

Representativeness of biota of the western part of Ukraine in the Data Centre ‘Biodiversity of Ukraine’

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abstract

This paper summarises the inventory of biota of the western region of Ukraine in the web resource Data Centre ‘Biodiversity of Ukraine’ (DCBU) (<http://dc.smmh.org>), a growing biodiversity platform launched on 25 May 2017 and which organises knowledge on the biodiversity of Ukraine. The main objective and originality of DCBU is to aggregate curated biodiversity data of different kinds (e.g. scientific and vernacular names, data records of species, their geotagged geographical and biotopic distribution, conservation categories, and representation in protected areas of Ukraine). The database of the resource is primarily filled with data concerning 7 oblasts (Volyn, Rivne, Lviv, Ternopil, Ivano-Frankivsk, Chernivtsi, and Zakarpattia oblasts) of the western region of Ukraine, which is discussed in this article. Currently, the following number of species of living organisms has been recorded for the mentioned oblasts of the region: Volyn Oblast—1311 species/80 protected species listed in the Red Data Book of Ukraine, Rivne Oblast—535/47, Lviv Oblast—3163/211, Ternopil Oblast—1081/164, Ivano-Frankivsk Oblast—1942/157, Chernivtsi Oblast—672/87, and Zakarpatska Oblast—2125/149. Taxonomic accounts in the DCBU cover 5 kingdoms (Chromista, Protista, Plantae, Fungi, and Animalia), 22 phyla, 81 classes, 283 orders, 1292 families, 4741 genera, and 11 763 species. DCBU enables the following operations to be accomplished: to create species lists of different taxonomic rank of separate territorial regions and water bodies of the country and also of different time intervals, to create lists of protected and endemic species and of those that are deposited in collections of scientific institutions; to find a particular specimen according to the inventory number, to create species lists according to the type of recording/collecting, collected or determined by certain specialists, to search for literature sources concerning the Ukrainian biota, and to advanced search for all mentioned parameters as well. The accumulation of information on biodiversity, the possibility of its searching and the free access would promote the development and speed-up of scientific research, the effective control of the ecological state of the environment by the public, and sustainable development.

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Представленість біоти західної частини України в Центрі даних «Біорізноманіття України»

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Резюме. Ця стаття підсумовує інвентаризацію біоти західного регіону України на веб-ресурсі Центр даних «Біорізноманіття України» (ЦДБУ). (<http://dc.smnh.org>) — платформі з біорізноманіття яка розвивається і систематизує знання про біорізноманіття України. Основним завданням та специфікою ЦДБУ є узагальнення даних про біорізноманіття різних типів (наприклад наукові і вернакулярні назви, дані про знахідки видів, їхнє геотеговане географічне і біотопічне поширення, охоронні категорії, представленість у резерватах України). База даних ресурсу наповнена, насамперед, даними щодо 7 областей (Волинська, Рівненська, Львівська, Тернопільська, Івано-Франківська, Чернівецька та Закарпатська) західного регіону України, що обговорюється у цій статті. На цей час для зазначених областей регіону зареєстровано наступну кількість видів живих організмів: Волинська область — 1311 видів / 80 видів включених до Червоної книги України, Рівненська область — 535 / 47, Львівська область — 3163 / 211, Тернопільська область — 1081 / 164, Івано-Франківська область — 1942 / 157, Чернівецька область — 672 / 87 і Закарпатська область — 2125 / 149. Таксономічно ЦДБУ охоплює 5 царств (Chromista, Protista, Plantae, Fungi, Animalia), 22 типи, 81 клас, 283 ряди, 1292 родин, 4741 родів і 11763 види. ЦДБУ дозволяє виконувати наступні операції: створювати списки видів різних таксономічних одиниць окремих територіальних виділів і водойм України як і різних часових проміжків, списки видів які мають охоронний статус та ендемічних видів, а також для видів які зберігаються у колекціях наукових інституцій; знаходити конкретні зразки за їхніми інвентарними номерами, створювати списки видів згідно з типом даних (способом збору/колекціонування), зібрані чи визначені певним спеціалістом, проводити пошук літературних джерел які стосуються біоти України і розширений пошук за усіма згаданими параметрами. Накопичення інформації про біорізноманіття, можливість її пошуку та вільний доступ до неї сприятиме як розвитку та прискоренню наукових досліджень, так і ефективному контролю за екологічним станом довкілля з боку громадськості та сталому розвитку.

Ключові слова: біологія, біорізноманіття, флора, фауна, Україна, великі дані

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Introduction

One of the tasks of the web resource Data Centre 'Biodiversity of Ukraine' (<http://dc.smnh.org/>) is the documentation of the biota of Ukraine based on reliable scientific data. Given that Ukraine is one of the largest countries in Europe, it is impossible to cover its entire territory with this process at once. Therefore, at this stage of development of the web resource, the main number of finds/records of species is concentrated in the western region of Ukraine.

The area of Ukraine is 603 700 km² and it is the largest country by area among those fully located in Europe. The following natural zones are located in the territory of Ukraine from north to south: mixed forests, forest-steppe, steppe, and the Ukrainian Carpathians and Crimean Mountains, which are separate natural areas (Fig. 1, *a-b*).

Scientific research into the biota of Ukraine has been carried out for more than 250 years and currently approximately 72 000 species are recorded (fungi and myxomycetes—15 000; algae—5000; lichens—1200; mosses—800; vascular plants—5100, and taking into account exotic species grown in the soil of botanical gardens—more than 7500 species; insects—35 000; other arthropods—3500; protozoans—1800; nematodes—1600; flatworms—1280; annelids—440; fishes—over 200; amphibians—20; reptiles—23; birds—424; and mammals—132) [Analysis... 2017].

For two and a half centuries, the nature of Ukraine has changed significantly and its biota has changed accordingly. Now the total area of the forest fund of Ukraine is 10.4 million hectares, of

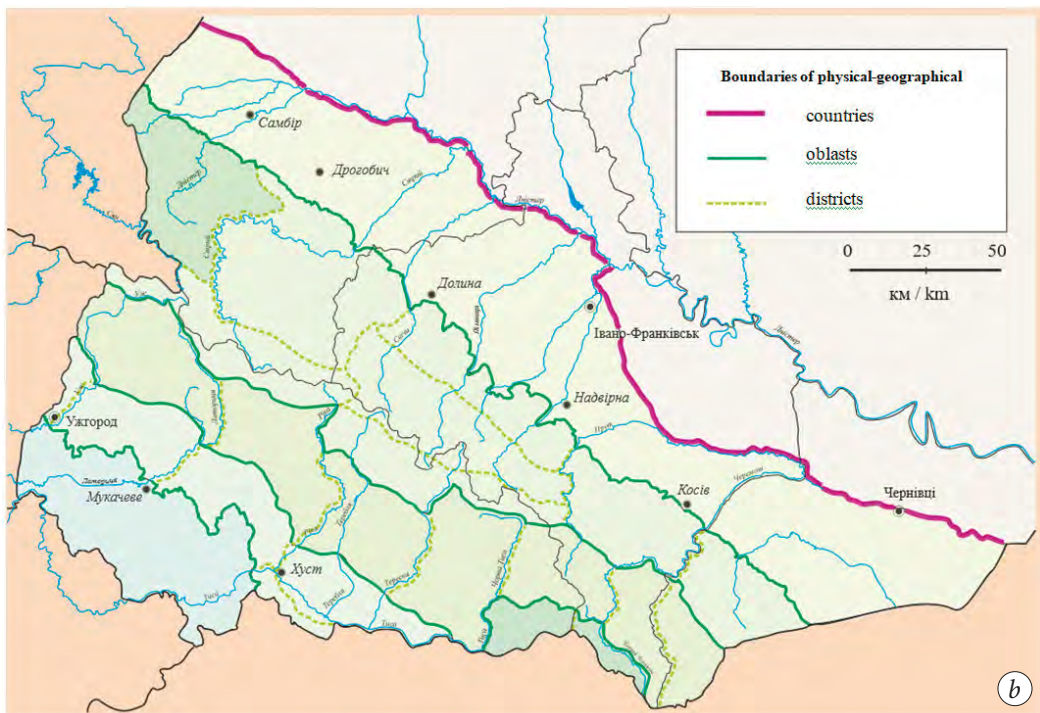


Fig. 1. The geographical zoning of Ukraine (a) and the Ukrainian Carpathians (b) used in the Data Centre 'Biodiversity of Ukraine' internet-resource based on the physiographic zoning of Ukraine according to the *General Geographic Atlas of Ukraine* / dir. R. Sossa, chief editor I. Rudenko. Kyiv: Ukrgeodezkartografiya & DNVP 'Kartografiya'. 2004. 112 p.

Рис. 1. Географічне зонування України (a) і Українських Карпат (b), що використано в інтернет-ресурсі Центр даних 'Біорізноманіття України' за основу взято фізико-географічне районування України за атласом: *Загальногеографічний атлас України* / дир. Р. Сосса, гол. ред. І. Руденко / Київ: Укргеодезкартографія & ДНВП 'Картографія'. 2004. 112 с.

which 9.6 million hectares are covered with forest vegetation. The forest cover of the country is 15.9% [Hensiruk 1992; Tkach 2012]. Ukraine has the highest percentage of arable land in the world, which, according to the Food and Agriculture Organisation FAO, is 53.9%. The proportion of ploughed agricultural lands is 78.2%. For comparison, in Poland these parameters are 36.5% and 75.1%, in Germany 34.1% and 71%, in the USA 17.5% and 38.9%, respectively. By climatic zones, the steppe zone has the highest proportion of ploughed lands at 81.2%, whereas their proportion in the forest-steppe zone is 80.8% and in the forest zone (Polissia) is 65.7% (<http://surl.li/mjryl>).

All these factors cause an urgent need to take into account biotic diversity and monitor current changes of natural populations and ecosystems. This is what the internet-resource Data Centre 'Biodiversity of Ukraine'—the only academic biodiversity informatics platform in Ukraine—is called to do. In DCBU we not only account for biodiversity, but also create a developed search engine that would meet the needs of a wide range of scientists, such as conservationists and other interested parties. Such opportunities are not available in most citizen science biodiversity resources, for instance in the Global Biodiversity Information Facility (GBIF), iNaturalist, or Ukrainian Biodiversity Information Network. Most of these initiatives focus on a single aspect of biodiversity (e.g. species distribution, taxonomic knowledge or literature) and very few combine different kinds of biodiversity data and make it available under a species axis [Vattakaven *et al.* 2016].

Material and Methods

In this article we attempt to analyse the representation of biota in the western regions (oblasts) of Ukraine: Volyn, Rivne, Lviv, Ternopil, Ivano-Frankivsk, Chernivtsi, and Zakarpattia.

The internet-resource Data Centre 'Biodiversity of Ukraine' (<http://dc.smnh.org/>) was created in the State Museum of Natural History, NAS of Ukraine (Lviv) and launched on 25 May 2017. DCBU has two main objectives: aggregating curated biodiversity data for all species in Ukraine and create a working tool for the basic study of biological diversity in various territorial units of the country. DCBU is managed by a group of specialists from the State Museum of Natural History, NAS of Ukraine and other scientific institutions of Ukraine. The internet-resource operates in two languages—in Ukrainian and, if possible, in English. In taxonomy, DCBU adheres to the scientific names accepted in the Global Biodiversity Information Facility (GBIF) and the Encyclopedia of Life (EOL) portals. When forming a DCBU database, the Darwin Core principles are applied.

The web resource, along with the administrative division of Ukraine, uses physical and geographical zoning of Ukraine after the *General Geographical Atlas of Ukraine* and the physical and geographical zoning of the Ukrainian Carpathians with some of our changes (Fig. 1).

The structure of the web resource includes a number of thematic modules. Below we will take a closer look at the main ones.

Results

Taxonomic coverage

One of the modules of the web resource is Species module. The web resource DCBU adheres to the systematics adopted in GBIF Backbone Taxonomy and Catalogue of Life Checklist, although in some cases (when curating a taxonomic group by leading specialists) other species names are used.

The database of DCBU contains information on the following taxa:

- 5 kingdoms (Animalia, Chromista, Fungi, Plantae, and Protista);
- 22 phyla (Acanthocephala, Amoebozoa, Annelida, Anthocerotophyta, Arthropoda, Ascomycota, Basidiomycota, Bryophyta, Bryozoa, Chordata, Cnidaria, Ctenophora, Echinodermata, Gastrotricha, Marchantiophyta, Mollusca, Nematoda, Nemertea, Ochrophyta, Rotifera, Tardigrada, and Tracheophyta);
- 81 classes (Acanthodii, Actinopterygii, Adenophorea, Agaricomycetes, Amphibia, Andreaeopsida, Anthocerotophyta, Arachnida, Asteroidea, Atractiellomycetes, Aves, Bacillariophyceae, Bivalvia,

Branchiopoda, Bryopsida, Caudofoveata, Cephalaspidomorphi, Cephalopoda, Chilopoda, Chondrichthyes, Chromadorea, Clitellata, Dacrymycetes, Diplopoda, Discosea, Echinoidea, Enoplea, Entognatha, Equisetopsida, Eurotatoria, Eutardigrada, Gastropoda, Gastrotricha_unranked_taxon, Ginkgoopsida, Gnetopsida, Haplomitriopsida, Heterotardigrada, Hexanauplia, Hirudinea, Hydrozoa, Insecta, Jungermanniopsida, Laboulbeniomyces, Lecanoromycetes, Leotiomyces, Liliopsida, Lobosea, Lycopodiopsida, Magnoliopsida, Malacostraca, Mammalia, Marchantiopsida, Maxillopoda, Monoplacophora, Myxogastria, Oligochaeta, Pauropoda, Pezizomycetes, Phaeophyceae, Phylactolaemata, Pilidiophora, Pinopsida, Placodermi, Polychaeta, Polyplacophora, Polypodiopsida, Polytrichopsida, Psilotopsida, Pteraspidomorphi, Reptilia, Scaphopoda, Scyphozoa, Secernentea, Solenogastres, Sordariomyces, Sphagnopsida, Symphylla, Tentaculata, Tetrarhynchida, Tremellomyces, and Tubulinea);

- 283 orders, 1292 families, 4741 genera, and 11763 species.

For each species, a page has been created with general information (binomial name, synonyms, conservation status, value of species, detailed information about species, book references, web references, taxonomic group expert name, taxonomic branch and 3 photos) (e.g. *Gentiana acaulis* L., *Carabus estreicher* Fisch. von Waldh., *Aromia moschata* (L)).

The representativeness of the biota of the western region of Ukraine at the regnum and phyla level is shown in Table 1 and at the species level is shown in Table 2. As can be seen from the tables, the coverage of both regions and taxa varies and primarily depends on the degree of the study of the territory, which, in turn, depends on the accessibility of the territory for research (proximity to scientific centres) and its importance/value for research. This leads to a greater representation of taxa in museum collections and a greater number of scientific publications from which primary data for biota inventories can be obtained.

Table 1. The representativeness of the biota of the western regions of Ukraine at regnum and phyla levels
Таблиця 1. Представленість біоти західного регіону України на рівні царств і типів

| Regnum | Phyla | VL spp | RV spp | LV spp | TR spp | IF spp | CH spp | ZK spp |
|--------------|------------------|-------------|------------|-------------|-------------|-------------|------------|-------------|
| Chromista | Ochrophyta | – | – | – | – | – | – | – |
| Protista | Amoebozoa | 8 | – | – | – | – | – | 1 |
| Plantae | Anthocerotophyta | – | – | – | – | – | – | – |
| | Bryophyta | 1 | – | 114 | 54 | 83 | 232 | 35 |
| | Marchantiophyta | 1 | 2 | 16 | 2 | 26 | 5 | 13 |
| Fungi | Tracheophyta | 80 | 6 | 886 | 203 | 438 | 78 | 311 |
| | Ascomycota | – | 1 | 4 | 19 | 2 | – | 45 |
| | Basidiomycota | 7 | 119 | 27 | 20 | 10 | 1 | 240 |
| Animalia | Acanthocephala | – | – | – | – | – | – | – |
| | Annelida | 9 | – | – | – | 3 | – | – |
| | Arthropoda | 840 | 296 | 1692 | 471 | 1172 | 286 | 1272 |
| | Bryozoa | – | – | – | – | – | – | – |
| | Chordata | 271 | 109 | 335 | 304 | 193 | 65 | 180 |
| | Cnidaria | – | – | – | – | – | – | – |
| | Ctenophora | – | – | – | – | – | – | – |
| | Echinodermata | – | – | – | – | – | – | – |
| | Gastrotricha | – | – | – | – | – | – | – |
| | Mollusca | 54 | 1 | 78 | 8 | 13 | 5 | 22 |
| | Nematoda | 2 | 1 | 11 | – | 2 | – | 6 |
| | Nemertea | – | – | – | – | – | – | – |
| | Rotifera | 38 | – | – | – | – | – | – |
| | Tardigrada | – | – | – | – | – | – | – |
| Total | (22) | 1311 | 535 | 3163 | 1081 | 1942 | 672 | 2125 |

Note: VL—Volyn Oblast, RV—Rivne Oblast, LV—Lviv Oblast, TR—Ternopil Oblast, IF—Ivano-Frankivsk Oblast, CH—Chernivtsi Oblast, ZK—Zakarpattia Oblast.

Table 2 also shows the representation of species listed in the Red Data Book of Ukraine in the regions, which generally confirms the trends outlined for the entire biota, but also depends on the degree of conservation of natural habitats and their diversity. Thus, the presence of Red Data Book species

is expected, for example, to be higher in the Carpathians (Lviv—211 species, Ivano-Frankivsk—157, Zakarpattia—149, and Chernivtsi—87) and western parts of Podillia (Ternopil—164) than in the Polissia (Volyn—80, Rivne—47).

Table 2. The representativeness of the biota of the western oblasts of Ukraine at species level

Таблиця 2. Представленість біоти областей західного регіону України на видовому рівні

| Oblasts | Data Centre 'Biodiversity of Ukraine' | | | |
|-----------------|---------------------------------------|---------|--------------------------|---------|
| | Species | Records | Red Data Book of Ukraine | |
| | | | Species | Records |
| Volyn | 1311 | 6950 | 80 | 461 |
| Rivne | 535 | 673 | 47 | 82 |
| Lviv | 3163 | 16553 | 211 | 1362 |
| Ternopil | 1081 | 3777 | 164 | 1315 |
| Ivano-Frankivsk | 1942 | 9640 | 157 | 1137 |
| Chernivtsi | 672 | 3461 | 87 | 236 |
| Zakarpattia | 2125 | 10099 | 149 | 833 |

Specimen module and species findings

In the Specimen module of DCBU, we sampled each literature occurrence, museum collections specimens, Nature Reserve collection specimens, Institute collection specimens, University collection specimens, private collection specimens, human observations, photos for the location of species occurrence (latitude and longitude) using the Darwin Core Biodiversity Standard format [Wieczorek *et al.* 2012]. Each species, except the page with general information, is accompanied by a list of finds/records, a distribution map and a gallery of photographs.

The DCBU database currently contains information about 66 141 georeferenced specimen occurrences of 6698 species mainly from the territory of Ukraine but also from other countries of the world (Austria, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Canada, Chile, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Italy, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Moldova, Montenegro, Morocco, Myanmar, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Samoa, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Turkey, and the United Kingdom) and Antarctica.

The 66 141 georeferenced specimen occurrences comprise 6 698 species from 5 taxonomic regnum and 22 phyla: Protista (21 records, 0.03%), (Amoebozoa—21 records, 0.03%); Fungi (585, 0.88%) (Ascomycota—100, 0.15%, Basidiomycota—485, 0.73%); Plantae (11 090, 16.77%) (Anthocerotophyta—2, 0.002%, Bryophyta—2093, 3.16%, Marchantiophyta—251, 0.38%, Tracheophyta—8 744, 13.22%); Animalia (54 445, 82.32%) (Annelida—99, 0.15%, Arthropoda—42 335, 64.01%, Bryozoa—1, 0.002%, Chordata—10 163, 15.37%, Cnidaria—6, 0.009%, Echinodermata—3, 0.005%, Gastrotricha—9, 0.01%, Mollusca—1 599, 2.42%, Nematoda—114, 0.17%, Nemertea—1, 0.001%, Rotifera—108, 0.16%, Tardigrada—5, 0.008%); Chromista (Ochrophyta— 2, 0.002%).

Temporal coverage. Date range (yyyy-mm-dd): 1821-04-21 until present. The oldest specimens are: *Galanthus nivalis* L., SMNH006272, 1821-04-21; *Viola lutea* Huds., SMNH000014, 1830-08-00; *Asplenium scolopendrium* L., SMNH004120, 1838-00-00; *A. trichomanes* L., SMNH000367, 1846-07-06; *Falco peregrinus* Tunstall, 1771, SMNH000703, 1849-05-10.

The three following tools visualise the number of recorded species for a specific area. Species diversity of physiographic regions of Ukraine—for the physiographic oblasts of Ukraine (Fig. 2, *b*), Species diversity of administrative regions (oblasts) of Ukraine and Species diversity of physiographic regions (oblasts) of the Ukrainian Carpathians (Fig. 2, *c*). More intense colour filling of a separate region indicates a higher number of species recorded in it; a six-level colour scale is used. Since the web resource was created not very long ago, and the territory of Ukraine is large, and the species diversity is large, at present most of the data comes from the western region of Ukraine.

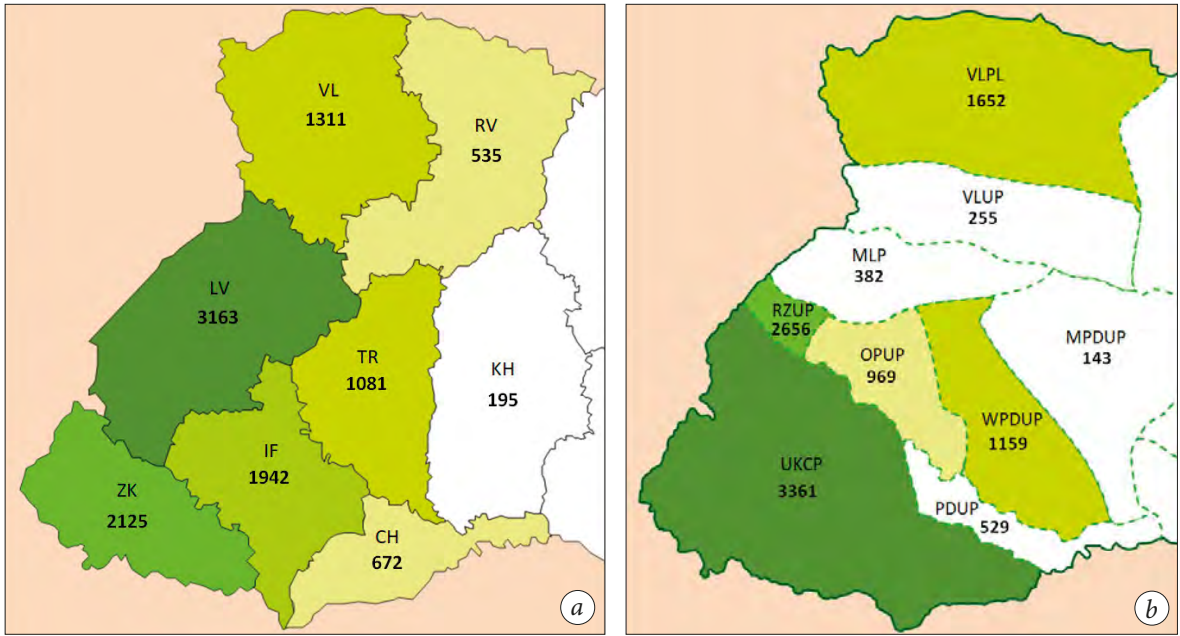
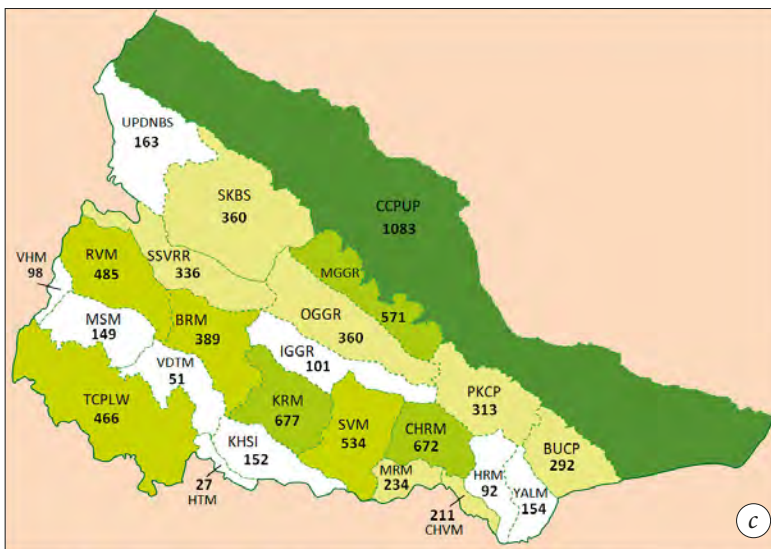


Fig. 2. Species diversity of administrative units (oblasts) (a) and physiographic regions (b) of Ukraine and the physiographic oblasts of the Ukrainian Carpathians (c).

Remarks: *administrative oblasts*: VL—Volyn, RV—Rivne, LV—Lviv, TR—Ternopil, IF—Ivano-Frankivsk, CH—Chernivtsi, ZK—Zakarpattia; *physiographic regions*: VLPL—Volynske Polissia, VLUP—Volynska Upland, MLP—Male Polissia, RZUP—Roztochchia Upland, OPUP—Opillia Upland, WPDUP—West Podillia Upland, MPDUP—Middle Podillia Upland, PDUP—Prut-Dnister Upland, UKCP—Ukrainian Carpathians: CCPUP—Ciscarpathian Upland, UPDNBS—Upper Dnister Beskydy, SKBS—Skolivski Beskydy, SSVRR—Stryisko-Sanska Verkhovyna & Verkhovynskiy Dividing Range, MGGR—Margin Gorgany Range,



OGGR—Outer Gorgany Range, IGGR—Inner Gorgany Range, PKCP—Pokutski Carpathians, BUCP—Bukovynski Carpathians, RVM—Polonyna Rivna massif, BRM—Polonyna Borzhava massif, KRM—Polonyna Krasna massif, SVM—Svydovets massif, CHRM—Chornohora massif, HRM—Hryniavy Mountains, YALM—Yalovychoriski Mountains, MRM—Marmarosh massif, CHVM—Chyvchyny massif, VHM—Vyhorlat massif, MSM—Makovytsia-Syniak massif, VDTM—Velykyi Dil-Tupyy massif, KHSI—Khust-Solotvyno Hollow, HTM—Hutynskiy massif, TCPLW—Trancarpathian Lowland.

Рис. 2. Видове різноманіття адміністративних (a), фізико-географічних (b) областей України і фізико-географічних областей Українських Карпат (c).

Примітки: *адміністративні області*: VL — Волинська область, RV — Рівненська, LV — Львівська, TR — Тернопільська, IF — Івано-Франківська, CH — Чернівецька, ZK — Закарпатська; *фізико-географічні регіони*: VLPL — Волинське Полісся, VLUP — Волинська височинна область, MLP — область Малого Полісся, RZUP — Розточчя, OPUP — Опілля, WPDUP — Західноподільська височинна область, MPDUP — Середньоподільська височинна область, PDUP — Прут-Дністровська височинна область, UKCP — Українські Карпати: CCPUP — Передкарпатська височинна область, UPDNBS — Верхньодністровські Бескиди, SKBS — Сколівські Бескиди, SSVRR — Стрийсько-Сянська Верховина і Верховинський Вододільний хребет, MGGR — Крайові Горгани, OGGR — Зовнішні (Скибові) Горгани, IGGR — Внутрішні (Привододільні) Горгани, PKCP — Покутські Карпати, BUCP — Буковинські Карпати, RVM — полонина Рівна, BRM — Полонина Боржава, KRM — Полонина Красна, SVM — Свидовець, CHRM — Чорногора, HRM — гори Гриняви, YALM — Яловичорські гори, MRM — Мармарош, CHVM — Чивчини, VHM — масив Вигорлат, MSM — масив Маковиця-Синяк, VDTM — масив Великий Діл-Тупий, KHSI — Хустсько-Солотвинська улоговина, HTM — Гутинський масив, TCPLW — Закарпатська низовинна область.

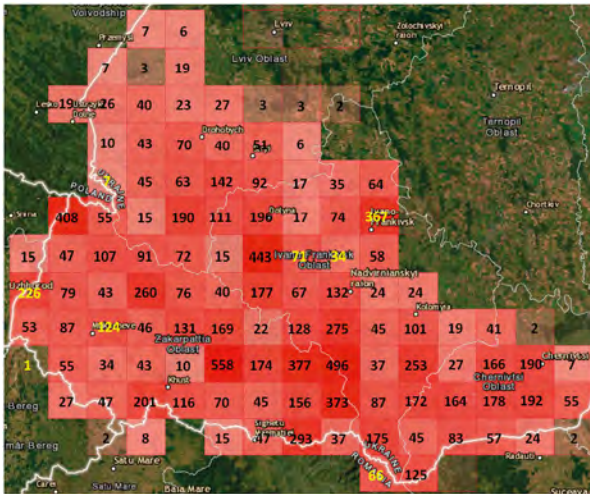


Fig. 4. Species aggregation map of the Ukrainian Carpathians region (squares 20 × 20 km) with the number of species in squares. Numbers are highlighted in yellow for better visibility.

Рис. 4. Видова агрегаційна карта Українських Карпат (квадрати 20 × 20 км) з кількістю зареєстрованих видів у квадратах. Числа виділені жовтим кольором для кращої видимості.

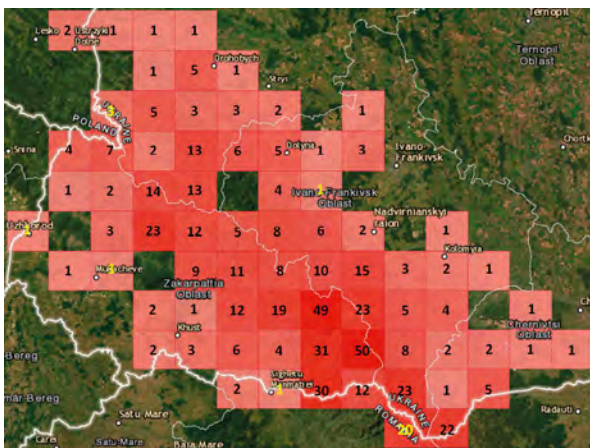


Fig. 5. Species aggregation map of the Ukrainian Carpathians region (squares 20 × 20 km) with the number of endemic species in squares. Numbers are highlighted in yellow for better visibility.

Рис. 5. Видова агрегаційна карта Українських Карпат (квадрати 20 × 20 км) з кількістю зареєстрованих ендемічних видів у квадратах. Числа виділені жовтим кольором для кращої видимості.

national nature parks (NNP): NRP Rivnenskyi (295 species), NNP Shatskyi (1204 species). As for other protected areas, the data entered into the database is not yet sufficient to characterise their biota.

The biota of the broadleaf forest zone is relatively better documented than in other regions. The best explored are the neighborhoods of Lviv City (1561 species) and the nature reserves Roztochchia (1040) and Medobory (702). And filling in data on the biota of other reserves (NNP Dnister Canyon (167), NNP Halytskyi (273), NNP Khotynskyi (7), NNP Kivertsivskyi ‘Tsumanska pushcha’ (63), NNP Kremenetski Hory (78), NNP Pivnichne Podillya (244), NNP Podilski Tovtry (95), NNP Prypiat-Stokhid (40), NNP Yavorivskyi (85)) is at the initial stage.

In the Ukrainian Carpathians, the following regions are better documented: neighborhoods of Ivano-Frankivsk City (362 species); Carpathian Biosphere Reserve—Chornohora protected massif (208), Kuziy-Trybushany protected massif (114), Svydovets protected massif (192), Uholka-Shyrokyi Luh protected massif (494); NNP Carpathian (677); NNP Hutsulshchyna (222); and NNP Uzhanyskyi (434).

Endemic species

The web resource DCBU includes 87 endemic species:

Plantae: *Heracleum carpaticum* Porcius, *Scilla kladnii* Schur, *Crocus banaticus* J.Gay, *Achillea carpatica* Błocki ex O.N. Dubovik, *A. oxyloba* (Sch. Bip.) Heimerl, *Carlina acaulis* L., *Centaurea maramarosiensis* (Jáv.) Czerep., *C. phrygia* L., *Cirsium waldsteinii* Rouy, *Leucanthemum rotundifolium* (Willd.) DC., *Scorzoneroides pseudotaraxaci* (Schur) Holub, *Campanula carpatica* Jacq., *C. tatrae* Borbás, *Phyteuma tetramerum* Schur, *Ph. vagneri* A. Kern., *Pulmonaria filarszkyana* Jáv., *Symphytum cordatum*

Waldst. & Kit., *Erysimum witmannii* Zaw., *Minuartia pauciflora* (Kit. ex Kanitz) Dvořáková, *Silene zawadzki* Herbich, *Scabiosa lucida* Vill., *Gentiana pyrenaica* L., *Thymus pulcherrimus* Schur, *Syringa josikaea* J. Jacq. ex Rchb., *Euphrasia tatrae* Wettst., *Melampyrum saxosum* Baumg., *Veronica baumgartenii* Roem. & Schult., *Euphorbia carpatica* Wol., *Viola dacica* Borbás, *V. declinata* Waldst. & Kit., *Festuca carpatica* F. Dietr., *F. porcii* Hack., *Poa granitica* Braun-Blanq., *Trisetum fuscum* (Schult.) Schult., *Aconitum degenii* Gayer, *A. firmum* Rchb., *A. lasiocarpum* (Rchb.) Gáyér, *A. moldavicum* Hacq., *Ranunculus carpaticus* Herbich, *R. malinovskii* Elenevsky & Derv.-Sokol., *Alchemilla szaferi* Pawl., *Sempervivum montanum* L., *Chrysosplenium alpinum* Schur, and *Saxifraga carpatica* Sternb.

Insecta, Coleoptera: *Carpathobyrrhulus transsylvanicus* (Suffrian, 1848), *Amara misella* L. Miller, 1868, *Carabus fabricii* Duftschmid, 1812, *C. hampei* Kuster, 1846, *C. obsoletus* Sturm, 1815, *C. sylvestris transsylvanicus* Dejean, 1826, *C. zawadzki* Kraatz, 1854, *Deltomerus carpathicus* (L. Miller, 1868), *Duvaliopsis pilosella* (L. Miller, 1868), *Duvalius corpulentus* (Weise, 1875), *D. roubali* Jeannel, 1926, *D. ruthenus* (Reitter, 1878), *D. subterraneus* (L. Miller, 1868), *D. transcarpathicus* Shilenkov & Rizun, 1989, *Leistus baenningeri* Roubal, 1926, *L. ucrainicus* Lazorko, 1954, *Nebria fuscipes* Fuss, 1849, *N. heegeri* Dejean, 1826, *N. reitteri* Rybinski, 1902, *N. transsylvanica* Germar, 1824, *Patrobus quadricollis* L. Miller, 1868, *P. styriacus* Chaudoir, 1871, *Pterostichus cordatus* Letzner, 1842, *P. foveolatus* (Duftschmid, 1812), *P. pilosus* (Host, 1789), *Trechus carpathicus* Rybiński, 1902, *T. fontinalis* Rybiński, 1901, *T. latus* Putzeys, 1847, *T. plicatulus* L. Miller, 1868, *T. pseudomontanellus* Rizun, 1994, *T. pulpani* Reška, 1965, *Athous mollis* Reitter, 1889, *Leptusa carpathica* Weise, 1877, and *Quedius transsylvanicus* (Weise, 1875).

Mollusca: *Acicula parcelineata* (Clessin, 1911), *Acicula perpusilla* (Reinhardt, 1880), *Bythiospeum carpathicum* (Soós, 1940), *Arianta petrii* Kimakowicz, 1890, *Plicuteria lubomirskii* (Ślósarski, 1881), *Prostenomphalia carpathica* Baidaschnikov, 1985, *Trochulus bielzi* (A. Schmidt, 1860), and *Bielzia coeruleans* (M. Bielz, 1851)

Chordata, Amphibia: *Lissotriton montandoni* (Boulenger, 1880).

These endemics were found in the Ukrainian Carpathians, representing 2044 records. It should be noted that the approaches to identify endemic species somewhat varies in different taxonomic groups. Most endemics are confined to the highest parts of the Ukrainian Carpathians, namely the Polonyno-Chornohirska region (oblast) and Marmarosh-Chyvchyny region (oblast) (Fig. 5), which are located in the south-eastern part of the mountains.

Virtual collections

In addition to the listed services, the Data Centre 'Biodiversity of Ukraine' internet-resource forms virtual collections from the scientifically researched and digitised collections of the State Museum of Natural History NAS of Ukraine (Lviv):

- Personal collections (of Franz Herbich, Alexander Zawadzki, Hiacynt Łobarzewski, Włodzimierz Dzieduszycki, Maksymilian Nowicki, Władysław Tyniecki, Ostap Voloshchak, Antoni Rheman, Antoni Wierzejski, Jozef Dziędzielewicz, Marjan Łomnicki, Ivan Verkhratskyi, August Stöckl, Volodymyr Zanko, Jan Noskiewicz, Hryhorii Kozii, Mark Sagan, Józef Mądalski, Volodymyr Lazorko, Kostiantyn Malynovskyi, Ivan Zahaikevych, Kupava Ulychna, Vasyl Kolishchuk, and Ivan Vainahii);
- Taxonomic collections (*Bazzania* (Lepidoziaceae, Jungermanniales), *Cicindela*, *Cylindera*, *Duvalius* (Coleoptera, Carabidae), *Habroloma* (Coleoptera, Buprestidae), Felidae (Mammalia, Carnivora));
- Reference collections (Collection of type specimens of the State Museum of Natural History, National Academy of Sciences of Ukraine);
- Institutional collections (Collection of the Museum of Nature of Medobory Nature Reserve, Collection of the Museum of Nature of Roztochia Nature Reserve, Collection of the Kremenetski Hory National Nature Park);
- Ivan Verkhratskyi's collection of butterflies and moths (Lepidoptera), digitised with the support of the Ukrainian Cultural Foundation (Fig. 6).



All virtual collections in the process of digitisation of museum collections are being constantly enriched, and new virtual collections will be created, in particular reference ones with type specimens that are stored in the State Museum of Natural History, NAS of Ukraine (Lviv).

Fig. 6. Ivan Verkhratskyi's collection of butterflies and moths (Lepidoptera) in the Data Centre 'Biodiversity of Ukraine' internet-resource.

Рис. 6. Колекція метеликів (Lepidoptera) Івана Верхратського у вебресурсі Центр даних Біорізноманіття України.

Discussion

The Data Centre 'Biodiversity of Ukraine' internet-resource was created relatively recently and intensively developed by both the current scientific study and digitisation of the collections of the State Museum of Natural History, NAS of Ukraine (Lviv), including more than 470 thousand specimens, and by the implementation of a number of projects and grants: 'Development and implementation of modern information and analytical methods in estimating the biodiversity of Ukraine' (2019–2021), 'Testing of the software complex the Data Centre 'Biodiversity of Ukraine' for scientific monitoring of biota' (2019), 'Evaluation of biotic diversity of model groups of arthropods of the Ukrainian Carpathians using modern information technologies' (2020–2021), 'Analysis of the history of the formation of museum collections using the museum information resource the Data Centre 'Biodiversity of Ukraine' (2022–2024), 'Digitalisation of Ivan Verkhratsky's historical butterflies collection' (2023), Digitalisation of natural collections that suffered damage as a result of hostilities and related factors: development of protocols and their implementation on the basis of the State Museum of Natural History NAS of Ukraine' (2023–2024).

The DCBU resource differs from similar resources for accounting biodiversity by its more scientific focus (data from qualitative scientific publications are entered into the database, leading specialists from individual taxonomic groups are involved and data also verified before entering) and practical orientation (DCBU tools). A significant number of tools enable scientists, nature reserve workers, managers, nature lovers, students, and all interested parties to be acquainted with the biota of Ukraine and conduct its basic analysis. It allows the linking of biological data with other data, such as environmental (soil, climate) or social (population, administrative units) data and thus has the potential to evolve as a data-driven decision support system for biodiversity conservation and management [Vattakaven *et al.* 2016].

And the fact that the resource database contains information about a significant number of museum specimens since the middle of the 19th century allows (using the tools of DCBU) monitoring the changes of the biota in time and space. All of the above makes the DCBU resource a very attractive working tool to stakeholders.

As the State Museum of Natural History, NAS of Ukraine is one of the publishers in the Global Biodiversity Information Facility (GBIF) portal, the datasets from DCBU are regularly published: in

botany [Sup-Novikova 2022, Novikov 2023, Novikov *et al.* 2024, Savytska *et al.* 2024], in acarology [Hushtan *et al.* 2023], in entomology [Hushtan *et al.* 2023; Rizun, 2023a–d], and on Nematoda [Susulovsky & Susulovska 2023].

In general, the situation with the accounting and monitoring of biodiversity in Ukraine is at an early stage of development, unlike in Sweden, where SBDI—Swedish Biodiversity Data Infrastructure—was created in 2021 as a result of a decades-long process of developing, merging, and consolidating the Swedish e-infrastructure for biodiversity and ecosystems research (<https://www.gbif.se/>). It is a major achievement in creating a powerful national Swedish platform for innovative, interdisciplinary research on biodiversity and ecosystems. Eleven organisations across Sweden are involved in SBDI: Swedish Museum of Natural History (NRM; host organisation), Swedish University of Agricultural Sciences (SLU), Karolinska Institute (KI), Linnaeus University (LnU), Lund University (LU), Royal Institute of Technology (KTH), Stockholm University (SU), Swedish Meteorological and Hydrological Institute (SMHI), Umeå University (UmU), University of Gothenburg (GU), and Uppsala University (UU). The consortium covers the entire range of biodiversity data sources represented in the Swedish research community. In our opinion, a similar structure should be developed in Ukraine based on academic institutions that study biodiversity in cooperation with the Ministry of Environmental Protection and Natural Resources of Ukraine and taken into account when reforming the state environmental monitoring system in Ukraine in the field of ‘Biodiversity’.

We are aware that at the moment our current database contains limited occurrence data of faunal groups and different regions of Ukraine are represented by different numbers of finds. But further development of the DCBU resource will be planned in filling these taxonomic and territorial gaps.

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