Small mammals of Uzhansky National Park (Ukrainian Carpathians) and its vicinities: a preliminary analysis. — Z. Barkaszi, N. Koval. — A preliminary analysis of species composition, abundance and habitat preferences of small mammals in the territory of Uzhansky National Nature Park and its vicinities was conducted. Since the creation of the park in 1999, detailed studies on small mammals have not been conducted in the area. Thus, the present research is a first attempt to clarify the species composition and some ecological features of small mammals in the region. In September–October 2017, trapping of small mammals was conducted by traditional methods using Hero traps and live traps. Five key habitats were investigated: ‘mixed forest’, ‘forest edge’, ‘windfall’, ‘meadow’, and ‘shrubs’. The total number of trap days was 705 during which 101 specimens of 7 species were collected. One species — *M. agrestis* — was recorded first in Uzhansky National Park. The part of females in the general sample was higher than the part of males (58.4 % vs. 41.6 %, respectively). Among the studied habitats, the highest species richness was revealed in ‘meadow’, where all 7 species occurred. The most abundant but, at the same time, the poorest habitats were ‘mixed forest’ (34.4 specimens / 100 trap-days, 2 species) and ‘forest edge’ (20.0 specimens, 2 species). Among the 7 species revealed in the park and its vicinities, only one is considered abundant (*S. tauricus*). According to Shannon and Simpson diversity indices, the highest species diversity was revealed in ‘meadow’ (*H* = 0.746, *D* = 4.741), ‘windfall’ (*H* = 0.436, *D* = 2.579), and ‘shrubs’ (*H* = 0.430, *D* = 2.528), while ‘mixed forest’ and ‘forest edge’ showed the lowest diversity. By the level of habitat preference, the most eurytopic species were *S. tauricus* and *M. glareolus*. The yellow-necked field mouse preferred ‘mixed forest’ the most (*Fij* = 0.57) and clearly avoided ‘meadow’ and waterside ‘shrubs’. The shrews (*Sorex*) and voles (*Microtus*) under conditions of Uzhansky Park were stenotopic species occurring only in ‘meadow’ (*Fij* = 1.00). Habitats having the highest level of species diversity deserve special conservation attention. The current revised taxonomic list of orders Soriciformes and Muriformes includes 14 species. The presence of 2 species previously mentioned for the region have not been confirmed yet by actual records.

**Key words:** insectivores, rodents, abundance, habitat preference, protected areas.

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**Introduction**

Uzhansky National Nature Park is located in the Ukrainian Carpathians, in the upper part of the Uzh River’s basin in the northwest part of Zakarpattia Oblast, Ukraine (Transcarpathia). The national park was created in 1999 based on former reserves ‘Stuzhytsia’ and ‘Tykhyi’ (which existed yet in the early 20th century in order to protect primeval forests) and of adjoined territories of the Uzh River’s basin. The area of Uzhansky Park is 391.6 km² and is part of the trilateral (Poland, Slovakia, and Ukraine) biosphere reserve ‘Eastern Carpathians’. Primeval and old-growth forests of Uzhansky National Park are part of UNESCO World Heritage.

During the 20 years since the creation of the Park, many groups of organisms have yet remained poorly investigated. Nevertheless, the flora of Uzhansky Park is studied quite in detail, which is represented by 2 160 species of plants and fungi (Chronicle…, 2018). Primeval beech forests of the Park are studied thoroughly (Zayats, 2009), as well as lichens on some mountain meadows (Pirogov et al., 2014).

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1 Data from the official website of Uzhansky National Nature Park, page ‘History of Establishment’. Accessed on 05 February 2019 from https://unpp.uz.ua/home/istoriya-stvorennya/
Among invertebrates of the Park, several groups of arthropods are relatively well studied, particularly the species composition of epigeal spiders represented here by 79 species, 3 of which were first recorded in the Ukrainian Carpathians (Hirna et al., 2015).

Insects of Uzhansky National Park are also studied in detail, especially their diversity and the distribution and ecology of rare and vulnerable species (Koval et al., 2011; Kanarskyi et al., 2012; Geryak et al., 2013; Koval, Kanarskyi, 2013).

Data on vertebrates are rather fragmented. Amphibians are the only group the taxonomic and species composition of which was fully clarified (Kurtyak, Krulko, 2010). Nevertheless, much attention was paid to mammals, which, according to current estimates, are represented by 63 species. The most thoroughly studied group of mammals are bats represented by 21 species, among which the presence of 19 species was confirmed by actual records (Bashta, Koval, 2014; Koval et al., 2018). Regarding other groups of mammals, separate studies were devoted to the population of the rare wildcat, the abundance of which has been showing a positive dynamic since 2007 (Koval, 2017), and to investigations into ecological conditions of the Park as a potentially suitable territory for breeding and restoration of the European bison (Perzanowski, Olech, 2007; Khoietskyy et al., 2014). Considerable attention was paid to studies into the ecology of large carnivores of Uzhansky Park as well (Shkvyría et al., 2014).

Special studies on small mammals of Uzhansky Park have not been conducted before. Many of the easily recognizable species (e.g., Sciurus vulgaris, Castor fiber, Apodemus agrarius etc.) were included into the very first checklists of species, while the presence of small-sized species was confirmed mainly based on single records or was not confirmed at all. Among rodents, only the Eurasian beaver is well studied, which is represented here by a mountain population and continues to expand its distribution range (Koval, 2015).

Therefore, the aim of the present research was to clarify the species composition, diversity, and habitat preferences of small mammals in Uzhansky National Park and to revise the current checklist of shrews and rodents.

Material and Methods

Field studies were conducted from 15 September to 14 October 2017 in the territory of Uzhansky National Park and adjacent areas (Fig. 1).

Trappings took place in 5 types of habitats using Hero traps (outside the park) and live traps (both within and outside the park) according to a standard methodology (e.g., Zagorodniuk, 2002; Numerov et al., 2010). Animals collected by live traps were marked before release to avoid their recensus in case of their recapture. Trappings in each habitat lasted for 2 days (or 3 days in case of unfavourable weather conditions). The total number of trap-days was 705.

The following types of habitats were investigated (Fig. 2):

1) mixed forest (49.043455, 22.583172) — relatively young-growth beech–hornbeam–oak forest,
2) forest edge (49.042251, 22.578786) — at the boundary of a meadow and a beech-hornbeam forest,
3) windfall (48.883814, 22.470153) — cleared, in a beech–hornbeam forest,
4) meadow (49.043615, 22.581042; 48.940980, 22.476291) — moderately moist meadows,
5) shrubs (48.948434, 22.472967) — common hazel, blackberry and black elder along a mountain stream.

Indices of species richness and species diversity (Shannon and Simpson indices) were calculated, as well as the level of dominance, relative abundance (Zagorodniuk et al., 2002) and habitat preferences of species (Pesenko, 1982; Naglov, Zagorodniuk, 2006).

The revised checklist of small mammals of Uzhansky National Park follows the latest taxonomic scheme of the mammal fauna of Ukraine (Zagorodniuk, Emelynov, 2012).
Results and discussion

Species composition and relative abundance

Based on trapping results, the presence of 7 small mammal species was revealed or confirmed in the territory of Uzhansky National Park (Table 2). Among them, 2 species (S. araneus and S. minutus) represent the order Soriciformes (seu Insectivora) and 5 belong to the order Muriformes (seu Rodentia).

In total, 101 specimens were trapped, most of which belong to S. tauricus. Two species — S. minutus and M. arvalis — have the least number of specimens in the general sample. In addition, all species are represented in the sample by a larger number of females than males (Fig. 3) except for A. agrarius, which is represented by an equal number of specimens of different sexes. The portion of females in the general sample is 58.4 %, while the portion of males is 41.6 %.

Among the studied habitats, the highest species richness was revealed in ‘meadow’, where all 7 species occurred. The highest abundance, although the lowest number of species, was revealed in ‘mixed forest’ (34.4 specimens, 2 species) and ‘forest edge’ (20.0 specimens, 2 species).

The lowest abundance of micromammals was revealed in ‘windfall’ (3.9 specimens), while ‘meadow’, which was the richest habitat by the number of species, had also a relatively low abundance of animals (8.4 specimens) due to the low number of specimens trapped in this habitat. The general relative abundance of micromammals in the studied area was 14.3 specimens.
Table 1. Results of trappings of small mammals in Uzhansky National Park and its vicinities

| Species                  | mixed forest | forest edge | windfall | meadow | shrubs | Total |
|--------------------------|--------------|-------------|----------|--------|--------|-------|
| Sorex araneus (S-ara)    | 0            | 0           | 0        | 3      | 0      | 3     |
| Sorex minutus (S-min)    | 0            | 0           | 0        | 1      | 0      | 1     |
| Apodemus agrarius (A-agr)| 0            | 0           | 1        | 4      | 7      | 12    |
| Sylvaemus tauricus (S-tau)| 52         | 6           | 3        | 1      | 2      | 64    |
| Myodes glareolus (M-gla)| 3            | 2           | 3        | 1      | 6      | 15    |
| Microtus agrestis (M-agr)| 0            | 0           | 0        | 5      | 0      | 5     |
| Microtus arvalis (M-ary)| 0            | 0           | 0        | 1      | 0      | 1     |
| Total specimens          | 55           | 8           | 7        | 16     | 15     | 101   |
| Total trap-days          | 160          | 40          | 180      | 190    | 135    | 705   |
| Specimens / 100 trap-days| 34.4         | 20.0        | 3.9      | 8.4    | 11.1   | 14.3  |
| Total species            | 2            | 2           | 3        | 7      | 3      | 7     |

Table 2. Scores of abundance of small mammal species in Uzhansky National Park and its vicinities

| Species                  | Females | Males | Total | %          | Category of presence* | Score of abundance |
|--------------------------|---------|-------|-------|------------|-----------------------|--------------------|
| Sorex araneus (S-ara)    | 3       | 0     | 3     | 3.0        | frequent              | 3                  |
| Sorex minutus (S-min)    | 1       | 0     | 1     | 1.0        | occasional            | 2                  |
| Apodemus agrarius (A-agr)| 6       | 6     | 12    | 11.9       | common                | 4                  |
| Sylvaemus tauricus (S-tau)| 35     | 29    | 64    | 63.4       | abundant              | 5                  |
| Myodes glareolus (M-gla)| 8       | 7     | 15    | 14.9       | common                | 4                  |
| Microtus agrestis (M-agr)| 5       | 0     | 5     | 5.0        | frequent              | 3                  |
| Microtus arvalis (M-ary)| 1       | 0     | 1     | 1.0        | occasional            | 2                  |
| Total                    | 59      | 42    | 101   | 100.0      | —                     | —                  |

* Note: for translation of categories proposed by Zagorodniuk et al., 2002 we used the ACFOR scale.

Since this is the first planned study on small mammals of Uzhansky National Park, we consider converting the relative abundance of species into abundance scores and estimating the category of presence of species in the territory. Such estimation considering some chorological features contributes to the issue of determination of conservation categories of species, which is necessary for creating red lists of fauna of the Park and of the Carpathian region in general.

Considering the volume of available data, using the method of score-based estimation of abundance (Zagorodniuk et al., 2002) seems to be the most convenient and accurate approach. The con-
version of census data into abundance scores also allows the unification of abundance data and makes their comparison with data from other protected areas much easier (see: Table 2).

Therefore, among the 7 species recorded in the territory only one is ‘abundant’ (S. tauricus), two species are ‘common’ (A. agrarius and M. glareolus), and another two belong to the category ‘occasional’ (S. minutus and M. arvalis). The ‘occasionality’ of M. arvalis in the area can be explained by two conditions. First, the common vole in the region of the Ukrainian Carpathians is a lowland species, which can disperse into the mountains along valleys. Second, it is restricted mainly to agricultural lands, while field research were conducted exclusively in natural habitats. Thus, the presence of a sole specimen of M. arvalis in the sample, trapped in the meadow, is rather an example of the species’ intrusion into the mountains and into a natural habitat from the nearest farmlands.

The field vole (M. agrestis) was recorded in the territory of Uzhansky National Park for the first time. The southern range edge of this boreal species runs along the Ukrainian Carpathians and its records from the area of Uzhansky Park were not available during the revision of the species’ range in the region (Barkaszi, 2017). Therefore, records of the field vole in the territory of the Park as well as further studies into the species’ distribution in the area are extremely important to clarify the field vole’s distribution patterns and ecological features in range edge populations.

**Species diversity and habitat preferences**

Species diversity in each type of habitat was measured by both the Shannon (H) and Simpson indices (D). By both indices, the highest species diversity was revealed in such habitats as ‘meadow’ (H = 0.746, D = 4.741), ‘windfall’ (H = 0.436, D = 2.579) and ‘shrubs’ (H = 0.430, D = 2.528). At the same time, the lowest diversity is recorded for ‘mixed forest’ and ‘forest edge’, where the same two species — S. tauricus and M. glareolus — occurred (see: Tables 3–4).

### Table 3. The Shannon index of diversity of small mammals in the studied biotopes

| Species mixed forest forest edge windfall meadow shrubs | Diversity, H | Evenness, J |
|--------------------------------------------------------|---------------|--------------|
| Sorex araneus (S-ara)                                  | 0.092         | 0.305        |
| Sorex minutus (S-min)                                  | 0.136         | 0.746        |
| *Apodemus agrarius* (A-agr)                           | 0.121         | 0.151        |
| *Sylvaemus tauricus* (S-tau)                           | 0.158         | 0.075        |
| *Myodes glareolus* (M-gla)                             | 0.158         | 0.075        |
| *Microtus agrestis* (M-agr)                            | 0.158         | 0.075        |
| *Microtus arvalis* (M-arv)                             | 0.158         | 0.075        |

### Table 4. The Simpson index of diversity of small mammals in the studied biotopes

| Species mixed forest forest edge windfall meadow shrubs | Diversity, D | Evenness, E |
|--------------------------------------------------------|---------------|--------------|
| Sorex araneus (S-ara)                                  | 1.115         | 0.558        |
| Sorex minutus (S-min)                                  | 1.600         | 0.800        |
| *Apodemus agrarius* (A-agr)                           | 2.579         | 0.860        |
| *Sylvaemus tauricus* (S-tau)                           | 4.741         | 0.677        |
| *Myodes glareolus* (M-gla)                             | 2.528         | 0.843        |

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Table 5. Habitat preferences (Fij) of small mammal species in Uzhansky National Park and its vicinities

| Species               | habitat, % | mixed forest | forest edge | windfall | meadow | shrubs |
|-----------------------|------------|--------------|-------------|----------|--------|--------|
| Sorex araneus (S-ara) | 20.0       | —            | —           | —        | 1.00   | —      |
| Sorex minutus (S-min) | 20.0       | —            | —           | —        | 1.00   | —      |
| Apodemus agrarius (A-agr) | 60.0   | —            | —           | 0.10     | 0.45   | 0.78   |
| Sylvaemus tauricus (S-tau) | 100.0  | 0.57         | 0.20        | -0.20    | -0.84  | -0.69  |
| Myodes glareolus (M-gla)  | 100.0  | -0.65        | 0.79        | 0.54     | -0.45  | 0.59   |
| Microtus agrestis (M-agr) | 20.0   | —            | —           | —        | 1.00   | —      |
| Microtus arvalis (M-arv) | 20.0   | —            | —           | —        | 1.00   | —      |

Species having Fij > 0.5

- 1 1 1 4 2

Obviously, the means of diversity indices are related not only to the species richness and abundance in each habitat but also to different habitat preferences of species. The latter largely affects the patterns of distribution and occurrence of species. The more uniform are the conditions in a habitat, the smaller number of species and the lower diversity characterize this habitat, which also lead to ‘monotypization’ of taxa and expressive domination of only a couple of species.

The obtained census data allow conducting a preliminary estimation of habitat preferences of species under conditions of Uzhansky National Park, which provides the opportunity to determine those habitats and micromammal communities that deserve priority conservation attention in order to preserve diversity in the Park (Table 5).

Results indicate that the most eurytopic species in the studied area are *S. tauricus* and *M. glareolus*. Though both species occur in each type of habitat, they demonstrate different levels of preference. For instance, the yellow-necked field mouse prefers the most ‘mixed forest’ (Fij = 0.57) and clearly avoids ‘meadow’ and stream bank ‘shrubs’. In Uzhansky Park and its vicinities, ‘forest edge’, ‘shrubs’, and cleared ‘windfall’ are habitats most preferred by the bank vole (Fij = 0.54–0.79), while the striped field mouse largely prefers ‘shrubs’ (Fij = 0.78). On the other hand, shrews and meadow voles (*Sorex* and *Microtus*) under conditions of Uzhansky National Park are stenotopic species occurring only in ‘meadow’ (Fij = 1.00).

**Revised checklist of small mammals of Uzhansky National Park**

During our studies, we confirmed the presence of 7 species of micromammals in the fauna of Uzhansky Park. The field vole (*M. agrestis*) was recorded in the area for the first time.

Considering all previously reported reliable and confirmed records and observations of species, we aim to present the current taxonomic list of orders Soriciformes and Muriformes of the Park and its vicinities based on our results, previously published data and reports on observation of relatively large and easily recognizable species. Thus, the current checklist based on data from field studies and literature sources (Koval, Berkovych, 2019) includes 14 species, 4 of which belong to shrews and 10 represent the order of rodents. Most of the species have been regularly observed during general fauna monitoring since their first record, while the presence of two species included into the fauna checklist earlier (*M. minutus* and *T. tatricus*) is yet to be confirmed.

The revised checklist of species with their conservation categories according to the Red Book of Ukraine, Red Book of the Ukrainian Carpathians, Red List of IUCN and Annexes of the Bern Convention are presented in Table 6.

**Conclusions**

During field studied, the presence of 7 species of small mammals was revealed or confirmed in the territory of Uzhansky National Park and its vicinities, such as *S. araneus*, *S. minutus*, *A. agrarius*, *S. tauricus*, *M. glareolus*, *M. agrestis*, *M. arvalis*. The field vole was recorded in the area for the first time.
Table 6. The revised checklist of small mammals of Uzhansky National Park and conservation categories of species according to several red lists*

Таблиця 6. Поточний список дрібних ссавців Ужанського національного парку та охоронні категорії видів за декількома червоними списками

| No. | Taxa                                      | Last confirmed record | RBU | RBUC | IUCN | BC |
|-----|-------------------------------------------|-----------------------|-----|------|------|----|
| 1.  | Crocidura leucodon (Hermann, 1780)         | Koval, Berkovych, 2019| DD  |      | LC   | III|
| 2.  | Sorex alpinus Schinz, 1837                 | Koval, Berkovych, 2019| R   | NT   | NT   | III|
| 3.  | Sorex minutus Linnaeus, 1766               | our field studies, 2017| —   | —    | LC   | III|
| 4.  | Sorex araneus Linnaeus, 1758               | our field studies, 2017| —   | —    | LC   | III|

SORICIFORMES (Insectivora)

Soricidae Fischer, 1814

1. Crocidura leucodon (Hermann, 1780) Koval, Berkovych, 2019 DD — LC III
2. Sorex alpinus Schinz, 1837 Koval, Berkovych, 2019 R NT NT III
3. Sorex minutus Linnaeus, 1766 our field studies, 2017 — — LC III
4. Sorex araneus Linnaeus, 1758 our field studies, 2017 — — LC III

MURIFORMES (Rodentia)

Sciuridae Fischer, 1817

5. Sciurus vulgaris Linnaeus, 1758 observed during field studies, 2019 — — LC III

Gliridae Muirhead, 1819

6. Glis glis (Linnaeus, 1766) Koval, Berkovych, 2019 — — LC III
7. Muscardinus avellanarius (L., 1758) Koval, Berkovych, 2019 — — LC III
8. Dryomys nitedula (Pallas, 1779) observed by N. Koval, 2017 — VU LC III

Castoridae Hemprich, 1820

9. Castor fiber Linnaeus, 1758 observed by N. Koval, 2019 — LC LC III

Muridae Illiger, 1811

10. Apodemus agrarius (Pallas, 1771) our field studies, 2017 — — LC —
11. Sylvaemus tauricus (Pallas, 1811) our field studies, 2017 — — LC —

Arvicolidae Gray, 1821

12. Myodes glareolus (Schreber, 1780) our field studies, 2017 — — LC —
13. Microtus agrestis (Linnaeus, 1761) our field studies, 2017 — — LC —
14. Microtus arvalis (Pallas, 1779) our field studies, 2017 — — LC —

* Note: RBU — Red Book of Ukraine (Akimov, 2009), RBUC — Red Book of the Ukrainian Carpathians (M ateleshko, Potish, 2011), BC — Bern Convention, IUCN — Red List of the International Union for Conservation of Nature. DD — data deficient, R — rare, NT — near threatened, VU — vulnerable, LC — least concern.

In total, 101 specimens were trapped, among which the portion of females was 58.4 %, while the portion of males was 41.6 %. Among the studied habitats, the highest species richness was revealed in ‘meadow’, where all 7 species occurred. ‘Mixed forest’ and ‘forest edge’ were characterized by the highest abundance but the least number of species.

By the level of relative abundance, only one species is considered abundant in the territory (S. tauricus), two species are common (A. agrarius and M. glareolus), two species are frequent (S. araneus and M. agrestis), while another two occur occasionally (S. minutus and M. arvalis).

According to the Shannon and Simpson diversity indices, the highest species diversity was revealed in ‘meadow’ and ‘shrubs’, while the lowest in ‘mixed forest’ and ‘forest edge’.

By the level of habitat preferences, S. tauricus and M. glareolus are the most eurytopic species, while shrews and meadow voles (Sorex and Microtus) display stenotopy in the studied area. Habitats maintaining higher levels of diversity and of habitat preferences of species deserve prior conservation attention.

The current revised checklist of shrews and rodents of Uzhansky National Park based on data from field studies and literature sources includes 14 species. The presence of two species — T. tatricus and M. minutus — previously included into the fauna list of the Park based on literature sources (Kricsfalussy et al., 2001) is yet to be confirmed by actual records.
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