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# **Data mobilization in the LWS herbarium: success and prospects**

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# Data mobilization in the LWS herbarium: success and prospects

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## Abstract

### Background

Digitization of hosted specimens is a crucial task for all herbaria worldwide and is one of the main streams for today. By digitizing their collections and publishing the datasets, the herbaria grant access to essential data to a wide research audience and, as a result, involve their collections in scientific work more actively. Digitization also allows virtual preservation of the collections, which is especially important in conditions of hostilities, when the entire collection can be destroyed or damaged in one moment. This paper describes two datasets recently published in GBIF in frames of the LWS herbarium digitization initiative. It also contains some considerations about further digitization priorities and plans in the LWS herbarium in the context of complicated war conditions and limited facilities.

### New information

In total, 2,419 occurrence records from Ukraine mobilized from LWS herbarium were published. These datasets are planned to be dynamic with the addition of new records along with progress of digitization work at LWS. At least 6,000 more records are planned to be published through these datasets in 2024.

### Keywords

occurrence, herbarium material, digitization, Ukraine, flora

## Introduction

Herbaria serve as an important source of primary data for many studies, including taxonomic, biogeographic, and phylogenetic ones (Holmes et al. 2016, Soltis 2017, James et al. 2018, Ball-Damerow et al. 2019). The herbarium management is a responsible task during which the curators face several issues, including organization of permanent access, long-term preservation of the collection, unintentional damage to specimens and, occasionally, vandalism (Funk 2002, Pennock 2017, Rabeler et al. 2019). Moreover, processing of the natural history collections, including the herbarium collections, by researchers in person is laborious and expensive (Suarez and Tsutsui 2004, Bradley et al. 2014, Popov et al. 2021). The digitization and the creation of freely available datasets and virtual herbaria allow solving these issues by making collections quickly and easily accessible through the Internet and providing numerous benefits of remote access (Cantrill 2018, Nieva de la Hidalga et al. 2020, Borsch et al. 2020, Powell et al. 2021, Davis 2023). In light of forcing hostilities in Ukraine (Mosyakin and Shiyan 2022), the mobilization of biodiversity data and, particularly, the digitization of herbarium materials acquires a new sense since it could be the only way to preserve, at least virtually, such collections being under permanent threat.

The herbarium of the State Museum of Natural History of the NAS of Ukraine, Lviv (SMNH), is one of the oldest and richest in Ukraine. This herbarium was established in 1832 and hosts unique specimens collected in the Carpathians and other, primarily western, regions of Ukraine. It includes ca. 120,000 specimens of vascular plants and over 26,000 specimens of non-vascular plants and is subdivided into two respective curating units. The commonly accepted code for both herbarium units is LWS (Thiers 2023).

In late 2023, the State Museum of Natural History of the NAS of Ukraine received a local governmental grant for digitization of its collections, including herbarium materials. In frames of this grant, the data about 2419 specimens of vascular and non-vascular plants deposited at LWS were mobilized and published as two datasets (Novikov et al. 2023, Savytska et al. 2023) in Global Biodiversity Information Facility (GBIF 2023). These datasets will be continually supported by additional data in the future. At least 6,000 more records are planned to be published through these datasets in 2024.

## General description

**Purpose:** The primary purpose of publishing these data is to secure the future of the LWS herbarium, which remains at risk of damage due to hostilities, and to make the mobilized data freely and remotely accessible through GBIF. This also aims to improve the implementation of Ukrainian biodiversity data and their integrative use in international research projects.

## Project description

**Title:** 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)

**Personnel: Project PI:** Andriy Novikov (Dr., Senior Research Scientist, SMNH, Department of Biosystematics and Evolution, ORCID <https://orcid.org/0000-0002-0112-5070>).

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**Study area description:** The project aims to (a) develop digitization protocols for the most valuable and vulnerable natural history collections; (b) mobilize and publish the data about such collections deposited at SMNH; and (c) digitize prioritized specimens deposited at SMNH, including those belonging to herbarium collection and the collection of invertebrates.

**Funding:** The grant program “Science for the Recovery of Ukraine in the War and Post-War Periods” (Nr 2022.01) of the National Research Foundation of Ukraine.

## Sampling methods

**Sampling description:** Three priority groups were defined within the LWS herbarium for digitization and data mobilization purposes. The first, red, group ascertains type material, authentic collections, specimens of endemic and rare taxa, and specimens collected from the 'locus classicus' localities. The second, yellow, group includes specimens of the taxa characteristic for the regional flora and specimens collected from hardly-accessible or currently inaccessible territories (e.g., border territories with limited access and occupied territories). The third, green, group includes specimens of regular species and specimens from supporting (e.g., loan and educational) collections. For the selected taxa, a rough capture of the labels has been conducted. The data from these labels were transferred to the draft tables correspondingly to GBIF's requirements for Occurrence datasets (GBIF 2023). After that, the localities were identified using the OpenStreetMap service and georeferenced. The taxonomy of vascular plants using GBIF (2023) taxonomic backbone and cross-checked with POWO (2023). The taxonomy of non-vascular plants was verified using GBIF (2023) taxonomic backbone and also cross-checked with Hodgetts et al. (2020).

**Quality control:** The quality of the final datasets was first manually checked. After that the datasets were processed using OpenRefine 3.7.7 software (OpenRefine 2023), and saved as a tsv file coded in UTF-8. To test datasets for outlets, QGIS 3.10 software (QGIS Association 2023) has been applied.

**Step description:** 1. Taking photos of herbarium labels; 2. Re-identification of taxa following recent taxonomy; 3. Extracting the locality, collector, date, and other relevant (e.g., identification history) information from the labels; 4. Translation of the primary label information from non-Romanian languages (i.e., Ukrainian and Russian) to English; 5. Georeferencing of localities using printed maps and OpenStreetMap web service (OpenStreetMap contributors 2023); 6. Quality check applying OpenRefine (OpenRefine 2023) and QGIS (QGIS Association 2023) for detecting outlets and coordinates issues.

## Geographic coverage

**Description:** The data mobilization in the LWS herbarium at the moment is focused on Ukrainian flora. Two described datasets containing the data mobilized in 2023 mainly cover the western part of Ukraine but only occasionally includes occurrences from other regions of Ukraine (Fig. 1).

**Coordinates:** 44.492 and 51.565 Latitude; 22.395 and 37.541 Longitude.

## Taxonomic coverage

**Description:** All processed specimens (except two unidentified specimens of Bryales) were identified to the level of species or infraspecies. The dataset of vascular plants describes data on 59 species representing 36 genera, 17 families, and 11 orders of the class Magnoliopsida (Table 1). Vascular plants' specimens belong mainly to the orders Ericales (28% of total number of processed specimens), Apiales (23%), and Saxifragales (13%). The most abundant families are Apiaceae (23%), Primulaceae (18%), and Ericaceae (10%). The most abundant genera of vascular plants among processed specimens are *Primula* (18%) and *Astartia* (10%). The dataset of non-vascular plants contains data on 190 species representing 99 genera, 39 families, and 11 orders of the class Bryopsida (Table 1). Three of the most represented orders among processed specimens of non-vascular plants are Hypnales (57%), Bryales (17%) and Orthotrichales (9%). The most abundant families of non-vascular plants are Brachytheciaceae (15%), Mniaceae (10%), Amblystegiaceae (9%), Orthotrichaceae (9%) and Bryaceae (7%). The genera of non-vascular plants in the processed material are distributed more or less symmetrically.

## Temporal coverage

**Notes:** The dataset of vascular plants covers specimens collected in 1852–2014 (Fig. 2). The dataset of non-vascular plants covers specimens collected in 1946–1969 (Fig. 3).

## Collection data

**Collection name:** Herbarium of the State Museum of Natural History of the NAS of Ukraine

**Collection identifier:** LWS

**Specimen preservation method:** Dried and pressed

**Curatorial unit:** LWS-vascular and LWS-non-vascular units.

## Usage licence

**Usage licence:** Other

**IP rights notes:** Creative Commons Attribution License (CC BY 4.0)

## Data resources

**Data package title:** LWS herbarium data mobilization

**Number of data sets:** 2

**Data set name:** LWS herbarium. Vascular plants

**Character set:** UTF-8

**Download URL:** <https://doi.org/10.15468/58zxna>

**Data format:** DarwinCore

**Description:** The tab-delimited CSV-formatted dataset created following the DarwinCore standard. It contains 1219 occurrence records on the digitized specimens of vascular plants deposited in the LWS herbarium. This dataset will be dynamically updated with new data along with digitization and data mobilization progress in the LWS herbarium. Currently it includes the data about 59 species of vascular plants.

Column label	Column description
occurrenceID	An unique identifier for the Occurrence (as opposed to a particular digital record of the occurrence).
basisOfRecord	The specific nature of the data record, for example, preserved specimen or field observation.
institutionCode	The acronym in use by the institution having custody of the object(s) or information referred to in the record.
collectionCode	Unique code of collection (e.g. herbarium) for depositing the identified specimen.
catalogNumber	An identifier for the record within the collection.
scientificName	The full scientific name of the taxon including at least the genus name and species epithet and, in some cases, including the infraspecific epithet.
taxonRank	The taxonomic rank of the most specific name in the scientificName.
kingdom	The full scientific name of the kingdom in which the taxon is classified. In our case, it is always Plantae.
recordedBy	A person, group or organisation responsible for recording the original Occurrence.
verbatimEventDate	The date of record as it appears in the original publication or specimen label.
EventDate	The date during which an event (e.g. collection of the specimen, photographing of the plant or its registering in the field in any other way), occurred.
fieldNumber	An identifier given to the specimen in the field by the collector.
identifiedBy	A list of names of people, who assigned the Taxon to the subject.

dateIdentified	The date on which the subject was determined as representing the Taxon.
identificationRemarks	Comments or notes about the Identification.
decimalLatitude	The geographic latitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic centre of a Location.
decimalLongitude	The geographic longitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic centre of a Location.
coordinateUncertaintyInMeters	The horizontal distance (in metres) from the given decimalLatitude and decimalLongitude describing the smallest circle containing the whole of the Location.
geodeticDatum	The ellipsoid, geodetic datum or spatial reference system (SRS) upon which the geographic coordinates given in decimalLatitude and decimalLongitude are based. In our case, it is always WGS84.
minimumElevationInMeters	The lower limit of the range of elevation (altitude, usually above sea level), in metres.
maximumElevationInMeters	The upper limit of the range of elevation (altitude, usually above sea level), in metres.
countryCode	The standard code (ISO 3166-1-alpha-2) for the country in which the Location occurs.
country	The name of the country in which the Location occurs.
locality	The specific description of the place where the specimen was registered or collected.
language	The language of the resource. In our case, herbarium labels contained information in different languages and sometimes different languages were even combined on a single label. To simplify the work with data, we indicated the languages applied for the data.
habitat	The description of the habitat where the specimen was collected or observed.
order	The scientific name of the order.
family	The scientific name of the family.
genus	The scientific name of the genus.
verbatimIdentification	The scientific name under which the specimen is currently stored in the herbarium.

**Data set name:** LWS herbarium. Non-vascular plants

**Character set:** UTF-8

**Download URL:** <https://doi.org/10.15468/2vyggv>

**Data format:** DarwinCore



**Description:** The tab-delimited CSV-formatted dataset created following the DarwinCore standard. It contains 1200 occurrence records on the digitized specimens of non-vascular plants deposited in the LWS herbarium. This dataset will be dynamically updated with new data along with digitization and data mobilization progress in the LWS herbarium. Currently it includes the data about 190 species of non-vascular plants (bryophyta). It starts with data on specimens collected and identified by famous Ukrainian bryologist Kupava Ulychna.

Column label	Column description
occurrenceID	An unique identifier for the Occurrence (as opposed to a particular digital record of the occurrence).
basisOfRecord	The specific nature of the data record, for example, preserved specimen or field observation.
institutionCode	The acronym in use by the institution having custody of the object(s) or information referred to in the record.
collectionCode	Unique code of collection (e.g. herbarium) for depositing the identified specimen.
catalogNumber	An identifier for the record within the collection.
scientificName	The full scientific name of the taxon including at least the genus name and species epithet and, in some cases, including the subspecies epithet.
taxonRank	The taxonomic rank of the most specific name in the scientificName.
kingdom	The full scientific name of the kingdom in which the taxon is classified. In our case, it is always Plantae.
recordedBy	A person, group or organisation responsible for recording the original Occurrence.
verbatimEventDate	The date of record as it appears in the original publication or specimen label.
EventDate	The date during which an event (e.g. collection of the specimen, photographing of the plant or its registering in the field in any other way), occurred.
fieldNumber	An identifier given to the specimen in the field by the collector.
identifiedBy	A list of names of people, who assigned the Taxon to the subject.
dateIdentified	The date on which the subject was determined as representing the Taxon.
identificationRemarks	Comments or notes about the Identification.
decimalLatitude	The geographic latitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic centre of a Location.
decimalLongitude	The geographic longitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic centre of a Location.
coordinateUncertaintyInMeters	The horizontal distance (in metres) from the given decimalLatitude and decimalLongitude describing the smallest circle containing the whole of theLocation.

geodeticDatum	The ellipsoid, geodetic datum or spatial reference system (SRS) upon which the geographic coordinates given in decimalLatitude and decimalLongitude are based. In our case, it is always WGS84.
minimumElevationInMeters	The lower limit of the range of elevation (altitude, usually above sea level), in metres.
maximumElevationInMeters	The upper limit of the range of elevation (altitude, usually above sea level), in metres.
countryCode	The standard code (ISO 3166-1-alpha-2) for the country in which the Location occurs.
country	The name of the country in which the Location occurs.
locality	The specific description of the place where the specimen was registered or collected.
language	The language of the resource. In our case, herbarium labels contained information in different languages and sometimes different languages were even combined on a single label. To simplify the work with data, we indicated the languages applied for the data.
habitat	The description of the habitat where the specimen was collected or observed.
order	The scientific name of the order.
family	The scientific name of the family.
genus	The scientific name of the genus.
verbatimIdentification	The scientific name under which the specimen is currently stored in the herbarium.

## Additional information

### Brief history and prospects of digitization and data mobilization in the LWS herbarium

Digitization of the LWS herbarium began in 2012–2013 when type specimens of vascular plants were digitized in frames of the Andrew W. Mellon Foundation grant. In particular, the data and images about 286 specimens, including 252 type specimens of vascular plants, were deposited at JACQ (JACQ consortium 2023) and JSTOR Global Plants (ITHAKA 2023). In 2007–2020, the data on the genus *Aconitum* were mobilized. In the common dataset, 420 records from the LWS herbarium were included (Novikov and Prylutskiy 2023). In 2021–2022, in frames of the IAPT Small Collections grant, the data about 1,873 specimens of vascular plants deposited in the LWS herbarium were mobilized. These data supplemented the investigations of endemism in the flora of the Ukrainian Carpathians and were published within the respective dataset (Novikov and Sup-Novikova 2022). In 2023 this dataset has been updated with additional georeferenced data and supported by images of digitized material. In 2022–2023, 11,437 more occurrence records were

mobilized from LWS and published. This dataset ascertained rare, relict, range-limited, and problematic taxa of vascular plants in the Ukrainian Carpathians and adjacent territories (Novikov 2023). In 2023, 1,219 specimens of vascular plants were digitized within the SRFU grant, and respective data were published in GBIF (Novikov et al. 2023) and Open Herbarium (SMNH-NASU-LWS 2023) platforms. Hence, at the moment, the data regarding 15,235 LWS's specimens of vascular plants (12.7% of the total number of deposited specimens) were mobilized and published online. In particular, 3092 specimens of vascular plants (2.6%) were digitized, and their images appeared online in JACQ (JACQ consortium 2023), GBIF (2023), and Open Herbarium (2023) platforms. The digitization of the herbarium of non-vascular plants started only in 2023, and at the moment only 1200 specimens (4.6%) were digitized. Their images are available through the Biodiversity of Ukraine (State Museum of Natural History of the NAS of Ukraine 2023) database. In 2024, we are going to digitize ca. 5,000 specimens of vascular plants (4.2% more) and ca. 2,000 specimens of non-vascular plants (7.7% more) in the frames of the SRFU grant. The data mobilized during this work will be published as extensions to the datasets described here. High-resolution (80 Mp) specimens' images from the herbarium of vascular plants and middle-resolution (20 Mp) specimens' images from the herbarium of non-vascular plants will be available online through GBIF (2023) and Open Herbarium (2023) platforms and other online resources.

## Digitization priorities for the near future

Due to limited facilities and the complicated situation in the country, the digitization of the herbarium LWS is currently limited by the flora of Ukraine since floras of other countries are rather in response of respective herbaria. It does not mean that specimens from other countries will not be digitized, but this will be done later or on request.

We will gladly consider requests for prioritized digitization from scientists worldwide. We believe that the most important is to digitize those materials that are in urgent need for research purposes. Therefore, please direct your requests, including the list of taxa and brief reasoning, to the herbarium curators, Andriy Novikov ([novikoffav@gmail.com](mailto:novikoffav@gmail.com)) and Anastasiia Savytska ([asavitska@gmail.com](mailto:asavitska@gmail.com)).

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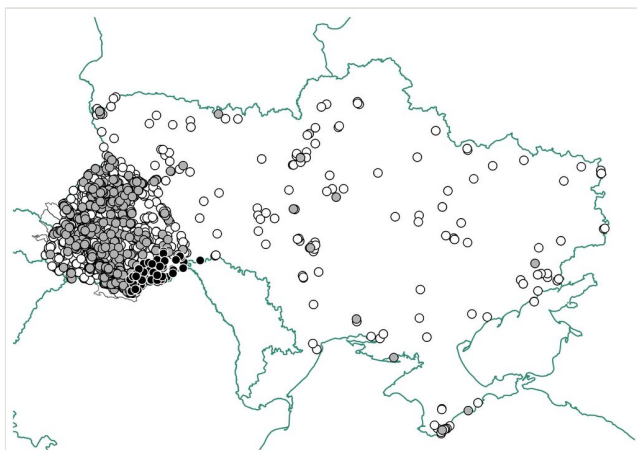


Figure 1.

Distribution of occurrences mobilized from the LWS herbarium in Ukraine. Grey circles indicate occurrences of vascular plants mobilized in 2023; black-filled circles - occurrences of non-vascular plants mobilized in 2023; white circles - occurrences of vascular plants mobilized in 2007-2022.

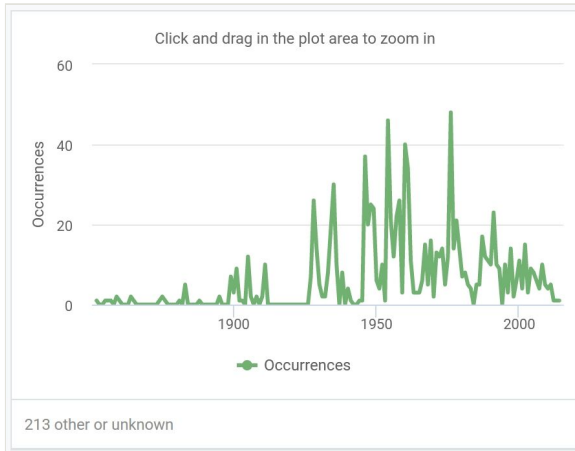


Figure 2.

The number of registered occurrences per year in the dataset of vascular plants.



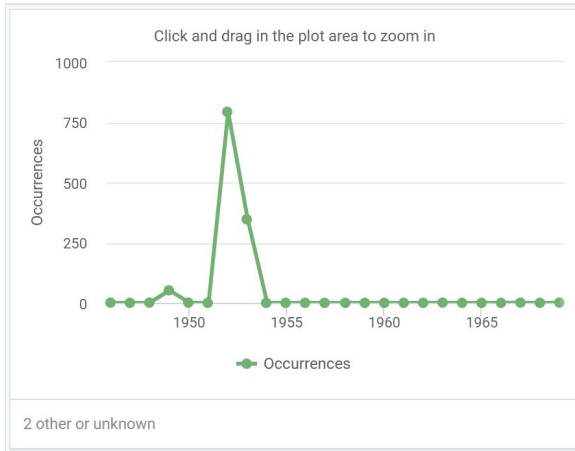


Figure 3.

The number of registered occurrences per year in the dataset of non-vascular plants.

Table 1.

The list of taxa and occurrences mobilized from the LWS herbarium in 2023.

Order	Family	Genus	Species
Apiales	Apiaceae	<i>Astrantia</i>	<i>Astrantia major</i>
Apiales	Apiaceae	<i>Bupleurum</i>	<i>Bupleurum falcatum</i>
Apiales	Apiaceae	<i>Bupleurum</i>	<i>Bupleurum longifolium</i>
Apiales	Apiaceae	<i>Bupleurum</i>	<i>Bupleurum tenuissimum</i>
Apiales	Apiaceae	<i>Meum</i>	<i>Meum athamanticum</i>
Apiales	Apiaceae	<i>Pleurospermum</i>	<i>Pleurospermum austriacum</i>
Apiales	Apiaceae	<i>Seseli</i>	<i>Seseli libanotis</i>
Caryophyllales	Caryophyllaceae	<i>Dianthus</i>	<i>Dianthus carthusianorum</i>
Caryophyllales	Caryophyllaceae	<i>Dianthus</i>	<i>Dianthus superbus</i>
Caryophyllales	Caryophyllaceae	<i>Dianthus</i>	<i>Dianthus superbus</i>
Caryophyllales	Caryophyllaceae	<i>Dianthus</i>	<i>Dianthus trifasciculatus</i>
Crossosomatales	Staphyleaceae	<i>Staphylea</i>	<i>Staphylea pinnata</i>
Ericales	Ericaceae	<i>Kalmia</i>	<i>Kalmia procumbens</i>
Ericales	Ericaceae	<i>Rhododendron</i>	<i>Rhododendron kotschyi</i>
Ericales	Ericaceae	<i>Vaccinium</i>	<i>Vaccinium microcarpum</i>
Ericales	Primulaceae	<i>Primula</i>	<i>Primula elatior</i>
Ericales	Primulaceae	<i>Primula</i>	<i>Primula halleri</i>
Ericales	Primulaceae	<i>Primula</i>	<i>Primula matthioli</i>
Ericales	Primulaceae	<i>Primula</i>	<i>Primula minima</i>
Fabales	Fabaceae	<i>Anthyllis</i>	<i>Anthyllis vulneraria</i>
Fabales	Fabaceae	<i>Astragalus</i>	<i>Astragalus australis</i>
Fabales	Fabaceae	<i>Chamaecytisus</i>	<i>Chamaecytisus albus</i>
Fabales	Fabaceae	<i>Chamaecytisus</i>	<i>Chamaecytisus lindemannii</i>
Fabales	Fabaceae	<i>Chamaecytisus</i>	<i>Chamaecytisus podolicus</i>
Fabales	Fabaceae	<i>Coronilla</i>	<i>Coronilla elegans</i>
Fabales	Fabaceae	<i>Cytisus</i>	<i>Cytisus kernerii</i>
Fabales	Fabaceae	<i>Genista</i>	<i>Genista sagittalis</i>
Fabales	Fabaceae	<i>Lathyrus</i>	<i>Lathyrus laevigatus</i>
Fabales	Fabaceae	<i>Trifolium</i>	<i>Trifolium pratense</i>
Fabales	Fabaceae	<i>Trifolium</i>	<i>Trifolium rubens</i>
Gentianales	Gentianaceae	<i>Gentiana</i>	<i>Gentiana acaulis</i>
Gentianales	Gentianaceae	<i>Gentiana</i>	<i>Gentiana lutea</i>
Gentianales	Gentianaceae	<i>Gentiana</i>	<i>Gentiana nivalis</i>

Gentianales	Gentianaceae	<i>Gentiana</i>	<i>Gentiana punctata</i>
Gentianales	Gentianaceae	<i>Gentiana</i>	<i>Gentiana verna</i>
Gentianales	Gentianaceae	<i>Gentianopsis</i>	<i>Gentianopsis ciliata</i>
Gentianales	Gentianaceae	<i>Swertia</i>	<i>Swertia perennis</i>
Lamiales	Oleaceae	<i>Fraxinus</i>	<i>Fraxinus omus</i>
Malpighiales	Euphorbiaceae	<i>Euphorbia</i>	<i>Euphorbia carpatica</i>
Malpighiales	Euphorbiaceae	<i>Euphorbia</i>	<i>Euphorbia dulcis</i>
Malpighiales	Euphorbiaceae	<i>Euphorbia</i>	<i>Euphorbia illirica</i>
Malpighiales	Hypericaceae	<i>Hypericum</i>	<i>Hypericum richeri</i>
Malpighiales	Violaceae	<i>Viola</i>	<i>Viola alba</i>
Malpighiales	Violaceae	<i>Viola</i>	<i>Viola dacica</i>
Malpighiales	Violaceae	<i>Viola</i>	<i>Viola tricolor</i>
Malvales	Cistaceae	<i>Helianthemum</i>	<i>Helianthemum nummularium</i>
Malvales	Cistaceae	<i>Helianthemum</i>	<i>Helianthemum nummularium</i>
Malvales	Malvaceae	<i>Tilia</i>	<i>Tilia platyphyllos</i>
Rosales	Rosaceae	<i>Alchemilla</i>	<i>Alchemilla sazaferi</i>
Rosales	Rosaceae	<i>Comarum</i>	<i>Comarum palustre</i>
Rosales	Rosaceae	<i>Dryas</i>	<i>Dryas octopetala</i>
Rosales	Rosaceae	<i>Rosa</i>	<i>Rosa gallica</i>
Rosales	Rosaceae	<i>Torminalis</i>	<i>Torminalis glaberrima</i>
Saxifragales	Crassulaceae	<i>Rhodiola</i>	<i>Rhodiola rosea</i>
Saxifragales	Grossulariaceae	<i>Ribes</i>	<i>Ribes petraeum</i>
Saxifragales	Saxifragaceae	<i>Saxifraga</i>	<i>Saxifraga adscendens</i>
Saxifragales	Saxifragaceae	<i>Saxifraga</i>	<i>Saxifraga aizoides</i>
Saxifragales	Saxifragaceae	<i>Saxifraga</i>	<i>Saxifraga androsacea</i>
Saxifragales	Saxifragaceae	<i>Saxifraga</i>	<i>Saxifraga bryoides</i>
Saxifragales	Saxifragaceae	<i>Saxifraga</i>	<i>Saxifraga carpatica</i>
Saxifragales	Saxifragaceae	<i>Saxifraga</i>	<i>Saxifraga paniculata</i>
Aulacomniales	Aulacomniaceae	<i>Aulacomnium</i>	<i>Aulacomnium palustre</i>
Bartramiales	Bartramiaceae	<i>Bartramia</i>	<i>Bartramia halleriana</i>
Bartramiales	Bartramiaceae	<i>Bartramia</i>	<i>Bartramia ithyphylla</i>
Bartramiales	Bartramiaceae	<i>Philonotis</i>	<i>Philonotis caespitosa</i>
Bartramiales	Bartramiaceae	<i>Philonotis</i>	<i>Philonotis calcarea</i>
Bartramiales	Bartramiaceae	<i>Philonotis</i>	<i>Philonotis fontana</i>
Bartramiales	Bartramiaceae	<i>Philonotis</i>	<i>Philonotis marchica</i>
Bryales	Bryaceae	<i>Bryum</i>	<i>Bryum argenteum</i>
Bryales	Bryaceae	<i>Bryum</i>	<i>Bryum bicolor</i>

Bryales	Bryaceae	<i>Bryum</i>	<i>Bryum inclinatum</i>
Bryales	Bryaceae	<i>Bryum</i>	<i>Bryum lanatum</i>
Bryales	Bryaceae	<i>Gemmabryum</i>	<i>Gemmabryum badium</i>
Bryales	Bryaceae	<i>Gemmabryum</i>	<i>Gemmabryum caespiticium</i>
Bryales	Bryaceae	<i>Gemmabryum</i>	<i>Gemmabryum klinggraeffii</i>
Bryales	Bryaceae	<i>Ptychostomum</i>	<i>Ptychostomum bimum</i>
Bryales	Bryaceae	<i>Ptychostomum</i>	<i>Ptychostomum cernuum</i>
Bryales	Bryaceae	<i>Ptychostomum</i>	<i>Ptychostomum compactum</i>
Bryales	Bryaceae	<i>Ptychostomum</i>	<i>Ptychostomum pallescens</i>
Bryales	Bryaceae	<i>Ptychostomum</i>	<i>Ptychostomum pseudotriquetrum</i>
Bryales	Bryaceae	<i>Ptychostomum</i>	<i>Ptychostomum turbinatum</i>
Bryales	Bryaceae	<i>Rosulabryum</i>	<i>Rosulabryum capillare</i>
Bryales	Bryaceae	<i>Rosulabryum</i>	<i>Rosulabryum moravicum</i>
Bryales	Bryaceae	<i>Rosulabryum</i>	<i>Rosulabryum rubens</i>
Bryales	Mniaceae	<i>Mnium</i>	<i>Mnium hornum</i>
Bryales	Mniaceae	<i>Mnium</i>	<i>Mnium marginatum</i>
Bryales	Mniaceae	<i>Mnium</i>	<i>Mnium spinosum</i>
Bryales	Mniaceae	<i>Mnium</i>	<i>Mnium stellare</i>
Bryales	Mniaceae	<i>Mnium</i>	<i>Mnium thomsonii</i>
Bryales	Mniaceae	<i>Plagiomnium</i>	<i>Plagiomnium cuspidatum</i>
Bryales	Mniaceae	<i>Plagiomnium</i>	<i>Plagiomnium elatum</i>
Bryales	Mniaceae	<i>Plagiomnium</i>	<i>Plagiomnium ellipticum</i>
Bryales	Mniaceae	<i>Plagiomnium</i>	<i>Plagiomnium rostratum</i>
Bryales	Mniaceae	<i>Plagiomnium</i>	<i>Plagiomnium undulatum</i>
Bryales	Mniaceae	<i>Pohlia</i>	<i>Pohlia cruda</i>
Bryales	Mniaceae	<i>Pohlia</i>	<i>Pohlia elongata</i>
Bryales	Mniaceae	<i>Pohlia</i>	<i>Pohlia filum</i>
Bryales	Mniaceae	<i>Pohlia</i>	<i>Pohlia longicolla</i>
Bryales	Mniaceae	<i>Pohlia</i>	<i>Pohlia nutans</i>
Bryales	Mniaceae	<i>Rhizomnium</i>	<i>Rhizomnium punctatum</i>
Dicranales	Dicranaceae	<i>Dicranum</i>	<i>Dicranum bonjeanii</i>
Dicranales	Dicranaceae	<i>Dicranum</i>	<i>Dicranum fuscescens</i>
Dicranales	Dicranaceae	<i>Dicranum</i>	<i>Dicranum polysetum</i>
Dicranales	Dicranaceae	<i>Dicranum</i>	<i>Dicranum scoparium</i>
Dicranales	Dicranaceae	<i>Dicranum</i>	<i>Dicranum viride</i>
Dicranales	Dicranaceae	<i>Orthodicranum</i>	<i>Orthodicranum montanum</i>
Dicranales	Dicranaceae	<i>Paraleucobryum</i>	<i>Paraleucobryum longifolium</i>

Dicranales	Ditrichaceae	<i>Ditrichum</i>	<i>Ditrichum heteromallum</i>
Dicranales	Ditrichaceae	<i>Ditrichum</i>	<i>Ditrichum pallidum</i>
Dicranales	Ditrichaceae	<i>Ditrichum</i>	<i>Ditrichum pusillum</i>
Dicranales	Ditrichaceae	<i>Pleuridium</i>	<i>Pleuridium subulatum</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens adianthoides</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens bryoides</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens crispus</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens gymnanthus</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens obtusifolius</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens pusillus</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens rufescens</i>
Dicranales	Fissidentaceae	<i>Fissidens</i>	<i>Fissidens viridulus</i>
Dicranales	Rhabdoweisiaceae	<i>Dicranoweisia</i>	<i>Dicranoweisia cirrata</i>
Encalyptales	Encalyptaceae	<i>Encalypta</i>	<i>Encalypta ciliata</i>
Encalyptales	Encalyptaceae	<i>Encalypta</i>	<i>Encalypta streptocarpa</i>
Encalyptales	Encalyptaceae	<i>Encalypta</i>	<i>Encalypta vulgaris</i>
Funariales	Funariaceae	<i>Entosthodon</i>	<i>Entosthodon hungaricus</i>
Funariales	Funariaceae	<i>Entosthodon</i>	<i>Entosthodon hungaricus</i>
Funariales	Funariaceae	<i>Funaria</i>	<i>Funaria hygrometrica</i>
Funariales	Funariaceae	<i>Physcomitrium</i>	<i>Physcomitrium acuminatum</i>
Funariales	Funariaceae	<i>Physcomitrium</i>	<i>Physcomitrium eurystomum</i>
Funariales	Funariaceae	<i>Physcomitrium</i>	<i>Physcomitrium patens</i>
Funariales	Funariaceae	<i>Physcomitrium</i>	<i>Physcomitrium pyriforme</i>
Grimmiales	Grimmiaceae	<i>Coscinodon</i>	<i>Coscinodon cribrosus</i>
Grimmiales	Grimmiaceae	<i>Grimmia</i>	<i>Grimmia pulvinata</i>
Grimmiales	Grimmiaceae	<i>Niphotrichum</i>	<i>Niphotrichum canescens</i>
Grimmiales	Grimmiaceae	<i>Schistidium</i>	<i>Schistidium apocarpum</i>
Grimmiales	Ptychomitriaceae	<i>Campylostelium</i>	<i>Campylostelium saxicola</i>
Grimmiales	Seligeriaceae	<i>Blindia</i>	<i>Blindia acuta</i>
Grimmiales	Seligeriaceae	<i>Blindiadelphus</i>	<i>Blindiadelphus recurvatus</i>
Hypnales	Amblystegiaceae	<i>Amblystegium</i>	<i>Amblystegium serpens</i>
Hypnales	Amblystegiaceae	<i>Anacamptodon</i>	<i>Anacamptodon splachnoides</i>
Hypnales	Amblystegiaceae	<i>Campylium</i>	<i>Campylium chrysophyllum</i>
Hypnales	Amblystegiaceae	<i>Campylium</i>	<i>Campylium stellatum</i>
Hypnales	Amblystegiaceae	<i>Campylophyllopsis</i>	<i>Campylophyllopsis sommerfeltii</i>
Hypnales	Amblystegiaceae	<i>Conardia</i>	<i>Conardia compacta</i>
Hypnales	Amblystegiaceae	<i>Drepanium</i>	<i>Drepanium fastigiatum</i>

Hypnales	Amblystegiaceae	<i>Drepanocladus</i>	<i>Drepanocladus polygamus</i>
Hypnales	Amblystegiaceae	<i>Drepanocladus</i>	<i>Drepanocladus polygamus</i>
Hypnales	Amblystegiaceae	<i>Hygroamblystegium</i>	<i>Hygroamblystegium tenax</i>
Hypnales	Amblystegiaceae	<i>Hygroamblystegium</i>	<i>Hygroamblystegium varium</i>
Hypnales	Amblystegiaceae	<i>Hygrohypnum</i>	<i>Hygrohypnum luridum</i>
Hypnales	Amblystegiaceae	<i>Leptodictyum</i>	<i>Leptodictyum riparium</i>
Hypnales	Amblystegiaceae	<i>Pseudoamblystegium</i>	<i>Pseudoamblystegium subtile</i>
Hypnales	Amblystegiaceae	<i>Serpoleskea</i>	<i>Serpoleskea confervoides</i>
Hypnales	Amblystegiaceae	<i>Tomentypnum</i>	<i>Tomentypnum nitens</i>
Hypnales	Anomodontaceae	<i>Anomodon</i>	<i>Anomodon viticulosus</i>
Hypnales	Anomodontaceae	<i>Anomodontella</i>	<i>Anomodontella longifolia</i>
Hypnales	Anomodontaceae	<i>Anomodontopsis</i>	<i>Anomodontopsis rugelii</i>
Hypnales	Brachytheciaceae	<i>Brachytheciastrum</i>	<i>Brachytheciastrum velutinum</i>
Hypnales	Brachytheciaceae	<i>Brachythecium</i>	<i>Brachythecium albicans</i>
Hypnales	Brachytheciaceae	<i>Brachythecium</i>	<i>Brachythecium campestre</i>
Hypnales	Brachytheciaceae	<i>Brachythecium</i>	<i>Brachythecium glareosum</i>
Hypnales	Brachytheciaceae	<i>Brachythecium</i>	<i>Brachythecium mildeanum</i>
Hypnales	Brachytheciaceae	<i>Brachythecium</i>	<i>Brachythecium rivulare</i>
Hypnales	Brachytheciaceae	<i>Brachythecium</i>	<i>Brachythecium rutabulum</i>
Hypnales	Brachytheciaceae	<i>Brachythecium</i>	<i>Brachythecium salebrosum</i>
Hypnales	Brachytheciaceae	<i>Cirriphyllum</i>	<i>Cirriphyllum piliferum</i>
Hypnales	Brachytheciaceae	<i>Eurhynchiastrum</i>	<i>Eurhynchiastrum pulchellum</i>
Hypnales	Brachytheciaceae	<i>Eurhynchium</i>	<i>Eurhynchium angustirete</i>
Hypnales	Brachytheciaceae	<i>Eurhynchium</i>	<i>Eurhynchium striatum</i>
Hypnales	Brachytheciaceae	<i>Homalothecium</i>	<i>Homalothecium lutescens</i>
Hypnales	Brachytheciaceae	<i>Kindbergia</i>	<i>Kindbergia praelonga</i>
Hypnales	Brachytheciaceae	<i>Oxyrrhynchium</i>	<i>Oxyrrhynchium hians</i>
Hypnales	Brachytheciaceae	<i>Pseudoscleropodium</i>	<i>Pseudoscleropodium purum</i>
Hypnales	Brachytheciaceae	<i>Rhynchostegium</i>	<i>Rhynchostegium murale</i>
Hypnales	Brachytheciaceae	<i>Rhynchostegium</i>	<i>Rhynchostegium riparioides</i>
Hypnales	Brachytheciaceae	<i>Sciuro-hypnum</i>	<i>Sciuro-hypnum plumosum</i>
Hypnales	Brachytheciaceae	<i>Sciuro-hypnum</i>	<i>Sciuro-hypnum populeum</i>
Hypnales	Calliergonaceae	<i>Calliergon</i>	<i>Calliergon cordifolium</i>
Hypnales	Calliergonaceae	<i>Sarmentypnum</i>	<i>Sarmentypnum exannulatum</i>
Hypnales	Climaciaceae	<i>Climacium</i>	<i>Climacium dendroides</i>
Hypnales	Entodontaceae	<i>Entodon</i>	<i>Entodon concinnus</i>
Hypnales	Fontinalaceae	<i>Fontinalis</i>	<i>Fontinalis antipyretica</i>

Hypnales	Hylocomiaceae	<i>Hylocomiadelphus</i>	<i>Hylocomiadelphus triquetrus</i>
Hypnales	Hylocomiaceae	<i>Rhytidiadelphus</i>	<i>Rhytidiadelphus squarrosus</i>
Hypnales	Hylocomiaceae	<i>Rhytidiadelphus</i>	<i>Rhytidiadelphus subpinnatus</i>
Hypnales	Hypnaceae	<i>Hypnum</i>	<i>Hypnum cupressiforme</i>
Hypnales	Hypnaceae	<i>Hypnum</i>	<i>Hypnum cupressiforme</i>
Hypnales	Jocheniaceae	<i>Jochenia</i>	<i>Jochenia pallescens</i>
Hypnales	Lembophyllaceae	<i>Isothecium</i>	<i>Isothecium alopecuroides</i>
Hypnales	Leskeaceae	<i>Leskea</i>	<i>Leskea polycarpa</i>
Hypnales	Leucodontaceae	<i>Leucodon</i>	<i>Leucodon sciuroides</i>
Hypnales	Myuriaceae	<i>Ctenidium</i>	<i>Ctenidium molluscum</i>
Hypnales	Neckeraceae	<i>Alleniella</i>	<i>Alleniella complanata</i>
Hypnales	Neckeraceae	<i>Homalia</i>	<i>Homalia trichomanoides</i>
Hypnales	Neckeraceae	<i>Pseudanomodon</i>	<i>Pseudanomodon attenuatus</i>
Hypnales	Plagiotheciaceae	<i>Herzogiella</i>	<i>Herzogiella seligeri</i>
Hypnales	Plagiotheciaceae	<i>Orthothecium</i>	<i>Orthothecium intricatum</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium cavifolium</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium denticulatum</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium denticulatum</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium laetum</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium nemorale</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium platyphyllum</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium succulentum</i>
Hypnales	Plagiotheciaceae	<i>Plagiothecium</i>	<i>Plagiothecium undulatum</i>
Hypnales	Pseudoleskeaceae	<i>Pseudoleskeella</i>	<i>Pseudoleskeella nervosa</i>
Hypnales	Pterigynandraceae	<i>Pterigynandrum</i>	<i>Pterigynandrum filiforme</i>
Hypnales	Pylaisiaceae	<i>Buckia</i>	<i>Buckia vaucheri</i>
Hypnales	Pylaisiaceae	<i>Calliergonella</i>	<i>Calliergonella cuspidata</i>
Hypnales	Pylaisiaceae	<i>Calliergonella</i>	<i>Calliergonella lindbergii</i>
Hypnales	Pylaisiaceae	<i>Homomallium</i>	<i>Homomallium incurvatum</i>
Hypnales	Pylaisiaceae	<i>Ptilium</i>	<i>Ptilium crista-castrensis</i>
Hypnales	Pylaisiaceae	<i>Pylaisia</i>	<i>Pylaisia polyantha</i>
Hypnales	Pylaisiadelphaceae	<i>Platygyrium</i>	<i>Platygyrium repens</i>
Hypnales	Rhytidiaceae	<i>Rhytidium</i>	<i>Rhytidium rugosum</i>
Hypnales	Scorpidiaceae	<i>Sanionia</i>	<i>Sanionia uncinata</i>
Hypnales	Taxiphyllaceae	<i>Taxiphyllum</i>	<i>Taxiphyllum wissgrillii</i>
Hypnales	Thuidiaceae	<i>Abietinella</i>	<i>Abietinella abietina</i>
Hypnales	Thuidiaceae	<i>Thuidium</i>	<i>Thuidium assimile</i>

Hypnales	Thuidiaceae	<i>Thuidium</i>	<i>Thuidium delicatulum</i>
Hypnales	Thuidiaceae	<i>Thuidium</i>	<i>Thuidium recognitum</i>
Hypnales	Thuidiaceae	<i>Thuidium</i>	<i>Thuidium tamariscinum</i>
Orthotrichales	Orthotrichaceae	<i>Lewinskya</i>	<i>Lewinskya affinis</i>
Orthotrichales	Orthotrichaceae	<i>Lewinskya</i>	<i>Lewinskya fastigiata</i>
Orthotrichales	Orthotrichaceae	<i>Lewinskya</i>	<i>Lewinskya speciosa</i>
Orthotrichales	Orthotrichaceae	<i>Lewinskya</i>	<i>Lewinskya striata</i>
Orthotrichales	Orthotrichaceae	<i>Nyholmiella</i>	<i>Nyholmiella obtusifolia</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum anomalum</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum cupulatum</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum pallens</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum patens</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum pumilum</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum scanicum</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum stramineum</i>
Orthotrichales	Orthotrichaceae	<i>Orthotrichum</i>	<i>Orthotrichum tenellum</i>
Orthotrichales	Orthotrichaceae	<i>Pulviger</i>	<i>Pulviger lyellii</i>
Orthotrichales	Orthotrichaceae	<i>Ulota</i>	<i>Ulota coarctata</i>
Orthotrichales	Orthotrichaceae	<i>Ulota</i>	<i>Ulota crispa</i>
Orthotrichales	Orthotrichaceae	<i>Ulota</i>	<i>Ulota crispula</i>
Orthotrichales	Orthotrichaceae	<i>Ulota</i>	<i>Ulota hutchinsiae</i>
Pottiales	Pottiaceae	<i>Bryoerythrophyllum</i>	<i>Bryoerythrophyllum recurvirostrum</i>
Pottiales	Pottiaceae	<i>Eucladium</i>	<i>Eucladium verticillatum</i>
Pottiales	Pottiaceae	<i>Geheebia</i>	<i>Geheebia fallax</i>
Pottiales	Pottiaceae	<i>Geheebia</i>	<i>Geheebia ferruginea</i>
Pottiales	Pottiaceae	<i>Geheebia</i>	<i>Geheebia spadicea</i>
Pottiales	Pottiaceae	<i>Gymnostomum</i>	<i>Gymnostomum aeruginosum</i>
Pottiales	Pottiaceae	<i>Microbryum</i>	<i>Microbryum davallianum</i>
Pottiales	Pottiaceae	<i>Tortella</i>	<i>Tortella tortuosa</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula acaulon</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula acaulon</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula caucasica</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula lindbergii</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula muralis</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula muralis</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula protobryoides</i>
Pottiales	Pottiaceae	<i>Tortula</i>	<i>Tortula truncata</i>



Scouleriales	Flexitrichaceae	<i>Flexitrichum</i>	<i>Flexitrichum flexicaule</i>
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