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ELEVATIONAL DISTRIBUTION OF SMALL TERRESTRIAL MAMMALS ON MT. POHORJE, SLOVENIA

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ABSTRACT

Small mammals were sampled on Mt. Pohorje at 33 localities, ranging in elevation from 250–300 m to 1530 m a.s.l. Species composition varied, depending on the method employed during field surveys. Snap trapping was more effective in sampling rodents while pitfall trapping provided more shrews. Twenty-two species were identified, but commensal Rattus rattus *and* Mus musculus *were excluded from further analyses. Fourteen species of a total 20 occurred all along the elevational gradient and the overall turnover rate was excessively low (β = 0.17). The overall elevational pattern in species richness on Mt. Pohorje was thus a steady decline in species numbers along the altitudinal gradient. Relative abundance of mice (Muridae) declined with increasing elevation (r = -0.844) while shrews (Soricidae) were becoming more abundant in the same direction (r = 0.839).*

Key words: Alps, Pohorje, elevational extent, mid-domain model, small mammals, species richness

DISTRIBUZIONE ALTITUDINALE DI PICCOLI MAMMIFERI TERRESTRI SUL MONTE POHORJE, SLOVENIA

SINTESI

I piccoli mammiferi sono stati campionati in 33 località del monte Pohorje, ad un'altitudine compresa fra i 250–300 m ed i 1530 m s.l.m. La composizione delle specie era variabile, in relazione al metodo impiegato durante il campionamento. Le trappole a scatto si sono rivelate più efficienti nel campionamento dei roditori, mentre le trappole coperte catturavano più toporagni. Ventidue specie sono state identificate, ma i commensali Rattus rattus *e* Mus musculus *sono stati esclusi da successive analisi. Quattordici specie delle venti totali sono state trovate lungo tutto il gradiente altitudinale, mentre il ricambio globale di specie è risultato molto basso (β = 0,17). Il modello altitudinale completo in ricchezza di specie sul monte Pohorje ha pertanto evidenziato un regolare declino nella ricchezza di specie lungo il gradiente altitudinale. L'abbondanza relativa dei topi (Muridae) è diminuita con l'aumentare dell'altitudine (r = -0,844), mentre i toporagni (Soricidae) sono risultati più abbondanti nella stessa direzione (r = 0,839).*

Parole chiave: Alpi, Pohorje, estensione altitudinale, modello di medio-dominio, piccoli mammiferi, ricchezza di specie

INTRODUCTION

Naturalists have been aware for centuries that species are not evenly distributed on the Earth's surface (Brown & Lomolino, 1998). The distribution of organisms is not random and few patterns of species richness are seemingly universal across time, geographical scale, and taxa (Rahbek, 1997). The oldest and one of the most fundamental patterns is the decrease in biological diversity from equatorial to polar regions and is known as latitudinal gradient (Willig *et al.*, 2003). A similar pattern of species decline along the elevational gradient was long believed to mirror the latitudinal gradient and to be a general pattern in mountain biotas (Stevens, 1992). Such a perception, derived primarily from tropical regions, claimed axiomatically that lowlands support the highest number of species (MacArthur, 1972). As shown subsequently, the relationship between species richness and elevation rather shows three basic patterns: a humped-shaped curve, a monotonic decrease, or almost horizontal species richness curve that declines at certain elevation (Rahbek, 1995). A series of recent papers based on small mammal distributions across continents (Heaney, 2001; Lomolino, 2001; Nor, 2001; Rickart, 2001; Sánchez-Cordero, 2001; McCain, 2004, 2005) revealed the predominance of a humped curve of species richness with clear mid-elevational peak.

Most data sets analysed so far are from the tropics, both for mammals (McCaine, 2005), and other taxonomic groups as well (Rahbek, 1995). Temperate regions are underrepresented in this respect, with the majority of case studies, at least on mammals, coming from the arid regions of USA (Rickart, 2001; McCain, 2005). Europe differs from regions studied so far in lower species richness per unit area (Kryštufek, 2004) and has thus a potential to provide data for testing the validity of hypotheses proposed so far. However, surprisingly little is known in this respect for the continent which is the cradle of biological science. We report in this paper on the distribution of small non-volant mammals along an elevational gradient on Mt. Pohorje, the south-eastern most extension of the Alpine mountain chain. Our study lacked a priori standardized sampling methodology which restricted our goal to a descriptive level. Despite this we trust that conclusion from this study allow some ideas on what may be a genuine elevational pattern in small mammal assemblages on a south-European mountain of moderate elevation.

MATERIAL AND METHODS

Study area

Mt. Pohorje, located in northeast Slovenia, is the south-eastern most extension of the Central Alps. The west to east oriented ridge is 68 km long, but higher elevations (above 1100 m a.s.l.) are mainly an extensive plateau with rounded peaks of modest altitude (Jezerski vrh: 1537 m, Črni vrh: 1543 m). Bedrock is metamorphic and impermeable. Climate is a continental one, with cold and snowy winters at higher elevations. Close to the mountain's top (Ribniška koča, 1507 m a.s.l.), the mean annual temperature is 3.7°C, with means for the coldest and the warmest months being -5.6°C and 13.9°C, respectively. Annual rainfall is abundant (1100–1300 mm) with peaks along the central ridge (1500–1600 mm). Forest is the dominant vegetation type, but natural stands of beech *(Fagus sylvatica)* were largely transformed in the past centuries into monotonous stands of Norway spruce *(Picea abies)*. The high plateau is marshy with isolated *Sphagnum* bogs which are largely overgrown by dwarf pine *(Pinus mugo)*. Agriculture is not an intensive one and stockbreeding, in addition to forestry, is the principal traditional activity. Single farms go as high as 1270 m a.s.l.

Material and methods

Data on local small mammal assemblages were obtained from published sources (Heneberg *et al.,* 1964; Šorgo & Janžekovič, 1995), unpublished reports and from the files of the Slovenian Museum of Natural History. Field sampling was performed in 33 sites (Fig. 1) in three different ways: snap trapping, pitfall trapping and owl pellet analysis. A modified version of Museum Special snap traps was mainly used with a mixture of canned sardines and oat flakes as bait. Traps were settled in lines of various lengths (usually > 50 traps per site) and were exposed overnight. Pitfalls used were five liter buckets dug in the ground and filled with water to approximately one third to prevent escapes. Five or ten pitfalls were fixed per site and exposed over the entire vegetation season. Owl pellets of *Strix aluco* (a forest species) and *Asio otus* (hunting on meadows) were collected at suitable places and elaborated according to a standard protocol. Voucher specimens are deposited in the collections of the Slovenian Museum of Natural History (Ljubljana) and in the Department of Biology, University of Maribor.

We considered non-volant small mammals belonging to six families: Soricidae, Talpidae, Erinaceidae, Cricetidae (Arvicolinae), Muridae, and Gliridae. Taxonomy and nomenclature follow Wilson & Reeder (2005). Species presence/absence matrix was constructed according to 200 m intervals (hereafter elevational intervals). We assumed that species occurred at an elevation if they were detected at both higher and lower elevation intervals. Intervals of 200 m proved sensitive enough to detect changes in the assemblages of species on the one hand, with a reasonably low share of empty intervals on the other.

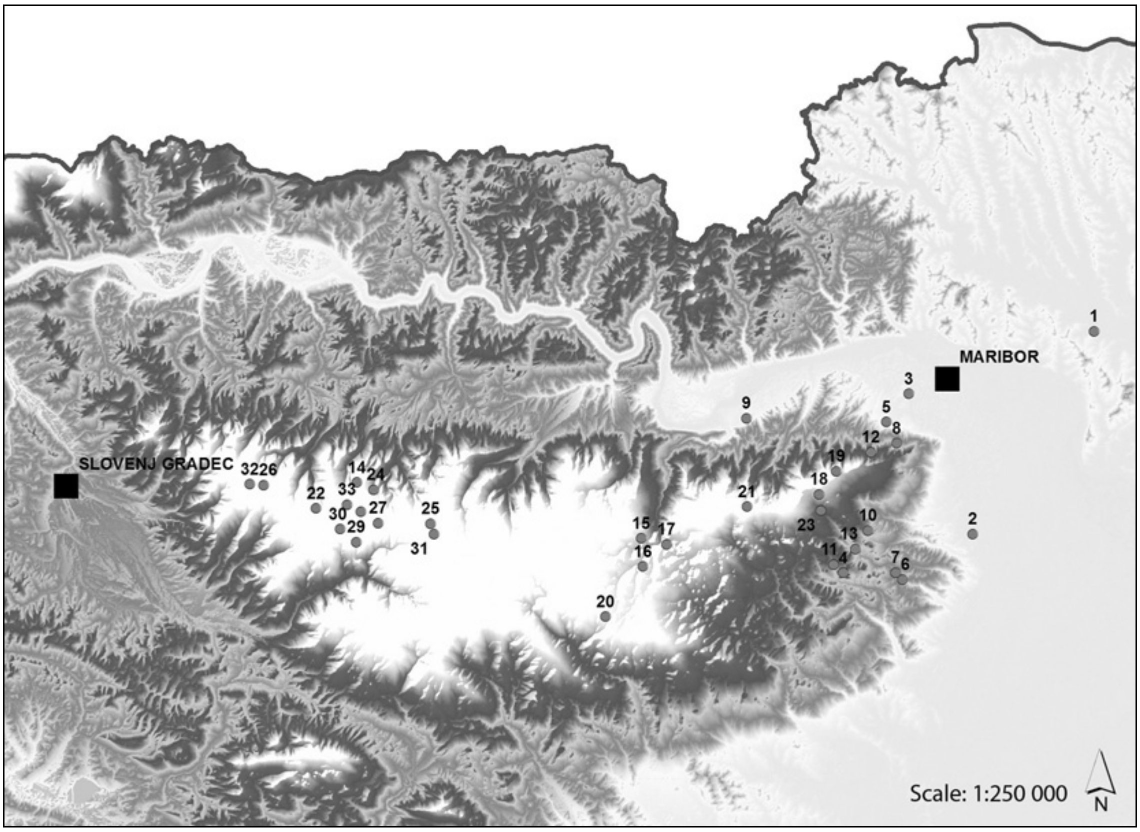

Fig. 1: Study area with sampling localities shown by dots. For list of localities see Appendix 1.
Sl. 1: Proučevano območje z vrisanimi mesti vzorčenja. Popoln seznam nahajališč je podan v Dodatku 1.

Species turnover (β diversity) across the elevational gradient was evaluated following Whittaker (1960):

$\beta = (s/\alpha) - 1$

where *s* is the total number of species recorded in the elevational gradient, and *α* is the average number of species within the elevational interval.

RESULTS AND DISCUSSION

Small mammals were sampled at 33 localities, ranging in elevation between 250–300 m and 1530 m a.s.l.; see Appendix 1 for details. The majority of sites (61%) was sampled by pitfalls while owl pellets were collected on two localities only. The number of specimens per site varied between 1 and 321. Median (19) and central quartile range (6–36) were low, consequently the majority of local samples were small. There were significant differences among sample sizes regarding the sampling method. The two owl pellet samples were by far the largest (145 and 321 specimens, respectively) and snap trapping provided the majority of small samples (Tab. 1). Samples, obtained by pitfall trapping were on average significantly larger than those by snap trapping ($Z = 2.72$, $p < 0.01$; Mann-Whitney U test).

Tab. 1: Number of small mammal specimens obtained by two trapping techniques. N – number of sites sampled.
Tab. 1: Število malih sesalcev, ujetih z dema različnima metodama vzorčenja. N – število vzorčenih lokacij.

Survey technique	N	Median	Min - Max	Central quartiles
Snap trapping	11	4	1 – 98	1 – 14
Pitfall trapping	20	24	4 – 72	16 – 35.5

In total, 1268 specimens were collected belonging to 22 species. On the basis of a current knowledge of small mammal distributions in Slovenia (Kryštufek, 1991) we assume that the faunal list is complete. Reiser (1933) reports for Pohorje also *Eliomys quercinus*, but this record is far outside the current range and is thus unlikely (Kryštufek, 2003). Two species *(Rattus rattus, Mus musculus)* are clearly associated with human settlements in this part of Slovenia (Kryštufek, 1991) and are excluded from further consideration for this reason. Their presence is only evidenced from a few owl pellet remnants.

Species composition in a sample clearly depended on a method used in faunal survey. Sampling by pitfalls and the owl pellet analysis approached closely to a total species pool of 22 species, while snap trapping emerged as being the least effective in this respect. Such a perception is likely biased however, because much less specimens were collected by snap trapping than by the two other techniques (Append. 2). As evident from Table 2, rodents strongly dominated in samples collected by snap traps (89.2% of specimens) and in owl pellets (93.9%). High share of voles (Arvicolinae) in owl pellet sample results from prey by *Asio otus*, which is known to be specialized on this particular rodent group (Andrews, 1990). Snap trapping was evidently not effective in sampling dormice (Gliridae) while owl pellet analysis (1) most likely underestimated shrews (Soricidae). Pitfalls sampled shrews most effectively which is in line with published evidence (Kirkland & Krim Sheppard, 1994). The impact of sampling technique on perceived small mammal assembly is well known (Maddock, 1992; Kirkland & Krim Sheppard, 1994; Torre *et al.*, 2004) consequently our results are not surprising in this respect.

Tab. 2: Frequency composition (share of specimens; in %) of pooled samples across taxonomic groups and according to the technique employed in field survey. Moles (Talpidae) and hedgehogs (Erinaceidae) were excluded. See also Appendix 2 for a species composition of samples.
Tab. 2: Frekvenčna sestava (delež osebkov; v %) v združenih vzorcih, urejenih po taksonomskih skupinah in po metodi terenskega vzorčenja. Krti (Talpidae) in ježi (Erinaceidae) niso vključeni. Glej Dodatek 2 za vrstno sestavo vzorcev.

	Snap trapping	Pitfall trapping	Owl pellets
Soricidae	10.8	37.7	6.1
Arvicolinae	44.3	19.5	58.2
Muridae	43.8	40.2	27.0
Gliridae	1.1	2.6	8.7
Total	100.0	100.0	100.0

Fourteen species of a total 20 occurred all along the elevational gradient but the statement is poorly documented for *Talpa europaea, Arvicola scherman, Microtus arvalis* and *Glis glis*. Noteworthy, 19 species were found in the lowest elevational zone, *i.e.*, all but *Dryomys nitedula* and we believe that the absence of this dormouse from low elevations is genuine. Altitudinal range for *Micromys minutus* is puzzling. Pitfall sampling confirmed its presence at low elevations (< 600 m a.s.l.), but remnants of two specimens were recorded in *A. otus* pellets at 1450 m a.s.l. Although this mouse does ascend as high as 1700 m a.s.l. in the southern Balkans (Kryštufek & Kovačić, 1984), it was not recorded above 900 m in Austria (Spitzenberger, 2001). In subsequent analyses we thus considered *M. micromys* to be restricted only to the lowest two elevational zones. The remaining four species gradually disappeared with increasing altitude: *Crocidura leucodon* and *C. suaveolens* at 700 m, *Erinaceus roumanicus* at 1100 m, and *Neomys anomalus* at 1130 m a.s.l. In conclusion, the core species are best classified as elevational generalists. With the exception of *Dryomys nitedula*, not a single species was added to the regional species pool with the increasing elevation. As a result, the overall turnover rate is excessively low ($\beta = 0.17$).

The overall elevational pattern in species richness on Mt. Pohorje is thus a steady decline in species numbers along the altitudinal gradient (Tab. 3, Fig. 1). Species richness also correlated negatively and significantly with elevation ($r = -0.931$, $p < 0.01$). Although such a response of species richness was long considered to be a general pattern in mountain biotas (MacArthur, 1972) and is certainly common in some taxonomic groups (Körner, 2002), the majority of recent studies, those based on small mammals in particular, demonstrate the predominance of a humped curve pattern (*cf.* McCain, 2005, and references therein). Possible reason for a deviation from the humped pattern might be lack of high elevation generalists, but this requires further evaluation on the continental scale. The decline might also be due to decrease in primary productivity (Körner, 2002). Presumption that species diversity increases with overall

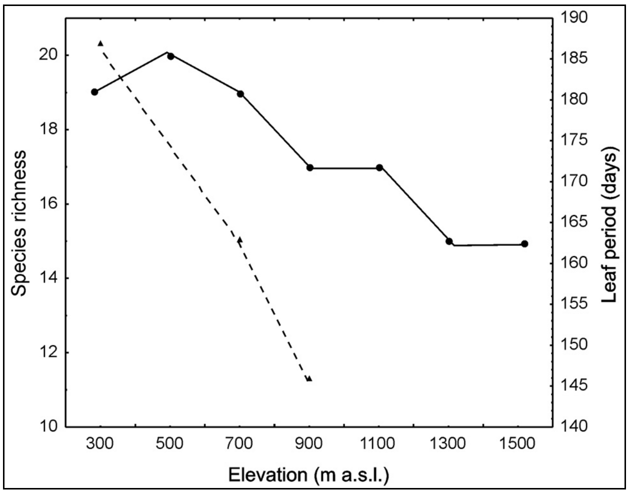

Fig. 2: Bivariate plot of small mammal species richness on Mt. Pohorje (dots) and of the period the beech is in leaf (triangles) against elevation.
Sl. 2: Število vrst malih sesalcev na Pohorju (pike) in trajanje olistanosti bukve (trikotniki) glede na nadmorsko višino.

Tab. 3: Small mammal species composition according to 200 m elevational zones on Mt. Pohorje. X – evidence based on trapping; O – evidence from owl pellets; not sign (--) – presence presumed; S – species richness (S_{total} = 20). Predicted species richness accounts also presumed presences.
Tab. 3: Vrstna sestava malih sesalcev na Pohorju po posameznih 200 metrskih višinskih pasovih. X – podatek temelji na ulovu; O – podatek temelji na izbljuvkih sov; pomišljaj (--) – domnevna prisotnost S – število vrst (S_{total} = 20). Ocenjeno število vrst vključuje tudi domnevne prisotnosti.

Elevational midpoint	300	500	700	900	1100	1300	1500
Sorex araneus	X	X	X	X	X	X	X
Sorex minutus	X	X	X	X	X	X	X
Sorex alpinus	X	X	--	X	X	X	X
Neomys fodiens	X	X	X	--	X	X	X
Neomys anomalus	X	X	O	--	X		
Crocidura leucodon	X	--	O				
Crocidura suaveolens	--	--	O				
Talpa europaea	--	X	X	--	X	--	X
Erinaceus roumanicus	--	--	--	--	X		
Myodes glareolus	X	X	X	X	X	X	X
Arvicola scherman	X	--	O	--	--	--	O
Microtus agrestis	X	X	X	X	X	X	X
Microtus arvalis	X	--	O	--	--	--	O
Microtus subterraneus	X	X	X	--	X	X	X
Apodemus flavicollis	X	X	X	X	X	X	X
Apodemus sylvaticus	X	X	X	X	X	--	O
Micromys minutus	X	X					O
Muscardinus avellanarius	X	--	X	X	X	--	X
Dryomys nitedula		X	X	X	X	--	X
Glis glis	--	--	X	--	--	--	O
Empirical S	15	13	17	9	14	8	15
Predicted S	19	20	19	17	17	15	15

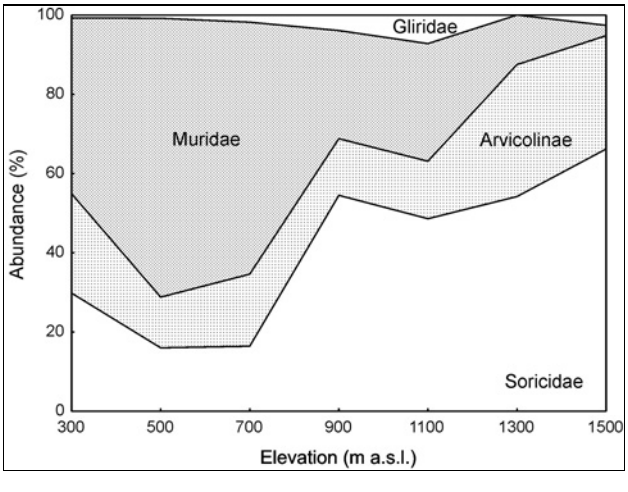

Fig. 3: Frequency distribution (relative abundance) of main small mammal groups along the elevational gradient on Mt. Pohorje.
Sl. 3: Frekvenčna razporeditev (relativna številčnost) glavnih skupin malih sesalcev vzdolž višinskega gradienta na Pohorju.

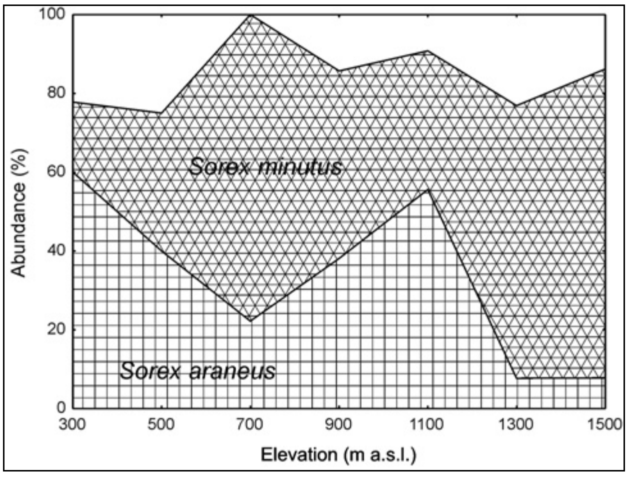

Fig. 4: Frequency distribution (relative abundance) along the elevational gradient on Mt. Pohorje of *Sorex araneus* ***and*** *Sorex minutus* ***within shrew assemblages.***
Sl. 4: Frekvenčna razporeditev (relativna številčnost) vzdolž višinskega gradienta na Pohorju vrst *Sorex araneus* ***in*** *Sorex minutus* ***v združbah rovk.***

productivity is one of the most widely cited causal hypotheses concerning variation in species richness (MaCArthur, 1972; Rahbek, 1995). Productivity is not easy to measure (Heaney, 2001) and data are seldom available for elevational transects. Data from the Alps of Slovenia do show decrease in a period the beech *(F. sylvatica)* is in leaf, which can be used as a proxy for the length of a productivity period. Over 45 years (1960–2004), this period lasted for 187 days at the elevation of 275 m, 163 days at 760 m, and 146 days at 970 m (data from the Environmental Agency of the Republic of Slovenia). However, the decline for the leaf period is steeper than for the species richness (Fig. 1).

The four main taxonomic groups showed a different response to increase in elevation (Fig. 2). Note also that taxonomic groups overlap with trophic groups (Kryštufek & Griffiths, 1999; 2001), *i.e.,* Soricidae are insectivorous, Arvicolinae are herbivorous, while Muridae and Gliridae are omnivorous. Pearson correlation coefficient between relative abundance and elevation was significant (at $p < 0.05$) for Soricidae ($r = 0.839$) and for Muridae ($r = -0.844$). Within shrews, *Sorex araneus* and *S. minutes* were the most abundant species throughout the elevational transect (Fig. 4). The former tended to dominate at lower elevations and the latter at higher altitudes, the trend however was not a simple one and correlations were not significant ($r < 0.67$, $p > 0.05$). Dormice (Gliridae) were rare throughout the elevational gradient (relative abundance < 10%). Noteworthy is their peak above 1000 m a.s.l. and their presence at the highest elevational zone, where even *Apodemus flavicollis*, the dominant small mammal in the study area, was rarely collected.

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VIŠINSKA RAZPOREDITEV MALIH TERESTRIČNIH SESALCEV NA POHORJU, SLOVENIJA

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POVZETEK

Na Pohorju smo vzorčili male sesalce na 33 lokacijah v nadmorskih višinah med 250–300 m in 1530 m. Vrstna sestava je bila odvisna od metode vzorčenja. Lov s pastmi na vzmet je bil učinkovitejši pri vzorčenju glodalcev, lovne jame pa pri vzorčenju rovk. V materialu smo določili 22 vrst, vendar dveh komenzalnih glodalcev (Rattus rattus *in* Mus musculus) *nismo upoštevali pri nadaljnjih analizah. Štirinajst vrst, od skupnega števila 20, je bilo prisotnih vzdolž celotnega višinskega gradienta, vrstni obrat pa je bil zelo nizek ($\beta = 0,17$). Za višinski vzorec vrstne raznolikosti na Pohorju je bilo tako značino postopno zmanjševanje števila vrst vzdolž višinskega gradienta. Relativna številčnost miši (Muridae) je upadala z naraščajo nadmorsko višino ($r = -0,844$), številčnost rovk (Soricidae) pa je naraščala ($r = 0,839$).*

Ključne besede: Alpe, Pohorje, višinski razpon, mali sesalci, model mid-domain, vrstna pestrost

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Appendix 1: Summary of faunal surveys on Mt. Pohorje (Fig. 1). Given are locality, elevation, method employed, date, total number of specimens collected and list of species with number of specimens in parentheses. List of species with acronyms: Soricidae: *Sorex araneus* ***(S.ar),*** *S. minutus* ***(S.mi),*** *Sorex alpinus* ***(S.al),*** *Sorex* ***sp. (S.sp),*** *Neomys fodiens* ***(N.fo),*** *Neomys anomalus* ***(N.an),*** *Crocidura suaveolens* ***(C.su),*** *C. leucodon* ***(C.le); Talpidae:*** *Talpa europaea* ***(T.eu); Erinaceidae:*** *Erinaceus roumanicus* ***(E.ro); Cricetidae, Arvicolinae:*** *Myodes glareolus* ***(M.gl),*** *Arvicola scherman* ***(A.sc),*** *Microtus agrestis* ***(M.ag),*** *M. arvalis* ***(M.ar),*** *M. subterraneus* ***(M.su),*** *Microtus* ***sp. (M.sp); Muridae:*** *Apodemus flavicollis* ***(A.fl),*** *A. sylvaticus* ***(A.sy),*** *Apodemus* ***sp. (A.sp),*** *Micromys minutus* ***(M.mi),*** *Rattus rattus* ***(R.ra),*** *Rattus* ***sp. (R.sp); Gliridae:*** *Muscardinus avellanarius* ***(M.av),*** *Dryomys nitedula* ***(D.ni),*** *Glis glis* ***(G.gl).***
Dodatek 1: Povzetek favnističnih vzorčenj na Pohorju (Sl. 1). Navedeni so nahajališče, nadmorska višina, uporabljena metoda vzorčenja, datum, skupno število zbranih osebkov in seznam vrst s številom osebkov v oklepaju. Za seznam vrst z oznakami glej zgoraj.

1. Maribor, Pernica, 250–300 m a.s.l.; snap trapping on 22 May 1985; N=4: *M.gl.* (1), *M.ag* (2), *A.fl* (1).
2. Slivnica, 275 m a.s.l.; pitfall sampling in 1991; N=71: *S.ar* (25), *S.mi* (5), *M.gl.* (20), *M.ar* (1), *A.fl* (19), *M.av* (1).
3. Pekre, Ledine, 280 m a.s.l.; pitfall sampling in 1987; N=55: *S.ar* (2), *S.mi* (3), *S.al* (1), *N.fo* (2), *N.an* (6), *C.le* (1), *A.sc* (2); *M.gl.* (10), *M.ag* (2), *M.su* (1), *A.fl* (11), *A.sy* (3), *A.sp* (10), *M.mi* (1).
4. Maribor, Fram, Planica, 310 m a.s.l.; snap trapping on 12 July 1977; N=1: *S.ar* (1).
5. Bolfenk, Vzpenjača, 330 m a.s.l.; pitfall sampling in 1987; N=25: *M.gl.* (1), *M.su* (1), *A.fl* (17), *A.sy* (2), *A.sp* (4).
6. Fram, 400 m a.s.l.; pitfall sampling in1991; N=59: *S.ar* (8), *S.mi* (2), *S.al* (1), *N.fo* (3), *N.an* (1), *T.eu* (1), *M.gl.* (9), *M.ag* (1), *M.su* (1), *A.fl* (30), *M.mi* (2).
7. Fram, 425 m a.s.l.; pitfall sampling in1991; N=31: *A.fl* (30), *D.ni* (1).
8. Bolfenk, Skalce, 560 m a.s.l.; pitfall sampling in 1987; N=36: *S.mi* (5), *M.gl.* (5), *A.fl* (14), *A.sy* (2), *A.sp* (10).
9. Ruše, 600–700 m a.s.l.; snapp trapping in 1963; N=98: *S.ar* (2), *T.eu* (1), *M.gl.* (40), *M.su* (1), *A.fl* (53), *D.ni* (1). Source: Heneberg *et al.* (1964).
10. Hoče – Areh, "Veronika Klinc", 675 m a.s.l.; pitfall sampling in 1991; N=55: *S.ar* (2), *S.mi* (7), *M.gl.* (10), *A.fl* (35), *G.gl* (1).
11. Planica nad Framom, 700 m a.s.l.; pellets of *Strix aluco*, collected in 1991 and 1992; N=145: *S.ar* (6), *S.mi* (1), *N.fo* (4), *N.an* (1), *C.su* (1), *C.le* (9), *T.eu* (4), *M.gl.* (14), *A.sc* (29), *M.ag* (4), *M.ar* (9), *M.su* (12), *A.fl* (5), *A.sy* (1), *A.sp* (18), *R.ra* (3), *R.sp* (1), *M.av* (3), *G.gl* (18). Source: Šorgo & Janžekovič (1995).
12. Bolfenk, Jonatan, 800 m a.s.l.; pitfall sampling in 1987; N=24: *S.ar* (1), *S.mi* (6), *N.fo* (1), *M.gl.* (4), *M.ag* (1), *A.fl* (5), *A.sy* (1), *A.sp* (4), *M.av* (1).
13. Slap na Framskem potoku, 925 m; pitfall sampling in 1991; N=35: *S.ar* (9), *S.mi* (8), *S.al* (5), *M.gl.* (5), *A.fl* (6), *D.ni* (1), *M.av* (1).
14. Predan, 975 m a.s.l.; pitfall sampling in 1991; N=18: *S.ar* (6), *S.mi* (6), *M.gl.* (1), *A.fl* (5).
15. Šumik, 1000–1100 m a.s.l.; snap trapping on 18 July 1969; N=14: *S.al* (1), *N.fo* (3), *T.eu* (1), *M.gl.* (3), *M.su* (4), *A.fl* (2).
16. Bajgot, 1050 m a.s.l.; pitfall sampling in 1991; N=4: *S.mi* (1), *M.ag* (1), *M.av* (2).
17. Šumik, 1075 m a.s.l.; pitfall sampling in 1991; N=22: *S.ar* (3), *S.mi* (6), *M.gl.* (3), *M.su* (1), *A.fl* (6), *D.ni* (3).
18. Pajkov dom, 1100 m a.s.l.; pitfall sampling in 1991; N=14: *E.ro* (1); *S.ar* (4), *S.mi* (1), *M.ag* (1), *A.fl* (6), *M.av* (1).
19. Bolfenk, Stolp, 1130 m a.s.l.; pitfall sampling in 1987; N=72: *S.ar* (23), *S.mi* (11), *S.al* (2), *N.fo* (1), *N.an* (2), *M.gl.* (5), *M.ag* (2), *M.su* (3), *A.fl* (11), *A.sy* (2), *A.sp* (8), *D.ni* (2).
20. Domna Osankarici, 1190 m a.s.l.; snap trapping on 21 June 1984; N=6: *N.fo* (1), *M.gl.* (1), *M.ag* (1), *A.fl* (3).
21. Areh, 1200–1300 m a.s.l.; pitfall sampling in 1991; N=24: *S.ar* (1), *S.mi* (9), *S.al* (3), *M.gl.* (6), *M.ag* (1), *M.su* (1), *A.fl* (3).
22. Šiklarica, Črni vrh, 1300 m a.s.l.; snap trapping on 10 Aug 1975; N=1; *S.ar* (1).
23. Grmovškov dom, 1370 m a.s.l.; snapp trapping on 7 July 1983; N=11: *S.mi* (1), *N.fo* (1), *M.gl.* (1), *M.su* (4), *A.fl* (4).
24. Ribniško jezero, 1425 m a.s.l.; pitfall sampling in 1991; N=15: *S.mi* (10), *M.gl.* (1), *M.ag* (2), *M.su* (1), *M.av* (1).
25. Lovrenško jezero, 1425 m a.s.l.; pitfall sampling in 1991; N=17: *S.ar* (2), *S.mi* (12), *M.ag* (1), *M.su* (2).
26. Velika Kopa, 1450 m a.s.l.; snapp trapping on 3–5 April 1983, 2–8 July 1993; N=37: *S.ar* (3), *S.mi* (2), *S.al* (2), *M.gl.* (1), *M.ag* (2), *M.su* (12), *A.fl* (14), *D.ni* (1).

27. Jezerski vrh, 1450 m a.s.l.; pitfall sampling in 1991; N=19: *S.mi* (8), *M.gl.* (9), *M.ag* (2).
28. Ribniško jezero, 1450 m a.s.l.; pellets of *Asio otus*, collected in 1993; N=321: *S.ar* (1), *S.mi* (4), *S.sp* (1), *M.gl.* (29), *A.sc* (3), *M.ag* (136), *M.ar* (4), *M.su* (24), *M.sp* (1), Arvicolinae inted. (3), *A.fl* (66), *A.sy* (13), *A.sp* (12), *M.mi* (2), *M.mu* (3), *M.av* (18), *G.gl* (1). Source: Šorgo & Janžekovič (1995).
29. Jezerski vrh, 1500 m a.s.l.; pitfall sampling in 1991; N=24: *S.ar* (2), *S.mi* (9), *S.al* (3), *N.fo* (3), *T.eu* (3), *M.gl.* (1), *M.su* (1), *A.fl* (2).
30. Ribniško jezero, 1500 m a.s.l.; snap trapping on 19 July 1969; N=1: *M.ag* (1).
31. Lovrenška jezera, 1520 m a.s.l.; pitfall sampling in 1987; N=5: *S.al* (1), *S.mi* (1), *M.gl.* (1), *M.ag* (1), *M.av* (1).
32. Mala Kopa, 1520 m a.s.l.; snap trapping on 13 July 1984; N=2: *S.ar* (1), *T.eu* (1).
33. Ribniška koča, 1530m a.s.l.; snap trapping on 20 July 1969; N=4: *M.su* (4).

Appendix 2: Summary table of small mammal species and their abundance according to method employed during faunal surveys. S – species richness.
Dodatek 2: Pregledna tabela vrst malih sesalcev in njihove številčnosti glede na uporabljeno metodo vzorčenja. S – število vrst.

	Snap trapping S = 10	**Pitfall trapping S = 19**	**Owl pellets S = 19**	**Total S = 22**
Sorex araneus	8	88	7	103
Sorex minutus	3	110	5	118
Sorex alpinus	3	17		20
Sorex sp.			1	1
Neomys fodiens	5	9	4	18
Neomys anomalus		9	1	10
Crocidura leucodon		1	9	10
Crocidura suaveolens			1	1
Talpa europaea	3	4	4	11
Erinaceus roumanicus		1		1
Myodes glareolus	47	91	43	181
Arvicola scherman		2	32	34
Microtus agrestis	6	15	140	161
Microtus arvalis		1	13	14
Microtus subterraneus	25	12	36	73
Microtus sp.			1	1
Arvicolinae *indet.*			3	3
Apodemus flavicollis	77	200	71	348
Apodemus sylvaticus		10	14	24
Apodemus sp.		36	30	66
Micromys minutus		3	2	5
Rattus rattus			3	3
Rattus sp.			1	1
Mus musculus			3	3
Muscardinus avellanarius		8	21	29
Dryomys nitedula	2	7		9
Glis glis		1	19	20
Total specimens	179	625	464	1268

Appendix 3: Summary table of small mammal numbers according to 200 m elevational zones. Based on pitfall sampling.
Dodatek 3: Pregledna tabela števila malih sesalcev po posameznih 200 metrskih višinskih pasovih. Temelji na vzorčenju z lovnimi jamami.

Elevational midpoint	**300**	**500**	**700**	**900**	**1100**	**1300**	**1500**	**Total**
Sorex araneus	27	8	2	16	30	1	4	88
Sorex minutus	8	7	7	20	19	9	40	110
Sorex alpinus	1	1		6	2	3	4	17
Neomys fodiens	2	3			1		3	9
Neomys anomalus	6	1			2			9
Crocidura leucodon	1							1
Talpa europaea		1					3	4
Erinaceus roumanicus					1			1
Myodes glareolus	31	14	10	10	8	6	12	91
Arvicola scherman	2							2
Microtus agrestis	2	1		1	4	1	6	15
Microtus arvalis	1							1
Microtus subterraneus	2	1			4	1	4	12
Apodemus flavicollis	47	74	35	16	23	3	2	200
Apodemus sylvaticus	5	2		1	2			10
Apodemus sp.	14	10		4	8			36
Micromys minutus	1	2						3
Muscardinus avellanarius	1			2	3		2	8
Dryomys nitedula		1		1	5			7
Glis glis			1					1
Total specimens	151	126	55	77	112	24	80	625