

## DISTRIBUTION OF SORICIDAE IN SLOVAKIA AND THEIR DEPENDENCY ON ALTITUDE GRADIENT

IVAN BALÁŽ<sup>1</sup> & MICHAL AMBROS<sup>2</sup>

<sup>1</sup> Department of Ecology and Environmental Sciences, Faculty of Natural Sciences,  
Constantine the Philosopher University, Tr. A. Hlinku 1, SK–949 74 Nitra, Slovakia [ibalaz@pobox.sk]

<sup>2</sup> State Nature Conservation SR, Protected Landscape Area Ponitrie, Samova 3,  
SK–949 01 Nitra, Slovakia [ambros@soprsr.sk]

**Abstract:** The Soricidae material comes from 77 geomorphological units of Slovakia and 288 squares of DFS (Databank of Slovak fauna, 68 % from all squares of DFS) between years 1974–2003. The work solves the synusias of small terrestrial mammals with shrews (consist of 21 species) and the preference of Soricidae to altitude levels in Slovakia. Species of genus *Sorex* occur in all altitude levels of Slovakia. Using RDA (redundancy analysis) we found out that *Sorex araneus* Linnaeus, 1758 prefers lowlands, *Sorex minutus* Linnaeus, 1766 prefers hillock level and occurrence of *Sorex alpinus* Schinz, 1837 correlates with increasing altitude (prefers mountain level). *Neomys anomalus* Cabrera, 1907 occurs from lowlands to oreale level but prefers hillock level and *Neomys fodiens* (Pennant, 1771) was found in all altitude levels with its preference to mountain level (like as *Sorex alpinus*). *Crocidura suaveolens* (Pallas, 1811) and *Crocidura leucodon* (Hermann, 1780) were found from lowlands to submountain level. *Crocidura suaveolens* prefers hillock level and *C. leucodon* lowlands.

**Key words:** *Sorex*, *Neomys*, *Crocidura*, hypsographic levels.

### INTRODUCTION

In Slovakia, family Soricidae is represented by species: common shrew – *Sorex araneus* Linnaeus, 1758; pigmy shrew – *Sorex minutus* Linnaeus, 1766; alpine shrew – *Sorex alpinus* Schinz, 1837; water shrew – *Neomys fodiens* (Pennant, 1771); Miller's water shrew – *Neomys anomalus* Cabrera, 1907; bi-coloured white-toothed shrew – *Crocidura leucodon* (Hermann, 1780) and lesser white-toothed shrew – *Crocidura suaveolens* (Pallas, 1811).

Occurrence of species in accordance with altitude gradient allows us to find out preferred altitude levels. Distribution of species, vertically or horizontally, can not be taken strictly only according to the altitude or latitude, but more important is vegetation belt conditioned by local substratum and climate attributes.

Synusias are similar communities of organisms belongs to the same living forms that settle uniform part of space and mostly have similar functions (Losos et al. 1984). Term synusia is used by zoologists in the meaning of taxocenosis, i.e. certain taxonomic unite population.

### MATERIAL AND METHODS

Evaluated data relate to a collection of 8045 specimens of shrews (*S. araneus* – 5763 ex., *S. minutus* – 1898 ex. and *S. alpinus* – 384 ex.), 1131 specimens of water shrews (*N. fodiens* – 748 ex., *N.*

*anomalous* – 383 ex.) and 147 specimens of white-toothed shrews (*C. leucodon* – 79 ex., *C. suaveolens* – 68 ex.).

Evaluated material comes from 77 geomorphological unites and 288 squares of Fauna Databank of Slovakia (DFS, 68% from all squares of DFS). Specimens of Soricidae were obtained during terrain trapping in the period of years 1974-2003. Majority of the material (89%) was collected by the staff of the Research station Staré hory, the Institute of experimental biology and ecology of the Slovak Academy of Science (SAS) in the years 1974-1996. Results of species expansion are evaluated according to mapping squares of standard mapping net of the DFS in relation to geomorphological units of Slovakia.

Representation of the Soricidae in synusias were evaluated in 6 hypsographic levels according to MAZÚR (1980): lowland (P-1, to 200 m a. s. l.), hillock (K-2, 200–400 m a. s. l.), submountainous (SM-3, 400–600 m a. s. l.), mountainous (M-4, 600–900 m a. s. l.), orear (O-5, 900–1200 m a. s. l.), subalpine (SA-6, 1200 m a. s. l. - upper forest limit). Synusias of small terrestrial mammals were formed by 21 species: *Apodemus agrarius* (Pallas, 1771), *A. flavicollis* (Melchior, 1834), *A. microps* Kratochvil et Rosicky, 1952 or *A. uralensis* (Pallas, 1811), *A. sylvaticus* (Linnaeus, 1758), *Arvicola terrestris* (Linnaeus, 1758), *Clethrionomys glareolus* (Schreber, 1780), *Crocidura leucodon*, *C. suaveolens*, *Micromys minutus* (Pallas, 1771), *Chionomys nivalis* Martins, 1842, *Microtus agrestis* (Linnaeus, 1761), *M. arvalis* (Pallas, 1779), *M. oeconomus* (Pallas, 1776), *Neomys anomalus*, *N. fodiens*, *Microtus subterraneus* (de Selys-Longchamps, 1836), *M. tataricus* Kratochvil, 1952, *Sicista betulina* (Pallas, 1779), *Sorex alpinus*, *S. araneus*, *S. minutus*.

In the CANOCO programme (TER BRAAK & ŠMILAUER 1998), using direct linear analysis RDA (redundancy analysis) we ordinated species, sites and hypsographic levels (environmental variable). We discovered preferred hypsographic levels of Soricidae.

## RESULTS AND DISCUSSION

### Occurrence of species Soricidae in Slovakia

We confirmed occurrence of *Sorex araneus* in 532 sites of Slovakia in 208 squares of DFS (49.3%) and in 77 geomorphological unites, from 100 up to 1800 m a. s. l. *Sorex minutus* was found on 318 sites, from 100 up to 1450 m a. s. l. Pigmy shrew was confirmed in 157 squares of DFS (37.2%) and in 70 geomorphological unites. *Sorex alpinus* was trapped on 128 sites of Slovakia, from 350 up to 1750 m a. s. l. Occurrence of alpine shrew was proved in 77 squares of DFS (18.2 %) and in 41 geomorphological unites (Figure 1).

Occurrence of *Neomys fodiens* is confirmed in 200 sites, in 105 squares of DFS (24.9%) and in 55 geomorphological unites, from 110 up to 1700 m a. s. l. *Neomys anomalus* was found in 153 sites, in 94 squares of DFS (22.3%) and in 57 geomorphological unites, from 110 up to 1100 m a. s. l. (Figure 2).

Occurrence of *Crocidura leucodon* is confirmed in 32 sites of Slovakia, in 24 squares of DFS (5.7%) and in 15 geomorphological unites, from 100 up to 550 m a. s. l. *Crocidura suaveolens* is confirmed in 36 sites, in 27 squares of DFS (6.4%) and in 23 geomorphological unites, from 100 up to 650 m a. s. l. (Figure 3).

### Synusias of small terrestrial mammals

**Lowland level (P-1)** – in synusias of small terrestrial mammals we found 16 species: *A. agrarius*, *A. flavicollis*, *A. microps*, *A. sylvaticus*, *Ar. terrestris*, *C. glareolus*, *C. leucodon*, *C. suaveolens*, *M. minutus*, *M. arvalis*, *M. oeconomus*, *N. anomalus*, *N. fodiens*, *P. subter-*

raneus, *S. araneus*, *S. minutus*. In lowland level, the mean dominance of species *Soricidae* in synusias was 22.5%.

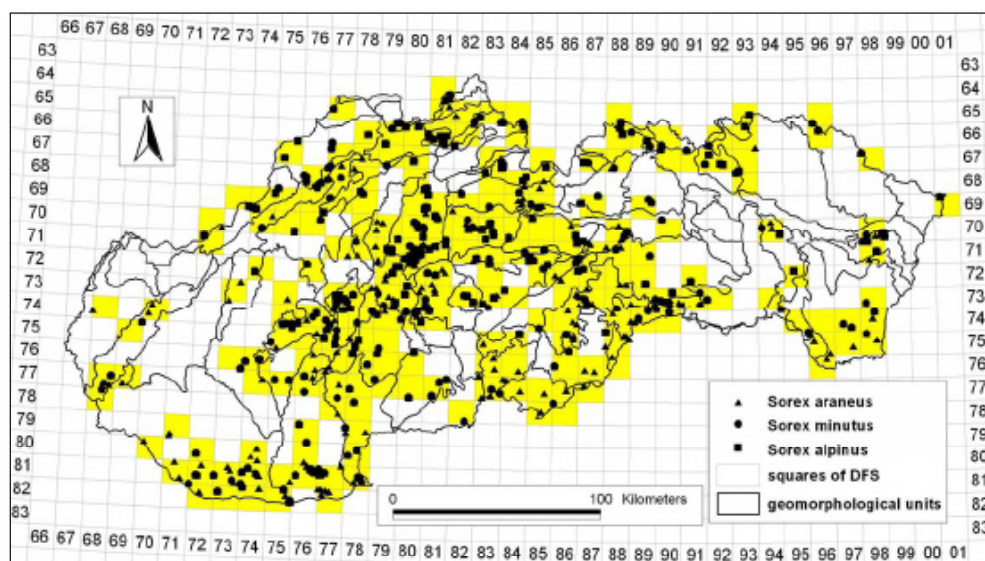
**Hillock level (K-2)** – in synusias of small terrestrial mammals were detected 16 species: *A. agrarius*, *A. flavicollis*, *A. microps*, *A. sylvaticus*, *A. terrestris*, *C. glareolus*, *C. leucodon*, *C. suaveolens*, *M. minutus*, *M. arvalis*, *N. anomalus*, *N. fodiens*, *P. subterraneus*, *S. alpinus*, *S. araneus* a *S. minutus*. The mean dominance of species *Soricidae* in synusias in hillock level was 24.6%.

**Submountainous level (SM-3)** – in synusias of small terrestrial mammals were ascertained 18 species: *A. agrarius*, *A. flavicollis*, *A. microps*, *A. sylvaticus*, *A. terrestris*, *C. glareolus*, *C. leucodon*, *C. suaveolens*, *M. minutus*, *M. agrestis*, *M. arvalis*, *N. anomalus*, *N. fodiens*, *P. subterraneus*, *P. tatraicus*, *S. alpinus*, *S. araneus*, *S. minutus*. In submountainous level the mean dominance of species *Soricidae* in synusias was 28.8%.

**Mountainous level (M-4)** – in synusias of small terrestrial mammals were approved 17 species: *A. agrarius*, *A. flavicollis*, *A. microps*, *A. sylvaticus*, *A. terrestris*, *C. glareolus*, *M. minutus*, *M. agrestis*, *M. arvalis*, *N. anomalus*, *N. fodiens*, *P. subterraneus*, *P. tatraicus*, *S. betulina*, *S. alpinus*, *S. araneus*, *S. minutus*. In mountainous level, the mean dominance of species *Soricidae* in synusias was 27.1%.

**Oreal level (O-5)** – in synusias of small terrestrial mammals were ascertained 18 species: *A. agrarius*, *A. flavicollis*, *A. microps*, *A. sylvaticus*, *A. terrestris*, *C. glareolus*, *M. minutus*, *M. agrestis*, *M. arvalis*, *M. nivalis*, *N. anomalus*, *N. fodiens*, *P. subterraneus*, *P. tatraicus*, *S. betulina*, *S. alpinus*, *S. araneus*, *S. minutus*. The mean dominance of species *Soricidae* in synusias in oréal level was 35.4%.

**Subalpine level (SA-6)** – in synusias of small terrestrial mammals were approved 12 species: *A. flavicollis*, *A. terrestris*, *C. glareolus*, *M. agrestis*, *M. arvalis*, *M. nivalis*, *P. subterraneus*, *P. tatraicus*, *S. betulina*, *S. alpinus*, *S. araneus*, *S. minutus*. In subalpine level, the mean dominance of species *Soricidae* in synusias was 24.2%.



**Figure 1.** Distribution of shrews (*Sorex* sp.) in Slovakia (1975-2003).

## Distribution of Soricidae in dependency on altitude gradient

Euryvalent species *Sorex araneus* and *Sorex minutus* are occurred in all 6 hypsographic levels. Using RDA analysis, we found out the lowest dependency on altitude for *Sorex minutus*. *Sorex araneus* prefers lowlands (38.1% dominance in synusias of small terrestrial mammals), *Sorex minutus* valleys (hillock level, Figure 4). Occurrence of *S. araneus* and *S. minutus* is not limited by the altitude. Species are represented in all hypsographic levels, from lowlands to high mountains (ANDĚRA 2000, KOCIANOVÁ 1980). Hypsometric range of *Sorex araneus* is relatively wide and was recorded from 97 m a. s. l. (Streda nad Bodrogom, NNR Tajba – MOŠANSKÝ & STANKO 1998) in Eastern Slovakian lowland to 2 000 m a. s. l. in High Tatras (Svišťové sedlo 2 221 m a. s. l., Kolové sedlo 2 060 m a. s. l., Téryho chata 2 016 m a. s. l. – HANZÁK & ROSICKÝ 1949). Catch range of *Sorex minutus* was assessed from 97 m a. s. l. in Eastern Slovakian lowland (Streda nad Bodrogom, NNR Tajba – MOŠANSKÝ & STANKO 1998) to 2 000 m a. s. l. in High Tatras (2 250 m – ROSICKÝ & KRATOCHVÍL 1955).

*Sorex alpinus* does not appear in lowland level, slight abundance is in hillock level and from submountainous level the occurrence is common. Using RDA analysis we found out, that expansion of *Sorex alpinus* depends on altitude (Figure 4) and its abundance is increasing with altitude. Vertical expansion of *Sorex alpinus* was noticed from 280 m a. s. l. to 300 m a. s. l. from Kremnické vrchy – Trnavá Hora, Lodnianska dolina and 300 m a. s. l. from Tribeč – Veľké Uherce, Drahožická dolina (AMBROS et al. 1986), from Strážovské vrchy in Manínska tiesňava (ŠTOLLMANN & DUDICH 1985) to catches in High Tatras 1 800 m a. s. l. (ROSICKÝ & KRATOCHVÍL 1955), 1 750 m a. s. l. Veľká studená dolina under Zbojnícka chata (PELIKÁN 1962) and 1 700 m a. s. l. Veľká studená dolina (KRATOCHVÍL & GRULICH 1950). ANDĚRA (2000) determined hypsographic occurrence of *S. alpinus* from 300 up to 1600 m a. s. l. KOCIANOVÁ (1980) found presence of *S. alpinus* in 2200 m a. s. l.

In Slovakia the attention was not paid to white-toothed shrew and water shrew species.

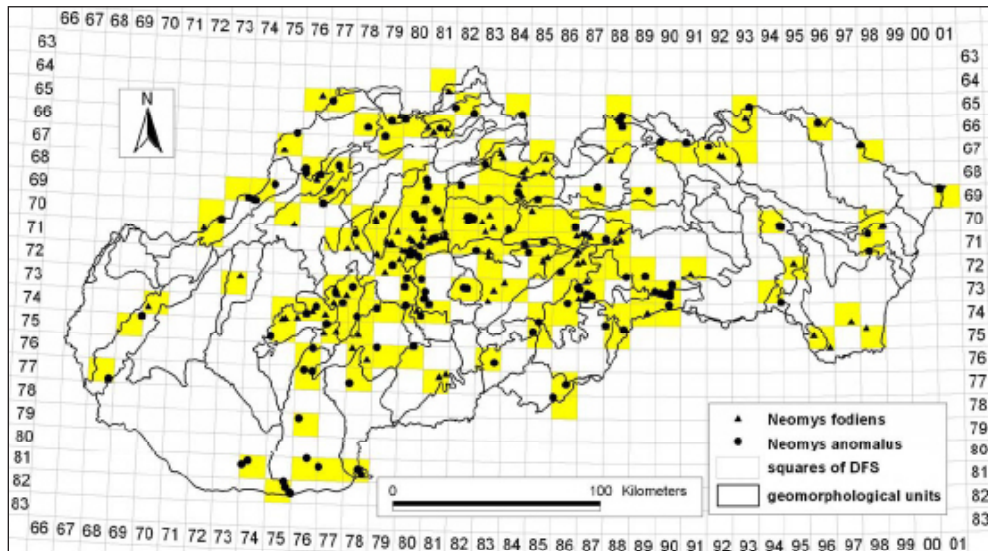


Figure 2. Distribution of water shrews (*Neomys* sp.) in Slovakia (1975-2002).

*Neomys anomalus* appears from lowland to orreal level. RDA analysis confirmed juncture to hillock and submountainous level. *Neomys fodiens* appears in all altitude levels with maximum in mountainous level (Figure 4). ANDĚRA (1993) speaks about dispersion of *Neomys anomalus* from 140 m a. s. l. to 1330 m a. s. l., while more than 64% were found in range 200 - 600 m a. s. l. ANDĚRA (2000) states the *N. anomalus* occurrence in hillock, submountainous and mountainous regions, in lower regions are findings more sporadic. Vertical dispersion of species in eastern Alps reaches 1850 m a. s. l. (SPITZENBERGER 1980). MITCHELL-JONES et al. (1999) show the influence of *N. anomalus* in eutrophic riparian vegetation of still freshwater bodies, bogs and slow-flowing brooks and rivers from lowlands to 1850 m a. s. l. ANDĚRA (2000) states that *N. fodiens* occurred regardless to altitude levels. However, HÜRKA (1988) states the most of his findings in range from 300 up to 699 m a. s. l. and whole hypsographic range from 150 up to 1450 m a. s. l. SPITZENBERGER (1980) speaks about the highest known occurrence in eastern Alps (2050 m a. s. l.).

*Crocidura suaveolens* was found from lowland to submountainous level. The species prefers hillock level as is proved by RDA analysis (Figure 4). In Czech Republic HÜRKA (1968), TYRNER & BĀRTA (1972) studied the *C. suaveolens* expansion. In Czechoslovakia MOŠANSKÝ (1980) and ANDĚRA & HÜRKA (1984) solve the species expansion from eastern Slovakia. CHUDOBA & HAITLINGER (1971) found out the occurrence of species surrounding the cottage in Kysucké Beskydy (1250 m a. s. l.) and found out, that *Crocidura suaveolens* prefers hillock level about 320 m a. s. l. ANDĚRA (2000) and ANDĚRA & HÜRKA (1984) mention expansion of synanthropic species *Crocidura suaveolens* from 100 up to 1603 m a. s. l., with maximum findings from 100 up to 600 m a. s. l.

Hypsographic validity of *Crocidura leucodon* is from lowland to submountainous level, using RDA analysis, *Crocidura leucodon* prefers lowland (Figure 4). Hypsometric range of *Crocidura leucodon* is from 97 m a. s. l. in Eastern Slovakian lowland in Streda nad Bodrogom, v NNR Tajba (MOŠANSKÝ & STANKO 1998), to 1100 m a. s. l. in Volovské vrchy in Kojšovská hola near cottage house Erika (MOŠANSKÝ 1957). The most abundance of species

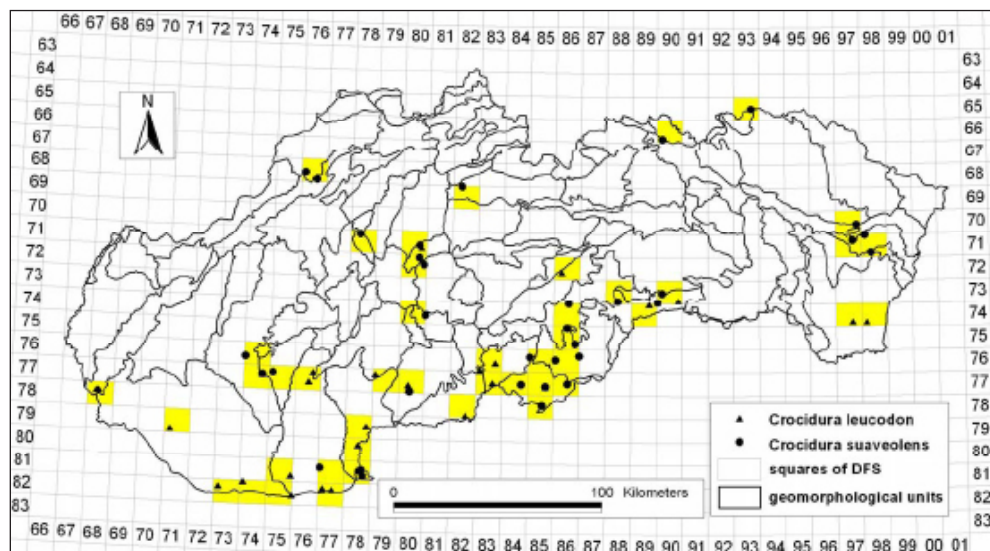


Figure 3. Distribution of white-toothed shrews (*Crocidura* sp.) in Slovakia (1975–2002).

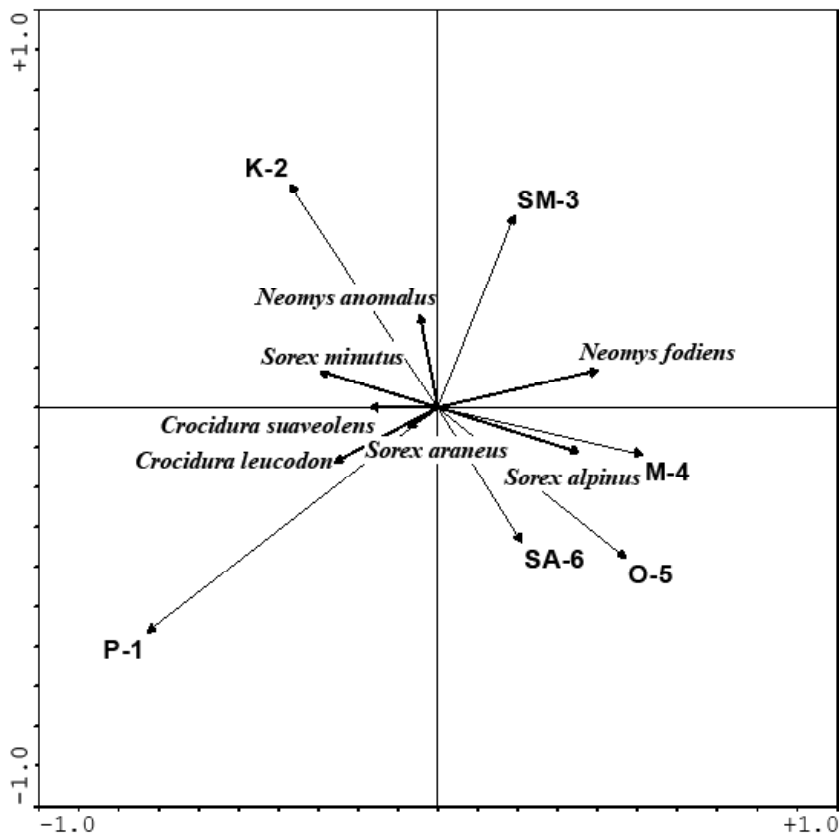
is occurred from 400 m a. s. l., occurrence above 600 m a. s. l. is rare (Banská Štiavnica 650 m a. s. l. – TURČEK 1951, Kalamárka in Poľana 800 m a. s. l. – TURČEK 1952, Vysoký vrch near Košice 853 m a. s. l. – MOŠANSKÝ 1957). Species *C. leucodon*, which unlike to *C. suaveolens* does not have tendency to synanthropy, was found in altitude level from 150 up to 650 m a. s. l., with maximum finds to 400 m a. s. l. (ANDĚRA & HŮRKA 1984).

Differences between our results and results of authors (for example ANDĚRA & HŮRKA 1984) can be followed by relatively insufficient *Crocidura* species material. State of expansion natural range and hypsographic range of both *Crocidura* species requires receiving of further faunistic information.

## SUMMARY

Synusias of small terrestrial mammals, in which Soricidae comprise certain qualitative and quantitative part, are composed from 21 species (in lowland level we approved 16, in hillock level 16 species, in submountainous level 18, in mountainous level 17, in oreale level 18 and in subalpine 12 species).

Genus *Sorex* is present in all hypsographic levels. *Sorex araneus* has the major repre-



**Figure 4.** Using RDA analysis were ordinated species, sites and hypsographic levels (P-1 - lowland, K-2 - hillock, SM-3 - submountainous, M-4 - mountainous, O-5 - oreale, SA-6 - subalpine level). We discovered preferred hypsographic levels of Soricidae.

sensation in lowland synusias (38.1%) and minor in hillock level (24.2%), it prefers lowlands. *Sorex minutus* takes the major portion in lowland (31.3%) and minor in mountain level (18.6%), despite of its correlation towards hillock level. *Sorex alpinus* is a common species occurred on suitable biotopes to submountainous level. Its presence correlates with increasing altitude and its mean dominance is from 9% (in subalpine level) to 17.2% (in oreale level).

*Neomys anomalus* appears from lowland to oreale level, but prefers hillocks up to submountainous level. *Neomys fodiens* was ascertained in all hypsographic levels, correlating to mountain level.

*Crocidura suaveolens* was detected from lowland up to submountainous and partially to mountainous level, but prefers hillock level. *Crocidura leucodon* was approved from lowland up to submountainous level with lowland level preference.

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