

Temporal changes in small mammal (Eulipotyphla, Rodentia) assemblages in Košice Zoo (Slovakia)

Alexander Csanády & Michal Stanko

Temporal changes in small mammal (Eulipotyphla, Rodentia) assemblages in Košice Zoo (Slovakia). – Acta Mus. Siles. Sci. Natur., 72: 208–220, 2023.

Abstract: This study summarizes 17-year results of teriological research of small mammal fauna in Košice Zoo (near the village of Kavečany, 48°47'10.04"N, 21°12'3.26"E, 380 – 420 m a.s.l.). The small mammals evaluated in this study were obtained by trapping in three periods (1992 – 1994, 2000 – 2001, 2003 – 2004) and were the results of three diploma theses. In total, 688 small mammals belonging to 13 species of four families Soricidae, Gliridae, Cricetidae and Muridae were recorded by trapping during the study period. Rodents significantly dominated with 8 species, 583 ex. (84.7%) compared to insectivores represented by 5 species, 105 ex. (15.3%). A gradual diversity decline of small mammal fauna was recorded, with only four mammal species confirmed in 2003 – 2004. This marked difference over the last 17 years was probably the result of anthropic modifications of the Zoo area, mainly the cutting of trees and shrubs of the alluvium, technical modifications of the streambeds as well as the deratization of the building areas and animal enclosures. The assemblage's structure of captured small mammals could also be influenced by other factors, such as the predominant type of traps used, or the number of exposed traps in the vegetation and non-vegetation periods of the year. The obtained results are also a suitable basis and source of information for comprehensive and long-term monitoring in this area, given the epidemiological importance of this group of animals and the possibility of contact with exotic animals.

Key words: biodiversity, small mammals, zoological garden, assemblages, Slovakia

Introduction

The study presents the results of the theriological research of the territory of the Zoological Garden in Košice (hereafter Košice Zoo) and the assessment of changes in the structure of the small mammal community over 17 years. The first data on the community of small insectivores and rodents from the studied area are given by Stanko *et al.* (1990). This study represented the research of the small mammal fauna in the first years of the Zoo's existence. The authors pointed out the need for research and knowledge of the fauna of these epidemiologically important groups of mammals, not only of theoretical but also of practical importance. A total of 42 species of mites (Mesostigmata), 2 species of ticks (Ixodida), 17 species of fleas (Siphonaptera) and 3 species of lice (Anoplura, Phtiraptera) were confirmed on small mammals in Zoo Košice in these periods. Several species of these haematophagous arthropods are important vectors of several serious zoonoses (Stanko 1990, 1991; Fričová & Stanko 1993). This is emphasized by the epidemiological aspects caused by the possible contact of introduced animals with the native fauna. This was also the reason why later research was carried out in the area in several years (1992 – 1994, 2000 – 2001, 2003 – 2004). Nevertheless, the obtained data have not been published so far and can be found only in diploma theses (cf. Olšav 1995; Rondošová 2002; Chatur 2005).

More comprehensive research directly in urban and suburban areas of Košice has been conducted by several authors (Mošanský 1985, 1989; Házelmayrová 1992; Čanády 2016; Čanády & Mošanský 2017).

The aim of this study was to evaluate the qualitative-quantitative composition of the fauna of small mammals of the studied area and to assess the changes in their structure from the temporal point of view.

Material and Methods

The territory of the Zoo Košice in the period of the research had an area of 288 ha, the area of which is situated north of Košice near the village of Kavečany (48°47'10.04"N, 21°12'3.26"E, 380 – 420 m a.s.l.). It is in the source area of the Hrubša stream, which is a right-side tributary of the Hornád River (Fig. 1). Geomorphologically, the area belongs to the Slovenské rudohorie Mts., its easternmost sub-region of the Čierna hora Mts. (Michaeli 2015).

The vegetation covers in the past consisted of diverse forest communities of oak-hornbeam and beech forests, and to a lesser extent oak subxerophyll and maple mountain forests were developed (Michalko *et al.* 1986). However, nowadays a substantial part of the study area is deforested with current existence only solitary trees or tree groups and shrubs for the needs of the Zoo. Several small streams originate here, forming the Hrubša stream with preserved bank vegetation. The original stands of the common alder (*Alnus glutinosa* (L.) Gaertn.) have been replaced by the European hornbeam (*Carpinus betulus* L.), the European beech (*Fagus sylvatica* L.) and maples (*Acer* sp.) in many of the drier places and especially on the slopes.

The small mammals evaluated in this study were obtained by trapping in three periods and were the results of three diploma theses. It should be noted that all the mentioned diploma theses were written under the supervision of the second author (M.S.) of the present paper:

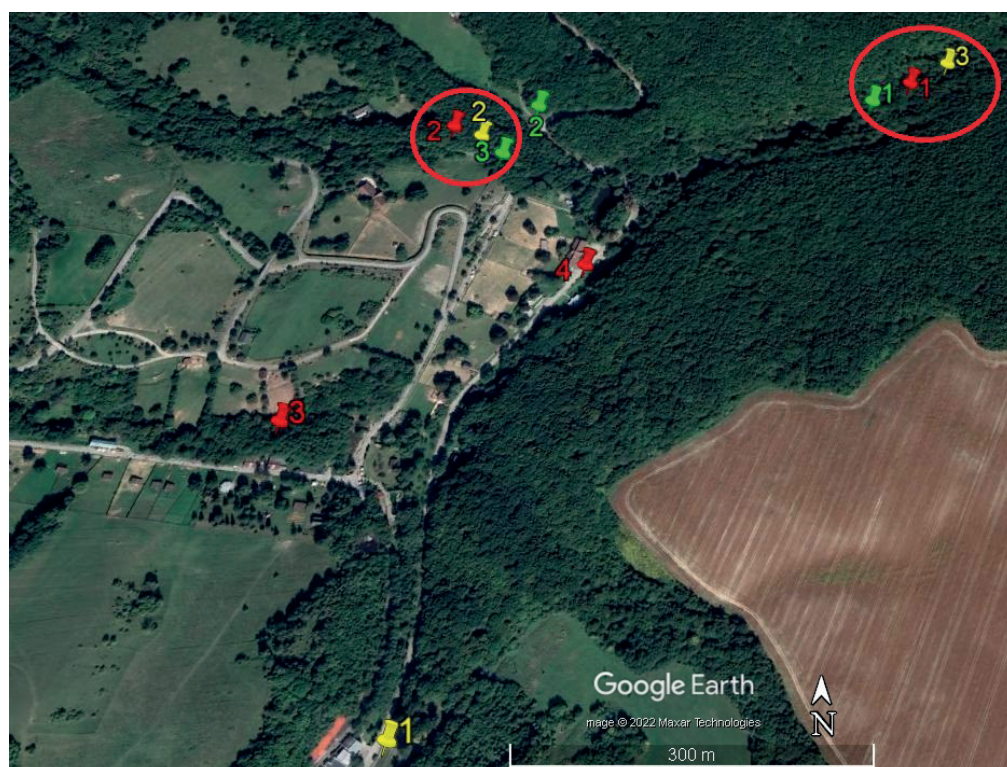


Fig. 1: Study areas of small mammal's capture in the Košice Zoo (Source: ©2022 Google, Image©2022 Maxar Technologies). Note: red markers indicate captures in 1992 – 1994 (cf. Olšav 1995), yellow markers indicate captures in 2000 – 2001 (cf. Rondošová 2002) and green markers indicate captures in 2003 – 2004 (cf. Chautur 2005). Red circles indicate a common location for all three trapping periods.

I. Researches between 1992 – 1994: The research was carried out using the line method with the use of snap traps of small type (cf. Olšav 1995). Trapping was carried out by the statistical method, i.e., traps were laid out in four lines of 50 traps in 5-meter intervals and exposed for 1 – 2 nights (Turček 1957). A total of 12 trapping intervals were conducted and 4000 traps/nights were exposed. During this period, 249 individuals of small mammals belonging to 10 species were trapped (Table 1).

Site (Line) 1: Hrubša stream alluvium (Fig. 1). Twelve trapping dates were conducted on this lineage. The line represented the section least altered by anthropogenic activity because it is located outside the main area of the Zoo Košice. The stream alluvium transitions continuously into deciduous forest with a rich tree species composition. The tree cover here was well developed, dominated by European beech (*F. sylvatica* L.). There was also occasional the common oak (*Quercus robur* L.). Shrubs were mainly the European elder (*Sambucus nigra* L.) and, in less shaded areas, the wild privet (*Ligustrum vulgare* L.). The herbaceous undergrowth was particularly abundant at the beginning of the line, dominated by the common nettle (*Urtica dioica* L.) and burdock (*Arctium* sp.). In the next part, various grass species, the male fern (*Dryopteris filix-mas* (L.) Schott, 1834) and the European wild ginger (*Asarum europaeum* L.) grew. Of the spring flowering herbs, there were the wood anemone (*Anemone nemorosa* L.) and the wood violet (*Viola odorata* L.).

Site (Line) 2: an alluvium of a stream flowing into a waterbird pond (Fig. 1). Twelve trapping sessions were conducted at the site as well, with two lines (before and behind the Gazdovský dom house) of 50 traps each exposed during the three trapping dates (October and November 1992, and February 1993), which followed each other. Later, for objective reasons, only one line (behind Gazdovský dom house) was laid out. The base of the tree line here consisted of the European hornbeam (*C. betulus* L.), the common alder (*A. glutinosa* (L.) Gaertn.) and the European ash (*Fraxinus excelsior* L.). The shrub layer consisted of the European elder (*S. nigra* L.), the Midland hawthorn (*Crataegus laevigata* L.) and the spindle tree (*Euonymus* sp.). Being a wet habitat there was a rich herbaceous understory consisting of the marsh-marigold (*Caltha palustris* L.), the meadow buttercup (*Ranunculus acris* L.), the wood anemone (*A. nemorosa* L.), the common nettle (*U. dioica* L.), and several species of grasses (Poaceae).

Site (Line) 3: stream flowing behind the Kamzík buffet (Fig. 1). The trapping line was in the alluvium of the stream flowing behind the Kamzík buffet. This site was adjacent to a visitor pathway next to goat, antelope, and other animal enclosures. Six trapping dates were conducted at the site (October 1992, February, March, April, June and September 1993). The above-mentioned locality was considerably affected by anthropogenic activities, e.g., Kamzík buffet, various garbage, toilets, feed store. The trees present were the European ash (*F. excelsior* L.), the common alder (*A. glutinosa* (L.) Gaertn.) and the European hornbeam (*C. betulus* L.). The shrubby vegetation consisted of stands of the Midland hawthorn (*C. laevigata* L.), the blackthorn (*Prunus spinosa* L.) and, at the edges the dog rose (*Rosa canina* L.). The herbaceous undergrowth included the marsh-marigold (*C. palustris* L.), the meadow buttercup (*R. acris* L.), the lungwort (*Pulmonaria officinalis* L.), and various species of grasses (Poaceae) grew along the roadside. The terrain was largely affected by increased water levels in the stream (rainfall, snowmelt), when the area became waterlogged.

Site (Line) 4: alluvium of central stream (Fig. 1). The site was an open, well-lighted habitat located in the alluvium of Hrubša stream, flowing through the centre of the Zoo, opposite the ungulate enclosures. This stream was regulated with a partially paved bank. Nevertheless, there was a rich herbaceous understory on the relatively high bank of the stream. On the other hand, this stretch was adjacent to an extensive forest complex. The trapping was carried out 7 times. Absence in trapping during two dates was due to logging and timber removal in the forest and to partial destruction of vegetation on the site. The herbaceous undergrowth was represented by various species of grasses (Poaceae), also the woolly burdock (*Arctium tomentosum* Mill.), the coltsfoot (*Tussilago farfara* L.), the wild strawberry (*Fragaria vesca* Coville), the brown knapweed (*Centaurea jacea* L.), the silverweed (*Potentilla anserina* L.) and the yarrow (*Achillea millefolium* L.). Sparsely represented shrubs were the dog roses (*R. canina* L.) and willows (*Salix* sp.).

II. Research between 2000 – 2001: The research was carried out using the linear method with the use of pitfall traps (cf. Rondošová 2002). Each line was formed by 10 pitfall traps placed at 5 m distances from each other. Two-litre plastic bottles with the neck cut off were used as traps, which were placed in the ground up to the edge and fitted with a roof. Each trap was filled about one-third full of a 4% formalin solution. Catches were checked at regular two-week intervals, deposited individually into glass bottles with caps accompanied by line and trap markings. Traps were exposed from 26.10.2000 to 22.11.2001, representing 23 trapping intervals and 8 280 trap-nights (during the period April 12 – 26.04, 2001, the Zoo was closed for quarantine and traps were inaccessible). A total of 264 individuals of small mammals belonging to 11 species were trapped (Table 1).

Site (Line) 1: the grassed area near the Zoo headquarters building (Fig. 1). At the same time, the site can be considered as strongly influenced by human activities as it was near the administration building and sanitary facilities. Part of the study area was also paved.

Site (Line) 2: the stream flowing behind the Kamzík buffet (Fig. 1). We provide a detailed description above, as the site was identical to a previous survey in 1992 – 1994 (cf. Site 3, Olšav 1995).

Site (Line) 3: the alluvium of the Hrubša stream (Fig. 1). We provide a detailed description above, as the site was identical to a previous survey in 1992 – 1994 (cf. Site 1, Olšav 1995).

III. Research between 2003 – 2004: The survey was carried out using the line method with the use of small snap traps (cf. Chatur 2005). Trapping was carried out using a statistical method, i.e., traps were laid out in four lines of 50 traps, spaced 5 m apart, and exposed for 1 – 2 nights. A total of 12 trapping intervals were carried out from 24.07.2003 to 13.10.2004 (July, August, October, November 2003, January, March, April, June, July August, September and October 2004) and 3 450 trap-nights exposed (in January 2004 only 150 traps were exposed due to zero catch after the first night). During this period 175 small mammals belonging to 4 species were captured (Table 1).

Site (Line) 1: Hrubša stream alluvium (Fig. 1). We provide a detailed description above, as the site was identical to previous investigations (cf. Olšav 1995, Rondošová 2002).

Site (Line) 2: an alluvium of a stream flowing into a pond with waterbirds (behind Gazdovský dom house, Fig. 1). We provide a detailed description above, as the site was identical to previous investigations (cf. Olšav 1995). An anthropic intervention occurred in spring 2004, during which the scrub cover was overcut.

Site (Line) 3: an alluvium of a stream flowing into a waterbird pond (before the Gazdovský dom house, Fig. 1). We provide a detailed description above, as the site was identical to previous investigations (cf. Olšav 1995). An anthropic intervention occurred in spring 2004, during which the scrub cover was overcut.

We analysed small mammal assemblage based on cenological characteristics such as dominance (D%). Also, cenological indices were used:

Jaccard's (Ja) species identity index, expressing the similarity in species composition of two or more habitats.

Renkonen's (Re) index of dominance, to quantitatively compare the syntheses of two or more zoocenoses (Losos *et al.* 1984; Májský 1985). Critical values of the Re index are as follows: $80 < Re$ – “marked similarity” to “identity”, $80 > Re > 60$ – “strong similarity”, $60 > Re > 40$ – “similarity”, $Re > 40$ – “low similarity” to “dissimilarity”.

At the same time, the recorded species were classified according to the classification of Tischler (1949) into five degrees of dominance: eudominant (Ed) $> 10.0\%$, dominant (Do) 5 to 9.9% , subdominant (Su) 2 to 4.9% , recedent (Re) 1 to 1.9% , and subrecedent species (Sr) $< 0.9\%$.

Frequency also reflects constancy of occurrence (Tischler 1949), according to which we distinguish species that are accidental (occurrence 0 – 25%), accessory ($25 - 50\%$), constant ($50 - 75\%$) and euconstant ($75 - 100\%$).

Results

In the study area, 688 small mammals belonging to 13 species of four families Soricidae, Gliridae, Cricetidae and Muridae were recorded by trapping during the study period (Table 1). Rodents significantly dominated ($N = 583$, 84.7%) compared to insectivores ($N = 105$, 15.3%).

Insectivores (Eulipotyphla) were represented by five species: the Lesser white-toothed shrew (*Crocidura suaveolens* Pallas, 1811), the Mediterranean water shrew (*Neomys anomalus* Cabrera, 1907), the Eurasian water shrew (*N. fodiens* Pennant, 1771), the Common shrew (*Sorex araneus* Linnaeus, 1758) and the Eurasian pygmy shrew (*S. minutus* Linnaeus, 1766). The activities of moles (*Talpa europaea*) were also recorded in the studied area, but the traps used are not suitable for catching them.

Rodents (Rodentia) were represented by eight species: the Hazel dormouse (*Muscardinus avellanarius* Linnaeus, 1758), the Common vole (*Microtus arvalis* Pallas, 1778), The European pine vole (*M. subterraneus* de Selys-Longchamps, 1836), the Bank vole (*Clethrionomys glareolus* Schreber, 1780), the Striped field mouse (*Apodemus agrarius* Pallas, 1771), the Yellow-necked mouse (*A. flavicollis* Melchior, 1834), the Wood mouse (*A. sylvaticus* Linnaeus, 1758) and the Harvest mouse (*Micromys minutus* Pallas, 1771).

Period 1992 – 1994

During the period 1992 – 1994, a total of 249 small mammals of 10 species were captured (Table 1, 2).

Group dominance (GD) of insectivores (Soricidae) accounted for 3.2% (8 ex.) of captures, representing a subdominant position in small mammal assemblages. *S. araneus* was the most

abundant species (2.0%, 5 ex.) in small mammal assemblages, with the remaining two species, *S. minutus* and *Neomys anomalus*, having subrecedent representation in small mammal assemblages (Table 1, 2). In terms of frequency of occurrence, all recorded insectivores had accidental occurrence.

Rodents dominated the total captures with 241 individuals (96.8%) belonging to three families. The family Gliridae was represented by one species, *Muscardinus avellanarius*, with a single individual captured. Three species of the family Cricetidae, subfamily Arvicolinae, formed the group dominance (16.2%), with eudominant representation of *C. glareolus* (13.7%), recedent representation of *M. arvalis* (1.2%, Table 2) and subrecedent representation of *M. subterraneus* (0.8%, Table 1, 2). While *C. glareolus* was euconstant in the captures, the other species had an accidental occurrence.

The family Muridae was represented by three species with group dominance (GD = 83.4%, 201 ex., Table 1, 2), with eudominant representation of *A. flavicollis* (57.4%), *A. agrarius* (22.5%) and subdominant representation of *A. sylvaticus* (0.8%). Euconstant occurrence (100%) was confirmed for *A. flavicollis*, constant (66.6%) for *A. agrarius* and finally *A. sylvaticus* represented the species with an accidental occurrence in small mammal assemblages.

The overview of captured mammals by sites (lines) shows differences in the species captured. In general, species of the genus *Apodemus* dominated in all four lines: *A. flavicollis* and *A. agrarius* (Table 2). Three species were common to all sites (*S. araneus*, *A. flavicollis* and *A. agrarius*), indicating differences in the fauna of the area. The compared sites also differed in the quantitative representation of each species. While the first three sites (1 – 3) were dominated by typical forest species, site 4 contained species well adapted to drier, over-lit habitats with herbaceous undergrowth.

The evaluation and comparison of the sites against each other using Jaccard's (Ja) and Renkonen's (Re) indices showed differences. In terms of small mammal species composition, Site 1 and Site 3 were the most similar (Ja = 66.6, Table 5). Species similarity was also found between Site 1 and Site 2 as well as Site 1 and Site 3 (for both comparisons was Ja = 57.1, Table 5).

Quantitative comparisons of communities revealed marked similarity between Site 1 and Site 3 (Re = 88.0) and "strong similarity" between Site 1 and Site 2 (Re = 66.6), Site 2 and Site 3 (Re = 71.1), Site 2 and Site 4 (Re = 63.0). Similarity in assemblages was found between Comparing Sites 1 and Sites 4 was found "similarity" between then (Re = 53.1).

Period 2000 – 2001

During the period 2000 – 2001, a total of 264 small mammals of 11 species were captured (Table 1, 3).

Group dominance (GD) of insectivores (Soricidae) accounted for 36.4% (96 ex.) of captures, representing a eudominant position in small mammal assemblages. *S. minutus* was the most abundant species with eudominant occurrence (12.9%, 34 ex.) in small mammal assemblages. Two species of the genus *Neomys*, *N. fodiens* and *N. anomalus*, dominated in the captures (Table 1, 3). *S. araneus* and *C. suaveolens* were only sporadically represented (Table 1, 3). In terms of frequency of occurrence, all recorded insectivores were accidental occurrence.

Three species of the family Cricetidae, subfamily Arvicolinae, formed the group dominance (14.7%), with dominant representation of *C. glareolus* (8.7%) and *M. arvalis* (5.6%, Table 3) and subrecedent representation of *M. subterraneus* (0.4%, Table 1, 2).

The family Muridae was represented by three species with group dominance ($GD = 48.9\%$, 129 ex., Table 1, 3), with eudominant representation of *A. flavicollis* (38.6%), dominant *A. agrarius* (9.5%) and subrecent representation of *M. minutus* (0.8%). Except for *A. flavicollis*, whose occurrence in period 2000 – 2001 was accessory, other rodent's species had accidental occurrence.

By comparing the dominance of species at each site (lines), differences were confirmed (Table 3). In terms of species composition and number of mammals captured, Site 2 dominated with 11 species and 143 individuals. The second most abundant was Site 3 (8 species, 106 ex.) and the least was Site 1 (3 species, 15 ex.).

Two species were common to all sites (*N. fodiens* and *A. flavicollis*), indicating differences in the fauna of the area.

The similarity of the lines was verified on the basis of Jaccard's (Ja) and Renkonen's (Re) indices. The highest similarity based on species composition was found between Site 2 and Site 3 ($Ja = 70$, Table 5).

Quantitative comparisons of communities revealed "marked similarity" between Site 2 and Site 3 ($Re = 65.9$). The "low similarity" were confirmed between Site 1 and Site 2 ($Re = 22.8$), Site 1 and Site 3 ($Re = 12.4$, Table 5).

Period 2003 – 2004

During the period 2003 – 2004, a total of 175 small mammals of four species were captured (Table 1, 4).

Only the species *N. fodiens* was recorded from insectivores (Soricidae family), with only one individual captured. In terms of frequency of occurrence, its occurrence was accidental (Table 1, 4).

Rodents strongly dominated the captures with 174 individuals (99.4%) belonging to two families. The family Cricetidae was represented by *C. glareolus* (13.7%), with 29 captured individuals representing a eudominant representation in small mammal communities. In terms of frequency of occurrence, its abundance was constant. The remaining two species, *A. agrarius* and *A. flavicollis*, belonged to the family Muridae with group dominance ($GD = 82.8\%$). Both species had eudominant abundance (16.6% and 61.1%, respectively) and their abundance in captures was also constant (Table 1, 4).

From a review of mammal captures by sites (lineages), there were no differences in the species captured, which were represented by three common species (*C. glareolus*, *A. agrarius*, and *A. flavicollis*). More pronounced differences were noted only in their abundances. In general, *A. flavicollis* was dominant on all three sites with *A. flavicollis* being the most dominant on Site 2 (Table 4).

Evaluation and comparison of sites against each other using Jaccard's (Ja) and Renkonen's (Re) indices showed no differences. In terms of small mammal species composition, Site 1 and Site 3 were most similar ($Ja = 100$, Table 5). Species similarity was also found between Site 1 and Site 2 as well as Site 1 and Site 3 (for both comparisons was $Ja = 75.0$, Table 5).

A quantitative comparison of the assemblages found "strong similarity" between Site 1 and Site 2 ($Re = 74.3$) and between Site 2 and Site 3 ($Re = 72.3$). Comparing Sites 1 and Site 3 was confirmed "similarity" in assemblages ($Re = 48.3$, Table 5).

Tab. 1: Overview of small mammals captured in Košice Zoo.

Species	1987 – 1988 Stanko et al. (1990)		1992 – 1994 Oľšav (1995)		2000 – 2001 Rondšošová (2002)		2003 – 2004 Chautur (2005)		Σ mammals	
	N	D%	N	D%	N	D%	N	D%	N	D%
<i>Crocidura suaveolens</i>	1	0.2(Sr)			1	0.4(Sr)			2	0.2(Sr)
<i>Neomys anomalus</i>	19	3.2(Su)	1	0.4(Sr)	27	10.2(Ed)			47	3.7(Su)
<i>Neomys fodiens</i>	14	2.3(Su)			28	10.6(Ed)	1	0.6(Sr)	43	3.3(Su)
<i>Sorex araneus</i>	6	1.0 (Re)	5	2.0(Su)	6	2.3(Su)			17	1.3(Re)
<i>Sorex minutus</i>	4	0.7(Sr)	2	0.8(Sr)	34	12.9(Ed)			40	3.1(Su)
<i>Glis glis</i>	4	0.7(Sr)							4	0.3(Sr)
<i>Muscardinus avellanarius</i>	2	0.3(Sr)	1	0.4(Sr)					3	0.2(Sr)
<i>Microtus arvalis</i>	21	3.5(Su)	3	1.2(Re)	15	5.6(Do)			39	3.0(Su)
<i>Microtus subterraneus</i>	5	0.8(Sr)	2	0.8(Sr)	1	0.4(Sr)			8	0.6(Sr)
<i>Clethrionomys glareolus</i>	44	7.4(Do)	34	13.7(Ed)	23	8.7(Do)	29	16.6(Ed)	130	10.1(Ed)
<i>Apodemus agrarius</i>	44	7.4(Do)	56	22.5(Ed)	25	9.5(Do)	38	21.7(Ed)	163	12.7(Ed)
<i>Apodemus flavicollis</i>	425	71.2(Ed)	143	57.4(Ed)	102	38.6(Ed)	107	61.1(Ed)	777	60.5(Ed)
<i>Apodemus sylvaticus</i>	6	1.0(Re)	2	0.8(Sr)					8	0.6(Sr)
<i>Micromys minutus</i>	2	0.3(Sr)			2	0.8(Sr)			4	0.3(Sr)
Σ mammals	597		249		264		175		1285	

Tab. 2: Overview of small mammals captured in Košice Zoo during period 1992 – 1994 (cf. Olšav 1995) according to lines.

Species	Line 1		Line 2		Line 3		Line 4		Σ mammals	
	N	D%	N	D%	N	D%	N	D%	N	D%
<i>Neomys anomalus</i>			1	1.4(Re)					1	0.4(Sr)
<i>Sorex araneus</i>	2	2.7(Su)	1	1.4(Re)	1	2.2(Su)	1	1.8(Re)	5	2.0(Su)
<i>Sorex minutus</i>							2	3.6(Su)	2	0.8(Sr)
<i>Muscardinus avellanarius</i>	1	1.3(Re)							1	0.4(Sr)
<i>Apodemus agrarius</i>	9	12.0(Ed)	15	20.5(Ed)	4	8.9(Do)	28	50.0(Ed)	56	22.5(Ed)
<i>Apodemus flavicollis</i>	57	76.0(Ed)	33	45.2(Ed)	31	68.9(Ed)	22	39.3(Ed)	143	57.4(Ed)
<i>Apodemus sylvaticus</i>					2	4.4(Su)			2	0.8(Sr)
<i>Microtus arvalis</i>			2	2.7(Su)			1	1.8(Re)	3	1.2(Re)
<i>Microtus subterraneus</i>							2	3.6(Su)	2	0.8(Sr)
<i>Clethrionomys glareolus</i>	6	8.0(Do)	21	28.8(Ed)	7	15.6(Ed)			34	13.7(Ed)
Σ mammals	75		73		45		56		249	

Tab. 3: Overview of small mammals captured in Košice Zoo during period 2000 – 2001 (cf. Rond’ošova 2002) according to lines.

Species	Line 1		Line 2		Line 3		Σ mammals	
	N	D%	N	D%	N	D%	N	D%
<i>Crocidura suaveolens</i>			1	0.7(Sr)			1	0.4(Sr)
<i>Neomys anomalus</i>			17	11.9(Ed)	10	9.4(Do)	27	10.2(Ed)
<i>Neomys fodiens</i>	4	26.7(Ed)	18	12.6(Ed)	6	5.7(Do)	28	10.6(Ed)
<i>Sorex araneus</i>			3	2.1(Su)	3	2.8(Su)	6	2.3(Su)
<i>Sorex minutus</i>			27	18.9(Ed)	7	6.6(Do)	34	12.9(Ed)
<i>Microtus arvalis</i>	10	66.7(Ed)	5	3.5(Su)			15	5.6(Do)
<i>Microtus subterraneus</i>			1	0.7(Sr)			1	0.4(Sr)
<i>Clethrionomys glareolus</i>			9	6.3(Do)	14	13.12(Ed)	23	8.7(Do)
<i>Apodemus agrarius</i>			19	13.3(Ed)	6	5.7(Do)	25	9.5(do)
<i>Apodemus flavicollis</i>	1	6.7(Do)	43	30.1(Ed)	58	54.7(Ed)	102	38.6(Ed)
<i>Micromys minutus</i>					2	1.9(Re)	2	0.8(Sr)
Σ mammals	15		143		106		264	

Tab. 4: Overview of small mammals captured in Košice Zoo during period 2003 – 2004 (cf. Chautur 2005) according to lines.

Species	Line 1		Line 2		Line 3		Σ mammals	
	N	D%	N	D%	N	D%	N	D%
<i>Neomys fodiens</i>			1	1.6(Re)			1	0.6(Sr)
<i>Clethrionomys glareolus</i>	4	8.3 (Do)	11	18.0(Ed)	14	21.2(Ed)	29	16.6(Ed)
<i>Apodemus agrarius</i>	1	2.1(Su)	10	16.4(Ed)	27	40.9(Ed)	38	21.7(Ed)
<i>Apodemus flavicollis</i>	43	89.6(Ed)	39	63.9(Ed)	25	37.9(Ed)	107	61.1(Ed)
Σ mammals	48		61		66		175	

Tab. 5: Similarity of small mammal communities at sites based on Jaccard's (above diagonal) and Renkonen's index (below diagonal).

1992 – 1994				
Lines	1	2	3	4
4	37.5	50	37.5	*
3	66.6	57.1	*	54.5
2	57.1	*	71.1	63.0
1	*	66.6	88.0	53.1
2000 – 2001				
Lines	1	2	3	
3	25	70	*	
2	30	*	65.9	
1	*	22.8	12.4	
2002 – 2003				
Lines	1	2	3	
3	100	75	*	
2	75	*	72.3	
1	*	74.3	48.3	

Discussion

The research of small mammal fauna was focused on the qualitative-quantitative structure of the ecotone assemblages (in the alluvium of streams) in the Košice Zoo area. At the same time, we tried to compare the three monitored periods and to find out the differences in the composition of small mammal communities. Trapping was carried out using snap traps (1992 – 1994, 2003 – 2004) and pitfall traps (2000 – 2001). The results were compared with earlier published data from the study area in 1987 – 1988 (Stanko *et al.* 1990). All study sites (lines) were located in the alluvium of streams with no significant differences found with respect to the species composition of the small mammal community.

Comparing data published by Stanko *et al.* (1990), the most similar composition was recorded using pitfall traps in 2000-2001 (cf. Rondošová 2002) when 11 common species were recorded ($Ja = 78.6$). The absence of the European edible dormouse (*G. glis*) and the hazel dormouse (*M. avellanarius*) in later surveys may be explained by the trapping methodology used. It means, the use of pitfall traps (cf. Rondošová 2002) compared with snap traps (Stanko *et al.* 1990). However, it should be emphasized that even in these traps their occurrence was only subrecedent, which was a consequence of the poorly effective trapping method for arboreal species such as dormice. Therefore, the occurrence in the traps does not reflect the real dominance of dormice in small mammal communities in the study area. The data obtained by trapping with snap traps were also different in terms of trapping fewer individuals, but

especially in terms of species composition. Compared to trapping with snap traps, the use of pitfall traps was more effective for trapping insectivores (cf. Pelikán *et al.* 1977; Dudich & Stollmann 1985; Dudich *et al.* 1987; Ambros & Gajdoš 1988; Ambros 1998; Stanko *et al.* 1999; Mošanský *et al.* 2000). Dudich *et al.* (1987) also confirmed that better results for trapping insectivores were obtained when using pitfall traps with a volume of (0.7-1 litres) and a smaller representation of rodents of the family Muridae. Conversely, Stanko *et al.* (1999) showed that when using larger pitfall traps (2-4 litres), the representation of the families Soricidae, Muridae and Cricetidae (subfamily Arvicolinae) is even.

These observations agreed with data obtained in the period 2000 – 2001 (cf. Rond'ošová 2002). Compared to previous periods (1987 – 1988 cf. Stanko *et al.* (1990); 1992 – 1994 cf. Olšav (1995) and 2003 – 2004 cf. Chautur (2005)) a significantly higher proportion of insectivores compared to rodents was recorded from the territory of Košice Zoo in this period. The group dominance of insectivores was 36.4% based on pitfall trapping, and was much higher compared to using snap traps (cf. Stanko *et al.* 1990, Olšav 1995, and Chautur 2005).

Rodents were significantly more abundant than insectivores in the Košice Zoo area and these results agreed with the data of Stanko *et al.* (1990). This can be explained by more suitable abiotic factors of the environment, better trophic possibilities and also by the already mentioned lower suitability of the use of traps for catching insectivores. The use of pitfall traps in the period 2000 – 2001 (cf. Rond'ošová 2002) has demonstrably confirmed these differences. Due to the prevailing habitat type, consisting of oak-hornbeam and beech communities, a higher proportion of representatives of the family Muridae was recorded compared to representatives of the family Cricetidae. These plant communities provide abundant seeds for food. At the same time, the herbaceous cover is more suitable for microtid rodents, which feed mainly on green parts of plants (Turček 1951; Holišová 1960, 1966, 1967).

In conclusion, a gradual decline of small mammal fauna was recorded, with only four mammal species confirmed in 2003 – 2004. This marked difference over the last 17 years was probably the result of anthropic modifications of the Zoo area, mainly the cutting of trees and shrubs of the alluvium, technical modifications of the streambeds as well as the deratization of the building areas and animal enclosures. The obtained results are also a suitable basis and source of information for comprehensive and long-term monitoring in this area, given the epidemiological importance of this group of animals and the possibility of contact with exotic animals. The assemblage's structure of captured small mammals could also be influenced by other factors, such as the predominant type of traps used, or the number of exposed traps in the vegetation and non-vegetation periods of the year. To confirm the hypothesis, it will be necessary to repeat the research of small mammals in the area of the Košice Zoo, if only because of further habitat changes became during the last twenty years since last researches.

Acknowledgements: Our special thanks go to Miloš Olšav, Žaneta Rond'ošová, Tomáš Chautur, Ladislav Mošanský and Monika Onderová for their help with field and laboratory works. This work was supported by grants VEGA 2/0014/21 and KEGA 051PU-4/2021.

References

- Ambros M. (1998): Small mammals (Insectivora, Rodentia) from pitfall traps in representative sites of then Bystrica valley in the Vtáčnik Mts. [Drobné cicavce (Insectivora, Rodentia) v zemných pasciach vybraných stanovišť Bystričianskej doliny vo Vtáčniku]. – Rosalia (Nitra) 13: 235–240.
- Ambros M. & Gajdoš P. (1988): The occurrence of some vertebrates (Amphibia, Reptilia, Mammalia) in samples obtained from pitfall traps on the territory of the protected landscape area Ponitrie. [Výskyt niektorých stavovcov (Amphibia, Reptilia, Mammalia) vo vzorkách získanými zemnými pascami na území chránenej krajiny oblasti Ponitrie]. – Rosalia (Nitra) 5: 177–188.
- Čanády A. (2016): First record of a flavistic black-striped field mouse (*Apodemus agrarius*) in Slovakia. – Turkish Journal of Zoology 40: 637–640.
- Čanády A. & Mošanský L. (2017): Public Cemetery as a biodiversity hotspot for birds and mammals in the urban environment of Kosice city (Slovakia). – Zoology and Ecology 27(3-4): 185–195.
- Dudich A. & Stollmann A. (1985): Pitfall traps and their effectiveness in terms of research on terrestrial micromammalian fauna. [Zemné lapáky a ich účinnosť z hľadiska výskumu fauny terestrických mikromamálií]. – Biológia (Bratislava) 40(10): 1049–1054.
- Dudich A., Kleinert J. & Stollmann A. (1987): Occurrence of small mammals in samples collected by pitfall traps. [Výskyt drobných cicavcov vo vzorkách získaných zemnými lapákmi]. – Lynx (Praha), nová série 23: 43–50.
- Fričová J. & Stanko M. Contribution to knowledge on lice fauna (Anoplura) of small mammals in Košice Zoo. [Príspevok k poznaniu vší (Anoplura) drobných cicavcov košickej zoologickej záhrady]. Zborník Východoslovenského múzea v Košiciach. Prírodné Vedy, 34: 145–150.
- Házelmayerová H. (1992): Communities of small terrestrial mammals of urban and suburban biotopes of the city of Košice. [Synúzie drobných zemných cicavcov urbánnych a suburbánnych biotopov mesta Košíc]. – Diplomová práca. Prírodovedecká fakulta Univerzity P. J. Šafárika v Košiciach, 39 pp.
- Holišová V. (1960): Food of the wood mouse *Apodemus sylvaticus* L. in the Bohemian-Moravian Highlands. [Potrava myšice krovíné *Apodemus sylvaticus* L. na Českomoravské vrchovině]. – Zoologické listy 9: 135–158.
- (1966): Food of overcrowded population of the bank vole, *Clethrionomys glareolus* Schreb., in a Lowland forest. – Zoologické listy 15: 207–224.
- (1967): The food of *Apodemus agrarius* (Pall.). – Zoologické listy 16: 1–14.
- Chautur T. (2005): Fauna of small terrestrial mammals (Insectivora, Rodentia) in the area of the ZOO in Košice. [Fauna drobných cicavcov (Insectivora, Rodentia) košickej zoologickej záhrady]. – Diplomová práca. Prírodovedecká fakulta Univerzity P. J. Šafárika v Košiciach, 38 pp.
- Losos B., Gulička J., Lellák J. & Pelikán J. (1984): Animal ecology. [Ekologie živočichů]. SPN Praha, 320 pp.
- Májsky J. (1985): Small terrestrial mammals of the floodplain forests and windbreaks of the upper part of Žitný ostrov Island. [Drobné zemné cicavce lužných lesov a vetrolamov hornej časti Žitného ostrova]. – Biologické práce SAV 31(2): 1–111.
- Michaeli E. (2015): Regional geography of the Slovak Republic. [Regionálna geografia Slovenskej republiky]. Vydavateľstvo Prešovská univerzita v Prešove, Prešov. 134 pp. (in Slovak)
- Michalko J., Berta J. & Magic D. (1986): Geobotanical map of the Czechoslovak Socialist Republic: text part. [Geobotanická mapa ČSSR: Slovenská socialistická republika: Textová časť]. Veda. 162 pp.
- Mošanský L. (1985): Fauna of small terrestrial mammals of Košice. [Fauna drobných zemných cicavcov Košíc]. – Zborník Východoslovenského múzea v Košiciach. Prírodné vedy 25[1984]: 125–142.
- (1989): Geographical variability of micromammalian populations in suburban ecosystems of the Košice agglomeration. [Geografická variabilnosť populácií mikromamálií suburbánnych ekosystémov Košickej aglomerácie]. – Lynx (Praha), nová série 24[1988]: 47–62.
- Mošanský L., Stanko M. & Fričová J. (2000): Present knowledge of pitfall trap utilization on theriological researches on the East Slovakia. – Lynx (Praha), nová série 31: 69–79.
- Olšav M. (1995): Fauna of small mammals in the area of the Košice Zoo. [Fauna drobných cicavcov v areáli Košickej zoologickej záhrady]. – Diplomová práca, Prírodovedecká fakulta Univerzity P. J. Šafárika v Košiciach, 41 pp.
- Pelikán J., Zejda J. & Holišová V. (1977): Efficiency of different traps in catching small mammals. – Folia Zoologica 26: 1–13.
- Rondošová Ž. (2002): Fauna of small mammals (Insectivora, Rodentia) of the Košice Zoo. [Fauna drobných cicavcov (Insectivora, Rodentia) Košickej zoologickej záhrady]. – Diplomová práca, Prírodovedecká fakulta Univerzity P. J. Šafárika v Košiciach, 36 str.
- Stanko M. (1990): Ektoparasites (Insecta: Siphonaptera) of small mammals of the ZOO Košice. [Ektoparazity (Insecta: Siphonaptera) drobných cicavcov (Insectivora, Rodentia) Zoologickej záhrady v Košiciach]. Zborník Východoslovenského múzea v Košiciach, Prírodné vedy, 1989, 30: 83–95.

- (1991): Ectoparasites (Acarina: Mesostigmata, Ixodoidea) of small mammals of the ZOO Košice. [Ektoparazity (Acarina: Mesostigmata, Ixodoidea) drobných zemných cicavcov zoologickej záhrady v Košiciach]. Zborník Východoslovenského múzea v Košiciach, Prírodné vedy, 1990, 31: 159–172.
- Stanko M., Mošanský L. & Gajdoš O. (1990): Small terrestrial mammals (Insectivora, Rodentia) of the area Košice Zoo. [Drobné zemné cicavce (Insectivora, Rodentia) územia zoologickej záhrady v Košiciach]. – Zborník Východoslovenského múzea v Košiciach 31: 9–21.
- Stanko M., Mošanský L., Fričová J. & Casanova J.G. (1999): Comparison of two sampling methods of small mammals in the margin of a lowland forest. *Biologia, Bratislava* 54 (5): 595–597.
- Tischler W. (1949): *Grundzüge der terrestrischen Tierökologie*. Braunschweig, Friedr. Vieweg, 219 pp.
- Turček F.J. (1951): Contribution to the ecology of some small mammals in Slovakia. [Príspevok k ekológii niektorých drobných sŕpcov na Slovensku]. – *Věstník Československé Zoologické společnosti* 15: 515–552.

Author's addresses: Alexander Csanády; University of Prešov, Faculty of Humanities and Natural Sciences, Department of Biology, 17. novembra 1, SK-080 01 Prešov;
E-mail: alexander.csanady@unipo.sk, alexander.canady@gmail.com

Michal Stanko; Institute of Parasitology, Slovak Academy of Sciences, Hlinkova 3, SK-04001 Košice; E-mail: stankom@saske.sk