Fraxinetum, Ulmeto-Fraxinetum*, 2112200 *Carici robori-Carpinenion betuli*, DFS 7774); KRS Krvavé Šenky (cadastral area Zbehy, biotopes: 2114400 *Quercetum petraeae-cerris*, 2112200 *Carici robori-Carpinenion betuli*, DFS 7674); Žitavská pahoraktina hillock: KLR Kolíňany, fishpond (cadastral area Kolíňany, biotopes: 8B10000 *Phragmition*, 2111100 *Salicion albae*, DFS 7675); KLS Kolíňany, orchard (cadastral area Kolíňany, biotope: A120000 *Fruit groves and vineyards*, DFS 7675); Tribeč: STI Štitáre (cadastral area Dolné Štitáre, biotope: 2112000 *Carici pilosae-Carpinenion betuli*, DFS 7675); ZIV Žirany, heathland (cadastral area Žirany, biotope: 4030 *Genistion*, DFS 7675); Hronská pahorkatina hillock: BVN Búč, water reservoir (cadastral area Vojnice, biotope: 8B10000 *Phragmition*, DFS 8176); BLU Búčske lúky meadows (cadastral area Búč, biotope: 8B21000 *Magnocaricion elatae*, DFS 8177); BYS Bystrička (cadastral area Radvaň nad Dunajom, biotope: 8B10000 *Phragmition*, DFS 8276); MOM Močianský majer grange (cadastral area Radvaň nad Dunajom, biotope: 8B21000 *Magnocaricion elatae*, DFS 8276); Podunajská rovina plain: CHFP Chotín, Fialkový stream (cadastral area Chotín, biotope: 8B10000 *Phragmition*, DFS 8175); MVA Malý Vék, residual deposit of the Žitava river (cadastral area Hurbanovo, biotope: 8B10000 *Phragmition*, DFS 8174); VVA Veľký Vék, residual deposit of the Žitava river (cadastral area Martovce, biotope: 8B10000 *Phragmition*, DFS 8174); VMD Veľký Meder (cadastral area Veľký Meder, biotope: 8B21000 *Magnocaricion elatae*, DFS 8172); HNP Hanské pastures (cadastral area Orechová Potôň, biotope: A112000 *Stellarietea mediae*, DFS 7971); KKC Kolárovský kanál channal, pumping device (cadastral area Šaľa, biotope: 8B30000 *Oenanthion*, DFS 7873).

Results

On 16 research localities we caught 1642 individuals of small terrestrial mammals of which we determined 16 species: Eulipotyphla – *Sorex araneus* L i n n a e u s , 1758; *Sorex minutus* L i n n a e u s , 1766; *Neomys anomalus* C a b r e r a , 1907; *Crocidura leucodon* (H e r m a n n , 1780); *Crocidura suaveolens* (P a l l a s , 1811); Rodentia – *Apodemus flavicollis* (M e l c h i o r , 1834); *Apodemus sylvaticus* (L i n n a e u s , 1758); *Apodemus uralensis* (*microps*) K r a t o c h v í l et R o s i c k ý , 1952; *Micromys minutus* (P a l l a s , 1771); *Mus spicilegus* P e t e n y i , 1882; *Arvicola terrestris* (L i n n a e u s , 1758); *Myodes* (*Clethrionomys*) *glareolus* (S c h r e b e r , 1780); *Microtus arvalis* (P a l l a s , 1779); *Microtus oeconomus* ssp. *méhely* (P a l l a s , 1776); *Microtus* (*Pitymys*) *subterraneus* (d e S é l y s L o n g - c h a m p s , 1835) and *Muscardinus avellanarius* (L i n n a e u s , 1758).

All shrews are protected by law *Microtus oeconomus*, *Muscardinus avellanarius*; LR:1c (least concern) – *Crocidura leucodon*, *Crocidura suaveolens, Micromys minutus, Muscardinus avellanarius*; LR:nt (near threatened) – *Neomys anomalus*; EN (endangered) – *Microtus oeconomus*; DD (data deficient) – *Mus spicilegus*; Bern3 (annex 3 of Bern convention) – *Crocidura leucodon*, *Crocidura suaveolens, Neomys anomalus, Microtus oeconomus, Muscardinus avellanarius*; HD4 (annex 4 Habitat Directive) – *Microtus oeconomus, Muscardinus avellanarius*.

To evaluate the aspect of dominance, we found out the following categories: eudominant (*Apodemus flavicollis, A. sylvaticus Myodes glareolus, Microtus arvalis*), dominant (*Sorex araneus*), subdominant (*Apodemus uralensis*), recedent (*Sorex minutus, Microtus oeconomus*), subrecedent (*Neomys anomalus, Crocidura leucodon, C. suaveolens, Micromys minutus, Mus spicilegus, Arvicola terrestris, Microtus subterraneus, Muscardinus avellanarius*).

Maximal values (numbers of small mammals individuals) and value of standard (SD) show high data heterogeneity (e.g. *Apodemus flavicollis*: maximal number of individuals 149, SD = 46.93). The high number of variables (number of individuals), deviated from the average are the cause of asymmetry of their division. Data have positive angularity (angularity > 0) => the average is larger than median.

The normality of species data distribution was tested by nonparametric test *Kolmogorov-Smirnov test* (K-S test). We tested the null hypothesis H_0 = data are normally distribute (alternative hypothesis H_A = data are not in accordance with normal distribution for importance level $\alpha = 0.05$). For species *Apodemus flavicollis* ($p < 0.05$), *Apodemus sylvaticus* ($p < 0.20$), *Sorex minutus* ($p < 0.20$) and *S. araneus* ($p <$ n.s.) we cannot reject the null hypothesis (species data are normally distributed). For other species the alternative hypothesis is valid.

The use of multivariable statistical methods has a point in confirmation of correlation between variables. To find out the correlation we used the factor analysis (FA). Due to the fact that our data are nonparametric we standardized species data in Statistika program. Factor analysis confirmed correlations between variables. Their structure was analyzed by PCA and cluster analysis.

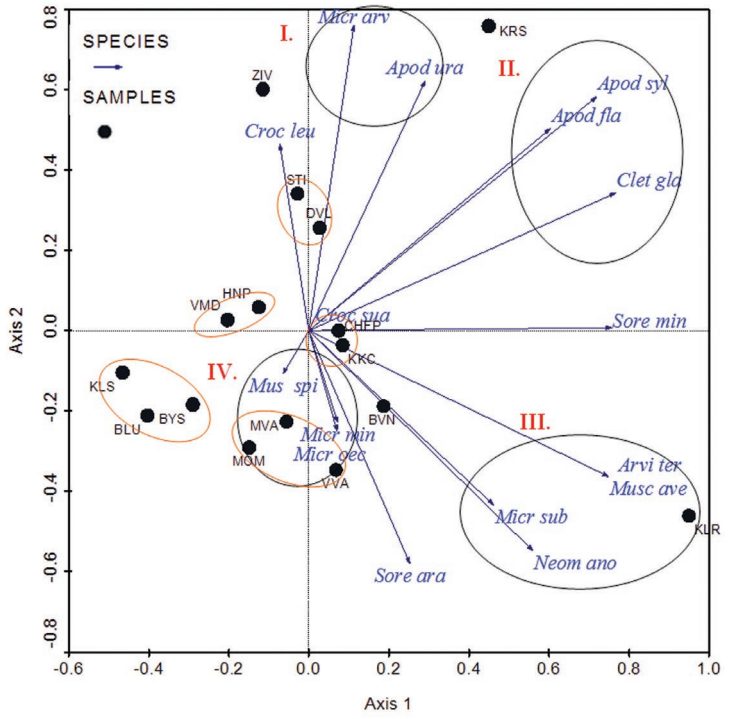

Fig. 1. The graph (biplot) of PCA analysis of small mammals and localities.

On the basis of the results of detrended correspondence analysis – DCA (*gradient lengths* = 2.24 < 4) the linear and nonlinear ordinance method (PCA a RDA) was used. Applied analysis of main components is successful procedure because first ordinance axis explains 24.2 % of data variability of small terrestrial mammals (fourth ordinance axis explains 71.9 % of cumulative variability of species data).

The results of main components ordinance PCA (Fig. 1) demarcated four groups of small mammals. First group consists of *Apodemus uralensis* and *Microtus arvalis* species; they prefer biotopes of cultural steppe. Second group is determined by *Apodemus sylvaticus*, *A. flavicollis* and *Myodes glareolus* species. These prefer sparse bright forests and forest complexes with rich bush and herb sub-canopy. The species most numerous group consists of *Arvicola terrestris*, *Muscardinus avellanarius*, *Microtus subterraneus* and *Neomys anomalus* species. All four species were found on Kolíňany pond locality. They prefer wetlands with thick vegetation growth. Fourth ordinance group is represented by *Mus spicilegus*, *Micromys minutus* and *Microtus oeconomus* species. The outer position (*outliers*) in ordinance graph is reserved for *Sorex araneus*, *S. minutus* and *Crocidura leucodon* species.

The habitat preference of small mammals was analysed by representational difference analysis (RDA), we used biotopes types as explanation variables. From RDA graph (Fig. 2)

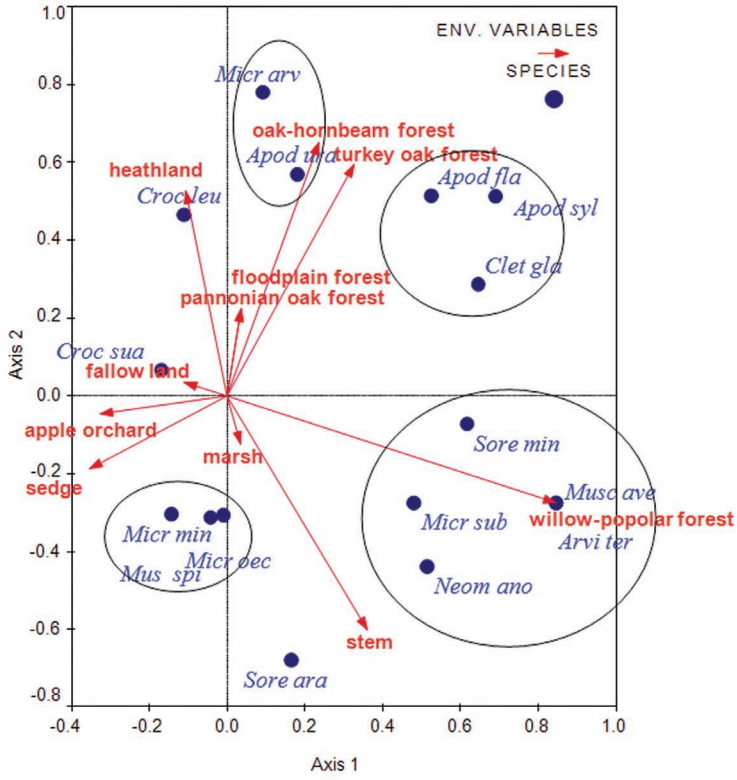

Fig. 2. The graph (biplot) of RDA analysis of small mammals' habitat preference.

independent groups of biotopes were defined: oak-hornbeam forest, Turkey oak forest with high measure of correlation, related to them are floodplain forest and Pannonian oak forest. Significantly different were biotopes of willow-poplar floodplain forests, stem vegetation (and swamps), heathlands and group of biotopes fallow land, apple orchard, sedge vegetation. We can see the connection of hosts (small mammals) and habitat types (biotopes). The preference of wet habitats and swamps indicate species *Sorex minutus*, *S. araneus*, *Neomys anomalus*, *Arvicola terrestris*, *Micromys minutus*, *Microtus oeconomus* and *M. subterraneus*. Species *Apodemus sylvaticus*, *A. uralensis*, *Microtus arvalis* and *Crocidura suaveolens* show the connection to drier habitats.

On the basis of dendrogram of cluster analysis we can determine the group consisting of species *Sorex minutus*, *Apodemus uralensis*, *A. sylvaticus*, *Myodes glareolus* and *Apodemus flavicollis*. According to cluster analysis the *A. uralensis* is closest to *A. sylvaticus* and *Myodes glareolus* to *Apodemus flavicollis*. Another cluster is created by *Microtus subterraneus*, *Muscardinus avellanarius* and *Arvicola terrestris*, in which last two species are mostly connected. The third cluster shows similarity between *Micromys minutus*, *Crocidura suaveolens*, *Microtus*

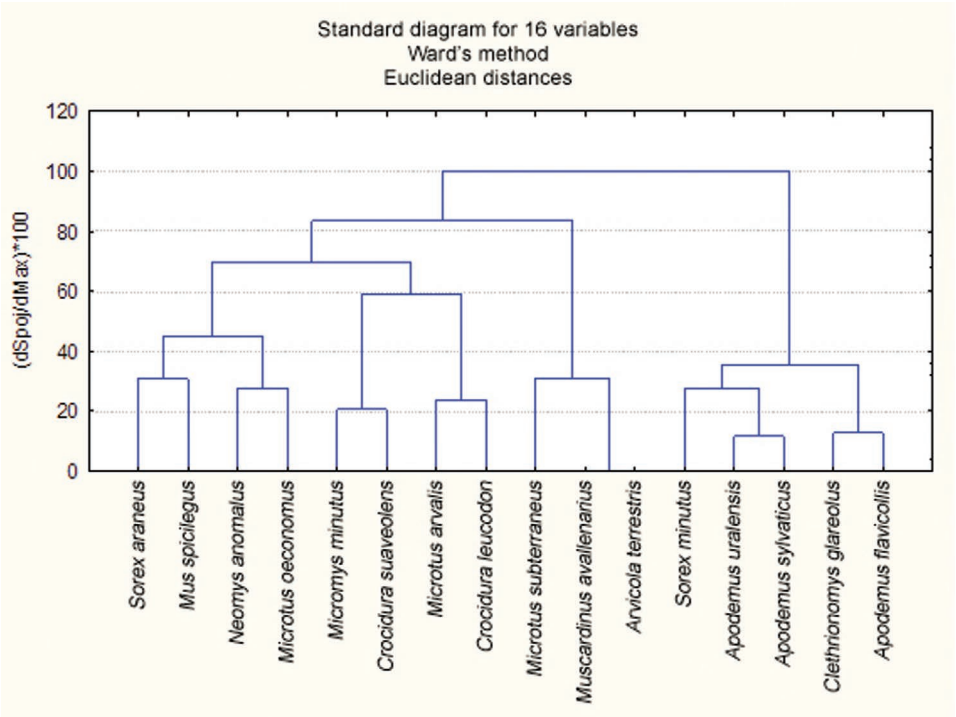

Fig. 3. Dendrogram of small terrestrial mammals.

arvalis and *Crocidura leucodon* species. The last cluster shows similarity of *Sorex araneus*, *Mus spicilegus*, *Neomys anomalus* and *Microtus oeconomus* species (Fig. 3).

Discussion

We confirmed the presence of 16 small mammals' species in the research area. Insectivores were represented by *Sorex araneus*, *S. minutus*, *Neomys anomalus*, *Crocidura leucodon* and *C. suaveolens* species. Rodents consist of *Apodemus flavicollis*, *A. uralensis*, *A. sylvaticus*, *Micromys minutus*, *Mus spicilegus*, *Arvicola terrestris*, *Clethrionomys* (*Myodes*) *glareolus*, *Microtus arvalis*, *M. oeconomus*, *M. subterraneus* and *Muscardinus avellanarius* species. Dudich et al. (1985) lists 17 species from Podunajská nížina lowland and Hronská pahorkatina hillock, in total he evaluates the occurrence of 22 species in this area. Comparing with our results the species structure of small mammals is the same except *Neomys fodiens* species, which presence we could not confirm.

In oak-hornbeam forest of Tribeč (Štitáre locality) we state like Dudich et al. (1993) poor small mammals species diversity with strong concentration of *Apodemus flavicollis* popula-

tion dominance. This locality is situated on the border of the Nitrianska pahorkatina hillock and Tribeč Mts. Dudich et al. (1993) mentions low rate of insectivores (5.6%) on Dvorčiansky forest locality and presence of "steppe" species as *Crocidura leucodon*, *Apodemus uralensis* and *Microtus arvalis*. In comparison with their results we did not catch species *Crocidura leucodon*, *Apodemus uralensis* and *Microtus subterraneus*. We found out three dominant rodent species that is in accordance with our results.

Along the Bocegaj kanál channel (Kolíňany locality, pond) we found out 10 species of small mammals. We confirmed the occurrence of *Muscardinus avellanarius*, *Neomys anomalus*, *Microtus arvalis* and *Sorex minutus* species that were not caught here by Jančová, Baláž (2004). Other situation is on Kolíňany locality, apple orchard where we caught only *Microtus arvalis* species, but 7 species were found here (Jančová, Baláž, 2004). Authors recorded the most favourable ecological indicators in spite of low numerousness that can be confirmed by our research as we caught only one species.

We documented the presence of relict species *Microtus oeconomus* ssp. *méhelyi* (17 individuals) on three localities Chotín, Fialkový potok, Malý and Veľký Vék, in Žitava alluvium). Kratochvíl, Rosický (1955) observe that the species is bound to specific habitats, which existence is dependant on water presence and its stable regime that is in accordance with our results. In this area the species is known from various localities (Stollmann, Ambros, 1998; Ambros et al., 1999, 2004; Bridišová, 2005).

The descriptive statistics (multiple box like graph, K-S test, we tested null hypothesis H_0 = data are normally distributes) confirmed high data heterogeneity with occurrence of elongate and extreme values for *Apodemus flavicollis*, *A. sylvaticus*, *A. uralensis*, *Myodes glareolus*, *Microtus arvalis* and *Sorex araneus* species. For example *Apodemus flavicollis* values were: maximum 149 individuals, average = 26.43, SD = 46.93, angularity = 2.04 a sharpness = 3.22. For species *Apodemus flavicollis* ($p < 0.05$), *A. sylvaticus* ($p < 0.20$), *Sorex minutus* ($p < 0.20$) and *S. araneus* ($p <$ n.s.) we cannot reject the null hypothesis (species data are normally distributed). For other species the alternative hypothesis is correct.

The PCA analysis determined 4 ordinance clusters of hosts. First group consists of *Apodemus uralensis* and *Microtus arvalis,* species that prefer cultural steppe biotopes. Forest species *Apodemus sylvaticus*, *A. flavicollis* and *Myodes glareolus* represent second ordinance group that correlate with forest locality near Krvavé Šenky village. Ordinance cluster III consist of wetland species *Arvicola terrestris*, *Muscardinus avellanarius*, *Microtus subterraneus* and *Neomys anomalus*. All species were caught on Kolíňany locality. Fourth ordinance cluster includes *Micromys minutus* and *M. oeconomus,* species with distinctive preference of sedge vegetation (Veľký Vék locality, Žitava alluvium). *Sorex araneus*, *S. minutus* and *Crocidura leucodon* represent the outer position in the graph (*outliers*).

On the basis of RDA analysis, the results are interpreted by determination of biotopes groups: oak-hornbeam forest and Turkey oak forest with high rate of correlation, related to them are floodplain forests, sedge vegetation, heathland and biotopes group of fallow land, apple orchard, sedge vegetation. RDA analysis shows the connection between species and habitat types (biotopes). We can see the preference of wet habitats by *Sorex minutus*, *S. araneus*, *Neomys anomalus*, *Arvicola terrestris*, *Micromys minutus*, *Microtus oeconomus* and

M. subterraneus. Species *Apodemus sylvaticus*, *A. uralensis*, *Microtus arvalis* and *Crocidura suaveolens* show preference towards drier habitats. These findings are confirmed by works of Baláž, Ambros (2005a, b, 2006, 2007). First ordinance axis of used RDA analysis explains 22.5% of cumulated data variability (fourth ordinance axis explain 62.7%). First ordinance axis of used RDA analysis explains 30.9% of cumulative environmental data variability (fourthordinance axis explains 85.9%). According to values of cumulative variability we can state that used RDA analysis is proper method for data analysis. Monte-Carlo permutation test confirmed the statistical significance (on the border of the significance) of willow-poplar forest and sedge vegetation biotope types (p–value = 0.05). The cluster analysis determined four groups. The result of high biotope bioindication value of small mammals is the similarity of species clusters in the PCA and cluster analysis. In dendrogram there is independent forest species group of *Apodemus flavicollis*, *A. sylvaticus* and *Myodes glareolus*, the group of wetland species *Microtus subterraneus* and *Arvicola terrestris* and subgroup on the limit of 30% similarity of wetland species *Neomys anomalus* and *Microtus oeconomus*.

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