

UDC 591.9:599(234)

## ENDEMISM IN THE MAMMALIAN FAUNA OF THE CARPATHIANS

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**Endemism in the Mammalian Fauna of the Carpathians.** — **Barkasi, Z.** — The paper presents a survey of the concept of endemism with special attention to the most actual problems of interpretation of this biogeographic phenomenon. The overview of the main processes that determine species richness in areas of endemism is presented as well. The unique biogeographic location of the Carpathian mountain system allows considering this region as a special area, where endemic elements are represented on such taxonomic levels as species and, especially, subspecies. Proposed here are 14 subspecies of mammals to consider them endemic for the Carpathian region and a brief overview of these subspecies is given as an annotated list. Substantiated here is the expediency to consider the Carpathian region a local biodiversity hotspot that requires increased attention for conservation, in particular because of significant number of isolated populations of highly specialized species. The loss of these taxa would mean not only a significant depletion of the local biodiversity, but also the loss of the region's uniqueness in general.

**Key words:** endemism, the Carpathian Mountains, mammals, local biodiversity.

**Ендемізм у теріофауні Карпат.** — **Баркасі, З.** — У праці представлено огляд концепції ендемізму, з особливою увагою на найбільш актуальні проблеми тлумачення цього біогеографічного феномену, а також основних процесів, що визначають видове різноманіття областей ендемізму. Унікальне біогеографічне розташування Карпатської гірської системи дозволяє розглядати цей регіон як особливу область, де ендемічні елементи представлені на рівні видів, а надто підвидів. Запропоновано виділити 14 підвидів ссавців у якості ендемічних для цього регіону, також подано короткий огляд кожного з них у вигляді анотованого списку. Обґрунтовано доцільність розглядати Карпатський регіон як локальну «гарячу точку» біорізноманіття, що потребує посиленої уваги природоохоронців, зокрема через наявність значної кількості ізольованих популяцій вузькоспеціалізованих видів. Втрата цих таксонів означатиме значне збіднення локального біорізноманіття і втрати унікальності регіону загалом.

**Ключові слова:** ендемізм, Карпати, ссавці, локальне біорізноманіття.

### Introduction

The most obvious and representative manifestation of biological diversity is the diversity of species, the current composition of which, as well as in case of other forms of biodiversity, is the result of a long evolutionary process. At the same time, the distribution of species on Earth is uneven — the highest species density characterizes centers of origin, which are very often also areas of endemism. Only being aware of species as historical entities existing on the planet during a certain period of time (evolutional duration) within a certain area (geographical range) is possible to understand the cause-and-effect mechanisms of changes in fauna and biodiversity in general. Such cause-and-effect approach should be considered when analyzing the fauna of a certain region, in particular when it comes to its endemic components.

Considering species through evolutionary history, endemic species, basically, could be grouped into three major categories: (i) “old” or relict species with long phylogenetic history, (ii) “young” species that have emerged relatively recently, and also (iii) species populations of which exist in isolation (species of insular habitats). Relatively low abundance and reduced ranges are common for species of these groups. The dynamics of ranges is related to several factors. Among them are the population's overall density and its changes over time, landscape and habitat peculiarities, the num-

ber of niches free or already occupied by other species, as well as certain biological characteristics of species (lifestyle, behavior, features of feeding and metabolism, adaptive abilities, etc.). Respectively, to explain the phenomenon of endemism and to determine the criteria of “being endemic” a variety of approaches could be applied.

As the Carpathian fauna, according to its composition, is a unique “island” surrounded by plain assemblages, we can expect to find a relatively considerable number of endemic elements. The main goal of the present work is to reveal the endemic component in the mammalian fauna of the Carpathians and to give a brief overview of them, as well as to justify the expedience to consider the region a local biodiversity hotspot that requires increased conservational attention.

### **The concept of endemism and its interpretation**

The terms “endemism” and “endemic” are widely used in biology, however the interpretation of these terms can be done by using several approaches. In fact, any area that has at least one unique species or unique combination of species (community) is considered as an area of endemism (Crother, Murray, 2011). For instance, the Ethiopian biogeographic region is considered as an area of endemism containing the largest portion of endemic genera (80 %) and species (> 90 %) (Cole et al., 1994), while most of the endemic genera have been revealed among rodents (Danell, 2002). Among European terrestrial vertebrates (excluding bats), it was revealed that most of the rare and endemic species occur in Southern Europe, and their number decreases northward (Baquero, Tellería, 2001).

A detailed analysis of the phenomenon of endemism is given by S. Anderson in his work “Area and endemism” (Anderson, 1994). According to this work, there are three major problems regarding interpretation of the concept of endemism. Firstly, a semantic problem — what exactly fit into the term from the time of its appearance until today? Secondly, an analytical problem, because there are different approaches to analyze the concept and phenomenon of endemism in general. Finally, there is no clear conceptual basis concerning what processes determine the portion of endemics in the fauna of a certain region. The author has noted that the most common definition of endemism used by Anglo-American researchers is the following: a species or a taxon is considered endemic for a certain territory, when it occurs only within this territory. Such definition leads to two important consequences. On the one hand, consideration of a taxon as endemic without clarification the territory where this taxon occurs (i.e., the taxon’s range), in fact, has no sense. On the other hand, because the taxon’s geographical range is constantly changing, the time during which the taxon is considered endemic also should be clarified, or at least understandable.

Endemism also depends on features of the territory. Larger territories usually have higher levels of endemism. At the same time, the portion of endemic species within a certain territory depends on not only its size and geographical location, but also the group of organisms under consideration, as well as the position of the territory in geological time. It means that the portion of endemics in a certain territory or within a certain group of organisms can change either during long periods of time because of speciation or during shorter periods of time due to changes of the geographical range, including its expansion or reduction even up to the species’ extinction (Anderson, 1994).

Eventually, Anderson’s conception can be summarized as the following: the main factors affecting the degree of endemism and species diversity of a region are the changes of ranges and speciation due to any evolutionary mechanism. In addition, the author notes that the concept of endemism can be applied not only for certain geographical regions, but also in an ecological sense, when species distribution is not limited to some geographical area, but a certain type of habitat.

Endemics are also characterized by a variety of ecological features that distinguish them from widespread (cosmopolitan) genera. Such differences were revealed for several mammalian genera in characteristic body dimensions, feeding habits (frugivore, omnivore, insectivore, herbivore) and substrate use (semifossorial, terrestrial, arboreal) (Danell, Aava-Olsson, 2002). Besides, it was also suggested that endemics as autochthonous components of an ecosystem are more susceptible to environmental changes (in particular, climate change), which could be related to disappearance of existing niche they occupy (Hermant, 2013).

The phenomenon of endemism is also closely related to the concept of insular fauna. In modern insular biogeography, an “island” is a suitable habitat surrounded by unfavorable environment that limits the dispersal of individuals (Brown, 1978). Such interpretation of the concept of insular biotas is applied to mountain systems as well, where “insularity” is clearly expressed for montane<sup>1</sup> ecosystems characterized by the highest number of endemic elements. It means that such ecosystems are exactly those that determine the uniqueness of the fauna of a mountainous region. While montane faunistic assemblages are relatively isolated (in the same manner as oceanic islands, both geographically and ecologically), the boreo-montane fauna usually has intermediate features, particularly due to dispersal of lowland species along certain eco-corridors (river valleys, set of human settlements, etc.) to higher altitudes.

Insular, i.e. also montane, fauna is characterized by specific origin as well, which determines the significant number of endemics in its composition. The main processes that determine the composition of such communities are the emergence of species via colonization (immigration) and speciation, and extinction (Brown, 1978). Colonization usually occurs either when species disperse across geographical barriers or via immigration when such barriers are temporarily absent. Speciation within an island is also a possible source of new species or subspecies; however, probably it has contributed not significantly to the diversity of an insular fauna. Extinction, obviously, reduces species diversity and could be caused by a variety of factors, including environmental changes (Brown, 1978). When environmental changes occur, endemic species undergo intense selective pressure because of high integrity between their phenotype and environment (i.e., they are highly specialized), which reduces the ability of endemics to adapt to new habitats and conditions (Hermant, 2013). Therefore, insular ecosystems are in need for increased conservational attention and constant monitoring to protect and preserve their unique elements.

The subsequent sections of this paper deal with an overview of endemic components of the mammalian fauna of the Carpathians in the light of the concept of insular fauna. The discussed above “territory–endemism” relationship implies that the degree of endemism within an area depends on its size. Since the Carpathians occupy relatively small area in global measures, we can expect to find endemic elements in its mammalian fauna representing lower taxonomic ranks, such as species, but mostly subspecies.

### **The endemic component of the Carpathian mammal fauna**

The biogeographic uniqueness of the Carpathian mountain system is determined by its location. Being located in Central Europe, where terrestrial vertebrates have the highest level of species richness (Baquero, Tellería, 2001), the Carpathians serve as a barrier preventing dispersal and migration of lowland species between the East European Plain, Pannonian Basin and the Balkans. On the other hand, mountain ridges of the Carpathians serve as a biogeographic corridor allowing dispersal of boreo-montane species from north to south and vice versa. Obviously, such specifics of location have significantly affected the origin, changes and current composition of the Carpathian’s fauna, in particular the mammalian fauna.

The first and still the only special review on endemic mammals of the Carpathian region was published in 1998 (Загороднюк, 1998). The present review is based mainly on that contribution with some modifications according to results published later and concerning, in particular, subspecies status and distribution of isolated populations. Basic modifications of the former checklist are either inclusion or exclusion of some taxa. In particular, taxa described from the Carpathians are included, although the current range of some of them, in addition to mountain ridges, may cover adjacent lowland–piedmont areas as well (for instance, the Carpathian form of the red deer). The Carpathian subspecies of the alpine shrew has been also added to the checklist, since its population is isolated from other subspecies (Spitzenberger, 1990).

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<sup>1</sup> We consider montane ecosystems and assemblages as those which occur at higher elevations, particularly in and above the tree-line zone, while boreo-montane assemblages are those which exist in the forest zone (mainly coniferous and mixed forests) of a mountain system.

On the other hand, we reckon unreasonable to consider the local form of *Arvicola scherman* Shaw, 1801 endemic for the Carpathians, at least until clarification the species' taxonomy in general and the subspecies status (if such status exists) of its Carpathian race in particular. Contrary to the previous review, we also believe that the northern bat *Eptesicus nilssonii* Keyserling et Blasius, 1839 should not be considered endemic for the entire Carpathians. The view that in Ukraine it occurs only in the Ukrainian Carpathians as an isolated population is still accepted (Абеленцев, Попов 1956). Such view is explained by the contraction from the south of the species' main lowland range in Europe (Загороднюк, 1999). However, regular records of this species in other regions of Ukraine have been published since the 2000s (Миропольський, 2001; Годлевська, 2012; Башта та ін., 2013), which means that the species' endemic status for the Carpathians within Ukraine should be revised as well because of expansion to the south of the Polissian part of its range.

In the recently published review by Mráz & Ronikier (2016) on the biogeography of the Carpathians, we can find 5 mammalian taxa considered endemic for the Carpathians. The present review offers to include 14 subspecies (tab. 1) into the checklist of the Carpathian endemic mammals represented mainly by isolated (montane subspecies) and semi-isolated (boreo-montane subspecies) populations<sup>2</sup>. It should be noted that the sole endemic mammal species of the Carpathians is the Tatra pine vole (*Terricola tatricus*) represented by two subspecies in the Western and Eastern Carpathians, respectively. Endemic genera and higher taxa in the mammalian fauna of the Carpathians are absent.

The order of rodents (Muriformes<sup>3</sup>, seu Rodentia) is represented by the largest number of endemics (7 subspecies). The order of Cerviformes (seu Artiodactyla) is represented by three endemic subspecies, while shrews (Soriciformes, seu Insectivora) and carnivores (Caniformes, seu Carnivora) only by two subspecies each. From the standpoint of vertical distribution patterns of mammals (fig. 1) is noticeable that most of the endemics are typical inhabitants of the upper forest and the tree-line zones (with krummholz type vegetation). Among 14 endemic subspecies 12 are considered to be rare — six of them are endangered (EN) and six are vulnerable (VU). Basically, it is because populations of these species/subspecies are mostly isolated and they almost never have high abundance. Such patterns prove again that endemism can be considered a manifestation of rarity.

Table 1. Mammal species represented by endemic subspecies in the fauna of the Carpathians

Таблиця 1. Види ссавців, що представлені у фауні Карпат ендемічними підвидами

Order	Species	Subspecies	CT*
Muriformes	<i>Sciurus vulgaris</i> Linnaeus, 1758	<i>carpathicus</i> Pietruski, 1853	VU
	<i>Marmota marmota</i> (Linnaeus, 1758)	<i>latirostris</i> Kratochvil, 1961	EN
	<i>Sicista betulina</i> (Pallas, 1779)	<i>montana</i> Mehely, 1913	EN
	<i>Chionomys nivalis</i> (Martins, 1842)	<i>ulpius</i> Miller, 1908	VU
		<i>mirhanreini</i> Schaefer, 1935	VU
	<i>Terricola tatricus</i> (Kratochvil, 1952)	<i>tatricus</i> Kratochvil, 1952	VU
		<i>zykovi</i> Zagorodnyuk, 1989	VU
Soriciformes	<i>Talpa europaea</i> Linnaeus, 1758	<i>kratochvili</i> Grulich, 1969	
	<i>Sorex alpinus</i> Schinz, 1837	<i>tatricus</i> Kratochvil et Rosicky, 1952	VU
Caniformes	<i>Ursus arctos</i> Linnaeus, 1758	<i>polonicus</i> Gray, 1864	EN
	<i>Lynx lynx</i> (Linnaeus, 1758)	<i>carpathica</i> Heptner, 1972	EN
Cerviformes	<i>Cervus elaphus</i> Linnaeus, 1758	<i>montanus</i> Botezat, 1903	
	<i>Rupicapra rupicapra</i> (Linnaeus, 1758)	<i>tatrica</i> Blahout, 1971	EN
		<i>carpathica</i> Couturier, 1937	EN

\* Category of threat for the species for the entire Carpathians, according to the Carpathian List of Endangered Species (Witkowski et al., 2003).

<sup>2</sup> Clearly lowland but distributed in adjacent to the Carpathians areas species such as *Spalax graecus* s. s. Nehring, 1898 and *Spalax antiquus* Méhely, 1909 (Németh et al., 2013) are not included into the checklist.

<sup>3</sup> The taxonomy and nomenclature in this work follows the latest survey *Taxonomy and nomenclature of mammals of Ukraine* published by I. V. Zagorodnyuk & I. G. Emelyanov (Загороднюк, Смельянов, 2012).

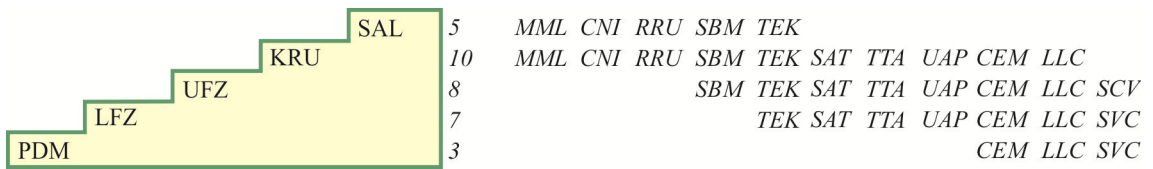


Fig. 1. Altitudinal distribution of endemic mammals in the Carpathians and the sum of species in different zones.

Рис. 1. Вертикальний розподіл ссавців-ендемів Карпат та суми видів за висотними поясами.

SAL — subalpine zone, KRU — tree line zone with krummholz type vegetation, UFZ — upper forest zone (coniferous and mixed forests), LFZ — lower forest zone (deciduous forests), PDM — piedmont zone.

MML — *Marmota marmota latirostris*, CNI — *Chionomys nivalis*, RRU — *Rupicapra rupicapra*, SBM — *Sicista betulina montana*, TEK — *Talpa europaea kratochvili*, SAT — *Sorex alpinus tatricus*, TTA — *Terricola tatricus*, UAP — *Ursus arctos polonicus*, CEM — *Cervus elaphus montanus*, LLC — *Lynx lynx carpathica*, SVC — *Sciurus vulgaris carpathicus*.

The annotated checklist of the mammalian taxa we consider endemic in the fauna of the Carpathian region is presented below.

***Sciurus vulgaris carpathicus* Pietruski, 1853.** Features of distribution and aspects of phenotypic variation (including morphology, fur coloration, etc.) of the Carpathian squirrel are relatively well studied. It was learned that the red squirrel is represented in the fauna of the Carpathians by three different color phases, such as red, black and dark. The black phase is considered to be the subspecies *S. v. carpathicus*, which is common in piedmont and mountain areas of the Carpathian region. This subspecies predominates the other color phases of the squirrel (Зізда, 2005, 2008). Its presence in the Romanian Carpathians is debated or rather declined, e.g., according to D. Murariu (2015), the squirrel in Romania is represented by the subspecies *S. v. fuscoater* Altman, 1855, associated by some authors with the species' dark phase (Zawidzka, 1958). It was also suggested earlier that the squirrel's dark phase is a hybrid form between *S. v. vulgaris* and *S. v. carpathicus* (Зізда, 2006, 2008). Recent genetic research indicate the absence of reproductive isolation between the red and black phases (Білоконь та ін., 2014), which may prove the former suggestion.

***Marmota marmota latirostris* Kratochvil, 1961.** The alpine marmot was widely spread from the Carpathians to the Pyrenees after the Würm glaciation, but the species abundance decreased during the Quaternary due to climate change and other factors (Mann et al., 1993). Endemic populations have remained only in the Alps and Western Carpathians represented by different subspecies. The Carpathian subspecies was described as *M. m. latirostris* (Kratochvil, 1961; Ballo, Sýkora, 2003; Вацькор, 2009). The alpine marmot in the Ukrainian Carpathians became extinct during the second half of the 18<sup>th</sup> century, while in the Romanian Carpathians the species' extinction occurred during the 19<sup>th</sup> century, in both cases due to strong anthropogenic pressure (Башта, Потіш, 2007). Successful reintroduction was conducted in 1972–1973 in three mountain ridges of the Romanian Carpathians, although those individuals originated from France and Austria, i.e. they and their descendants belong to the Alpine subspecies *M. m. marmota* (Murariu, 1995, 2015; Szabo, 2010).

***Sicista betulina montana* Mehely, 1913.** The northern birch mouse has a large range that covers boreal and montane forests, subalpine meadows and tundra (Meinig et al., 2007). The taxonomy of birch mice has been considerably modified for the past few years, mainly due to division of former “large” species into a few “small” ones (Загороднюк, 2007). The Carpathian form of the birch mouse was repeatedly considered a separate species *S. montana* Mehely (Попов, 1936; Емельянов, Загороднюк, 1993). In Ukraine, according to the results of the latest karyological research, all birch mice having 32 chromosomes were classified as *S. betulina* s. str. (Загороднюк, Кондратенко, 2000). Consequently, the Carpathian form of the northern birch mouse has been identified as a separate subspecies *S. b. montana* Mehely.

***Chionomys nivalis* (Martins, 1842).** There are three snow vole species occurring in mountain regions of Europe, Western Asia and Anatolia, respectively. Among them, the European snow vole (*C. nivalis*) has the widest, though highly fragmented, geographical range (Yannic et al., 2012). Due to excessive fragmentation of mountain habitats, high isolation of populations and the species' polymorphism a large number of subspecies was described (Janeau, Aulagnier, 1997; Amori, 1999). Recently, 18 subspecies of the European snow vole have been recognized, two of them occur in the Carpathians (fig. 2)<sup>4</sup> — *C. n. ulpius* is common in the Eastern and Southern Carpathians, while *C. n. mirhanreini* has an isolated population in the High Tatras (Kowalski, 1957; Nadachowski, 1991; Yannic et al., 2012; Murariu, 2015).

***Terricola tatricus* (Kratochvil, 1952).** The sole endemic species in the mammalian fauna of the Carpathians (fig. 3). The geographical range of the Tatra pine vole is fragmented and considered being in reduce (Martínková, Dudich, 2003). The Tatra pine vole is a typical species of mountain forests inhabiting simultaneously with its sibling species *T. subterraneus* (Selys-Longchamps, 1836). The presence of this species in the fauna of the Eastern Carpathians was revealed in the late 1980s (Загороднюк, 1989; Загороднюк та ін., 1992). Most of its records in the Ukrainian Carpathians are known from Chornohora, which were described as *T. t. zykovi* Zagorodnyuk, a separate from *tatricus* subspecies, presumably represented in the Romanian part of the Carpathians as well (Zagorodnyuk, Zima, 1992; Murariu, 2015).

***Talpa europaea kratochvili* Grulich, 1969.** The European mole is one of the most abundant small mammals in the region. Its peculiar form was described from the mountains of the Western and Eastern Carpathians distinguished by a number of characters, such as smaller body dimensions and blindness, bringing it close to the Caucasian and Balkan blind mole *T. caeca* (Savi, 1822) (Niethammer, 1990; Загороднюк та ін., 1997; Коробченко, 2009). Earlier this form was considered as a Balkan subspecies *T. e. pancici* Martino, 1930 (Сеньк, 1974).

***Sorex alpinus tatricus* Kratochvil et Rosicky, 1952.** This subspecies of the alpine shrew was described from the High Tatras with a range restricted to the Carpathians (Kratochvil, Rosicky, 1952; Spitzenberger, 1990). However, based on comparison of morphological features N. Kuruts (2014) stated that in the Ukrainian part of the Carpathians the alpine shrew is represented by the subspecies *S. a. hercynicus* Miller, 1909, while in Romania, according to D. Murariu (2015), the alpine shrew is represented only by the nominative subspecies *S. a. alpinus* Schinz, 1837. It was also studied that the species' distribution is related to the altitude — its populations are more abundant on higher elevations (Balaz, Ambros, 2007).

***Ursus arctos polonicus* Gray, 1864.** Initially this form of the brown bear was described as a subvariant of the nominative subspecies (Ellerman, Morrison-Scott, 1951); therefore, its subspecies status is rejected by many researchers. Nevertheless, the brown bear is represented by two populations in the Carpathians that are isolated from other populations of this species. The brown bear population, which exists in the Eastern and Southern Carpathians, is the largest in Europe, excluding the European part of Russia (Zachos et al., 2008). In the Ukrainian Carpathians, the brown bear has two distribution centers in the Beskids and in Máramaros (Баура, Потіш, 2007). Another population exists in the Western Carpathians — it is less abundant and isolated from the former one (Hartl, Hell, 1994). It was also revealed that the Romanian subpopulation consists of two sympatric haplotypes (western and eastern lineages) having the highest variability for mtDNA sequences (Zachos et al., 2008).

<sup>4</sup> On the maps that demonstrate the distribution of some species (figs. 2–4), record localities are taken from several sources. 1) CLES — Carpathian List of Endangered Species (Witkowski et al., 2003); 2) list of records published by Baláz, Ambros, 2010; 3) catalogues of collections deposited in the National Museum of Natural History, NAS of Ukraine (NMNHU, Kyiv), State Natural History Museum, NAS of Ukraine (SNHM, Lviv) and the Zoological Museum of Ivan Franko Lviv National University (ZMD, Lviv); 4) some other locations are taken from the appendix to the paper published by Martínková, Dudich, 2003.

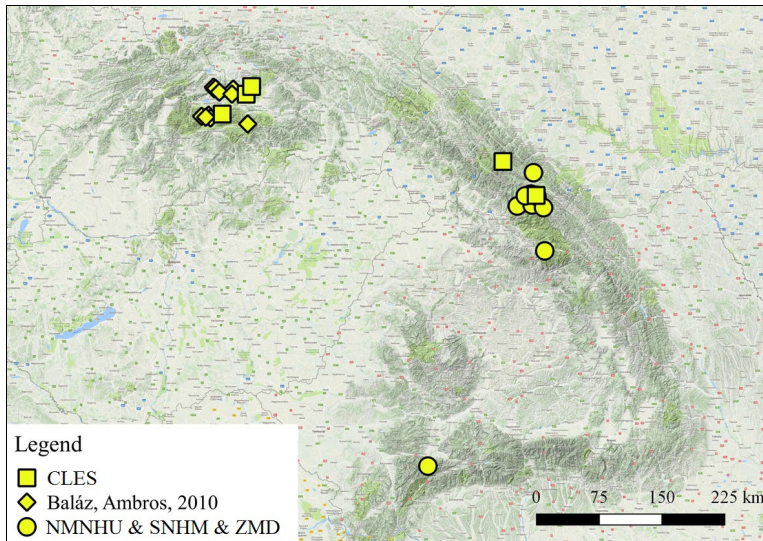


Fig. 2. Records of the alpine vole *Chionomys nivalis* in the Carpathians (Map Data Info: Google, 2016, with modifications).

Рис. 2. Знахідки снігурки альпійської *Chionomys nivalis* у Карпатах (Картографічні дані: Google, 2016, зі змінами).

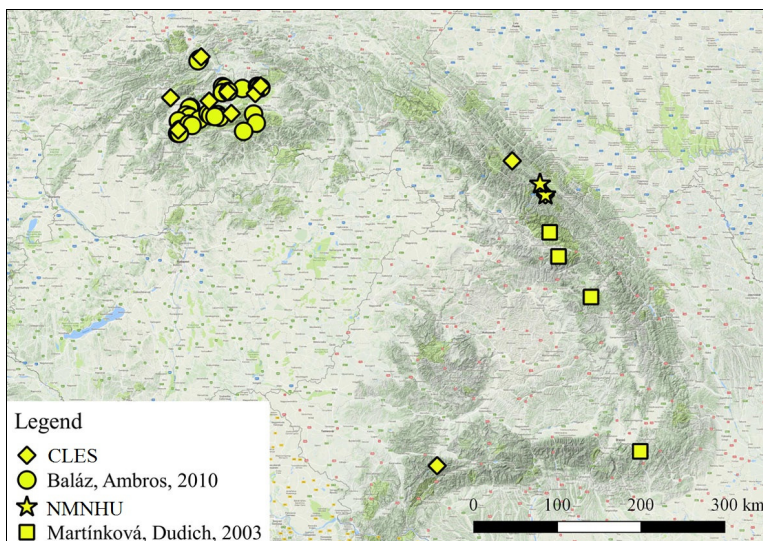


Fig. 3. Records of the Tatra pine vole *Terricola tatricus* in the Carpathians (Map Data Info: Google, 2016, with modifications).

Рис. 3. Знахідки норика татринського *Terricola tatricus* у Карпатах (Картографічні дані: Google, 2016, зі змінами).

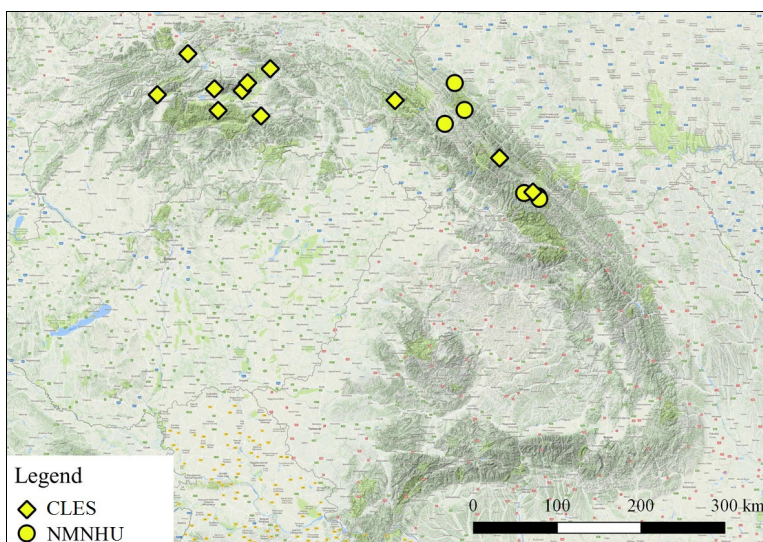


Fig. 2. Records of the alpine shrew *Sorex alpinus* in the Carpathians (Map Data Info: Google, 2016, with modifications).

Рис. 4. Знахідки мідіці альпійської *Sorex alpinus* у Карпатах (Картографічні дані: Google, 2016, зі змінами).

***Lynx lynx carpathica* Heptner, 1972.** The Carpathian population of the Eurasian lynx was described as a separate form *L. l. orientalis natio carpathica* Kratochvil et Stollman, 1963 (Stollman, 1963). Later, in 1972, Heptner and Sludsky, according to morphological descriptions by Stollman, established the taxon *F. l. carpathica* (Гептнер, Слудский, 1972). Other researchers, including researchers of the Ukrainian fauna (Шевченко, Гелл, 1983; Hell, 1990; Шевченко, Песков, 2007) confirmed such point of view somewhat later. The high level of genetic variability between the European lynx populations recently has been discovered (Schmidt et al., 2011), which may also provide grounds to confirm the taxonomic separateness of these populations. The Carpathian population of the European lynx is under protection in all countries except Romania, where controlled hunting is allowed (Schmidt et al., 2011).

***Cervus elaphus montanus* Botezat, 1903.** One of the eight red deer subspecies, which is distributed mainly in the Carpathian region (Baskin, Danell, 2003; Murariu, 2015). According to different authors, the geographical range of this subspecies may also include the southern regions of Ukraine and Crimea (Dobroruka, 1960), and in north it may reach the Baltics (Groves, Grubb, 1987). The study of mitochondrial DNA confirmed the genetic integrity of the Carpathian form regarding to other European red deer populations identifying it as one of the few remaining natural populations of the species (Feulner et al., 2004). Such results may provide grounds to confirm the subspecies status of the Carpathian red deer.

***Rupicapra rupicapra* (Linnaeus, 1758).** Among seven chamois subspecies, two are endemic for the Carpathians. The subspecies *R. r. tatrica* is restricted to the Western Carpathians, while the other subspecies — *R. r. carpathica* — has two isolated populations in the Eastern and Southern Carpathians, respectively (Lovari, 1987). The population of *R. r. tatrica* consists of ca. 200 individuals, and the subspecies is considered endangered, while *R. r. carpathica* is represented by ca. 9'000 individuals (Corlatti et al., 2011). Introduction of the Alpine *R. r. rupicapra* in the Western Carpathians can lead to its hybridization with the native subspecies and to its genetic extinction (Corlatti et al., 2011). Perspectives of re-introduction of the chamois in the Ukrainian part of the Carpathians have been considered as well — ca. 1000 individuals can exist here causing no harm to local ecosystems (Хоєцький, Часковський, 2011).

### The Carpathian region as a local biodiversity hotspot

Endemic and endangered species are often used to determine conservation priorities. Such approach suggests that reserve networks focusing on these species will be an effective “umbrella” for the entire species diversity of a country or region. In case of endangered species, there is a high probability of their extinction in the near future requiring urgent protection activities for their conservation. Endemic species are quite often endangered in the same time due to their isolation and relatively low abundance.

It was revealed that protected areas including distributional ranges of both endemic and endangered species perform their functions better than those created in a random manner. However, such approach gives no guarantee to represent the complete species diversity within the protected area. Nonetheless, it was shown that a conservation reserve network focusing on protection of endangered and endemic species of a certain territory ultimately represents 96 % and 63 %, respectively, of the entire species diversity of this territory. This implies that conservation activities focusing on both endemic and endangered species could be the first step in creation of an effective network of protected areas (Bonn et al., 2002).

The Carpathian mountain system is located in the territory of six countries. Each of these countries has its peculiar fauna composition, including the mammal fauna as well. Mountain regions are characterized by significant landscape diversity, which creates in these regions a variety of specific habitats supporting higher biodiversity. As a result, in “Carpathian countries” specific local biodiversity hotspots emerge concentrating the largest species diversity, including endemic and endangered species. Conservation of taxa represented in these areas is extremely important because their loss would mean the loss of the uniqueness of the entire region (Зізда, Загороднюк, 2004).



Approaches used in biodiversity conservation may differ notably, as well as conservation priorities, even between two neighboring countries. Taking into consideration that the number of species in need of protection far exceeds conservation resources (Myers, 2000), the concept of biodiversity hotspots has a key role when setting conservation priorities on global level. It is known that biodiversity hotspots are regions with high level of endemism and species diversity (Ladle, Whittaker, 2011). As of today, there are 25 biodiversity hotspots on Earth covering 1.4 % of its land surface and including 35 % of all known vertebrates (Myers, 2000).

Howsoever, some researchers are quite ambiguous when it comes to determination of these hotspots, because species diversity represents only one attribute of overall biodiversity, and there are also many other locations (“biodiversity coldspots”, such as the savannas and polar regions) deserving increased attention (Kareiva, Marvier, 2003).

The Carpathian region is not included into the list of biodiversity hotspot areas, because it does not meet the criteria established for the global scale. However, on a local level, e.g. for a country or the entire Carpathian region, the concept could be applied to determine the territories that require prior conservational attention. For instance, studies on distribution of terrestrial vertebrates of Ukraine, including mammals, showed that most of the rare and protected species inhabit exactly in the mountain regions, i.e. in the Carpathians and in the Crimean Mountains. These regions were determined as zones of the highest vertebrate species diversity in Ukraine (Загороднюк, 2004). Similar results were obtained in other Carpathian countries as well (Mráz, Ronikier, 2016).

Such approach, i.e. identification of the Carpathians as a local biodiversity hotspot, certainly draws attention to the significance of monitoring, protection and conservation of the region’s biota, in particular isolated populations of mammals. In our opinion, it is highly required, because climate change, habitat fragmentation and degradation (mainly because of expansion of agrocoenoses, urbanization and pasture), and appearance of alien invasive species have major impact on biodiversity, ecological networks and on functioning of ecosystems threatening local species of the Carpathian region such as in other parts of the world (Bellard et al., 2014).

## Afterword

The unique biogeographic location of the Carpathians had and still has a significant role in formation and changes of the region’s fauna. In particular, the presence here of a significant number of peculiar montane forms of mammals considered by many authors as separate subspecies determines the uniqueness of the region. Mammals that occupy highland habitats exist here as isolated populations, while inhabitants of the forest zones have chance to expand their ranges along mountain ridges. These taxa represent a valuable part of the local mammalian fauna and determine not only biogeographic, but also evolutionary–phylogenetic uniqueness of local biodiversity.

Typical habitats of mountain species are consistently violated, gradually reduced and, finally, disappearing because of ever more intensive use of natural resources. Even a minor violation of environmental conditions can cause the loss of montane species due to their strict ecological specialization. The disappearance of large forested areas (which is occurring in the Ukrainian Carpathians in a catastrophic scale during the last few years) leads to the loss of not only habitats, but also ecological corridors, which can serve as special “evacuation routes” from violated ecosystems and no longer suitable habitats. Therefore, enhanced protection of local biodiversity hotspots along with balanced and ecologically sound use of natural resources, including game mammal fauna management and poaching prevention (some of the endemic mammals are also game species) are strongly required instruments for conservation of endemic forms of the Carpathian fauna and the biogeographic uniqueness of the region.

## Acknowledgements

I wish to thank I. V. Zagorodniuk for the idea of this paper, I. V. Delehan for valuable comments and advice he has kindly provided, as well as O. M. Kovalchuk for proofreading and linguistic corrections of the manuscript.

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