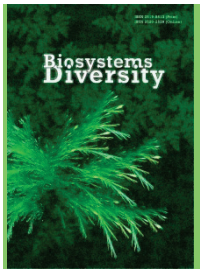

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Rare component of biota in the Data Centre "Biodiversity of Ukraine" and its possible use to identify hotspot areas and evaluation of biodiversity

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The problem of assessing the diversity of biotic complexes is extremely important and relevant and has been covered in numerous publications, mostly for certain taxonomic groups. The use of information retrieval systems with large databases opens up new opportunities and approaches to automated biodiversity assessment. All the data used in this article are taken from the web resource of the Data Centre "Biodiversity of Ukraine" and include data from museum collections, literature and human observation. To evaluate species diversity included in the Red Data Book of Ukraine, we developed a scoring scale for each protected category based on a ranking system according to its protected category. For the assessment, we used Disappearing species, Vulnerable species, and Rare species only. To highlight hotspot areas we used the aggregation maps with 20 × 20 km squares. Species diversity of the species included in the Red Data Book of Ukraine of the western region of Ukraine in the CDBU is represented by 498 species (fungi – 41, plants – 191, animals – 266). By oblasts of the western region of Ukraine: Volyn oblast – 139 species (fungi – 3, plants – 51, animals – 85), Rivne oblast – 85 (fungi – 5, plants – 32, animals – 48), Lviv oblast – 260 (fungi – 17, plants – 90, animals – 153), Ternopil oblast – 182 (fungi – 9, plants – 48, animals – 125), Ivano-Frankivsk oblast – 219 (fungi – 28, plants – 59, animals – 132), Chernivtsi oblast – 105 (fungi – 6, plants – 49, animals – 50), Zakarpattia oblast – 190 (fungi – 26, plants – 70, animals – 94). Most of the defined hotspots coincide with the territories of the nature reserve fund of Ukraine, and some hotspots are located in large cities (scientific centers) with vicinities. We have also identified hotspots outside of existing nature reserves, including the territories of large water reservoirs, river valleys, and historical biodiversity hotspots. Thus, Data centre "Biodiversity of Ukraine" tools can be used to assess rare biodiversity and its restoration in the post-war period, as well as to identify hotspots and locations for creating new protected territories, identifying ecological corridors and developing ecological networks and monitor changes in biodiversity caused by climate change.

Keywords: biodiversity; hotspot areas; evaluation; rare species; endangered species; Red Data Book of Ukraine.

Introduction

Biodiversity is globally recognized as a cornerstone of healthy ecosystems, and biodiversity conservation is increasingly becoming one of the most essential goals in environmental management. The division of biodiversity into three domains – genetic diversity (intraspecific diversity), species diversity (number of species), and ecosystem diversity (diversity of communities) – has been widely accepted since its introduction at the 1992 Convention on Biological Diversity. Another critical aspect of biodiversity is functional diversity, which represents the functional richness of organisms. Functionally diverse communities tend to be more resilient to external influences. In addition, Tilman et al. (1997) found that species differ in their ability to alter ecosystem processes, but some species with certain functional characteristics have a more significant impact than others.

There are two approaches to biodiversity valuation: 1) based on the assessment in terms of services provided to society; 2) based on the assessment of socio-cultural values. However, there is a lack of integrated approaches considering all aspects of sustainable development at once (Nieto-Romero et al., 2014). One of the main shortcomings of economic approaches to valuing biodiversity is that some of the goods or services provided by different ecosystems are difficult to value. Even the scientific understanding of the role of biodiversity in the functioning and health of ecosystems, as well as in the provision of ecosystem services, remains incomplete. Therefore, there is an urgent need to complement the monetary and sociocultural approaches to biodiversity valuation with an approach based on natural science and understanding how ecosystems function. The natural science approach is to determine the minimum level of biodiversity that should be maintained. This will require researchers to measure biodiversity needs, which is usually done through indices that reduce multifaceted issues to a few key variables that describe a particular aspect of the phenomenon (Heip et al., 1998; Taszakowski & Depa, 2022).

To evaluate something, you first need to know what it is (Bartkowski et al., 2015) and how much of it there is. Lyashevska et al. (2012) showed that biodiversity could be quantified at any (or all) molecular, cellular, subspecies, species and other taxonomic levels, as well as at the level of community structure, which they called "levels" of organization. They identified three principal axes of variation from a variety of biodiversity indicators: phylogenetic, structural, and functional. In our assessment, we will focus on phylogenetic, partly structural, and functional indicators of biodiversity, taking into account the axes of variation.

The heterogeneity of landscapes, habitats, and consumable resources leads to an uneven distribution of biota in space. One of the crucial consequences of this is that the "concentration of life" in space is uneven, and the taxonomic density of communities is also uneven (Terentiev, 1963;

Swarts et al., 1995). As a result, a natural situation is created when, against the background of relatively low "taxonomic density" of biological objects in space, there are areas where the number of recorded species and the proportion of rare species is extraordinary – we call them "hotspots", or habitats of high diversity. Some authors (Hill, 1993) consider a specific analog of this term as " biodiversity hotspots". Hotspots are local areas and regions where the proportion of rare species is exceptionally high and which should be recognized as the most promising for conservation (Zahorodniuk, 1997).

Different approaches are generally used to identify hotspots: species endemism and degree of threat and analysis has considered five key factors: numbers of endemics and endemic species/area ratios for both plants and vertebrates, and habitat loss. These factors do not carry equal weight, so they cannot be combined into a single quantitative ranking (Myers et al., 2000). Using data of the Red Data Book of European Butterflies and the methods of the species-area relationship, and the endemics-area relationship, it has been shown that in the case of butterflies, hotspots of endemism and hotspots of total species richness do not coincide (Werner & Buszko, 2005). Similar approaches have been used to identify hotspots for terrestrial vertebrates in SW Europe including three criteria: species richness, vulnerability, and endemism and for the identification of hotspots, a method was used based on the cumulative distribution functions of species richness values (López-López et al., 2011). In the above-mentioned paper, it was shown that existing protected areas are not specifically concentrated in areas of high species richness. An influential paper (Marchese, 2015) states that delineating hotspots includes quantitative criteria along with subjective considerations and there is a risk of neglecting areas, such as coldspots, with other types of conservation value. Nowadays, it is widely acknowledged that biodiversity is much more than just the number of species in a region and a conservation strategy cannot be based merely on the number of taxa present in an ecosystem. Therefore, it is necessary to reconsider the priorities in biodiversity conservation and move to an interdisciplinary approach through the creation of partnerships between science and policy. When identifying hotspots for reptiles in Iran, it was also shown that exists a large gap between identified hotspot reptile diversity and the current network of protected areas in the country (Noori et al., 2021). Calculation and modeling projecting the future state of most of studied hotspots for the year 2050, based on future climatic and agroeconomic pressure confirms that, in the short term, habitat loss is of greater concern than climate change for hotspots and their biodiversity (Habel et al., 2019). The study of hotspots is also important in the seasonal aspect at the local spatial scale to identify inter-seasonal biodiversity hotspots and provide a more complete representation of ecosystems for the identification of priority protected areas (Morelli et al., 2019).

Crucially, projections of biological responses to climate change in biodiversity hotspots are much needed. This is especially important for mountainous areas (i.e. Ukrainian Carpathians) where spatio-temporal variation in climate experienced by many biodiversity hotspots has helped to drive the aggregation of high concentrations of specialized, rare and range-restricted species because in the mountainous conditions this spatial heterogeneity will be likely to play a dominant role in determining whether species persist or go extinct as a result of climate change, although barriers to dispersal could fragment populations and result in the disappearance of some mountain top species (Trew & Maclean, 2021).

The Data Centre "Biodiversity of Ukraine" (DCBU) (http://dc.smnh.org) has been launched at the State Museum of Natural History of the National Academy of Sciences of Ukraine, Lviv (SNMH) in 2017. It aggregates comprehensive data on the Ukrainian biota: scientific and vernacular names, occurrence records, description of geographical and habitat distribution preferences, protection categories, and representation in the nature reserves of Ukraine. The main objective of DCBU is to aggregate curated biodiversity data of different origins (i.e., mobilized from the literature and collections, and during the direct field observations) under the supervision of experts.

Currently, in Ukraine, there exist two internet platforms focused on mobilizing and providing biodiversity data online – the Data Centre "Biodiversity of Ukraine" and UkrBin. These two platforms differ in their structure and core principles. While UkrBin is focused chiefly on citizen science and data mobilization from field observations, the DCBU is focused on data mobilized from scientific collections and publications. Estimates are that less than 10% of information about specimens is in digital form, and even less is available online (Page et al., 2015). This paper describes the DCBU, an open-access collaborative platform maintained by the State Museum of Natural History of the National Academy of Sciences of Ukraine, Lviv (SNMH).

At the moment, the DCBU taxonomy comprises five kingdoms (Animalia, Chromista, Fungi, Plantae, and Protista), 22 phyla, 82 classes, 290 orders, 1,324 families, 4,885 genera and 12,146 species. The DCBU database contains 72,340 occurrence records, mainly covering Ukraine but also representing some findings from other countries.

The implementation of the project "Digitization of natural history collections damaged as a result of hostilities and related factors: development of protocols and implementation on the basis of the State Museum of Natural History of the National Academy of Sciences of Ukraine" (Nr 2022.01/0013), financed by the National Research Foundation of Ukraine in the grant call "Science for the Recovery of Ukraine in the War and Post-War Periods" allowed for intensive aggregation of biodiversity data from the State Museum of Natural History, National Academy of Sciences of Ukraine collections. First of all, these data relate to the western region of Ukraine and many of them relate to rare and threatened species that are of the greatest interest in conservation activities. The results of the project have already been partially published (Novikov et al., 2023, 2024; Rizun et al., 2023), and the digitized collection materials are published in the Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine (Kuzyarin, 2023, 2024; Rizun & Diedus, 2023; Savytska, 2023, 2024; Hushtan K. & Hushtan H., 2024; Rizun, 2024a, 2024b) and 12 datasets with 25,827 occurences are uploaded to the GBIF database (http://surl.li/pyavyg).

The main biodiversity hotspots in Europe with high levels of species variety and endemism include the Mediterranean Basin, Iberian Peninsula, Alps, Carpathian Mountains, Caucasus, Baltic Sea, and Danube River Basin. Two of these territories (Carpathian Mountains and Danube River Basin) cover a part of the region discussed in this article. In this study, we tried to summarise data on species listed in the Red Data Book of Ukraine (2009a, 2009b) and (Nakaz…, 2021: https://salo.li/d0d1C58, https://salo.li/4949948) from the western region of Ukraine to make an attempt to assess their representation by territory and to identify hotspots of biodiversity for the physical-geographical areas of the region, which is important in making management decisions in the field of nature management, agriculture and forestry, etc. and providing modern approaches and methods for biodiversity restoration in the post-war recovery of Ukraine.

Materials and methods

All the data used in this article are taken from the web resource of the Data centre "Biodiversity of Ukraine" and include data from museum collections, literature (more than 180 sources, all used sources are cited on the species pages in the DCBU) and human observation data documented by photographs.

Since the Red Data Books of Ukraine often applies outdated taxonomy, in this article, we adopted the taxonomy following the contemporary vision of the Encyclopedia of Life (EOL) (www.eol.org) and Global Biodiversity Information Facility (GBIF) (www.gbif.org).

According to the Law of Ukraine on the Red Data Book of Ukraine (RDBU), species listed in the Red Data Book (Chervona…, 2009a, 2009b; Nakaz…, 2021a, 2021b) are divided into the following protected categories:

– Extinct species (EX) (7) – species for which, after repeated searches in typical areas or other known and possible habitats, there is no information about their presence in nature or in specially created conditions;

– Extinct in the wild (EW) (6) – species that have disappeared in nature but have been preserved in specially created conditions;

– Disappearing species (DP) (5) – species that are threatened with extinction in their natural habitats and whose conservation is unlikely if the factors that negatively affect the state of their populations continue to act;

– Vulnerable species (VU) (4) – that may be classified as endangered in the near future if the factors that adversely affect their populations continue to exist;

– Rare species (RR) (3) – whose populations are small and are not currently classified as endangered or vulnerable, although they are threatened;

– Not Evaluated species (NE) (2) – that are known to be endangered, vulnerable, or rare but not yet classified as such;

– Data Deficient (DD) (1) – that cannot be assigned to any of the above categories due to the lack of necessary complete and reliable information.

To evaluate species diversity included in the Red Data Book of Ukraine, we developed a scoring scale for each protected category based on a ranking system according to its protected category. A score of each protected category is in parentheses above, and these scores are shown in Tables 1–3. We consider that protected statuses Extinct (EX), Extinct in the wild (EW), Not Evaluated species (NE), Data Deficient species (DD) are not suitable for assessing biodiversity, as the first two refer to species that no longer exist in nature, and the latter two only indicate insufficient study level of the species to which they have been assigned.

In the aggregation maps we used 20 × 20 km squares to highlight hotspot areas (Rizun & Shcherbachenko, 2019).

Results

In total, 498 species included in the Red Data Book of Ukraine (Chervona…, 2009a, 2009b; Nakaz…, 2021: https://salo.li/d0d1C58, https://salo.li/4949948) have been registered in the Western region of Ukraine in the Data centre "Biodiversity of Ukraine", including 41 species of fungi, 191 species of plants, and 266 species of animals. By oblasts of the western region of Ukraine: Volynska – 139 species (fungi – 3, plants – 51, animals – 85), Rivnenska – 85 (fungi – 5, plants – 32, animals – 48), Lvivska – 260 (fungi – 17, plants – 90, animals – 153), Ternopilska – 182 (fungi – 9, plants – 48, animals – 125), Ivano-Frankivska – 219 (fungi – 28, plants – 59, animals – 132), Chernivetska – 105 (fungi – 6, plants – 49, animals – 50), Zakarpatska – 190 (fungi – 26, plants – 70, animals – 94).

The least documented were mushrooms, by oblasts of the western region of Ukraine: Volynska – 3 species, Rivnenska – 5, Lvivska – 17, Ternopilska – 9, Ivano-Frankivska – 28, Chernivetska – 6, Zakarpatska – 26 (Table 1). None of these species have protected statuses Not Evaluated (NE) or Data Deficient (DD). One species (*Amylocystis lapponica*) has a protected status Extinct species (EX) – circumboreal species; distributed in coniferous forests of Northern Europe, North Asia, China (Yu-Cheng & Reijo, 2005) and western North America; occasionally found in Central and Southern Europe; in Ukraine, it is known only in Transcarpathia. The rest of the species have protected statuses such as Disappearing species (DP), Vulnerable species (VU), and Rare species (RR).

A total of 191 plant species included in the Red Data Book of Ukraine were recorded in the DCBU. By oblasts of the western region of Ukraine: Volyn – 51 species, Rivne – 32, Lviv – 90, Ternopil – 48, Ivano-Frankivsk – 59, Chernivtsi – 49, Zakarpattia – 70 (Table 2). Among the listed species, there are 23 with Not Evaluated species (NE) status (*Adonis vernalis*, *Allium ursinum*, *Carex umbrosa*, *Colchicum autumnale*, *Crocus heuffelianus*, *Dactylorhiza fuchsii*, *Epipactis helleborine*, *Galanthus nivalis*, *Huperzia selago*, *Leucojum vernum*, *Lilium martagon*, *Lunaria rediviva*, *Lycopodium annotinum*, *Neottia nidus-avis*, *Neottia ovata*, *Platanthera bifolia*, *P. chlorantha*, *Pulsatilla patens*, *Rhododendron myrtifolium*, *Rosa gallica*, *Scopolia carniolica*, *Sorbus torminalis*, *Stipa capillata*). There are no plant species with a conservation status Data Deficient (DD). This is a specificity of the botanical section of the Red Data Book of Ukraine because among the not evaluated species there are many widespread and sometimes quite numerous species. Among the listed plant species, there are no species with the statuses Extinct species (EX) and Extinct in the wild (EW). The remaining species have protected statuses: Disappearing species (DP), Vulnerable species (VU), and Rare species (RR).

Table 1

The representation of fungi listed in the Red Data Book of Ukraine in the western oblasts of Ukraine

No.	Fungi	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
1	*Agaricus bresadolanus* Bohus	–	–	–	–	–	–	5
2	*A. praerimosus* Peck	–	–	–	–	5	–	–
3	*Amanita caesarea* (Scop.) Pers.	–	–	–	–	–	–	5
4	*Amylocystis lapponica* (Romell) Bondartsev & Singer	–	–	–	–	–	–	7
5	*Aspidella solitaria* (Fr.) E.-J. Gilbert	–	–	–	–	5	–	–
6	*Boletus aereus* Bull.	–	–	–	–	–	–	4
7	*Butyriboletus appendiculatus* (Schaeff.) D. Arora & J.L. Frank	–	–	–	–	4	–	4
8	*B. fechtneri* (Velen.) D. Arora & J.L. Frank, 2014	–	–	5	–	5	–	–
9	*B. fuscoroseus* (Smotl.) Vizzini & Gelardi	–	–	–	–	–	5	5
10	*B. regius* (Krombh.) D. Arora & J.L. Frank	–	–	–	–	5	–	5
11	*B. subappendiculatus* (Dermek, Lazebn. & J. Veselský) D. Arora & J.L. Frank	–	–	5	–	5	5	5
12	*Catathelasma imperiale* (P. Karst.) Singer	–	–	3	–	3	3	–
13	*Chalciporus rubinus* (W.G.Sm.) Singer	–	–	5	–	–	–	–
14	*Clavariadelphus pistillaris* (L.) Donk	–	–	3	–	3	3	3
15	*Gomphus clavatus* (Pers.) Gray	–	–	–	–	5	–	–
16	*Grifola frondosa* (Dicks.) Gray	–	–	–	4	4	–	4
17	*Hemileccinum depilatum* (Redeuilh) Šutara	–	–	4	4	4	–	4
18	*Hericium coralloides* (Scop.) Pers.	4	–	4	4	4	–	4
19	*H. erinaceus* (Bull.) Pers.	–	–	5	5	–	–	5
20	*Lactarius chrysorrheus* Fr.	–	–	–	–	4	–	–
21	*L. lignyotus* Fr.	–	–	3	–	3	3	3
22	*Leucoagaricus nympharum* (Kalchbr.) Bon	–	–	–	–	3	–	3
23	*Leucocortinarius bulbiger* (Alb. & Schwein.) Singer	–	–	–	3	3	–	–
24	*Mutinus caninus* (Huds.) Fr.	3	–	3	3	3	–	3
25	*Mythicomyces corneipes* (Fr.) Redhead & A.H.Sm.	–	–	–	–	4	–	–
26	*Phaeolepiota aurea* (Matt.) Maire	–	–	–	–	4	–	–
27	*Phellinidium ferrugineofuscum* (P. Karst.) Fiasson & Niemelä	–	–	–	–	–	–	4
28	*Phylloporus pelletieri* (Lév.) Quél.	–	–	–	–	5	–	5
29	*Plectania melastoma* (Sowerby) Fuckel	–	–	–	–	4	–	–
30	*Polyporus umbellatus* (Pers.) Fr.	–	–	3	–	3	–	3
31	*Poronia punctata* (L.) Fr.	–	5	–	–	–	–	–
32	*Pseudoboletus parasiticus* (Bull.) Šutara	–	4	4	–	4	–	4
33	*Rubroboletus lupinus* (Fr.) Costanzo, Gelardi, Simonini & Vizzini	–	–	–	4	–	–	–
34	*R. rhodoxanthus* (Krombh.) Kuan Zhao & Zhu L.Yang	–	–	–	–	–	–	5
35	*R. rubrosanguineus* (Cheype) Kuan Zhao & Zhu L.Yang	–	–	5	–	5	–	–
36	*R. satanas* (Lenz) Kuan Zhao & Zhu L. Yang	–	–	5	5	5	–	–
37	*Russula turci* Bres.	–	4	4	–	4	–	4
38	*Sparassis crispa* (Wulfen) Fr.	5	5	5	–	–	–	5
39	*Strobilomyces strobilaceus* (Scop.) Berk.	–	4	4	4	4	4	4
40	*Suillus plorans* (Rolland) Kuntze	–	–	–	–	4	–	4
41	*Tuber aestivum* (Wulfen) Spreng.	–	–	–	–	–	–	5
	Species	3	5	17	9	28	6	26
	Total score	12	22	70	36	114	23	112
	Total score/Species	4.0	4.4	4.1	4.0	4.1	3.8	4.3

Note: VL – Volyn oblast, RV – Rivne oblast, LV – Lviv oblast, TR – Ternopil oblast, IF – Ivano-Frankivsk oblast, CH – Chernivtsi oblast, ZK – Zakarpattia oblast, "–" – absence of recorded findings of the species in the DCBU.

Table 2

The representation of plants listed in the Red Data Book of Ukraine in the western oblasts of Ukraine

No.	Plantae	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
1	*Achillea lingulata* Waldst. & Kit.	–	–	–	–	–	–	3
2	*A. oxyloba* (Sch. Bip.) Heimerl	–	–	–	–	3	–	3
3	*Aconitum besserianum* Andrz.	–	–	4	4	–	–	–
4	*A. lasiocarpum* (Rchb.) Gáyer	–	–	4	–	4	–	4
5	*A. lycoctonum* L.	–	–	4	–	–	–	–
6	*A. pseudanthora* Wender.	–	–	–	3	3	–	–
7	*Adonis vernalis* L.	–	–	2	2	–	–	–
8	*Aldrovanda vesiculosa* L.	3	–	–	–	–	–	–
9	*Allium ursinum* L.	–	–	2	2	–	–	–
10	*Anacamptis morio* (L.) R.M. Bateman, Pridgeon et M.W. Chase	–	–	4	–	–	4	4
11	*A. palustris* (Jacq.) R.M. Bateman, Pridgeon et M.W. Chase	–	–	–	–	–	4	–
12	*Anacamptodon splachnoides* (Froel. ex	–	–	–	–	–	4	–

No.	Plantae	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
	Brid.) Brid.							
13	*Anemonastrum narcissiflorum* (L.) Holub	–	–	4	–	–	–	–
14	*Anthemis cretica carpatica* (Willd.) Grierson	–	–	–	–	4	–	4
15	*Aster alpinus* L.	–	–	–	–	3	–	3
16	*Astragalus arenarius* L.	4	4	–	–	–	–	–
17	*A. australis* (L.) Lam.	–	–	–	–	–	–	5
18	*Betula humilis* Schrank	4	–	4	–	–	–	–
19	*B. klokovii* Zaverucha	–	–	–	5	–	–	–
20	*Botrychium lunaria* (L.) Sw.	4	–	4	–	–	4	–
21	*B. matricariifolium* (Döll) A. Braun ex Koch	–	–	–	–	–	5	–
22	*B. multifidum* (S.G.Gmel.) Rupr.	–	–	3	–	–	3	–
23	*B. virginianum* (L.) Sw.	–	5	5	–	–	5	–
24	*Campanula carpatica* Jacq.	–	–	–	–	3	–	3
25	*Campylostelium saxicola* Bruch & W.P. Schimper, 1846	–	–	3	–	3	3	3
26	*Carex bohemica* Schreb.	–	–	4	–	–	–	–
27	*C. chordorrhiza* L.f.	4	4	4	–	–	–	–
28	*C. davalliana* Sm.	4	–	4	–	–	–	–
29	*C. dioica* L.	4	4	4	–	–	–	–
30	*C. umbrosa* Host	2	–	–	–	–	–	–
31	*Carlina acanthifolia* (Hacq.) Meusel & Kästner	–	–	4	–	–	–	–
32	*C. acaulis* L.	–	4	4	4	4	4	4
33	*Cephalanthera damasonium* (Mill.) Druce	3	3	3	3	–	3	–
34	*C. longifolia* (L.) Fritsch.	3	–	–	3	–	3	–
35	*C. rubra* (L.) Rich.	3	–	3	3	–	3	–
36	*Chamaedaphne calyculata* (L.) Moench	–	4	–	–	–	–	–
37	*Cladium mariscus* (L.) Pohl s.l.	4	–	–	–	–	–	–
38	*Coeloglossum viride* (L.) C. Hartm.	–	–	–	–	–	–	3
39	*Colchicum autumnale* L.	–	–	–	–	2	–	2
40	*Cololejeunea rossettiana* (C. Massal.) Schiffn.	–	–	–	–	–	–	3
41	*Conardia compacta* (Drumm. ex Müll. Hal.) H. Rob.	–	–	–	–	–	3	–
42	*Corallorhiza trifida* Châtel.	–	–	3	–	–	3	–
43	*Cortusa matthioli* L.	–	–	–	–	5	5	5
44	*Crocus heuffelianus* Herb.	–	–	2	2	2	2	2
45	*Cypripedium calceolus* L.	4	–	4	4	–	–	–
46	*Cystopteris montana* (Lam.) Bernh. ex Desv.	–	–	–	–	–	4	–
47	*C. sudetica* A.Braun et Milde	–	–	–	–	–	5	–
48	*Cytisus albus* Hacq.	–	–	4	4	–	–	–
49	*C. kerneri* Blocki	–	–	–	3	3	–	–
50	*C. paczoskii* V.I. Krecz.	–	–	3	3	–	–	–
51	*C. podolicus* Błocki	–	–	4	4	–	–	–
52	*Dactylorhiza cordigera* (Fries) Soó	–	–	–	–	–	–	4
53	*D. fuchsii* (Druce) Soó	2	2	2	2	–	–	–
54	*D. incarnata* (L.) Soó	4	4	4	–	–	4	–
55	*D. maculata* (L.) Soó	–	–	4	–	–	–	–
56	*D. majalis* (Rchb.) P. F. Hunt & Summerh.	3	–	3	3	3	3	3
57	*D. sambucina* (L.) Soó	–	–	4	–	–	–	4
58	*D. traunsteineri* (Saut. ex Rchb.) Soó	–	–	3	–	–	–	–
59	*Daphne cneorum* L.	4	–	4	–	–	–	–
60	*Dianthus arenarius* L.	4	–	4	–	–	–	–
61	*D. superbus* L.	4	–	4	–	–	4	–
62	*Dicranodontium asperulum* (Mitt.) Broth.	–	–	–	–	3	–	–
63	*Dictamnus albus* L.	–	–	–	3	–	–	–
64	*Diphasiastrum complanatum* (L.) Holub	–	3	3	–	–	–	–
65	*D. zeilleri* (Rouy) Holub	5	–	–	–	–	–	–
66	*Dracocephalum austriacum* L.	–	–	–	4	–	–	–
67	*Drosera intermedia* Hayne	4	4	–	–	–	–	–
68	*D. longifolia* L.	4	4	–	–	–	–	–
69	*Dryas octopetala* L.	–	–	–	–	3	–	3
70	*Epipactis atrorubens* (Hoffm. ex Bernh.) Besser	4	4	–	4	–	–	–
71	*E. helleborine* (L.) Crantz	2	2	2	2	2	2	–
72	*E. palustris* (L.) Crantz	4	4	4	4	–	4	–
73	*E. purpurata* Sm.	–	–	–	3	–	3	–
74	*Epipogium aphyllum* Sw.	–	–	5	–	–	–	–
75	*Erigeron alpinus* L.	–	–	–	–	3	–	3
76	*Erythronium dens-canis* L.	–	–	–	–	–	–	3
77	*Euonymus nanus* M. Bieb.	–	–	–	4	–	–	–
78	*Festuca heterophylla* Lam.	–	–	–	4	–	–	–
79	*F. porcii* Hack.	–	–	–	–	4	4	–
80	*Fissidens rufulus* Bruch et Schimp.	–	–	–	–	–	3	–
81	*Fraxinus ornus* L.	–	–	–	–	–	–	3
82	*Fritillaria meleagris* L.	–	–	4	–	–	–	–
83	*Frullania jackii* Gottsche	–	–	–	–	–	–	3

No.	Plantae	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
84	*Galanthus nivalis* L.	–	–	2	2	2	2	2
85	*Genista sagittalis* L.	–	–	–	–	–	–	3
86	*Gentiana acaulis* L.	–	–	4	–	4	–	4
87	*G. lutea* L.	–	–	–	–	–	–	5
88	*G. nivalis* L.	–	–	–	–	5	–	–
89	*G. punctata* L.	–	–	–	–	4	–	4
90	*G. pyrenaica* L.	–	–	–	–	3	–	3
91	*G. verna* L.	–	–	–	–	–	–	5
92	*Gladiolus imbricatus* L.	–	–	4	–	4	–	–
93	*Goodyera repens* (L.) R.Br.	4	–	–	–	–	–	–
94	*Gymnadenia conopsea* (L.) R.Br.	4	–	4	–	–	4	4
95	*G. densiflora* (Wahlenb.) A.Dietr.	4	–	–	–	–	–	–
96	*Gypsophilla thyraica* Krasnova	–	–	–	4	–	–	–
97	*Hammarbya paludosa* (L.) O.Kuntze	–	5	–	–	–	–	–
98	*Haplomitrium hookeri* (Sm.) Nees	–	–	–	–	5	–	–
99	*Helodium blandowii* (F.Weber et D.Mohr) Warnst.	–	–	4	–	–	–	–
100	*Hookeria lucens* (Hedw.) Sm.	–	–	–	–	3	–	–
101	*Huperzia selago* (L.) Bernh.	2	2	2	–	–	2	2
102	*Hydrocotyle vulgaris* L.	3	–	–	–	–	–	–
103	*Isoetes lacustris* L.	4	4	–	–	–	–	–
104	*Juncus bulbosus* L.	4	4	–	–	–	–	–
105	*Larix polonica* Racib.	–	–	–	–	5	5	–
106	*Leontopodium nivale* (Cass.) Greuter	–	–	4	–	–	–	4
107	*Leucojum aestivum* L.	–	–	–	4	–	–	–
108	*L. vernum* L.	–	–	2	–	2	2	2
109	*Ligularia sibirica* Cass.	–	–	–	–	–	4	–
110	*Lilium martagon* L.	2	2	2	2	2	2	–
111	*Linnaea borealis* L.	–	–	5	–	5	–	–
112	*Liparis loeselii* (L.) Rich.	4	–	4	–	–	–	–
113	*Loiseleuria procumbens* (L.) Desv.	–	–	–	–	3	–	3
114	*Lonicera caerulea* L.	–	–	–	–	–	–	3
115	*Lunaria rediviva* L.	–	–	2	2	–	–	2
116	*Lycopodiella inundata* (L.) Holub	4	4	4	–	–	4	–
117	*Lycopodium alpinum* L.	–	–	3	–	–	–	3
118	*L. annotinum* L., 1753	2	2	2	–	–	2	2
119	*L. complanatum* L.	–	–	3	–	–	3	–
120	*Marsilea quadrifolia* L.	4	–	–	–	–	–	–
121	*Meesia uliginosa* Hedw.	–	–	–	–	4	–	4
122	*Minuartia pauciflora* (Kit. ex Kanitz) Dvořaková	–	–	–	–	–	–	3
123	*M. verna* (L.) Rchb.	–	–	–	–	4	–	4
124	*Muscari botryoides* (L.) Mill.	–	–	5	–	–	–	–
125	*Neottia nidus-avis* (L.) Rich.	2	2	2	2	–	2	–
126	*N. ovata* (L.) Bluff & Fingerh.	–	–	2	2	–	2	2
127	*Neotinea ustulata* (L.) R.M. Bateman, Pridgeon et M.W. Chase	–	–	5	–	–	–	–
128	*Orchis mascula* (Mutel) Hegi	–	–	4	–	–	–	–
129	*O. militaris* L.	–	–	4	–	–	–	–
130	*O. purpurea* Huds.	–	–	4	–	–	4	–
131	*Paludella squarrosa* (Hedw.) Brid.	5	–	–	–	–	–	–
132	*Pedicularis exaltata* Besser	–	–	–	–	4	4	–
133	*P. oederi* Vahl	–	–	–	–	5	5	5
134	*P. sceptrum-carolinum* L.	4	4	4	4	4	–	–
135	*P. sylvatica* L.	–	–	4	–	4	–	–
136	*Pinguicula alpina* L.	–	–	–	–	–	–	4
137	*P. vulgaris* L.	4	4	4	4	4	–	4
138	*Pinus cembra* L.	–	–	4	–	4	4	–
139	*Plagiothecium neckeroideum* Schimp.	–	–	–	–	3	–	3
140	*Platanthera bifolia* (L.) Rich.	2	2	2	2	–	2	2
141	*P. chlorantha* (Cust.) Rchb.	–	–	2	2	–	2	–
142	*Poa rehmannii* (Asch. et Graebn.) Woł.	–	–	3	–	3	–	–
143	*Primula halleri* J.F.Gmel.	–	–	–	–	3	–	3
144	*P. minima* L.	–	–	–	–	3	–	3
145	*Pseudorchis albida* (L.) A. Löve et D. Löve	–	–	–	–	–	–	4
146	*Pulsatilla alba* Reichenb.	–	–	–	–	3	–	3
147	*P. grandis* Wender.	–	–	4	4	–	–	–
148	*P. patens* (L.) Mill.	–	–	2	2	–	–	–
149	*P. pratensis* (L.) Mill.	–	–	–	2	–	–	–
150	*Rhodiola rosea* L.	–	–	–	4	4	–	4
151	*Rhododendron myrtifolium* Schott et Kotschy	–	–	–	–	2	–	2
152	*Rosa gallica* L.	–	–	2	2	–	–	–
153	*Saelania glaucescens* (Hedw.) Broth.	–	–	–	–	3	–	3
154	*Salix herbacea* L.	–	–	–	–	3	–	3
155	*S. lapponum* L.	4	4	4	–	–	–	–
156	*S. myrtilloides* L.	4	4	4	–	–	–	–
157	*S. starkeana* Willd.	4	–	–	–	–	–	–
158	*Saxifraga aizoides* L.	–	–	–	–	5	–	–
159	*S. androsacea* L.	–	–	–	–	–	–	3

No.	Plantae	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
160	*S. bryoides* L.	–	–	–	–	3	–	–
161	*S. carpatica* Sternb.	–	–	–	–	–	–	3
162	*S. hirculus* L.	–	–	4	–	–	–	–
163	*Scheuchzeria palustris* L.	4	4	–	–	–	–	–
164	*Schivereckia podolica* (Besser) Andrz.	–	–	–	4	–	–	–
165	*Schoenus ferrugineus* L.	–	–	4	–	–	–	–
166	*Scopolia carniolica* Jacq.	–	–	2	2	–	–	–
167	*Scorpidium scorpioides* (Hedw.) Limpr	4	–	–	–	–	–	–
168	*Securigera elegans* (Pančić) Lassen	–	–	–	–	4	–	4
169	*Sempervivum globiferum* L.	3	–	–	–	–	–	3
170	*S. montanum* L.	–	–	3	–	–	–	3
171	*Sesleria caerulea* (L.) Ard.	–	–	5	–	–	–	–
172	*Silene zawadzkii* Herbich	–	–	–	–	5	5	5
173	*Sorbus torminalis* (L.) Crantz	–	–	–	2	–	–	2
174	*Sphagnum molle* Sull.	–	–	4	–	–	–	–
175	*S. subnitens* Russow & Warnstorf	–	–	–	–	–	5	–
176	*S. tenellum* (Brid.) Pers. ex Brid.	–	–	–	–	4	–	–
177	*Staphylea pinnata* L.	–	–	3	3	3	–	3
178	*Stipa capillata* L.	–	–	–	2	–	–	–
179	*S. pennata* L.	–	–	–	4	–	–	–
180	*Syringa josikaea* J. Jacq. ex Rchb.	–	–	4	–	4	–	4
181	*Succisella inflexa* (Kluk) G. Beck	3	3	–	–	–	–	3
182	*Swertia perennis* L.	–	4	4	–	4	4	4
183	*Taxus baccata* L.	–	–	4	4	–	4	–
184	*Tofieldia calyculata* (L.) Wahlenb.	–	–	4	–	–	–	–
185	*Traunsteinera globosa* (L.) Rchb.	–	–	–	–	–	4	–
186	*Trifolium rubens* L.	–	–	3	–	3	–	3
187	*Utricularia australis* R. Br.	–	–	4	–	–	–	–
188	*U. intermedia* Hayne	4	–	–	–	–	–	–
189	*Vaccinium microcarpum* (Rupr.) Schmalh.	4	4	4	–	4	–	4
190	*Veronica fruticans* Jacq.	–	–	–	–	–	–	3
191	*Viola alba* Besser	–	–	3	–	3	–	–
	Species	51	32	90	48	59	49	70
	Total score	182	113	314	147	206	171	231
	Total score/Species	3.57	3.53	3.49	3.06	3.49	3.45	3.30

Note: VL – Volyn oblast, RV – Rivne oblast, LV – Lviv oblast, TR – Ternopil oblast, IF – Ivano-Frankivsk oblast, CH – Chernivtsi oblast, ZK – Zakarpattia oblast, "–" – absence of recorded findings of the species in the DCBU.

A total of 266 species of animals included in the Red Data Book of Ukraine were recorded in the DCBU. By oblasts of the western region of Ukraine: Volyn – 85 species, Rivne – 48, Lviv – 153, Ternopil – 125, Ivano-Frankivsk – 132, Chernivtsi – 50, Zakarpattia – 94 (Table 3). Among the listed species, there are one with Extinct species (EX) status (*Vertigo geyeri*), one species with Extinct in the wild (EW) status (*Bison bonasus*), three with Not Evaluated species (NE) status (*Megascolia maculata*, *Regulus ignicapillus*, *Sphex funerarius*) and five with Data Deficient (DD) status (*Crocidura leucodon*, *Dytiscus latissimus*, *Orussus unicolor*, *Polydesmus montanus*, *Strix uralensis*). The remaining species have protected statuses: Disappearing species (DP), Vulnerable species (VU), and Rare species (RR).

Table 3

The representation of animals listed in the Red Data Book of Ukraine in the western oblasts of Ukraine

No.	Animalia	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
1	*Abia nitens* (Linnaeus, 1758)	–	–	3	–	–	–	–
2	*Acicula parcelineata* (Clessin, 1911)	–	–	3	–	–	–	3
3	*A. perpusilla* (Reinhardt, 1880)	–	–	–	–	–	–	4
4	*Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833	–	–	–	5	–	–	–
5	*A. ruthenus* Linnaeus, 1758	–	–	4	4	4	4	–
6	*A. stellatus* Pallas, 1771	–	–	–	5	–	–	–
7	*Acrocephalus paludicola* (Vieillot, 1817)	5	–	5	–	–	–	–
8	*Acrossus bimaculatus* (Laxmann, 1770)	–	–	3	–	–	–	–
9	*Aegypius monachus* (Linnaeus, 1766)	–	–	4	4	–	–	–
10	*Agrodiaetus damon* (Denis & Schiffermüller, 1775)	–	–	5	–	–	–	–
11	*Alburnoides rossicus* Berg, 1924	–	–	4	–	4	–	–
12	*Anas strepera* Linnaeus, 1758	3	–	3	3	3	–	–
13	*Anax imperator* Leach, 1815	4	4	4	4	4	4	4
14	*Anguilla anguilla* (Linnaeus, 1758)	5	–	–	–	–	–	–
15	*Anodonta cygnea* (Linnaeus, 1758)	4	4	4	4	–	–	–
16	*Anoplius samariensis* (Pallas, 1771)	–	3	–	–	–	–	–
17	*Anser erythropus* (Linnaeus, 1758)	4	–	–	–	–	–	–
18	*Apatura iris* (Linnaeus, 1758)	4	4	4	4	4	–	4
19	*Aquila chrysaetos* (Linnaeus, 1758)	4	4	4	4	4	4	4
20	*A. clanga* Pallas, 1811	–	–	–	3	–	–	–
21	*A. heliaca* Savigny, 1809	–	–	3	–	–	–	–
22	*A. pomarina* C. L. Brehm, 1831	3	–	3	3	–	3	3
23	*Argna bielzi* (Rossmässler, 1859)	–	–	3	–	3	–	3
24	*Arianta petrii* Kimakowicz, 1890	–	–	–	–	3	–	3
25	*Aromia moschata* (Linnaeus, 1758)	4	4	4	4	4	4	4
26	*Asio flammeus* (Pontoppidan, 1763)	3	–	3	3	–	–	–
27	*Astacus astacus* (Linnaeus, 1758)	–	–	–	–	4	–	4
28	*Aythya nyroca* (Guldenstadt, 1770)	4	–	4	–	4	–	4
29	*Barbastella barbastellus* (Schreber, 1774)	5	5	5	5	–	–	–
30	*Barbus barbus* (Linnaeus, 1758)	–	–	4	–	4	4	4
31	*B. petenyi* Heckel, 1852	–	–	–	–	–	–	4
32	*Bison bonasus* (Linnaeus, 1758)	6	–	6	–	6	6	–
33	*Bittacus italicus* (Müller, 1786)	–	–	–	4	4	–	–
34	*Bombina variegata* (Linnaeus, 1758)	–	–	4	–	4	4	4
35	*Bombus argillaceus* (Scopoli, 1763)	–	–	–	4	–	–	–
36	*B. armeniacus* Radoszkowski, 1877	–	–	–	5	–	–	–
37	*B. fragrans* (Pallas, 1771)	–	–	–	5	–	–	–
38	*B. laesus* Morawitz, 1875	–	–	4	–	–	–	4
39	*B. muscorum* (Linnaeus, 1758)	3	–	3	3	3	–	–
40	*B. pomorum* (Panzer, 1805)	–	–	4	4	4	–	–
41	*B. ruderatus* (Fabricius, 1775)	–	–	–	3	3	–	–
42	*Boreus westwoodi* Hagen, 1866	–	4	–	–	4	–	–
43	*Boros schneideri* (Panzer, 1795)	–	–	–	–	–	–	3
44	*Bubo bubo* (Linnaeus, 1758)	3	3	3	3	–	–	–
45	*Bucephala clangula* (Linnaeus, 1758)	3	3	3	3	3	3	3
46	*Bufo calamita* Laurenti, 1768	4	–	–	–	–	–	–
47	*Buteo rufinus* (Cretzschmar, 1827)	–	–	–	3	–	–	–
48	*Callimorpha dominula* (Linnaeus, 1758)	4	4	4	–	4	–	4
49	*Calopteryx virgo* (Linnaeus, 1758)	4	4	4	4	4	4	4
50	*Calosoma sycophanta* (Linnaeus, 1758)	4	–	4	4	4	–	4
51	*Carabus estreicheri* Fischer von Waldheim, 1822	–	–	4	4	4	–	–
52	*C. menetriesi* (Faldermann in Hummel, 1827)	4	4	4	4	4	–	–
53	*C. nitens* Linnaeus, 1758	–	–	3	–	–	–	–
54	*Carassius carassius* (Linnaeus, 1758)	4	–	4	4	–	–	–
55	*Catocala sponsa* (Linnaeus, 1767)	–	–	3	3	3	–	3
56	*Cerambyx cerdo* Linnaeus, 1758	–	–	4	4	4	–	4
57	*Charadrius hiaticula* Linnaeus, 1758	3	–	3	–	–	–	–
58	*Chondrostoma nasus* (Linnaeus, 1758)	–	–	4	–	4	–	4
59	*Chrysolina carpathica* (Fuss, 1856)	–	–	–	–	5	–	–
60	*Ciconia nigra* (Linnaeus, 1758)	3	3	3	3	3	3	3
61	*Circaetus gallicus* (Gmelin, 1788)	3	–	3	3	3	3	3
62	*Circus cyaneus* (Linnaeus, 1766)	–	–	3	3	3	–	–
63	*C. macrourus* (S. G. Gmelin, 1771)	–	–	5	–	5	–	–
64	*C. pygargus* (Linnaeus, 1758)	4	–	4	4	–	–	–
65	*Clausilia cruciata* (S. Studer, 1820)	–	–	3	–	3	–	3
66	*C. pumila* C. Pfeiffer, 1828	–	–	4	–	4	–	–
67	*Coenagrion armatum* (Charpentier, 1840)	5	–	5	–	5	–	–
68	*Coenonympha hero* (Linnaeus, 1761)	–	–	–	–	4	–	–
69	*C. oedippus* (Fabricius, 1787)	5	5	–	–	–	–	–
70	*Colias chrysotheme* (Esper, 1781)	–	–	–	5	–	–	–
71	*C. myrmidone* (Esper, 1781)	–	–	5	5	–	–	–
72	*C. palaeno* (Linnaeus, 1761)	–	5	5	–	5	–	–
73	*Columba oenas* Linnaeus, 1758	4	–	4	4	–	–	–
74	*Coracias garrulus* Linnaeus, 1758	5	–	5	5	5	–	–
75	*Cordulegaster bidentata* Selys, 1843	–	–	5	–	5	5	5
76	*C. boltonii* (Donovan, 1807)	–	–	–	–	4	4	–
77	*Cornumutila quadrivittata* Gebler, 1830	–	–	–	–	3	–	–
78	*Coronella austriaca* Laurenti, 1768	–	–	4	4	–	4	4
79	*Cricetus cricetus* (Linnaeus, 1758)	4	4	4	4	4	4	–
80	*Crocidura leucodon* (Hermann, 1780)	1	–	1	1	–	–	–
81	*Cyanistes cyanus* Pallas, 1770	3	–	–	–	–	–	–
82	*Cygnus bewickii* Yarrell, 1830	3	–	–	–	–	–	–
83	*Cucujus cinnaberinus* (Scopoli, 1763)	–	–	4	4	4	–	4
84	*Cucullia argentea* (Hufnagel, 1766)	3	–	–	–	–	–	–
85	*Daudebardia brevipes* (Draparnaud, 1805)	–	–	4	–	–	–	–
86	*D. rufa* (Draparnaud, 1805)	–	–	4	–	–	–	–
87	*Dendrocopos leucotos* (Bechstein, 1803)	3	–	3	–	–	–	–
88	*Discus perspectivus* (Megerle von Mühlfeld, 1816)	–	–	4	4	4	–	–
89	*Dorcadion equestre* (Laxmann, 1770)	–	–	–	4	4	4	–
90	*Drobacia banatica* (Rossmässler, 1838)	–	–	–	–	–	–	4
91	*Dytiscus latissimus* (Linnaeus, 1758)	–	–	–	–	1	–	–
92	*Emus hirtus* (Linnaeus, 1758)	–	–	3	–	3	–	3
93	*Eptesicus nilssonii* (Keyserling, Blasius, 1839)	4	–	–	–	–	–	4
94	*E. serotinus* (Schreber, 1774)	4	4	4	4	–	–	–

No.	Animalia	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
95	*Erebia manto* (Denis & Schiffermüller, 1775)	–	–	–	–	3	–	–
96	*Euchalcia variabilis* (Piller, 1783)	–	–	3	–	3	–	3
97	*Eudia pavonia* (Linnaeus, 1758)	–	–	3	–	3	–	–
98	*Eudontomyzon danfordi* Regan, 1911	–	–	–	–	–	–	5
99	*E. mariae* Berg, 1931	–	–	–	5	5	–	–
100	*Euphydryas aurinia* (Rottemburg, 1775)	–	–	4	–	4	–	–
101	*E. maturna* (Linnaeus, 1758)	–	–	4	4	4	–	–
102	*Eurythyrea quercus* (Herbst, 1780)	–	–	3	–	3	–	–
103	*Falco cherrug* Gray, 1834	–	–	4	4	–	–	–
104	*F. naumanni* Fleischer, 1818	–	–	5	5	–	–	–
105	*F. peregrinus* Tunstall, 1771	–	3	3	3	3	–	–
106	*Felis silvestris* Schreber, 1777	–	–	4	4	4	4	–
107	*Gallinago media* (Latham, 1787)	5	–	–	–	–	–	–
108	*Glareola nordmanni* Fischer von Waldheim, 1842	–	–	5	–	–	–	–
109	*Glaucidium passerinum* (Linnaeus, 1758)	–	–	4	–	–	–	4
110	*Glaucopsyche alcon* (Denis & Schiffermüller, 1775)	–	–	–	–	5	–	–
111	*Granaria frumentum* (Draparnaud, 1801)	–	–	4	–	–	–	–
112	*Grus grus* (Linnaeus, 1758)	3	–	3	3	–	–	–
113	*Gymnocephalus acerinus* (Güldenstädt, 1774)	–	5	–	–	5	–	–
114	*Gyps fulvus* (Hablizl, 1783)	–	–	4	4	4	–	–
115	*Haematopus ostralegus* (Linnaeus, 1758)	4	–	–	–	–	–	–
116	*Haliaeetus albicilla* (Linnaeus, 1758)	3	3	3	3	–	3	3
117	*Hamearis lucina* (Linnaeus, 1758)	–	–	–	–	4	–	–
118	*Hemaris tityus* (Linnaeus, 1758)	–	–	–	–	3	–	3
119	*Hieraaetus pennatus* (Gmelin, 1788)	3	–	3	3	–	3	–
120	*Himantopus himantopus* (Linnaeus, 1758)	–	4	–	4	4	–	4
121	*Hipparchia statilinus* (Hufnagel, 1766)	–	3	–	–	–	–	–
122	*Hirudo medicinalis* Linnaeus, 1758	–	–	–	–	4	–	–
123	*Hucho hucho* Linnaeus, 1758	–	–	–	–	–	–	5
124	*Hydroprogne caspia* (Pallas, 1770)	–	–	–	–	–	–	4
125	*Hypsugo savii* (Bonaparte, 1837)	–	–	–	–	5	–	5
126	*Isophya modesta* (Frivaldsky, 1867)	–	–	4	–	4	–	–
127	*Lacerta viridis* (Laurenti, 1768)	–	–	–	4	–	–	–
128	*Ladislavella terebra* (Westerlund, 1885)	–	–	4	–	–	–	–
129	*Lanius excubitor* Linnaeus, 1758	3	3	3	3	–	3	3
130	*Lemonia taraxaci* Esper, 1783	–	–	4	–	–	–	–
131	*Leuciscus idus* (Linnaeus, 1758)	4	–	–	–	–	–	–
132	*L. leuciscus* (Linnaeus, 1758)	–	–	–	–	4	–	–
133	*Leucorrhinia albifrons* (Burmeister, 1839)	5	–	–	–	–	–	–
134	*Limenitis populi* (Linnaeus, 1758)	4	4	4	4	4	4	4
135	*Lissotriton montandoni* (Boulenger, 1880)	–	–	4	–	4	4	4
136	*Lota lota* (Linnaeus, 1758)	–	–	4	–	–	–	–
137	*Lucanus cervus* (Linnaeus, 1758)	3	3	3	3	3	3	3
138	*Lutra lutra* (Linnaeus, 1758)	4	–	4	4	4	–	–
139	*Lynx lynx* (Linnaeus, 1758)	–	–	4	–	4	–	4
140	*Lyrurus tetrix* (Linnaeus, 1758)	5	–	5	–	5	5	5
141	*Macrogastra plicatula* (Draparnaud, 1801)	–	–	4	–	–	–	–
142	*M. tumida* (Rossmässler, 1836)	–	–	3	3	3	3	3
143	*Mantispa styriaca* Poda, 1761	–	–	–	–	–	–	3
144	*Marstoniopsis insubrica* (Küster, 1853)	–	–	3	–	–	–	–
145	*Megarhyssa rixator* (Schellenberg, 1802)	–	–	–	–	3	–	–
146	*M. superba* (Schrank, 1781)	–	–	–	3	–	–	–
147	*Megascolia maculata* (Drury, 1773)	–	2	–	2	2	2	2
148	*Melitturga clavicornis* (Latreille, 1806)	–	–	4	–	–	–	–
149	*Mergus serrator* Linnaeus 1758	4	–	–	–	–	–	–
150	*Mesotriton alpestris* (Laurenti, 1768)	–	–	–	–	4	4	4
151	*Milvus migrans* (Boddaert, 1783)	4	–	4	4	–	–	–
152	*M. milvus* (Linnaeus, 1758)	–	–	5	5	–	–	–
153	*Morimus funereus* Mulsant, 1862	–	–	–	–	–	4	–
154	*Mormo maura* (Linnaeus, 1758)	–	–	–	–	–	–	4
155	*Morulina verrucosa* (Börner, 1903)	–	–	–	3	3	–	–
156	*Myotis bechsteinii* (Kuhl, 1817)	–	5	5	5	–	–	–
157	*M. brandtii* (Eversmann, 1845)	4	4	–	4	–	4	–
158	*M. dasycneme* (Boie, 1825)	5	5	5	5	–	–	–
159	*M. daubentonii* (Kuhl, 1817)	4	4	4	4	–	–	–
160	*M.s myotis* (Borkhausen, 1797)	4	4	4	4	–	–	–
161	*M. mystacinus* (Kuhl, 1817)	4	4	4	4	–	–	–
162	*M. nattereri* (Kuhl, 1817)	5	5	5	5	–	–	5
163	*Mustela erminea* (Linnaeus, 1758)	4	–	4	4	4	–	–
164	*M. eversmanni* Lesson, 1827	–	–	5	–	–	–	–
165	*M. lutreola* Linnaeus, 1758	5	–	5	–	–	–	–
166	*M. putorius* Linnaeus, 1758	4	–	4	4	–	–	–
167	*Nehalennia speciosa* (Charpentier, 1840)	4	–	4	–	4	–	–
168	*Neomys anomalus* (Cabrera, 1907)	4	–	4	–	–	–	–
169	*Netta rufina* (Pallas, 1773)	–	–	–	3	–	–	–
170	*Nyctalus leisleri* (Kuhl, 1817)	4	4	–	4	–	–	–
171	*N. noctula* (Schreber, 1774)	4	4	4	4	–	–	–
172	*Numenius arquata* (Linnaeus, 1758)	5	–	5	–	5	5	–
173	*Ophiogomphus cecilia* (Geoffroy in Fourcroy, 1785)	–	4	4	4	4	4	4
174	*Oreina plagiata* (Suffrian, 1861)	–	–	–	–	3	–	–
175	*O. viridis* (Duftschmid, 1825)	–	–	–	–	3	–	–
176	*Orussus abietinus* (Scopoli, 1763)	–	–	–	–	4	–	–
177	*O. unicolor* Latreille, 1812	–	–	–	–	–	–	1
178	*Osmoderma barnabita* (Motschulsky, 1845)	–	–	4	4	4	–	4
179	*Otis tarda* Linnaeus, 1758	–	–	–	5	–	–	–
180	*Otus scops* (Linnaeus, 1758)	–	–	–	–	–	–	3
181	*Oxyura leucocephala* (Scopoli, 1769)	5	–	–	–	–	–	–
182	*Pandion haliaetus* (Linnaeus, 1758)	–	5	5	5	5	5	–
183	*Parnassius apollo* (Linnaeus, 1758)	–	–	5	5	5	–	5
184	*P. mnemosyne* (Linnaeus, 1758)	–	4	4	4	4	–	4
185	*Pelecanus onocrotalus* Linnaeus, 1758	–	–	5	–	–	5	–
186	*Pericallia matronula* (Linnaeus, 1758)	–	4	4	4	4	–	4
187	*Phlogophora scita* (Hübner, 1790)	–	–	–	–	4	–	4
188	*Phytoecia tigrina* Mulsant, 1851	–	–	–	–	3	–	3
189	*Picoides tridactylus* (Linnaeus, 1758)	–	–	–	–	4	–	4
190	*Picus viridis* Linnaeus, 1758	4	–	4	4	4	4	4
191	*Pipistrellus kuhlii* (Kuhl, 1819)	4	4	–	4	–	–	–
192	*P. nathusii* (Keyserling et Blasius, 1839)	4	4	4	4	–	–	–
193	*P. pipistrellus* (Schreber, 1774)	4	–	4	4	–	–	–
194	*P.s pygmaeus* (Leach, 1825)	4	4	–	4	–	–	–
195	*Platalea leucorodia* Linnaeus, 1758	–	–	4	–	–	–	4
196	*Plebejus pylaon* (Fischer von Waldheim, 1832)	–	–	–	4	–	–	–
197	*Plebicula dorylas* (Denis & Schiffermüller, 1775)	–	–	5	–	5	–	–
198	*Plecotus auritus* (Linnaeus, 1758)	4	4	4	4	–	–	4
199	*P. austriacus* (Fischer, 1829)	–	4	–	4	–	–	–
200	*Plicuteria lubomirskii* (Ślósarski, 1881)	–	–	3	3	3	–	–
201	*Poecilimon ukrainicus* Bey-Bienko, 1951	–	–	4	4	4	–	–
202	*Polydesmus montanus* Daday, 1889	–	–	–	–	1	–	–
203	*Proclossiana eunomia* (Esper, 1799)	–	–	4	–	–	–	–
204	*Proserpinus proserpina* (Pallas, 1772)	3	–	–	3	3	–	3
205	*Prostenomphalia carpathica* Baidaschnikov, 1985	–	–	–	–	4	–	–
206	*Prunella collaris* (Scopoli, 1769)	–	–	–	–	4	–	4
207	*Pseudanodonta complanata* (Rossmässler, 1835)	4	–	4	4	4	–	–
208	*Pseudogaurotina excellens* (Brancsik, 1874)	–	–	–	–	4	–	4
209	*Pupilla sterrii* (Voith, 1840)	–	–	–	5	–	–	–
210	*P. triplicata* (S. Studer, 1820)	–	–	3	–	–	–	–
211	*Purpuricenus kaehleri* (Linnaeus, 1758)	4	–	4	4	–	4	4
212	*Quedius transsylvanicus* (Weise, 1875)	–	–	–	–	4	–	–
213	*Rana dalmatina* Fitzinger in Bonaparte, 1839	–	–	4	–	4	4	4
214	*Recurvirostra avosetta* Linnaeus, 1758	–	–	3	–	–	–	–
215	*Regulus ignicapillus* (Temminck, 1820)	–	–	2	–	–	–	–
216	*Rhinolophus ferrumequinum* (Schreber, 1774)	–	–	–	–	–	–	4
217	*Rh. hipposideros* (Bechstein, 1800)	–	–	–	4	4	–	4
218	*Rhysodes sulcatus* (Fabricius, 1787)	–	–	4	4	4	–	4
219	*Rhyssa kriechbaumeri* Ozols, 1973	–	–	–	–	3	–	–
220	*Romanogobio kesslerii* (Dybowski, 1862)	–	–	–	4	–	–	–
221	*Rosalia alpina* (Linnaeus, 1758)	–	–	4	–	4	4	4
222	*Rufibrenta ruficollis* (Pallas, 1769)	–	–	–	–	4	4	–
223	*Ruthenica filograna* (Rossmässler, 1836)	–	–	3	3	3	–	3
224	*Rutilus frisii* (Nordmann, 1840)	–	–	–	5	5	5	–
225	*Saga pedo* (Pallas, 1771)	–	–	–	–	3	–	3
226	*Salamandra salamandra* (Linnaeus, 1758)	–	–	4	–	4	4	4
227	*Saturnia pyri* (Denis & Schiffermüller, 1775)	–	–	4	4	4	–	4
228	*Sicista betulina* (Pallas, 1779)	4	–	4	4	–	–	–
229	*Somateria mollissima* (Linnaeus, 1758)	–	–	–	–	4	–	–
230	*Somatochlora arctica* Zetterstedt, 1840	–	4	–	–	–	–	–
231	*Sorex alpinus* Schinz, 1837	–	–	4	–	–	–	4
232	*Spalax zemni* (Erxleben, 1777)	–	–	4	–	–	–	–
233	*Spermophilus citellus* (Linnaeus, 1766)	–	–	–	–	–	5	–
234	*S. suslicus* (Güldenstaedt, 1770)	–	–	5	–	5	–	–
235	*Sphaerium nucleus* (Studer, 1820)	4	–	4	4	–	–	–
236	*Sphex funerarius* Gussakovskij, 1934	–	–	–	2	–	–	–
237	*Sphyradium doliolum* (Bruguière, 1792)	–	–	–	3	3	–	–
238	*Sterna albifrons* Pallas, 1764	3	–	3	–	–	–	–
239	*Strix uralensis* Pallas, 1771	–	–	1	1	1	1	1
240	*Sturnus roseus* (Linnaeus, 1758)	–	–	–	–	–	–	3
241	*Sympetrum pedemontanum* O.F. Müller, 1766	4	4	4	4	4	4	4
242	*Telestes souffia* Risso, 1827	–	–	–	–	–	–	4
243	*Temnostoma meridionale* Krivosheina, Mamayev, 1962	–	–	–	–	4	–	–

No.	Animalia	Western oblasts of Ukraine						
		Vl	Rv	Lv	Tr	IF	Ch	Zk
244	*Terricola tatricus* (Kratochvil, 1952)	–	–	–	–	–	–	4
245	*Tetrao urogallus* Linnaeus, 1758	–	–	–	–	–	5	–
246	*Tetrastes bonasia* (Linnaeus, 1758)	4	–	–	–	–	4	–
247	*Tetrodontophora bielanensis* (Waga, 1842)	–	–	3	3	3	–	3
248	*Thymallus thymallus* (Linnaeus, 1758)	–	–	–	–	4	–	4
249	*Trichoferus pallidus* (Olivier, 1790)	–	–	–	–	–	–	4
250	*Tringa stagnatilis* (Bechstein, 1803)	–	–	–	5	–	–	–
251	*Triturus cristatus* (Laurenti, 1768)	–	–	4	4	4	4	–
252	*Trocheta cylindrica* Orley, 1886	–	–	–	–	4	–	–
253	*Trochulus bielzi* (A. Schmidt, 1860)	–	–	–	–	3	3	3
254	*T. villosulus* (Rossmässler, 1838)	–	–	4	–	–	–	–
255	*Tyto alba* (Scopoli, 1769)	–	–	–	5	–	–	5
256	*Unio crassus* Philipsson, 1788	4	–	4	4	4	–	–
257	*Urophora dzieduszyckii* Frauenfeld, 1867	–	–	–	3	–	–	–
258	*Ursus arctos* (Linnaeus, 1758)	–	–	5	–	5	5	5
259	*Vertigo geyeri* Lindholm, 1925	7	–	–	–	–	–	–
260	*Vespertilio murinus* Linnaeus,1758	4	4	4	4	–	–	–
261	*Vestia elata* (Rossmässler, 1836)	–	–	–	4	4	–	–
262	*Xylocopa valga* Gerstaecker, 1872	–	–	3	3	3	3	3
263	*X. violacea* (Linnaeus, 1758)	–	–	–	3	–	–	–
264	*Zamenis longissimus* (Laurenti, 1768)	–	–	5	5	5	–	5
265	*Zerynthia polyxena* (Denis & Schiffermüller, 1775)	–	–	–	–	–	–	4
266	*Zingel zingel* (Linnaeus, 1766)	–	–	4	4	4	–	–
	Species	85	48	153	125	132	50	94
	Total score	336	189	598	485	503	195	351
	Total score/Species	3.95	3.94	3.91	3.88	3.81	3.9	3.73

Note: VL – Volyn oblast, RV – Rivne oblast, LV – Lviv oblast, TR – Ternopil oblast, IF – Ivano-Frankivsk oblast, CH – Chernivtsi oblast, ZK – Zakarpattia oblast, "–" – absence of recorded findings of the species in the DCBU.

Biodiversity assessment approaches. We assessed the diversity of species included in the Red Data Book of Ukraine by their conservation statuses by providing a scoring scale for each species (i.e., Disappearing species (DP), Vulnerable species (VU), and Rare species (RR)).

The ratio of the total number of points to the total number of species (Fig. 1) shows that the determination of the conservation category of species in different taxonomic groups (fungi, plants, animals) is carried out by specialists who have compiled the Red Data Books of Ukraine in different ways. As a result, the ratio of the number of points to the total number of species is underestimated for plants and overestimated for fungi.

The total scores and percentage estimates of the number of species of different conservation categories in the oblasts of the western region of Ukraine are shown in Table 4 and Figure 2 (A, B). In terms of the total number of registered species included in the Red Data Book of Ukraine, the leading positions are occupied by Lviv oblast (260 species), Ivano-Frankivsk oblast (219), Ternopil oblast (182) and Zakarpattia oblast (190). But if we take into account only the (Disappearing species (DP), Vulnerable species (VU), and Rare species (RR) species, then leading positions are occupied by Lviv oblast (238 species), Ivano-Frankivsk oblast (207), Zakarpattia oblast (175) and Ternopil oblast (160).

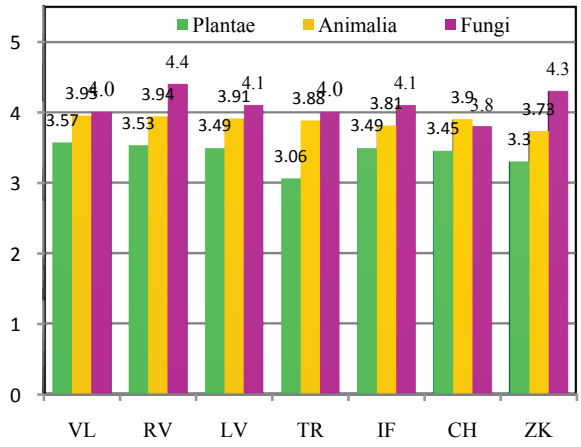
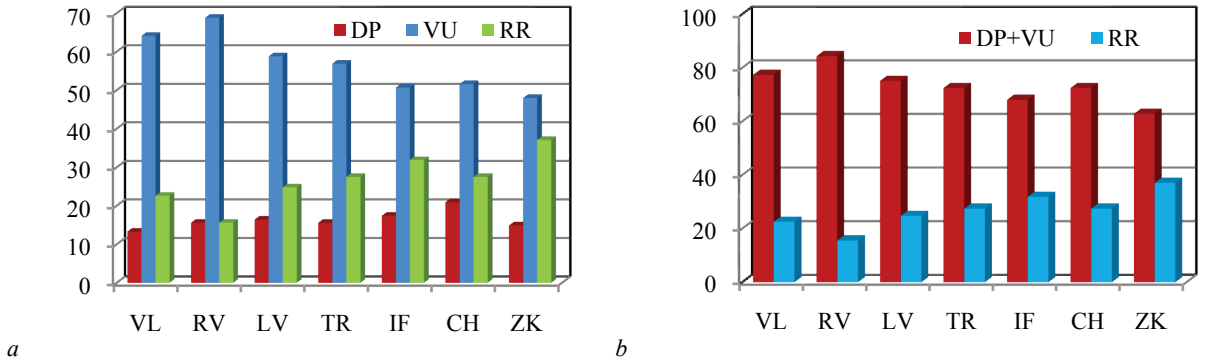


Fig. 1. Ratio of the total number of points to the total number of species in the oblasts of the western region of Ukraine

Table 4

Total scores and percentage (score %) estimates of species of different protected categories in the oblasts of the western region of Ukraine (grey fill highlights the rows used for evaluation)

RDBU protected categories	Oblasts						
	Vl	Rv	Lv	Tr	IF	Ch	Zk
EX	1/–	–	–	–	–	–	1/–
EW	1/–	–	1/–	–	1/–	1/–	–
DP	17/13.3%	12/15.6%	39/16.4%	25/15.6%	36/17.4%	19/20.9%	26/14,9%
VU	82/64.1%	53/68.8%	140/58.8%	91/56.9%	105/50.7%	47/51.6%	84/48.0%
RR	29/22.6%	12/15.6%	59/24.8%	44/27.5%	66/31.9%	25/27.5%	65/37.1%
NE	8/–	8/–	19/–	20/–	8/–	12/–	12/–
DD	1/–	–	2/–	2/–	3/–	1/–	2/–
Total	139	85	260	182	219	105	190
Total (DP+VU+RR)	128/100%	77/100%	238/100%	160/100%	207/100%	91/100%	175/100%



a *b*

Fig. 2. Percentage estimates of species of Disappearing species (DP), Vulnerable species (VU) and Rare species (RR) protected categories (*a*) and Disappearing species (DP) + Vulnerable species (VU) and Rare species (RR) protected categories (*b*) in the oblasts of the western region of Ukraine

Lviv and Ivano-Frankivsk oblasts have the highest number of Disappearing species (DP) (39 and 36 species respectively), and Rivne oblast has the lowest (12 species), and in percentage terms, Chernivtsi and Ivano-Frankivsk oblasts have the highest rates (20.9% and 17.4% species respectively), and Volyn oblast has the lowest (13.3%). In terms of Vulnerable species (VU), Lviv and Ivano-Frankivsk oblasts have the highest number

(140 and 105 species, respectively), and Chernivtsi oblast has the lowest (47 species), while in percentage terms, Rivne and Volyn oblasts have the highest (68.8% and 64.1% species, respectively) and Zakarpattia oblast the lowest (48.0%). In terms of Rare species (RR), Ivano-Frankivsk, Zakarpattia and Lviv oblasts have the highest number (66, 65 and 59 species respectively), and Rivne oblast has the lowest (12 species). In contrast, Zakarpattia and Ivano-Frankivsk oblasts have the highest (37.1% and 31.9% species, respectively) and Rivne oblast (15.6%) has the lowest percentage of Rare species (RR) (Table 4, Fig. 2a).

By supporting these outcomes with Disappearing species (DP) and Vulnerable species (VU) species as the most valuable from a conservation point of view, the result will be slightly different (Fig. 2b). Lviv oblast is the richest in terms of the number of these species (179 species), followed by Ivano-Frankivsk, Ternopil and Zakarpattia oblasts (141, 116, and 110 species respectively), and Rivne region with the lowest number of species (65). The most significant number of these species in percentage terms is represented by Rivne oblast (84.4%), Volyn and Lviv regions have a slightly smaller number (77.4% and 75.2% species respectively), and Zakarpattia region has the smallest number (62.9%).

Hotspot areas. We distinguished three prominent biodiversity hotspots in the western part of Ukraine (1. Shatskyi National Nature Park – 112 species included in the Red Data Book of Ukraine up to 57 per aggregation square; 2. Lviv city vicinity and Nature Reserve "Roztochchia" – 104 species are included in the Red Data Book of Ukraine, up to 104 per aggregation square; 3. Nature Reserve "Medobory" – 136 species included in the Red Data Book of Ukraine up to 80 per aggregation square) and 5 smaller ones (4. National Nature Park "Prypiat-Stokhid" – 21 species included in the Red Data Book of Ukraine up to 11 per aggregation square; 5. Nature Reserve "Rivnenskyi" – 48 species included in the Red Data Book of Ukraine, locality Dubky-Rozvylka up to 14 per aggregation square; 6. National Nature Park "Pivnichne Podillia" – 50 species are included in the Red Data Book of Ukraine, and locality Lysa Hora is up to 14 per aggregation square; 7. National Nature Park "Halytskyi" – 47 species included in the Red Data Book of Ukraine up to 46 per aggregation square; 8. National Nature Park "Carpathians" – 63 species included in the Red Data Book of Ukraine and Carpathian Biosphere Reserve: Chornohora protected massif – 46 species included in the Red Data Book of Ukraine, Chornohora mountain range in general – 91 species included in the Red Data Book of Ukraine, Fig. 3).

Using the Data Centre "Biodiversity of Ukraine" species aggregation maps with a search engine tool (20 × 20 km aggregation square), we have identified species included in the Red Data Book of Ukraine hotspots for Volyn Polissya, the Temperate broad-leaf forests zone and the Ukrainian Carpathians, which fully cover the territory of the western region of Ukraine.

Not many hotspots were identified in Volyn Polissya (Fig. 4) apparently due to the poorer knowledge of this region. The main hotspot is located on the territory of the Shatsk National Nature Park (squares: d, e, f, g). The following two hotspots are situated within larger nature reserves: the Prypiat-Stokhid National Nature Park (squares: b, c) and the Rivne Nature Reserve (squares: h – Bile Lake locality, i – Syra Pohonia locality, j – Dubky-Rozvylka locality), where there is a lot of data on the occurrence of species included in the Red Data Book of Ukraine. One hotspot is connected with the territory of the Zalukhivskyi hydrological reserve and the outskirts of the village of Mezhysyt (square: a).

There are significantly more hotspots for the Temperate broad-leaved forests zone (Fig. 5) and, importantly, they are not always confined to protected areas. Here is a list of them from top left to bottom right. The hotspot (squares: a, b) is located in the valley of the Western Buh River near the village of Potorytsia. In 1778, this village, along with others, was bought by Yozef Diduszytskyi, the father of Count Volodymyr Diduszytskyi, the founder of the Natural History Museum in Lviv. There was a family estate in the village, and in its vicinity, the count himself and other researchers collected numerous specimens that are now stored in the collections of the State Museum of Natural History, National Academy of Sciences of Ukraine in Lviv. These hotspots can be called historical biodiversity hotspots where high levels of species diversity have been observed in the past. The next two hotspots (squares: c, d) are associated with water reservoirs: Burshtyn Reservoir and Khmelnytskyi NPP Reservoir, as wintering grounds for migratory waterfowl.

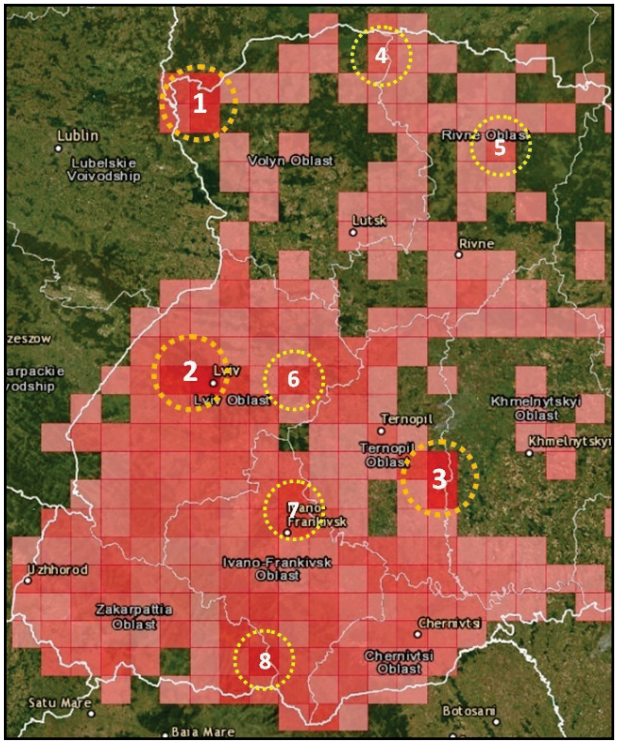


Fig. 3. Species aggregation map of the western part of Ukraine (squares 20 × 20 km) with biodiversity hotspots: *1* – Shatskyi National Nature Park; *2* – Lviv city and Nature Reserve "Roztochchia"; *3* – Nature Reserve "Medobory"; *4* – National Nature Park "Prypiat-Stokhid"; *5* – Nature Reserve "Rivnenskyi", locality Dubky-Rozvylka; *6* – National Nature Park "Pivnichne Podillia", locality Lysa Hora; *7* – National Nature Park "Halytskyi"; *8* – National Nature Park "Carpathians" and Carpathian Biosphere Reserve, Chornohora mountain range

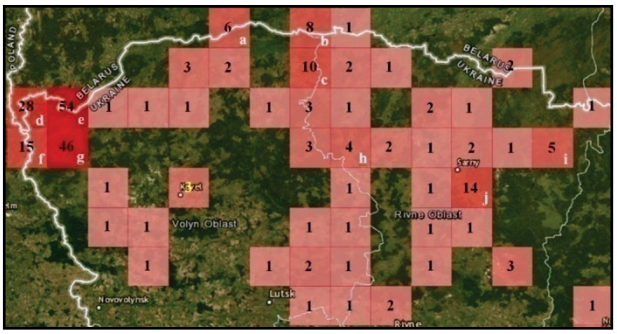


Fig. 4. Species included in the Red Data Book of Ukraine aggregation map of the Volynske Polissia region (squares 20 × 20 km) with the number of registered species in squares: white letters indicate squares with increased diversity; numbers are highlighted in yellow for better visibility

A significant area is occupied by the hotspot of the city of Lviv and its surroundings, where the Roztochchia Biosphere Reserve is located, which includes the Roztochia Nature Reserve, the Yavorivskyi National Nature Park and the Ravske Roztochia Regional Landscape Park (squares: e, f, i, j, k), and where biological research has been conducted since the mid-19th century. The next, a resonably large array of hotspot territories, is located in the Northern Podillya National Natural Park (squares: g, l – Lysa Hora Mt and Sypukha Mt reserve, m and n – Peniaky village vicinity (historical biodiversity hotspot)), which combines both mountain and steppe flora and fauna. In the Peniaky village there was also the estate of the founder of the State Museum of Natural History, National Academy of Sciences of Ukraine in Lviv, Count Volodymyr Didushytskyi. He, and other scientists conducted research in the vicinity of the village, and the collected material

was deposited in the collections of his museum. In addition, near the village in 1886, V. Didushytskyi founded the first nature reserve created within the boundaries of modern Ukraine, the "Pamiatka Peniatska", which is now an integral part of the Northern Podillya National Nature Park.

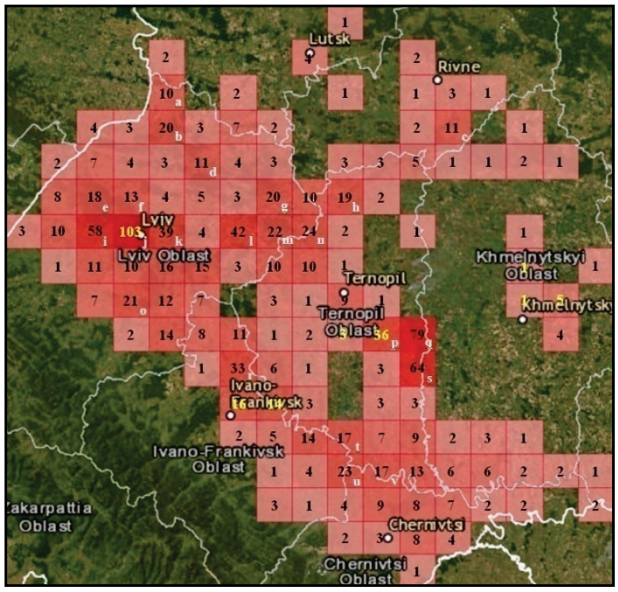


Fig. 5. Species included in the Red Data Book of Ukraine aggregation map of the Temparate broad-leaf forests zone (squares 20 × 20 km) with the number of registered species in squares: white letters indicate squares with increased diversity; numbers are highlighted in yellow for better visibility

The next hotspot is located in the National Nature Park Kremenetski Hory (square: h). Several hotspot territories confined to the valley of the Dnister River and natural reserves located along the banks of this river (squares: o – floodplain oak forests and meadows in the Koshiv reserve; t, u, v – valley of the Dnister River and National Nature Park "Dnistrovskyi Canyon" and Regional Landscape Papk "Dnister"). The Nature Reserve "Medobory" represents a principal hotspot territory (squares: p, q, s). Another hotspot area is associated with the National Nature Park "Halytskyi" (square: r – Kasova Hora locality).

In the Ukrainian Carpathians, there are registered quite a lot of hotspot areas that reflect the richness of mountainous biota and diversity of high-altitude plant zones (Fig. 6). Also, a significant number of hotspot areas contributed to the increased attention of researchers to the study of the Carpathian flora and fauna since the mid-19th century. Hotspot areas (squares: a, b, c) are located in the area of famous resorts Truskavets, Skhidnytsia, and Morshyn that attract both ordinary tourists and naturalists. The next hotspot area is located in the National Nature Park "Halytskyi" and Ivano-Frankivsk city vicinity (squares: d, e, h, i, k). The following hot areas are located in the National Nature Park "Uzhanskyi" (square: f), National Nature Park "Skolivski Beskydy" (square: g), "Pikui" reserve / zakaznyk (square: j). A hotspot territory is also in the area of the city of Uzhgorod (square: g). An important hotspot area covers beech forests and the subalpine zone (a place where wind power stations are going to be installed) of the Borzhava ridge (square: m). Two hotspot territories are located in the vicinity of large cities: Kolomyia (square: q) and Chernivtsi (square: u), which is since in the 19th and 20th centuries, the routes of scientists to the highest part of the Ukrainian Carpathians – the Chornohora ridge ran through Kolomyia city where they stayed and conducted scientific research, and in Chernivtsi city at that time many scientists lived and worked. The remaining hot areas are confined to nature reserves: National Nature Park "Zacharovanyi Krai" (square: n), Nature Reserve "Gorgany" (square: o), National Nature Park "Carpathian" (square: p, s, w), National Nature Park "Hutsulshchyna" (square: t), National Nature Park "Verkhovynskyi", Chyvchyny mountain range (square: y), National Nature Park "Cheremoskyi", Chornyi Dil mountain range (square: z) and the Carparthian Biosphere Reserve: Svydovets protected massif (square: r), Chornohora protected massif (square: w), Marmarosh and Kuziy-Trybushany protected massifs (square: x) and Chorna Hora protected massif (square: v).

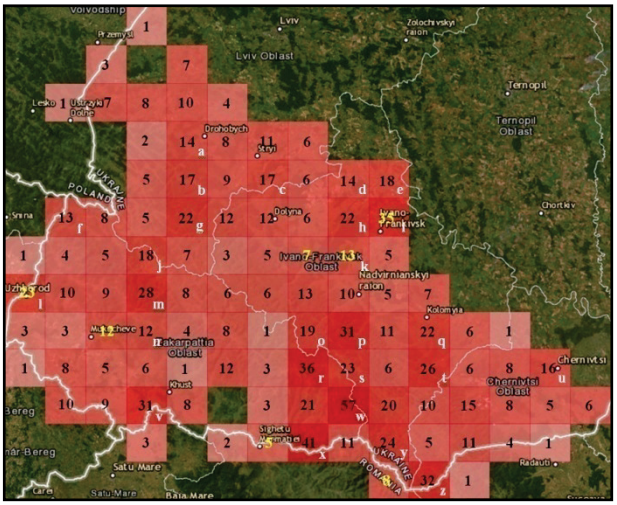


Fig. 6. Species included in the Red Data Book of Ukraine aggregation map of the Ukrainian Carpathians (squares 20 × 20 km) with the number of registered species in squares: white letters indicate squares with increased diversity; numbers are highlighted in yellow for better visibility

Discussion

In Ukraine, the problem of approaches to assessing the diversity of faunal complexes was studied at the end of the second millennium – the first decade of the third millennium (Zahorodniuk et al., 1995; Yemelyanov et al., 1999; Zahorodniuk, 2009). In ecological, faunal, and floral studies, it is not always possible to obtain quantitative data on the number of a species, population density of different groups of animals or plants in a region, etc., while qualitative data are present in any study. Therefore, the question often arises about how this data can be used in the analysis. As was shown, using qualitative data from faunal studies for a systematic approach and information theory can answer these questions. For this purpose, data on the species richness of the community can be used. Further, by analyzing the representation of species within taxa of higher hierarchical levels (for genera, families, orders, etc.), it is possible to quantify (as a proportion of the total number of species in the community) the species richness of taxa of different ranks. If species abundance data are available, they are included in the analysis instead of the proportion of species represented.

Indicators of species and taxonomic diversity can be used to assess the complexity of the structural organization of faunal complexes, plant associations or biotic communities. While the indicator of species diversity assesses the quantitative side of the organisation in a community, the indicator of taxonomic diversity reflects the qualitative side of the degree of community organization.

As a result, in addition to assessing taxonomic richness and diversity, we proposed a formula for evaluating the structural complexity of the community $C = (H_{tax} * 1/N \Sigma H_i)^n$, which takes into account H_{tax} – an indicator of taxonomic diversity; Hi – an indicator of species diversity of the *i*-th taxonomic level, N – the number of analyzed levels, n – an indicator of degree (n = 1/2). The proposed indicator takes into account both the structure of taxonomic relationships of organisms and their partial representation at different taxonomic levels. At the same time, it reflects a qualitative and quantitative characteristic of the organization of the community. In this regard, it can be considered an integral indicator that assesses the diversity of biotic communities. The modeling analysis showed sufficient efficiency of this indicator in determining the complexity or degree of organization of communities of organisms of different taxonomic groups.

An attempt at a score assessment of the biodiversity of the nature reserve fund (NRF) of Donetsk oblast during the formation of local eco-networks was carried out by Spinova (2015). For the assessment, she applied

the characteristics and their score estimates: a) by area (S) of the NRF objects according to the corresponding scale; b) biological diversity (B) (number of plant species) of NRF objects according to the corresponding scale; c) the number of rare species was taken into account as follows: for each species from the Red Book of Ukraine, 0.5 points were added, and for each species from the European List and the IUCN Red Book – 1 point; d) phytocoenotic diversity (F) was calculated by the number of phytocoenoses – plant groups listed in the Green Book of Ukraine, 2 points for each such phytocoenosis; e) edaphic diversity (E) was taken as a variety of soil types and subtypes: 1 soil type = 0.5 points, and for each subtype 1 point. The formula determined the cumulative score of the natural potential of each object is following: C = B + F + E + S, where B is the sum of points for biological diversity; F – score for phytocoenotic diversity; E – the sum of points for edaphic diversity; S – points for the area of objects. According to the obtained data, the highest comprehensive scores were given to the National Nature Parks, the Nature Reserves and the Regional Landscape Parks (Spinova, 2015).

Recently, hotspots of diversity have been identified for Ukrainian grassland habitats (Kuzemko, 2022). The study was based on the determination of the total species richness and biodiversity indices of Shannon-Wiener and Simpson for 15,550 vegetation plots, divided into three groups (steppes, mesic grasslands, wet grasslands), the plots with the lowest and highest values for all three indicators were determined. For steppe habitats, the Dniester basin and river valleys of the steppe zone, primarily the Southern Bug and Ingul basins, as well as the Askania-Nova Biosphere Reserve, were identified as hotspots based on available data. For mesic grasslands, the "hotspot" was the Carpathian region with a small enclave in Bukovina, and for wet grasslands – the basins of the Western Bug and Desna rivers.

The assessment system we have used is not as elaborate as Spinova's assessment and can, with further refinement and improvement, be used as a component of a more complex biodiversity assessment system. However, using the automated search engine of the Data Centre "Biodiversity of Ukraine" using its existing database offers significant advantages and speeds up the acquisition of the necessary data.

Use of a search engine of the Data Centre "Biodiversity of Ukraine" to identify biodiversity hotspots demonstrated promising results. Applying the 20 × 20 km net, we managed to identify many hotspot territories not tied to protected areas.While applying more extensive data aggregation with 1 × 1 and 0.5 × 0.5 km squares is even more promising in the case of ascertaining local biodiversity.

Conclusion

Species diversity of the species included in the Red Data Book of Ukraine of the western region of Ukraine in the CDBU is represented by 498 species (fungi – 41, plants – 191, animals – 266). By oblasts: Volyn oblast – 139 species (fungi – 3, plants – 51, animals – 85), Rivne oblast – 85 (fungi – 5, plants – 32, animals – 48), Lviv oblast – 260 (fungi – 17, plants – 90, animals – 153), Ternopil oblast – 182 (fungi – 9, plants – 48, animals – 125), Ivano-Frankivsk jblast – 219 (fungi – 28, plants – 59, animals – 132), Chernivtsi oblast – 105 (fungi – 6, plants – 49, animals – 50), Zakarpattia oblast – 190 (fungi – 26, plants – 70, animals – 94).

In terms of the total number of registered species included in the Red Data Book of Ukraine, the leading positions are occupied by Lviv oblast (260 species), Ivano-Frankivsk oblast (219), Ternopil oblast (182) and Zakarpattia oblast (190). But if we take into account only the (Disappearing species (DP), Vulnerable species (VU), and Rare species (RR) species, then leading positions are occupied by Lviv oblast (238 species), Ivano-Frankivsk oblast (207), Zakarpattia oblast (175) and Ternopil oblast (160).

Considering the Disappearing species (DP) and Vulnerable species (VU) species jointly, as the most valuable from a conservation point of view, Lviv oblast is the richest in terms of the number of these species (179 species), followed by Ivano-Frankivsk, Ternopil and Zakarpattia oblasts (141, 116 and 110 species respectively), and Rivne region with the lowest number of species (65). The largest number of these species in percentage terms is represented by Rivne region (84.4%), Volyn and Lviv regions have a slightly smaller number (77.4% and 75.2% species respectively), and Zakarpattia region has the smallest number (62.9%).

We consider that protected statuses Extinct in the wild (EW), Disappearing species (DP), Not Evaluated species (NE), Data Deficient (DD) are not suitable for assessing biodiversity, as the first two refer to species that no longer exist in nature, and the latter two only indicate insufficient study level of the species to which they have been assigned.

Unifying the approach to identifying protected categories in the Red Data Books of Ukraine is important to optimize the biodiversity assessment process.

The attempt to evaluate the diversity of the species included in the Red Data Book of Ukraine using a point scale showed that it is possible, but the point scale needs to be improved and additional indicators applied. The use of the automated search engine of the Data Centre "Biodiversity of Ukraine" using its existing database offers significant advantages and speeds up the acquisition of the necessary data.

Using the CDBU's map aggregation tool, a number of hotspots were identified for Volyn Polissya, the Broad-leaf forest zone, and the Ukrainian Carpathians. Most hotspots coincide with the territories of the nature reserve fund of Ukraine, and some hotspots are located in large cities (scientific centers) with vicinities. Importantly, we managed to identify hotspots outside the boundaries of the Ukrainian nature reserve fund, including the territories of large water reservoirs, river valleys, and historical biodiversity hotspots.

Thus, CDBU tools can be used to assess rare biodiversity and its restoration in the post-war period, as well as to identify hotspots and locations for creating new protected territories, identifying ecological corridors and developing ecological networks.

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References

Akimov, I. A. (Ed.). (2009). Chervona knyha Ukrainy. Tvarynnyi svit [Red Data Book of Ukraine. Animals]. Globalkonsaltynh, Kyiv (in Ukrainian).

Bartkowski, B., Lienhoop, N., & Hansjürgens, B. (2015). Capturing the complexity of biodiversity: A critical review of economic valuation studies of biological diversity. Ecological Economics, 113, 1–14.

Didukh, Y. P. (Ed.). (2009). Chervona knyha Ukrainy. Roslynnyi svit [Red Data Book of Ukraine. Plants]. Globalkonsaltynh, Kyiv (in Ukrainian).

Habel, J. C., Rasche, L., Schneider, U. A., Engler, J. O., Schmid, E., Rödder, D., Meyer, S. T., Trapp, N., Sos del Diego, R., Eggermont, H., Lens, L., & Stork, N. E. (2019). Final countdown for biodiversity hotspots. Conservation Letters, 12(6), e12668.

Heip, C. H. R., Herman, P. M. J., & Soetaert, K. (1998). Indices of diversity and evenness. Oceanis, 24(4), 61–87.

Hill, Y. (1993). How birds help map hotspots. People and the Planet, 2(3), 10.

Hushtan, K., & Hushtan, H. (2024). Catalogue of Bracychthoniidae (Sarcoptiformes, Oribatida) specimens deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 2. Herbarium, acarological and entomological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 31–40.

Kuzemko, A. A. (2022). "Hariachi" ta "kholodni" tochky bioriznomanittia travianykh biotopiv Ukrayiny [Biodiversity "hot" spots and "coldspots" of grassland habitats of Ukraine]. News Biosphere Reserve "Askania Nova", 24, 22–27 (in Ukrainian).

Kuzyarin, O. (2023). Catalogue of *Asplenium viride* Huds. (Aspleniaseae, Polypodiopsida, Polypodiophyta) samples deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 1. Herbarium, entomological and mammological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 38–74.

Kuzyarin, O. (2024). Catalogue of *Asplenium septentrionale* (L.) (Tracheophyta, Polypodiopsida, Aspleniaceae) specimens deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 2. Herbarium, acarological and entomological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 15–30.

López-López, P., Maiorano, L., Falcucci, A., Barba, E. & Boitani, L. (2011). Hotspots of species richness, threat and endemism for terrestrial vertebrates in SW Europe. Acta Oecologica, 37(5), 399–412.
Lyashevska, O., & Farnsworth, K. D. (2012). How many dimensions of biodiversity do we need? Ecological Indicators, 18, 485–492.
Marchese, C. (2015). Biodiversity hotspots: A shortcut for a more complicated concept. Global Ecology and Conservation, 3, 297–309.
Morelli, F., Kwieciński, Z., Indykiewicz, P., Jankowiak, Ł., Szymański, P., Šímová, P., & Tryjanowski, P. (2019). Congruence between breeding and wintering biodiversity hotspots: A case study in farmlands of Western Poland. European Journal of Ecology, 4(2), 75–83.
Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Ken, J. (2000). Biodiversity hotspots for conservation priorities. Nature, 403, 853–858.
Nieto-Romero, M., Oteros-Rozas, E., González, J. A., & Martín-López, B. (2014). Exploring the knowledge landscape of ecosystem services assessments in Mediterranean agroecosystems: Insights for future research. Environmental Science and Policy, 37, 21–133.
Noori, S., Hawlitschek, O., Oldeland, J., Rajaei, H., Husemann, M., Simões, M. (2021). Biodiversity modelling reveals a significant gap between diversity hotspots and protected areas for Iranian reptiles. Journal of Zoological Systematics and Evolutionary Research, 59, 1642–1655.
Novikov, A. V., Hushtan, H. H., Hushtan, K. V., Kuzyarin, O. T., Leleka, D. Y., Nachychko, V. O., Prots, B. H., Rizun, V. B., Savytska, A. H., Sususlovska, S. A., & Susulovskyi, A. S. (2023). Okreslennia tsiley i format proiektu "Otsyfruvannia pryrodnychykh kolektsii, shcho zaznaly ushkodzhennia vnaslidok boiovykh dii i suputnikh faktoriv: Rozrobka protokoliv i vprovadzhennia na bazi Derzhavnoho pryrodoznavchoho muzeiu NAN Ukrainy [Digitization of natural history collections damaged as a result of hostilities and related factors: Development of protocols and implementation on the basis of the State Museum of Natural History of the National Academy of Sciences of Ukraine]. Proceedings of the State Natural History Museum. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 19–30 (in Ukrainian).
Novikov, A., Savytska, A., Kuzyarin, O., Nachychko, V., Susulovska, S., Rizun, V., Susulovsky, A., Hushtan, H., Hushtan, K., & Leleka, D. (2024). Data mobilisation in the LWS Herbarium: Success and prospects. Biodiversity Data Journal, 12, e117292.
Page, L. M., Macfadden, B. J., Fortes, J. A., Soltis, P. S., & Riccardi G. (2015). Digitization of biodiversity collections reveals biggest data on biodiversity. Bioscience, 65(9), 841–842.
Rizun, V. (2024a). Catalogue of *Carabus estreicheri* Fischer von Waldheim, 1820 & *Carabus excellens* Fabricius, 1798 (Coleoptera, Carabidae) specimens deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 2. Herbarium, acarological and entomological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 41–94.
Rizun, V. (2024b). Catalogue of *Nebria picicornis* (Fabricius, 1792) (Coleoptera, Carabidae) specimens deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 2. Herbarium, acarological and entomological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 95–114.
Rizun, V., & Diedus, V. (2023). Catalogue of *Rhysodes sulcatus* (Fabricius, 1787) (Coleoptera, Carabidae) specimens deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 1. Herbarium, entomological and mammological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 101–110.
Rizun, V., & Shcherbachenko, T. (2019). Vykorystannia ahrehatsiinykh kart v internet-portali Tsentr danykh "Bioriznomanittia Ukrainy" dlia analizu prostorovoho rozpodilu bioty [The use of aggregated maps on the web portal Data Centre "Biodiversity of Ukraine" in spatial distribution analysis of the biota]. Geo&Bio, 18, 164–172 (in Ukrainian).
Rizun, V., Diedus, V., Hushtan, H., Hushtan, K., Konovalova, I., Kuzyarin, O., Novikov, A., Savytska, A., Serediuk, H., Shcherbachenko, T., Yanytsky, T., & Zamoroka, A. (2023). Representativeness of biota of the western part of Ukraine in the Data Centre 'Biodiversity of Ukraine'. Geo&Bio, 25, 51–63.
Savytska, A. (2023). Catalogue of specimens of genus Bazzania Gray (Lepidoziaceae, Jungermanniales) deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 1. Herbarium, entomological and mammological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 5–37.
Savytska, A. (2024). Catalogue of *Palamocladium euchloron* (Müll. Hal.) Wijk et Margad. (Hypnales, Brachytheciaceae) specimens deposited in the State Museum of Natural History NASU, Lviv, Ukraine. In: Catalogue of the digitized collections, deposited in the State Museum of Natural History, National Academy of Sciences of Ukraine. Issue 2. Herbarium, acarological and entomological collections. State Museum of Natural History, NAS of Ukraine, Lviv. Pp. 5–14.
Spinova, Y. O. (2015). Balna otsinka bioriznomanittia pryrodno-zapovidnoho fondu Donetskoyi oblasti pry formuvanni lokal'nykh ekomerezh [Score evaluation of biodiversity of the nature reserve fund of Donetsk oblast in the formation of local ecological networks]. NaUKMA Research Papers, Biology and Ecology, 171, 56–63 (in Ukrainian).
Swarts, E. A., Pushkaryov, S. V., Krever, V. G., & Ostrovsky, M. A. (1995). Geography of mammal diversity and searching for ways to predict global changes in biodiversity. Journal of Biogeography, 22, 907–914.
Taszakowski, A., & Depa, Ł. (2022). The rapid decrease of biodiversity studies in well-researched areas – the case of Poland. Annals of the Upper Silesian Museum in Bytom, Entomology, 31, 1–5.
Terentiev, P. V. (1963). Opyt primenieniya analiza kolichiestviennogo bogatstva fauny naziemnykh pozvonochnykh SSSR [Experience in applying the analysis of quantitative richness of the terrestrial vertebrate fauna of the USSR]. Vestnik Leningradskogo Universiteta, Biologiya, 21, 19–26 (in Russian).
Tilman, D., Knops, J., Wedin, D., Reich, P., Ritchie, M., & Siemann, E. (1997). The influence of functional diversity and composition on ecosystem processes. Science, 277, 1300–1302.
Trew, B. T., & Maclean, I. M. D. (2021). Vulnerability of global biodiversity hotspots to climate change. Global Ecology and Biogeography, 30(4), 768–783.
Werner, U., & Buszko, J. (2005). Detecting biodiversity hotspots using species-area and endemics-area relationships: The case of butterflies. Biodiversity and Conservation, 14, 1977–1988.
Yemelianov, I. H., Zahorodniuk, I. V., & Khomenko, V. N. (1999). Taksonomicheskaya struktura i slozhnost' bioticheskikh soobshchiestv [Taxonomic structure and complexity of biotic communities]. Ecology and Noospherology, 8(4), 6–17 (in Russian).
Zahorodniuk, I. V. (1997). Kontseptsiia "hariachykh terytorii" i zberezhennia bioriznomanittia [The concept of 'hotspots' and biodiversity conservation]. In: Hardashuk, Y. (Ed.). The convention on biological diversity: Public awareness and participation. Stylos, Kyiv. Pp. 59–68 (in Ukrainian).
Zahorodniuk, I. V. (2009). Indykatory bioriznomanittia stepovykh ecosystem yak kryteriyi tsinnosti pryrodnykh yader [Indicators of steppe ecosystem biodiversity as criteria of natural core value]. In: Ecological aspects of the Luhanschyna in context of sustainable development. LNAU, Luhansk. Pp. 120–125 (in Ukrainian).
Zahorodniuk, I. V., Yemelianov, U. H., & Khomenko, V. N. (1995). Otsenka taksonomicheskogo raznoobraziya faunisticheskikh kompleksov [Estimation of taxonomic diversity in faunistic communities]. Reports of the National Academy of Sciences of Ukraine, 7, 145–148 (in Russian).