Non-target small mammal communities in invertebrate pitfall traps: effects of season, habitat, and elevation

Jakub Košša[1,2]*, Ivan Baláž[1], Filip Tulis[1], Peter Gajdoš[2], Michal Ambros[3]

[1]Department of Ecology and Environmental Science, Faculty of Natural Sciences and Informatics, Constantine the Philosopher University, Trieda A. Hlinku 1, 949 01 Nitra, Slovakia
[2]Institute of Landscape Ecology, Slovak Academy of Sciences, Nitra Branch, Akademická 2, 949 01 Nitra, Slovakia
[3]Ponitrie Protected Landscape Area, State Nature Conservancy of the Slovak Republic, Samova 3, 949 01 Nitra, Slovakia

Abstract

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Despite considerable endeavours of scientists to avoid it, non-target species are frequently trapped for ecological and conservation research. Nevertheless, these data can provide valuable insights into how ecosystems function. Small mammals not targeted for epigeic fauna research were caught in pitfall traps over 20 years. At 186 sites between 2003 and 2023, 1,091 specimens of 21 species of insectivores and small rodents (Eulipotyphla, Rodentia) were caught in such traps. Our results show: (i) abundance of small mammals is affected by season, habitat, and elevation level; (ii) species richness of small mammals is affected by habitat and elevation levels and not by season. The efficiency of pitfall traps was compared with snap traps and live traps for sampling small mammals, where the results suggested significant differences in species richness only between pitfall and snap traps. The assemblage of small mammals found in pitfall traps was completely separated from that in live and snap traps. Capturing small mammals in pitfall traps is suitable for determining species richness for faunistic research in specific territories.

Keywords

Eulipotyphla, live traps, method comparison, Rodentia, Slovakia, snap traps

Introduction

To a great degree, edaphic and epigeic macrofauna are captured for research using pitfall traps (Gajdoš, 1986) and two basic types exist. Dry pitfall traps contain bait to lure the animals while wet pitfall traps are filled with a formaldehyde solution to preserve the captured material (Mošanský et al., 2000). Amphibians, reptiles, and also small mammals are the non-target species for such research (Ambros, 1998; Ambros and Gajdoš, 1988; Čanády and Mock, 2009; Cogger, 2014; Mošanský and Stanko, 2001; Menkhorst and Knight, 2011). Even though the data on small animals obtained from pitfall traps can be employed for faunistic assessment of a selected area (Ambros, 1998), researchers are abandoning them because these traps have accidentally caught species deemed critical in conservation ecology (Pelikán et al., 1977). The species are used for diversity inventories of small mammals, or information on species diversity and relative abundance of this fauna (Kalko and Handley, 1993; Animal Research Review Panel, 2020; Helder-José et al., 2019).

Snap, pitfall, and live traps are the different types mostly used to describe assemblages of small mammals (Sheftel, 2018). While snap traps used to be common (Anděra and Horáček, 2005), they are mainly used to-

*Corresponding author:
e-mail: jakub.kossa@ukf.sk
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day in epidemiological or virological research (Csanády et al., 2022). Live traps now constitute a normal way of researching small mammals (Stanko, 2014; Jackson, 1987; Sikes and Gannon, 2011; Powell and Proulx, 2003) and have led to the development of a range of research methods differing in both design and process (Krebs, 1999). Pitfall traps have been applied to analyse the composition of small mammal communities ordinarily found in the Carpathian Mountains of Europe (Dudich and Štollmann, 1985; Dudich et al., 1987, Ambros and Gajdoš, 1988; Ambros, 1998) and the Neotropical realm (Figueiredo et al., 2021; Garey et al., 2023), seasonal trends in small-mammal movements (Briese and Smith, 1974), or to evaluate farming practice and their impact on the spatial structure of small mammals (Langraf et al., 2022).

Numerous studies have already been devoted to comparing the effectiveness of different trapping methods and types of traps. Some authors recommend combining snap and pitfall traps to capture the overall community of small terrestrial mammals because they give different results (Kalko and Handley, 1993; Nicolas and Colyn, 2006). Overall, trapping methods can strongly influence the sampling of mammal communities (Santos-Filho et al., 2006). Stanko (2014) points out that any of these methods will yield different results and a variable quantitative and qualitative picture of how small mammal assemblages are structured. Pitfall traps had greater success in determining species richness, where their efficiency and that of Sherman traps diverged among the habitats where they were set due to differences in species composition (Vieira et al., 2014). From a comparison of snap and pitfall traps by Stanko et al. (1999), they concluded that snap traps were more effective. Nevertheless, they argued that, in general, pitfall traps would provide a more complete picture of small mammal communities. Variations were even found among the different types of live traps used to capture the animals.

Irrespective of the trapping method used, the results primarily reflect environmental conditions like the habitat in which the traps are exposed. This is because the distribution of individual species varies with changing habitats. Forests and ecotones are richer in both the abundance and species richness of small mammals (Mulungu et al., 2008). Elevation and associated changes in elevational diversity gradients in lowland, colline, submontane, montane, supramontane, and subalpine regions play a major role in the distribution of small mammals. Small terrestrial mammal communities change as altitude increases. There are changes in species composition – qualitative remodelling – and in the overall abundance of individuals in the population – quantitative change, alongside the dominance of individual species in the community. Baláž and Jakab (2010) confirmed the mid-domain effect in Slovakia from their recording of the highest species richness of small terrestrial mammals in middle elevations of 500–700 metres above sea level.

This paper seeks (i) to assess the community composition of small mammals (as non-target species in edaphic and epigeic fauna research) based on pitfall traps; (ii) to analyse the influence of habitat, elevation, and season on community composition; and (iii) to compare trap success rates based on small mammal abundance and species richness.

Materials and methods

Study area

Small mammals were captured at 186 sites, in 25 geomorphic units (Fig. 1). Localities were scattered throughout Slovakia ranging from the lowlands of the Pannonian Plain to river valleys and the base of mountains in the Carpathian

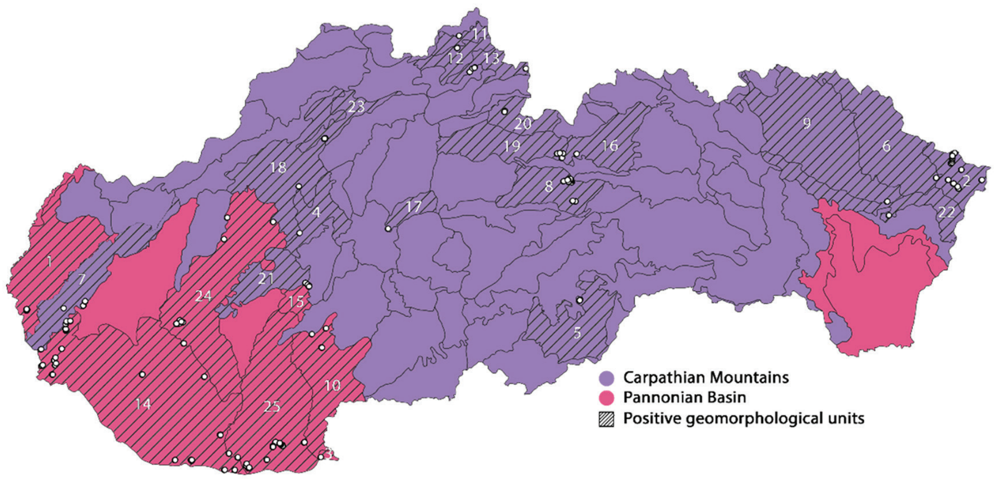


Fig. 1. Sites where small mammals were caught in pitfall traps (1. Borská nížina – 1, 2. Bukovské vrchy – 8, 3. Burda – 1, 4. Hornonitrianska kotlina – 1, 5. Rimavská kotlina – 3, 6. Laborecká vrchovina – 1, 7. Malé Karpaty – 19, 8. Nízke Tatry – 3, 9. Ondavská vrchovina – 1, 10. Ipeľská pahorkatina – 4, 11. Podbeskydská brázda – 1, 12. Podbeskydská vrchovina – 1, 13. Oravská kotlina – 2, 14. Podunajská rovina – 41, 15. Pohronský Inovec – 6, 16. Popradská kotlina – 2, 17. Starohorské vrchy – 1, 18. Strážovské vrchy – 2, 19. Liptovská kotlina – 3, 20. Západné Tatry – 4, 21. Tribeč – 2, 22. Beskydské predhorie – 1, 23. Žilinská kotlina – 5, 24. Trnavská pahorkatina – 9, 25. Hronská pahorkatina – 21).

range. The essential characteristics of the natural conditions found in Slovakia are presented by Baláž et al. (2021).

Sampling method

Small mammals were captured in wet pitfall traps (with seven-decilitre plastic cups) whose metal cover was placed at a height of about 1–2 centimetres above the opening. The traps were exposed at selected sites throughout the year, with 41 sets of pitfall traps exposed in spring, 77 in summer, 43 in autumn, and 25 in winter. Three lines were chosen at each site, and five traps were buried at each line for a total of 15 traps per site. Individual traps were placed in lines approximately two metres apart. At each site, the three lines of pitfall traps were installed using a consistent spatial layout across all sites.

The fixation fluid was composed of a 4% formaldehyde solution and, in winter, a combination of either kitchen salt or ethylene glycol antifreeze. The traps were checked once a month. The captured specimens were preserved in 75% petroleum alcohol at a laboratory and prepared for processing.

Environmental factors

The pitfall traps were installed at sites located at the following hypsometric classifications: P – planar (86 sites below 200 m), K – colline (36 locations from 200 to 400 m), SM – submontane (23 sites from 400 to 600 m), M – montane (22 locations from 600 to 900 m), O – supra-montane (14 sites from 900 to1 200 m), and SA – subalpine (5 sites from 1,200 m to the upper tree limit) (Futák, 1972).

Sites for trapping small mammals were located at these biotopes taken from the Habitat Catalogue (Stanová and Valachovič, 2002): anthropogenic habitats, decorative gardens, orchards, dump sites, ecotones, forests, natural grasslands, pastures, riparian vegetation, ruderal habitats, salt marshes, sands, vineyards, and xerothermic habitats.

To assess seasonality among small mammals, the data was divided into four seasons: 41 sites were set in spring from March to May, 77 sites were set in summer from June to August, 43 sites were set in autumn from September to November, and 25 sites were set from December to February of the following year.

Method comparison

The capture efficiency of pitfall, snap, and live traps was compared based on abundance, species richness, and the similarity of small mammals. Seven sites were selected for trapping small mammals simultaneously with all three trap types. After standardising the data to unify catch per unit effort from all three trap types, PAST was used to visualise comparisons of trap success rates.

Statistical analysis

Species dominance was assessed according to Tischler (1949) as follows: eudominant (D > 10%) dominant (D = 5–10%) subdominant (D = 2–5%) recedent (D = 1–2%) subrecedent (D < 1%).

Variations in species abundance and diversity across various seasons, habitats, and elevation gradients were assessed using the Kruskal-Wallis test and subsequent Dunn's non-parametric post-hoc analyses with Bonferroni corrected p-value. Moreover, the Kruskal-Wallis test was utilised to examine any distinctions found in abundance

Table 1. Overview by season of small mammals captured in pitfall traps

Species	Spring		Summer		Autumn		Winter		Total	
	n	%	n	%	n	%	n	%	n	%
A. agrarius	7	3.78	9	2.03	13	3.76	15	12.82	44	4.03
A. flavicollis	2	1.08	5	1.13	3	0.87	2	1.71	12	1.10
A. sylvaticus	9	4.86	6	1.35	8	2.31	6	5.13	29	2.66
A. uralensis	4	2.16	12	2.71	12	3.47	8	6.84	36	3.30
M. minutus	6	3.24	7	1.58	8	2.31	6	5.13	27	2.47
M. spicilegus	1	0.54	6	1.35	5	1.45	26	22.22	38	3.48
A. amphibius	–	–	2	0.45	–	–	–	–	2	0.18
C. glareolus	12	6.49	18	4.06	5	1.45	3	2.56	38	3.48
M. agrestis	8	4.32	7	1.58	3	0.87	–	–	18	1.65
M. arvalis	74	40.00	164	37.02	126	36.42	34	29.06	398	36.48
M. subterraneus	–	–	4	0.90	2	0.58	–	–	6	0.55
Ch. nivalis	–	–	–	–	1	0.29	–	–	1	0.09
S. betulina	3	1.62	4	0.90	3	0.87	–	–	10	0.92
T. europaea	1	0.54	–	–	–	–	–	–	1	0.09
S. araneus	18	9.73	62	14.00	45	13.01	4	3.42	129	11.82
S. minutus	28	15.14	87	19.64	83	23.99	2	1.71	200	18.33
S. alpinus	–	–	1	0.23	2	0.58	–	–	3	0.27
N. milleri	2	1.08	5	1.13	5	1.45	–	–	12	1.10
N. fodiens	1	0.54	3	0.68	2	0.58	–	–	6	0.55
C. leucodon	7	3.78	18	4.06	6	1.73	8	6.84	39	3.57
C. suaveolens	2	1.08	23	5.19	14	4.05	3	2.56	42	3.85
Total	185	100	443	100	346	100	117	100	1,091	100

and species richness among the three different trap types. Permutational multivariate analysis of the variance using distance matrices (PERMANOVA) based on binary Jaccard similarity index was used to compare assemblage similarity in the three different trapping methods. All analysis were performed in PAST 4.08 (Hammer, 1999–2021).

Results

Between 2003 and 2023, 1,114 specimens were caught in pitfall traps intended for the capture of edaphic and epigeic fauna, of which 23 were lizards (*Lacerta* sp.) and 1,091 specimens came from 21 species of insectivores and small rodents (*Eulipotyphla*, *Rodentia*), all of which had not been targeted (Table 1): mice – striped field mouse *Apodemus agrarius* (Pallas, 1771), yellow-necked mouse *Apodemus flavicollis* (Melchior, 1834), wood mouse *Apodemus sylvaticus* (Linnaeus, 1758), pygmy field mouse *Apodemus uralensis* (Pallas, 1811), harvest mouse *Micromys minutus* (Pallas, 1771), eastern house mouse *Mus spicilegus* Petényi, 1882, voles – water vole *Arvicola amphibius* (Linnaeus, 1758), bank vole *Clethrionomys glareolus* (Schreber, 1780), field vole *Microtus agrestis* (Linnaeus, 1761), common vole *Microtus arvalis* (Pallas, 1778), common pine vole *Microtus subterraneus* (de Selys-Longchamps, 1836), snow vole *Chionomys nivalis* (Martins, 1842), shrews – common shrew *Sorex araneus* Linnaeus, 1758, pygmy shrew *Sorex minutus* Linnaeus, 1766, alpine shrew *Sorex alpinus* Schinz, 1837, Miller´s water shrew *Neomys milleri* Motaz, 1907, water shrew *Neomys fodiens* (Pennant, 1771), bi-coloured white-toothed shrew *Crocidura leucodon* (Hermann, 1780), lesser white-toothed shrew *Crocidura suaveolens* (Pallas, 1811), other species – northern birch mouse *Sicista betulina* (Pallas, 1779), common mole *Talpa europaea* Linnaeus, 1758. Common voles, pygmy shrews, and common shrews were among the highly eudominant species captured. Subrecedent species caught in the traps were the snow vole, common mole, water vole, alpine shrew, and water shrew (Table 1).

When determining group dominance, pitfall traps were found to have mostly captured more shrews (39.5%) and voles (42.5%) than mice.

Season and abundance have a significant effect on all small mammals ($H_c = 12.24$, $p = 0.007$) as well as for individual families of small mammals (Soricidae – shrews: $H_c = 29.26$, $p < 0.001$, *Muridae* – mice: $Hc = 19.18$, $p < 0.001$, Cricetidae – voles: $Hc = 18.8$, $p < 0.001$). The overall abundance of small mammals increased from spring to summer and then gradually declined until the winter period. The abundance of shrews (*Soricidae*) showed a similar trend, with peak numbers recorded in summer. For the *Muridae* family, we observed a steadily increasing trend in abundance across the seasons (from spring to winter), while the *Cricetidae* family exhibited the opposite pattern. We recorded the highest abundance of small mammals in pitfall traps during the summer (Fig. 2, Table 1). Post hoc tests show winter's significant effect on all analysed groups (Fig. 2). Seasons were found to have no effect on the species richness of small mammals ($H_c = 7.505$, $p = 0.057$).

The distribution and abundance of individual species varied between elevations (Fig. 3), where common voles, pygmy shrews, and striped field mice were most numerous at planar elevations and common voles, pygmy shrews, and common shrews similarly dominated in colline elevations. The most numerous species in submontane elevations were pygmy shrews, common shrews, and common voles, with common voles, pygmy shrews, and northern birch mice being the species most found in montane elevations. Common shrews, pygmy shrews, and common voles likewise dominated at subalpine elevations. The Kruskal-Wallis test

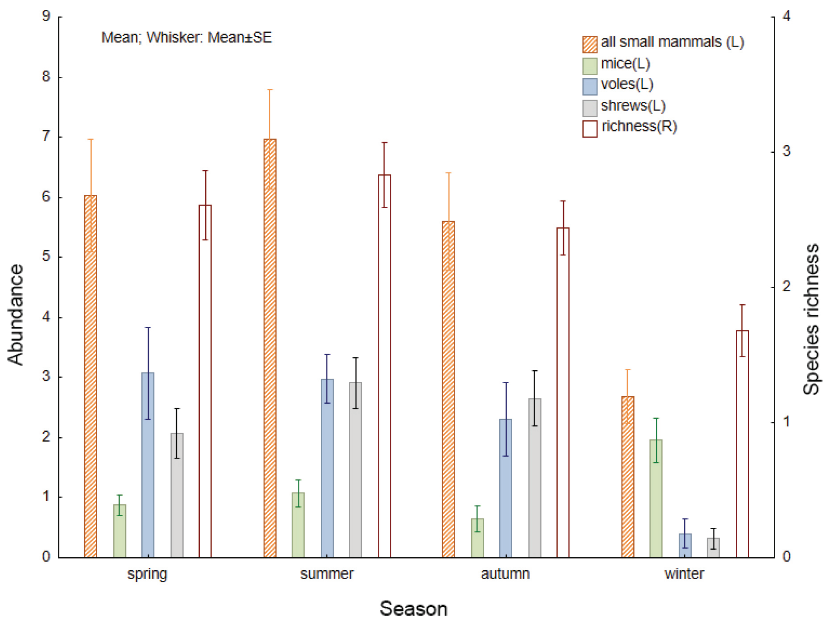


Fig. 2. Seasonal dynamics of small mammal abundance and species richness based on pitfall trap data. Mean abundances of all small mammals, mice, voles, and shrews are shown on the left y-axis (L). Mean species richness is shown on the right y-axis (R).

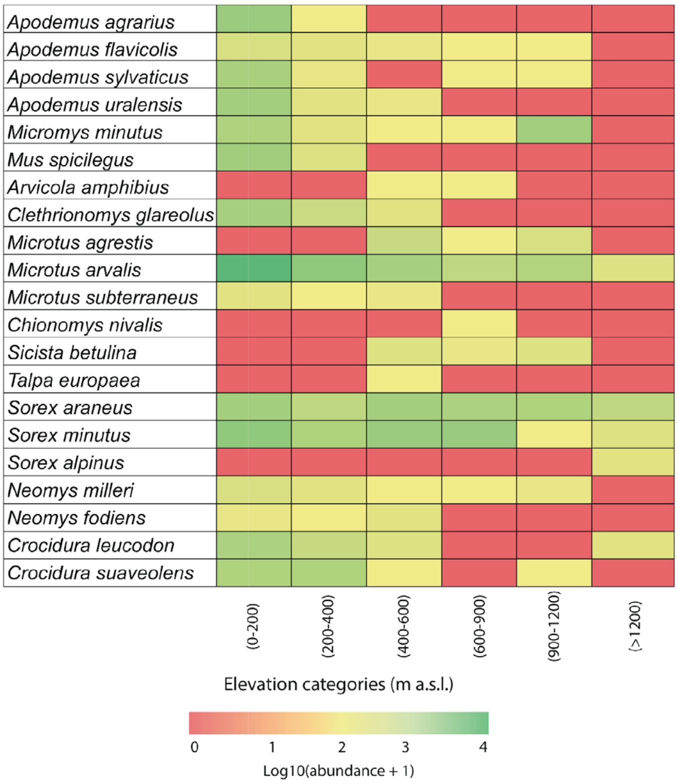


Fig. 3. Changes in species distribution and abundance along the elevational gradient.

Table 2. Overview by habitat of small mammals caught in pitfall traps

	Anthropogenic habitats	Decorative gardens	Orchards	Dump sites	Ecotones	Forests	Natural grasslands	Pastures	Riparian vegetation	Ruderal habitats	Salt marshes	Sands	Vineyards	Xerothermic habitats	Σ
A. agrarius	3	1	–	2	6	10	5	–	4	–	2	3	8	–	44
A. flavicollis	3	–	–	–	2	4	–	2	–	–	1	–	–	–	12
A. sylvaticus	3	1	–	3	1	5	2	–	2	–	1	6	5	–	29
A. uralensis	3	3	–	–	5	2	2	1	–	1	3	12	4	–	36
M. minutus	1	2	1	4	3	3	4	–	1	1	3	1	2	1	27
M. spicilegus	1	–	–	21	–	3	1	–	2	1	2	4	3	–	38
A. amphibius	–	–	–	–	1	–	–	–	1	–	–	–	–	–	2
C. glareolus	13	–	–	–	5	10	1	1	5	–	1	1	1	–	38
M. agrestis	1	1	–	–	7	6	–	3	–	–	–	–	–	–	18
M. arvalis	25	21	–	16	35	19	39	7	17	26	43	72	41	27	388
M. subterraneus	–	1	–	–	3	1	–	–	–	–	–	–	1	–	6
Ch. nivalis	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
S. betulina	–	–	–	–	3	4	–	3	–	–	–	–	–	–	10
T. europaea	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
S. araneus	9	4	3	1	30	29	20	13	16	–	9	3	–	2	139
S. minutus	17	13	7	–	38	45	28	14	12	–	13	5	6	2	200
S. alpinus	–	–	–	–	–	–	3	–	–	–	–	–	–	–	3
N. milleri	1	–	–	–	4	2	–	2	3	–	–	–	–	–	12
N. fodiens	–	–	–	–	3	3	–	–	–	–	–	–	–	–	6
C. leucodon	2	–	–	7	3	3	4	–	–	–	7	5	6	2	39
C. suaveolens	9	–	–	–	3	4	6	–	4	3	2	–	11	–	42
Σ	91	47	11	54	153	153	115	46	68	32	87	112	88	34	1,091

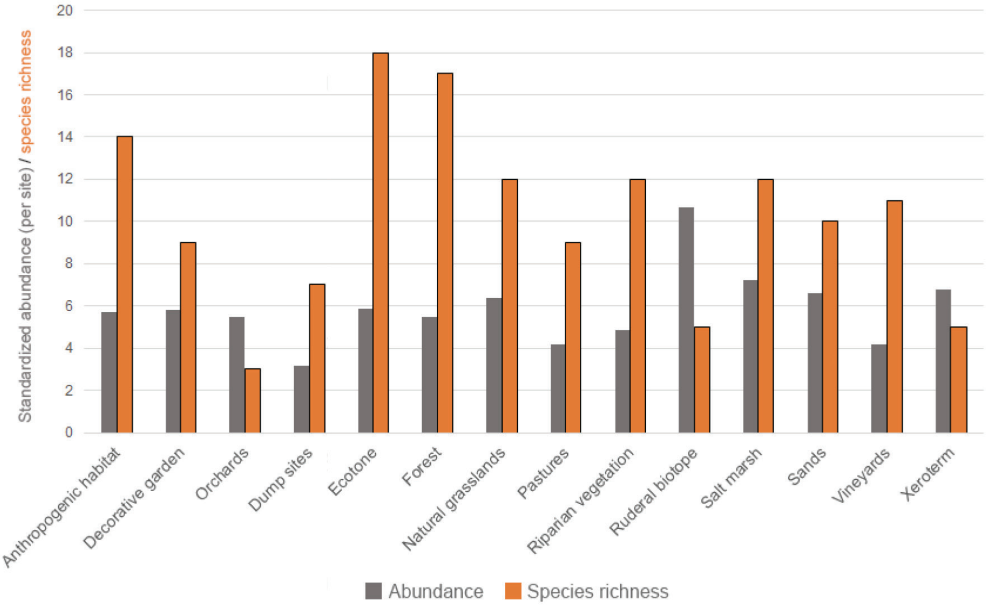


Fig. 4. Abundance and species richness values for small mammals in individual habitats.

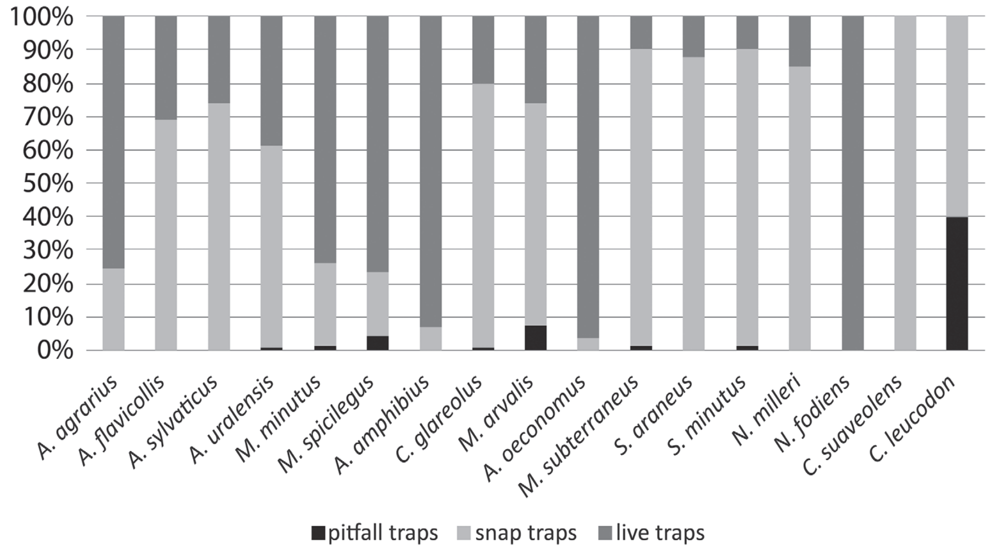
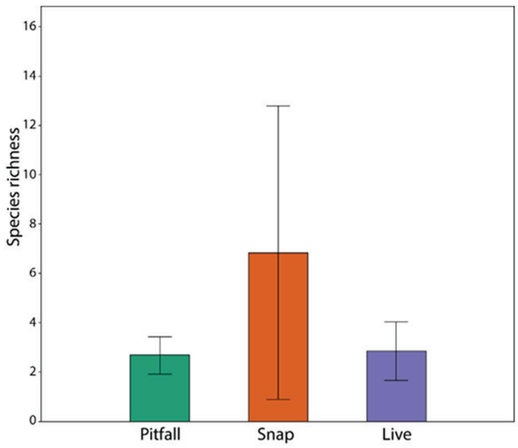


Fig. 5. Percentage of small mammal species captured by three different types of traps at the seven common locations.

detected a significant difference in species richness between different elevations ($H_c = 23.89$, $p < 0.001$). Post-hoc testing showed significant differences between the following elevation pairs (Fig. 3): planar and colline ($p < 0.001$), planar and submontane ($p = 0.016$), planar and montane ($p < 0.001$), and colline and supramontane ($p = 0.012$).

The abundance of small mammals captured in pitfall traps fell as elevation increased. Species richness reached its maximum (17 species) in colline elevations and was lowest (5 species) in montane and subalpine elevations. At lowland and submontane elevations, 15 species were found.

The habitats recording the highest species richness (Table 2) of small mammals were ecotones (18) and forests (17), while the greatest abundance was found in ruderal habitats (10.7) and salt marshes (7.25). The lowest species richness values were obtained in ruderal and xerothermic habitats (5), and the lowest abundance values were documented at dump sites (3.2) and in pastures (4.2). The common vole and pygmy shrew were the most abundant species found in anthropogenic habitats and decorative gardens, while in orchards it was the pygmy shrew, at dump sites the pygmy shrew and common vole, in ecotones the pygmy shrew and common vole, in forests and pastures the pygmy and common shrews, in natural grasslands and salt marshes the common vole and pygmy shrew, in riparian vegetation the common vole and common shrew, in ruderal and xerothermic habitats the common vole, in sands the common vole and pygmy field mouse, and in vineyards the common vole and lesser white-toothed shrew (Fig. 4).



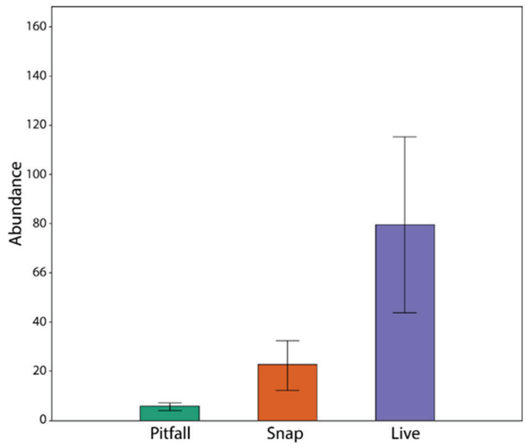


Fig. 6. Comparison of small mammal species richness according to the three types of traps (mean ± standard deviation).

Fig. 7. Comparison of small mammal abundance according to the three types of traps (mean ± standard deviation).

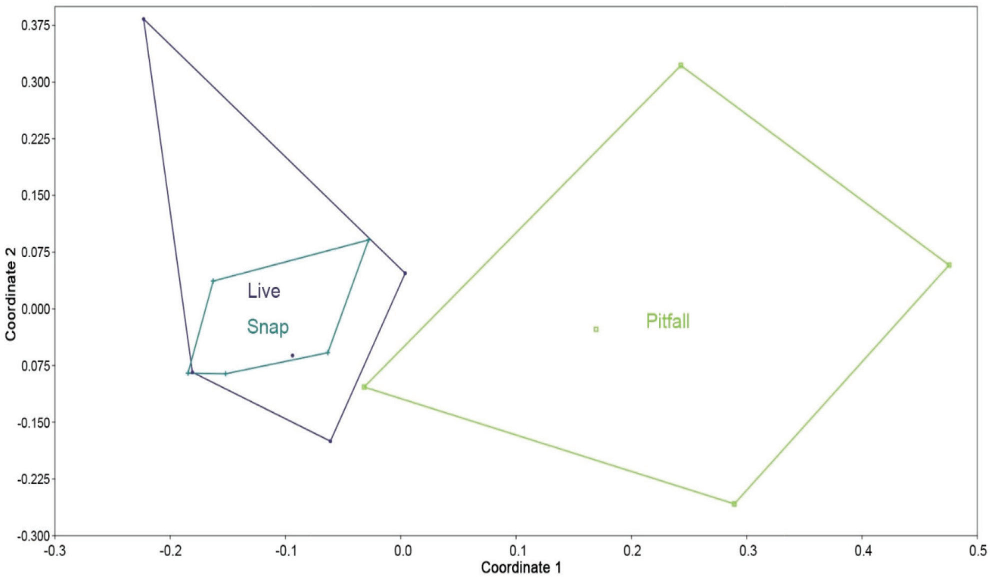


Fig. 8. Ordination produced by non–metric multidimensional scaling to assemblages of small mammals obtained by different–type traps.

Comparison of the three trap types

At the seven common sites, all from Podunajská nížina lowland, a total of 2,644 specimens from 16 different small mammal species were captured by snap traps, 37 specimens from nine different small mammal species were caught by pitfall traps, and 2,038 specimens from 15 different species were found in live traps (Fig. 5). Similarity in small mammal assemblages varied demonstrably depending on the traps used (Permanova $p = 0.0212$, Fig. 6 and 7). The highest species diversity values were obtained from snap traps, while similar values were obtained from pitfall and live traps. Different values were derived from an analysis of abundance values, where the highest recorded values came from live traps and the lowest from pitfall traps.

The small mammal assemblage derived from pitfall traps was completely distinct, while similar assemblages came from live and snap traps (Fig. 8).

Discussion

When opting for pitfall traps, the capture of non-target species, including small mammals, cannot be ruled out even if the trap has a metal cover or smaller traps are used. Pearce et al. (2005) have determined the trap type that would reduce incidental catches of vertebrates without compromising the capture of invertebrates, while Thompson (2008) discussed vertebrate by-catch in invertebrate wet pitfall traps.

Pitfall traps are characterised by a significantly higher number of insectivores caught in them than rodents (Pankakoski, 1979; Dudich and Štollmann, 1985; Ambros and Gajdoš, 1988; Ambros, 1998; Stephens and Anderson, 2014; Mošanský et al., 2000). A low abundance of murids in the genus *Apodemus* was observed in pitfall traps because they are very active, leap high, and can easily escape from the traps. Dudich et al. (1987) recommend larger-volume pitfall traps, while Stephens and

Anderson (2014) also state that pitfall traps were more effective at capturing shrews and voles. A high proportion of both were also recorded by us and the common vole was the most abundant species caught in our pitfall traps.

Santos-Filho et al. (2006) noted no statistically significant difference from the higher number of captures during the rainy season of December, January, and February compared to the dry season of June, July, and August. The slightly higher numbers reported during the dry season by traps of other types, such as snap, Tomahawk, and Sherman traps, were likewise not statistically significant. These figures suggest that, even though seasonal changes may affect the activity or availability of certain species, these changes would not have a drastic impact on the effectiveness of particular trap types. Hice and Schmidly's (2002) study of the Amazon rainforest noted a significant seasonal variance in capture success with a rate of 0.14% during the dry season as opposed to 4.55% during the rainy season. Carmignotto et al. (2014) recorded higher species richness during the rainy season (19 species) than during the dry season (12 species), indicating a seasonal influence on diversity and higher values during the rainy season on the Shannon diversity index (D = 12.68) and Pielou's evenness index (J = 0.86) compared to the dry season (D = 3.16, J = 0.46).

Species composition and diversity varied among different habitats, with gallery forests and dense savannahs providing the environment for the highest diversity, while lower species diversity values were obtained from flooded habitats and dry grasslands. The data indicated seasonal trends in species activity, such as the peak densities of *Peromyscus polionotus* and *Reithrodontomys humulis* in January, with the former showing a delayed peak of activity in December before settling in the available habitat. The analysis suggested that the density of species like *Sigmodon hispidus* and *Peromyscus gossypinus* was highest in January, with changes in habitat influencing their movements. *Microtus pinetorum* showed uniform movement with no seasonal trends, while *Mus musculus* had peak densities in January, followed by a sharp decline. Seasonal trends were also observed for shrews, with activity peaking in spring and autumn for *Blarina brevicauda* and *Cryptotis parva*, while *Sorex longirostris* had its peak in June (Briese and Smith, 1974). For rodents, pitfalls were more effective in the wet season, while Sherman traps were more effective in the dry season (Brito and Fernandez, 2014).

The study revealed distinct patterns of species distribution across different habitats. Both flooded and unflooded gallery forests hosted a relatively lower number of species than open dry formations, which supported a broader range of species. Flooded grasslands stood out as the least diverse habitat; with a unique set of species the others did not exhibit. A significant portion of the species was either restricted to forests or open formations, with only a few species occurring across both habitats, suggesting a strong habitat preference and the formation of distinct ecological groups within the study area (Carmignotto et al., 2014). *Peromyscus polionotus* showed a preference for roadsides, while *R. humulis* favoured pine plantations and ecotones (Briese and Smith, 1974).

Pitfall traps were the most efficient in agroforestry corridors and pastures, while Sherman traps were more efficient than pitfall traps (Brito and Fernandez, 2014). Nonetheless, there is evidence of pitfall traps being more effective (Pelikán et al., 1977; Pucek et al., 1993). Their efficacy may also vary depending on the time of year (Pucek, 1969; Mengak and Guynn, 1987). Pankakoski (1979) examined the effectiveness of three other trap types and stated that cone traps are more effective than live or snap traps for catching small mammals, particularly shrews, as is commonly known. Caceres et al. (2010) and Vieira et al. (2014) compared pitfall, Sherman, and wire traps), recording the greatest success from pitfall traps. Dizney et al. (2008) compared the efficacy of pitfall, Sherman, and mesh traps, finding pitfall traps to be the most effective. Longworth traps captured a significantly greater abundance of vagrant shrews than pitfall traps on agricultural set-asides (Umetsu et al. 2006, Stromgren and Sullivan, 2014). Santos-Filho et al. (2006) sampled Tomahawk, Sherman, snap, and pitfall traps for efficiency and found Sherman traps to have captured a significantly greater abundance of specimens and from them documented higher species richness than the other traps. Pitfall traps captured four times more specimens during the wet season than during the dry season. According to Čepelka et al. (2019), pitfall traps were more effective in capturing smaller species with a predominance toward shrews, which consume animal food. Snap traps captured the broader species spectrum and were more successful in catching larger species of small terrestrial mammals, specifically mice and particularly voles, both of which consume a higher proportion of plant food. Bovendorp et al. (2017) recorded a higher overall diversity of small mammal species caught by pitfall traps than live traps and these two methods may be capturing different species (Santos-Filho et al., 2015; Ardente et al., 2017). When compared to live traps, pitfall traps are less influenced by factors such as food availability (Adler and Lambert, 1997; Ribeiro-Júnior et al., 2011), species-specific bait preferences (Laurance, 1992), bait consumption by other animals (McClearn et al., 1994), and the propensity to capture only adult specimens (Boonstra and Krebs, 1978). Stephens and Anderson (2014), Čepelka et al. (2019), and Palmeirim et al. (2018) recommend that live and pitfall traps (and also pitfall and snap traps) be used in tandem with each other when assessing species richness and diversity. Palmeirim et al. (2018) state that live and pitfall traps enable the capture of a variety of small mammal species. Each method has its strengths and weaknesses, and each has caught some individual species the other has not.

In conclusion, there was a high probability of shrews and voles to be found in pitfall traps, with common voles being the most numerous species caught. Analysis of obtained results confirms the advantage of pitfall traps as an appropriate method of capturing small mammals for baseline faunistic studies of selected areas. In comparing how effectively different types of traps captured small mammals in terms of species richness, demonstrable differences were found only between snap and pitfall traps. Differences between snap and live traps, as well as between pitfall and live traps, were not statistically significant. Each type of trap was more suitable for monitoring a different group of small terrestrial mammals. At least two types of traps are needed (snap and pitfall traps are the best combination) to cover the small mammal species spectrum to the maximum extent possible. Our results likewise show species richness to vary at different elevations. The most significant differences were found between planar and higher elevations (colline, submontane, and montane), suggesting that elevation has an effect on species distribution in the study area. The highest species richness was found in colline elevations, with values decreasing progressively at higher hypsographic classifications. The highest species richness of small mammals was observed in ecotones and forest habitats, while the highest abundance was documented in ruderal habitats and salt marshes. The lowest species richness values were recorded in ruderal and xerothermic habitats and the lowest abundance values were obtained at dump sites and in pastures.

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