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Pladias Database of the Czech Flora and Vegetation

Pladias – databáze české flóry a vegetace

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The Pladias (**Pla**nt **Di**versity **A**nalysis and **S**ynthesis) Database of the Czech Flora and Vegetation was developed by the Pladias project team in 2014–2018 and has been continuously updated since then. The flora section of the database contains critically revised information on the Czech vascular flora, including 13.6 million plant occurrence records, which are dynamically displayed in maps, and data on 120 plant characteristics (traits, environmental associations and other information), divided into the sections: (1) Habitus and growth type, (2) Leaf, (3) Flower, (4) Fruit, seed and dispersal, (5) Belowground organs and clonality, (6) Trophic mode, (7) Karyology, (8) Taxon origin, (9) Ecological indicator values, (10) Habitat and sociology, (11) Distribution and frequency, and (12) Threats and protection. The vegetation section of the database contains information on Czech vegetation types extracted from the monograph Vegetation of the Czech Republic. The data are supplemented by national botanical bibliographies, electronic versions of the standard national flora and vegetation monographs, a database of more than 19,000 pictures of plant taxa and vegetation types, and digital maps (shapefiles) with botanical information. The data from the database are available online on a public portal www.pladias.cz, which also provides download options for various datasets and online identification keys to the species and vegetation types of the Czech Republic. In this paper, we describe the general scope, structure and content of the database, and details of the data on plant characteristics. To illustrate the data and describe the main geographic patterns in selected plant characteristics, we provide maps of mean values of numerical characteristics or proportions of categories for categorical characteristics on the map of the country in a grid of 5 longitudinal × 3 latitudinal minutes (approximately 6.0 km × 5.5 km). We also summarize the main variation patterns in the functional traits in the Czech flora using the principal component analysis.

Keywords: biodiversity information, Czech Republic, ecoinformatics, flora, online database, plant traits, species distribution data, vascular plants, vegetation types

Introduction

Collection of botanical data has a long tradition that stretches back for centuries. In many parts of the world, species distribution data have been systematically collected for more than 200 years and vegetation-plot data for about 100 years. A large amount of data on ecological or biogeographical characteristics of plants have been published in various floras and identification keys. With the onset of information technologies, it became feasible to collect data more systematically. These efforts resulted in the creation of several extensive databases collecting information on species distributions (e.g. GBIF – Edwards et al. 2000; BIEN – Enquist et al. 2016; GloNAF – Pyšek et al. 2017, van Kleunen et al. 2019; GIFT – Weigelt et al. 2020), vegetation plots (GIVD – Dengler et al. 2011; EVA – Chytrý et al. 2016; sPlot – Bruelheide et al. 2019) and plant traits (TRY – Kattge et al. 2020; GIFT – Weigelt et al. 2020). Nowadays, the knowledge accumulated in databases covering different aspects of plant diversity can be integrated in order to make full use of its enormous potential. Such database integrations can reveal unknown biodiversity patterns at various scales, answer fundamental questions about the origin of these patterns, or address novel research questions (e.g. van Kleunen et al. 2015, Enquist et al. 2016, Bruelheide et al. 2018).

The Czech Republic is a country with a long history of botanical research, including detailed floristic recording, taxonomic studies, vegetation surveys and various types of ecological studies (see Danihelka et al. 2017 for historical overview). Detailed information on various aspects of plant diversity is available for the whole national territory and to a large extent, it is stored in electronic databases. However, until very recently, different thematic and regional databases had been maintained separately. The most important sources of information on plant diversity in the Czech Republic are the modern national flora (Hejný et al. 1988 onwards), identification keys (Kubát et al. 2002, Kaplan et al. 2019a), a species list (Danihelka et al. 2012), a vegetation monograph (Chytrý 2007–2013), several databases of plant distribution held by different institutions and individuals, a national database of vegetation-plot records (Czech National Phytosociological Database, CNPD; Chytrý & Rafajová 2003), and various databases of plant traits (e.g. CLO-PLA, Klimešová & de Bello 2009), habitat affinities (Chytrý & Tichý 2003, Sádlo et al. 2007, Prach et al. 2014) and alien species (Pyšek et al. 2002, 2012). Some steps towards the integration of this information have been done in recent years, primarily motivated by the specific needs of various research projects. For example, the alien species database was linked with the vegetation-plot database (Chytrý et al. 2005) and both of them with a database of geographic information (Chytrý et al. 2009). There were also integrations of plant-trait databases with the alien species databases and a plant distribution database (Pyšek et al. 2009, 2015). Each particular project that involved joint analyses of different databases revealed previously undetected patterns of plant diversity and offered novel explanations contributing to the general understanding of the evolution of plant diversity.

Critical revision and integration of all the available information on various characteristics of vascular plant species and vegetation types occurring in the Czech Republic were among the aims of the Pladias (**Pla**nt **Di**versity **A**nalysis and **S**ynthesis) project. This project, funded by the Czech Science Foundation as a Centre of Excellence in 2014–2018, involved botanists from Masaryk University (Brno), Institute of Botany of the Czech Academy of Sciences (Průhonice, Třeboň and Brno), University of South Bohemia (České Budějovice) and dozens of external collaborators. The Pladias Database of the Czech Flora and Vegetation was compiled within this project with a proximate aim to support research into trade-offs in life histories of temperate plants, plant community assembly rules and plant invasions. However, the aim of the database compilation was broader, with a long-term vision of developing permanent data infrastructure for botanical survey and research on the national scale. Such an infrastructure should also support biodiversity conservation and environmental assessment by providing critically revised and publicly accessible data on plant species occurrences. It should also be useful for education, helping students and the public to identify plants and learn about their characteristics and ecology. In order to support these broader aims, the database was made available to the public on the internet.

The aim of this paper is to (i) present the overall scope, structure and content of the Pladias Database, (ii) describe the data on plant characteristics included in the database, and (iii) show the main patterns of the spatial distribution of plant characteristics on the national scale by linking the data on species characteristics with species occurrence records.

Database scope

The Pladias Database includes comprehensive and critically revised information on vascular plant taxa and vegetation types occurring in the Czech Republic. All the native and spontaneously established alien vascular plant taxa ever recorded in the country are included. In addition, the database also contains some commonly cultivated crop plants or alien woody plants that have been traditionally mentioned in the Czech flora handbooks and species lists (Hejný et al. 1988 onwards, Kubát et al. 2002, Danihelka et al. 2012, Pyšek et al. 2012, Kaplan et al. 2019a). In the vegetation part, the database includes information on vegetation types accepted in the current national vegetation classification system (Chytrý 2007–2013), including the syntaxonomic ranks of class, alliance and association.

The expected users of the database include the scientific community (botanists, ecologists, biogeographers and conservation biologists), nature conservation practitioners, teachers, students, amateur botanists and the informed public. The database does not include data related to plant cultivation, medicinal use, edibility or toxicity. The vegetation part of the database contains data on spontaneously established plant communities, excluding planted ecosystems such as forestry plantations or crop fields (except the spontaneously established weed communities in crop cultures).

Database structure

The Pladias Database comprises three data management modules and the public portal for data presentation (Fig. 1). It contains species occurrence records, data on species characteristics, data on vegetation types, pictures, spatial data in the form of digital map layers, bibliographic data and pdf files of key national botanical publications.

The data management modules are used by the database administrators and collaborators for data upload, editing, checking, correcting and export. The first, simplest module, provides tools for editing the taxonomic backbone, i.e. a hierarchical list of plant taxa used in the database. The current state of the taxonomic backbone is used as a source of taxon names and concepts across the whole database. The second module was developed for managing the species occurrence records and the third module for managing the data on plant characteristics. The last two modules contain import functions with various quality assurance tools. For example, these tools check whether the imported taxon names match the taxonomic backbone, whether the values of plant characteristics match the expected data type, and whether the imported values are within a predefined range.

Data on species distribution and plant characteristics are changing dynamically in the database. Any change to the database content made by the data managers in the database management modules immediately appears in the public portal. In the case of plant traits, numbered versions of the data are stored in the database whenever data are exported for analyses. The other kinds of data (pictures, information on vegetation types, digital map layers, bibliographies and pdf files) are stored in the database as static packages that are updated occasionally but not subject to ongoing changes. Therefore the database does not contain any management modules for these data.

Data are presented on the public portal "Pladias – Database of the Czech Flora and Vegetation" (www.pladias.cz), which has two parallel language versions, Czech and English. This portal is divided into the sections Species, Vegetation, Identification (both

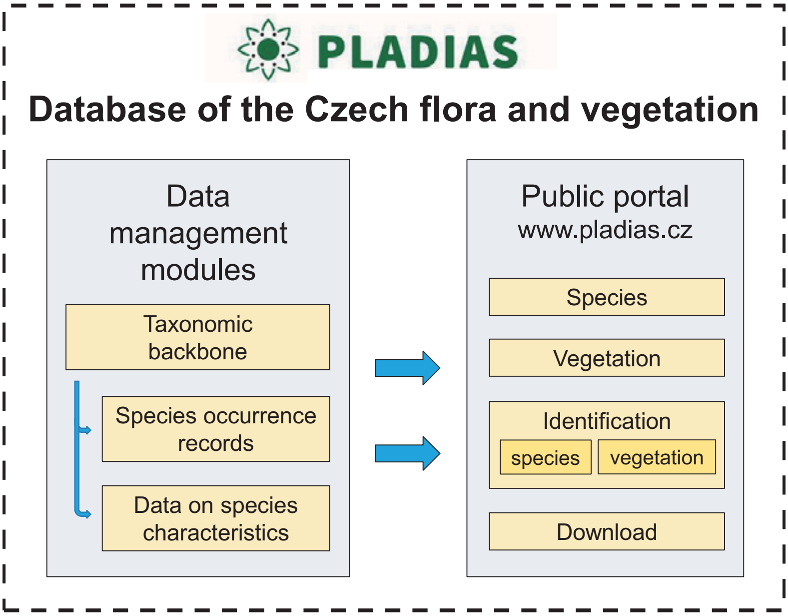

Fig. 1. – Structure of the Pladias Database, with arrows indicating the dynamic data flow.

for species and vegetation types) and Download. The section Species summarizes data for vascular plant species but also infraspecific taxa and taxa between the levels of genus and species. The sections Species and Vegetation are organized as sets of structured factsheets for individual taxa or vegetation types, each containing all the available information for the selected taxon or vegetation type. Any change in taxon occurrence records or taxon characteristics made in the data management modules is immediately displayed in the relevant parts of the sections Species, Identification and Download in the public portal and used by the identification key for species. The section Identification is divided into identification keys for plant species and vegetation types. The section Download provides some of the background datasets used as sources of factsheets in the sections Species and Vegetation, which can be downloaded here as spreadsheets suitable for data analysis. Moreover, this section contains some data that are not available in any other section of the public portal, e.g. digital maps and bibliographies.

Database content

Species distribution data

In November 2020, the Pladias Database contained approximately 13.6 million taxon occurrence records from the Czech Republic. This subset of the database was described in detail by Wild et al. (2019). The occurrence records are continuously revised by several experts using the data management module and dynamically displayed in the distribution maps on the Pladias public portal. Once all the occurrence records for a taxon are revised at a level of quadrants of the grid flora mapping, a map of this taxon is published in the series Distributions of vascular plants in the Czech Republic (Kaplan et al. 2015, 2016a, b, 2017a, b, 2018a, b, 2019b, 2020, to be continued). The published map is added to this taxon's factsheet on the Pladias public portal. For some taxa, the published maps contain information that is not displayed in the dynamically generated maps on the Pladias website, e.g. different symbols for older vs newer records or occurrences documented by herbarium specimens vs those based on other records.

Data on species characteristics

The Pladias Database contains information on 120 characteristics of vascular plant species and other taxa below the level of genus. These characteristics are divided into 12 sections: (1) Habitus and growth type, (2) Leaf, (3) Flower, (4) Fruit, seed and dispersal, (5) Belowground organs and clonality, (6) Trophic mode, (7) Karyology, (8) Taxon origin, (9) Ecological indicator values, (10) Habitat and sociology, (11) Distribution and frequency, and (12) Threats and protection.

These 120 characteristics comprise plant traits, environmental associations and other information about plants. Traits are a subset of plant characteristics defined as morphological, physiological or phenological features measurable at the individual plant level, without reference to the environment or population or community level (McGill et al. 2006, Violle et al. 2007, Pérez-Harguindeguy et al. 2013, Garnier et al. 2017). Some traits in the database are functional, i.e. directly affecting plant fitness or its environment. Other traits are morphological characters that may be important for plant identification but have no apparent effect on plant performance. The trait values in the database are means or ranges for a taxon, not multiple measurements for plant individuals. Environmental associations are another subset of plant characteristics defined as non-random associations of individual plants, plant populations or plant species with particular characteristics of the environment (Garnier et al. 2017). They include ecological and biogeographical characteristics. The database also contains other types of information about plant species, such as their legal protection or, for alien species, the year of the first record in the wild in the country. The names of the characteristics were selected considering the proposals in the Thesaurus of Plant Characteristics (Garnier et al. 2017). However, in several cases, we used alternative names in order to follow the original data sources or national and regional tradition.

Other data on species

In November 2020, the Pladias Database contained a total of 17,763 photographs of whole plants and details important for identification, representing 3272 taxa, which were carefully selected for this purpose. Details and taxa not available from in situ photos were photographed in the Herbarium of Masaryk University (BRNU). Moreover, 502 taxa were illustrated by 725 original drawings of their underground organs by Jitka Klimešová, many of which were also published in the book Temperate herbs: an architectural analysis (Klimešová 2018).

For all the species that were included in the first seven volumes of the Flora of the Czech Republic (Hejný et al. 1988 onwards), the public portal provides a link to a pdf file containing the relevant chapter from this Flora (with permission from the copyright holders).

Data on vegetation types

The Pladias Database contains the complete information from the monograph Vegetation of the Czech Republic (Chytrý 2007–2013), including textual descriptions of vegetation units, lists of their diagnostic, constant and dominant species, distribution maps, and a link to a pdf file containing the relevant chapter from this vegetation monograph (with permission from the publisher). Newer information on the Czech vegetation published after 2013 (e.g. Dřevojan et al. 2016 onwards, Willner et al. 2019, Landucci et al. 2020, Novák et al. 2020, Zukal et al. 2020) is not included, but an update is planned in the future. Each species name in the lists is hyperlinked to information on this species on the Pladias portal. In November 2020, the database also contained 868 photographs representing all 496 phytosociological associations described in Vegetation of the Czech Republic.

The Pladias Database only contains information on vegetation types, not vegetation-plot data. The plot data are kept separately in the Czech National Phytosociological Database (Chytrý & Rafajová 2003) managed using the Turboveg program (Hennekens & Schaminée 2001), which is specifically tailored for this data type and enables international data sharing (Chytrý et al. 2016, Bruelheide et al. 2019). However, species occurrence records were extracted from the plots stored in the Czech National Phytosociological Database and used as one of the sources of species distribution data in the Pladias database.

Supporting data and bibliographies

Further data included in the Pladias Database are available in the Download section of the public portal. They include spreadsheets containing the species lists of the country's flora (Kubát et al. 2002, Danihelka et al. 2012), a list of vegetation units (Chytrý 2007–2013), pdf files of articles describing various datasets integrated into the Pladias Database, and shapefiles with the phytogeographic division of the Czech Republic (Skalický 1988, Kaplan 2012), flora mapping grid (Niklfeld 1971), Map of potential natural vegetation of the Czech Republic (Neuhäuslová et al. 1998) and maps of plant invasions in the Czech Republic (Chytrý et al. 2009).

The public portal also provides bibliographic information from the series Bibliographia botanica čechoslovaca, Bibliographia botanica čechica and Bibliographia syntaxonomica čechoslovaca, all available in a searchable pdf format. A total of 22 volumes of Bibliographia botanica čechoslovaca and Bibliographia botanica čechica were published by the Institute of Botany of the Czechoslovak (later Czech) Academy of Sciences in 1967–2005. The bibliography contains a list of botanical publications from 1952–1957 and 1959–2000 related to the Czech Republic and until 1992 also to Slovakia. In addition, there is the Licit database in the Microsoft Access format, which contains a list of botanical publications related to the territory of the Czech Republic mainly from the years 1989–2002 and of Slovakia from 1989–1992. This database, compiled in the Institute of Botany of the Czech Academy of Sciences, was used to prepare two volumes of Bibliographia botanica čechoslovaca for the years 1989–1992 and four volumes of Bibliographia botanica čechica for the years 1993–2000. It also contains a list of publications from 2001 and 2002 compiled for the fifth volume of Bibliographia botanica čechica, which has not been printed. A syntaxonomical bibliography (Bibliographia syntaxonomica čechoslovaca ad annum 1970) was published by the Institute of Botany of the Czechoslovak Academy of Sciences in 1983–1992. The bibliography is organized by the classes of phytosociological classification. Each of its 20 volumes contains a list of literature sources that relate to the individual vegetation classes and a list of subordinate syntaxonomic units of these classes with references to literature sources. The geographic scope of the bibliography is former Czechoslovakia.

Identification keys

The interactive identification keys that use various information from the Pladias Database are online applications available on the public portal. There are two identification keys, one for plant species and one for vegetation types.

The species identification key supports the identification of species or, for some genera, also sections or groups or cultivars of cultivated plants. It does not include subspecies, aggregates or any other taxa. In this key, the total species list of the Czech flora can be filtered by selecting attributes of any of these characteristics: genus, family or a higher taxon, height, growth form, life form, life span, leaf presence and metamorphosis, leaf arrangement, leaf shape (with the subcategories of simple leaf division and compound leaf shape), stipules, petiole, leaf life span, leaf deciduousness in woody plants, leaf anatomy, functional leaf type in woody plants, flowering period, flower colour, flower symmetry, perianth type, perianth fusion, shape of the sympetalous corolla or syntepalous perianth, calyx fusion, inflorescence type, fruit type (with the subcategories of fleshy fruit type and dry fruit type), shoot metamorphosis, fruit colour, parasitism and mycoheterotrophy, carnivory, relationships to light, temperature, moisture, soil reaction, nutrients and salinity (based on Ellenberg-type indicator values with scales merged to three to four categories), habitat type (using 13 broad categories) and elevational belt in the Czech Republic. The application proposes a list of species that are characterized by a combination of the entered values. Species for which the value of at least one of the criteria used in the selection is missing cannot be safely selected or excluded from the selection. Therefore, such species are listed below. The species list can be further filtered by selecting only those species that were previously recorded within 10 km from the locality of the target plant identified by clicking into an interactive map. It should be noted that this key provides only suggestions for potentially matching species. A safe identification can only be made using taxonomic literature such as a flora manual or an identification key.

The vegetation key enables quick identification of phytosociological associations or alliances according to the Vegetation of the Czech Republic (Chytrý 2007–2013). It uses the probabilistic identification method proposed by Tichý & Chytrý (2019). The expected input data is information on the structure of the considered vegetation type (forest or scrub vs other vegetation types), a few names of species occurring in the vegetation type, and optionally information on whether some of these species have a high cover. The method uses the data on the occurrence frequency (constancy) of the entered species in individual associations or alliances as published in the synoptic tables in the Vegetation of the Czech Republic. It calculates the probability of the co-occurrence of the entered set of species in each vegetation type and suggests vegetation types with the highest probability as potential matches. The accuracy of the identification increases with the number of entered species. However, it usually returns meaningful results already after entering three or four species (see the tests in Tichý & Chytrý 2019). The vegetation key is also available as an Android application for smartphones (https://play.google.com/store/apps/details?id=com.test.tichy.vegkey).

Taxonomy

The taxonomic backbone of the Pladias Database is a hierarchical checklist of the Czech flora based on Danihelka et al. (2012) with further corrections and additions published in the Identification Key to the Czech Flora (Kaplan et al. 2019a). It is expected that in the near future, the taxonomic backbone will be converted to Kaplan et al. (2019a). The system at the family level follows version 11 of the Angiosperm Phylogeny Website (http://www.mobot.org/MOBOT/research/APweb) for angiosperms and Smith et al. (2006) for ferns. The taxonomic ranks used in the database include division, class, order, family, genus, subgenus, section, aggregate, series and other informal infrageneric ranks, species, subspecies, variety, form, group, cultivar, nothospecies and nothosubspecies. Some hybrids are represented by hybrid formulas. Data are systematically collected for the ranks below the genus level.

Software

The Pladias Database was developed as a complex software stack storing different types of botanical data. It is run on infrastructure hosted by the Institute of Botany of the Czech Academy of Sciences in Průhonice. Its user interface is designed as a web-based granted-access application respecting ergonomics of shared data handling. The requirement for long-term sustainability was met by adopting third-party open-source components as much as possible to avoid future software license expenditures. The data store is based on a PostgreSQL object-relational database system with the spatial extension PostGIS. The unified web environment allows for viewing, mapping, searching and downloading separate data on the occurrence and various characteristics of species as well as spatial queries on the combination of both layers (Wild et al. 2019).

The following data types were defined in the Pladias Database to store different types of plant characteristics:

- Boolean (boolean) – logical values True/False
- Unsorted list (enum_nominal) – a multi-state categorical variable with an a priori list of unsorted categories; each taxon can be assigned to more than one category
- Sorted list (enum_ordinal) – an ordinal variable with an a priori list of sorted categories; each taxon can be assigned to more than one category
- Sorted list without multiplicity (enum_ordinal_single) – an ordinal variable with an a priori list of sorted categories; each taxon can be assigned to a single category
- Integer (integer) – positive or negative whole numbers and zero
- Real number (real) – real (decimal) numbers; each taxon can be assigned to a single value
- Real number with multiplicity (real_multi) – real (decimal) numbers; each taxon can be assigned to more than one value
- Interval with the mean (interval_avg) – a set of values (real numbers) including the ultra-minimum, minimum, mean, standard error of the mean, maximum and ultra-maximum; ultra-minimum and ultra-maximum can be used for rarely occurring outlier values to distinguish them from typical minimum or maximum values
- Percentage (percentage) – percentage values
- Month (month) – intervals of months within a year (values of 1–12)
- Year (year) – years of the Gregorian calendar

- Occurrence frequency (occurrence_frequency) – numbers of taxon occurrences in grid cells generated dynamically from the taxon occurrence data
- List of syntaxa (enum_syntaxons) – unsorted lists of vegetation units
- Inter-taxon association (taxon_taxon_real) – pairs of taxa with a real number quantifying the degree of association between them

Data access, download and export options

Most data in the Pladias Database are available via the public portal www.pladias.cz. The publicly non-available datasets include older versions of some datasets that are available in an updated version, fragmentary datasets, datasets waiting for revision, and a few datasets that cannot be made public because of third-party copyright restrictions. Individuals interested in obtaining additional data not available on the public portal should contact the Governing Board of the Pladias Database, following the Pladias Data Management and Access Rules available at www.pladias.cz/en/homepage/rules.

Various datasets, including digital map layers (shapefiles), can be downloaded in the section Download of the public portal. Data on a large part of plant characteristics are available there in a spreadsheet format, which enables their use in analyses. Most of these spreadsheets are generated from the current version of the database at each download. Consequently, they always contain up-to-date information. If a particular species characteristic is not available in the spreadsheet format on the public portal, the user can contact the data provider. In this section, the user can also generate and export a list of all plant taxa recorded in the selected grid cell or quadrant of the flora mapping. Alternatively, they can also generate a complementary list of all taxa present in the country flora but not recorded in the grid cell or the quadrant. The latter list can be used in the field for a targeted recording of missing taxa.

Both the data management modules of the Pladias Database contain various options of complex data exports, including the automatic transfer of occurrence information or the values of plant characteristics between different taxonomic levels. The transfer can be done either in the top-down direction (from higher to lower taxonomic levels) or the bottom-up direction (Fig. 2). The top-down transfer is only applied if there is a single taxon at the lower taxonomic level in the Czech flora (e.g. a species has only one subspecies). The bottom-up transfer can also be applied if there are two or more taxa at the lower taxonomic level. In such cases, values of the taxa at the lower level are merged according to specific rules for the given data type. For example, True and False in the Boolean data type are merged into True, more categories are added in the Unsorted list data type, or the mean or the maximum value is taken in the Integer or Real number data types. These transfers are also used for generating the dynamic species distribution maps that are displayed on the Pladias public portal. Automatically transferred values are always kept separately from the original values, and their use depends on the specific research needs.

Plant characteristics in the Pladias Database: data description

In the following, we provide a detailed description of the publicly available data on plant characteristics contained in the Pladias Database, divided into 12 sections (Table 1).

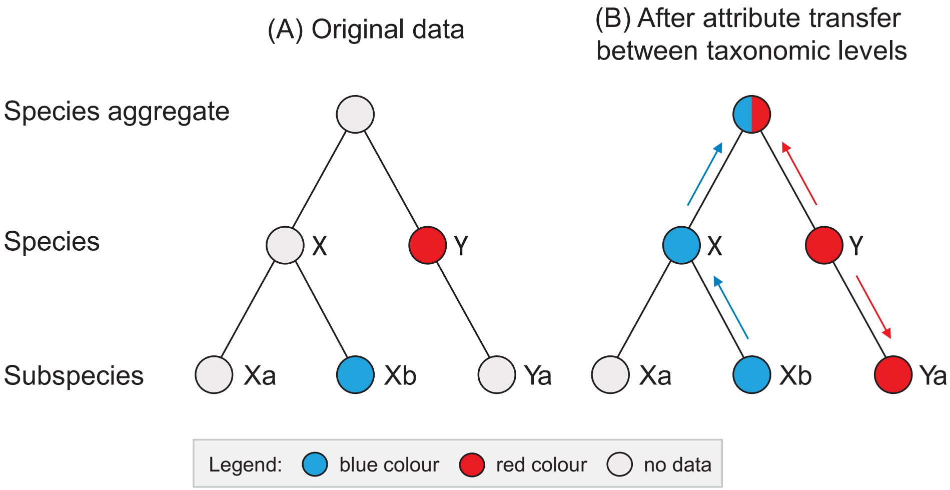

Fig. 2. – A scheme of the attribute value transfer across levels of the taxonomic hierarchy. Flower colour is used as an example characteristic. In the original data (A), the attribute is available only for subspecies Xb (blue) of species X and for species Y (red). After the attribute transfer, species X is assigned the blue colour from the subspecies Xb. The aggregate, including both species X and Y, is assigned to both colours. The red colour is also assigned to subspecies Ya of species Y because this is the only subspecies of this species in the national flora. However, no value can be assigned to subspecies Xa.

While the data on taxon occurrence and distribution were described by Wild et al. (2019), vegetation data by Chytrý (2007–2013) and other datasets in their corresponding references, this is the first summary of metadata for characteristics of species and other taxa contained in the Pladias Database. In addition to data description, we take advantage of the integration of species occurrence records and species characteristics in a single database and provide maps of the spatial distribution of the values of selected species characteristics across the country.

Origin of the data on plant characteristics

Data on plant characteristics in the Pladias Database were compiled from multiple sources. Morphological traits, as well as data on plant height, life form and flowering period, were collected mainly from the national flora handbooks (Hejný et al. 1988 onwards, Kubát et al. 2002). Data on some traits were revised simultaneously with the preparation of the new edition of the Key to the Flora of the Czech Republic (Kaplan et al. 2019a), in cooperation with its editors and authors. Some pieces of missing information were also extracted from foreign floras. Some parts of the Pladias Database incorporated data from previously established specialized databases. In particular, most of the data on belowground organs and clonality were taken from an updated and aggregated version of the CLO-PLA3 database (Klimešová et al. 2017). This database provides a freely available comprehensive data set of clonal and bud bank traits for almost 3000 species of the central-European flora. The data on the origin, status and introduction time and pathways of alien flora were taken from an updated version of the 2nd edition of the Catalogue of alien plants of the Czech Republic (Pyšek et al. 2012). The data on habitat affinity were

Table 1. – Overview of 120 publicly available plant characteristics contained in the Pladias Database. The data types are explained on pages 9–10. The table reports data for species, although the database also contains data for other taxa such as subspecies, varieties, aggregates, sections and hybrids. At least some data are available for 3878 species, which is the complete Czech flora including casual aliens and recently extinct species. The table reports the numbers and percentages of species for which information on each characteristic is available and for a subset of 2246 species which are usually considered in the analyses of the national flora (excluding species that are only present in cultivation in the country, casual neophytes, and specious genera or groups with a large proportion of apomictic species: *Alchemilla*, *Hieracium*, *Pilosella*, *Ranunculus auricomus* agg., *Rubus*, *Sorbus* and *Taraxacum*). The traits used for PCA analysis are marked by an asterisk in the last column. Notes indicate the group of species for which the characteristic is available: 1 – only for woody plants; 2 – only for flowering plants; 3 – only for angiosperms; 4 – only for plants with the developed perianth; 5 – only for plants with sympetalous corolla or syntepalous perianth; 6 – only for plants with heterochlamydeous flowers with calyx present; 7 – only for plants with some kind of shoot metamorphosis, root metamorphosis or storage organ, respectively for the corresponding traits; 8 – only for clonal herbs or dwarf shrubs; 9 – only for herbs or dwarf shrubs; 10 – only for alien plants; 11 – only for neophytes; 12 – only for the taxa listed in the Vegetation of the Czech Republic.

Plant characteristic	Data type	All species (n = 3878)	% of all 3878	Without cultivated, casual neophytes and apomicts (n = 2246)	% of 2246	Note	PCA
1. Habitus and growth type							
Height	interval_avg	3101	80	2083	93		*
Growth form	enum_nominal	3106	80	2086	93		*
Life form	enum_nominal	3042	78	2069	92		*
Life strategy	enum_nominal	1692	44	1295	58		
Life strategy (C-score)	percentage	1692	44	1295	58		
Life strategy (S-score)	percentage	1692	44	1295	58		
Life strategy (R-score)	percentage	1692	44	1295	58		
2. Leaf							
Leaf presence and metamorphosis	enum_nominal	3797	98	2210	98		
Leaf arrangement (phyllotaxis)	enum_nominal	3733	96	2165	96		*
Leaf shape	enum_nominal	3780	97	2199	98		*
Stipules	boolean	3800	98	2210	98		
Petiole	enum_nominal	3723	96	2164	96		
Leaf life span	enum_nominal	2065	53	1621	72		*
Leaf deciduousness in woody plants	enum_nominal	467	12	223	10	1	
Leaf anatomy	enum_nominal	2048	53	1586	71		*
Functional leaf type in woody plants	enum_nominal	471	12	225	10	1	
3. Flower							
Flowering period	month	3040	78	2067	92	2	*
Flowering phase	enum_nominal	1308	34	1102	49	2	
Flower colour	enum_nominal	3714	96	2146	96	3	
Flower symmetry	enum_nominal	3023	78	1701	76	4	
Perianth type	enum_nominal	3675	95	2138	95	3	
Perianth fusion	enum_nominal	3434	89	1961	87	4	
Shape of the sympetalous corolla or syntepalous perianth	enum_nominal	1409	36	744	33	5	
Calyx fusion	enum_nominal	2480	64	1313	58	6	
Inflorescence type	enum_nominal	3711	96	2146	96	3	
Dicliny	enum_nominal	2245	58	1703	76	2	*
Generative reproduction type	enum_nominal	2297	59	1628	72	2	*
Pollination syndrome	enum_nominal	2196	57	1676	75	2	*
Pollinator spectrum	enum_nominal	293	8	237	11	3	

Plant characteristic	Data type	All species (n = 3878)	% of all 3878	Without cultivated, casual neophytes and apomicts (n = 2246)	% of 2246	Note	PCA
4. Fruit, seed and dispersal							
Fruit type	enum_nominal	3674	95	2136	95	3	*
Fruit colour	enum_nominal	1949	50	1500	67	3	
Reproduction type	enum_nominal	2282	59	1730	77	3	*
Dispersal unit (diaspore)	enum_nominal	2782	72	1997	89		*
Dispersal strategy	enum_nominal	2840	73	2026	90		*
Myrmecochory	enum_nominal	3741	96	2164	96		*
5. Belowground organs and clonality							
Shoot metamorphosis	enum_nominal	1384	36	1073	48	7	
Root metamorphosis	enum_nominal	422	11	360	16	7	
Storage organ	enum_nominal	1433	37	1282	57	7	
Type of clonal growth organ	enum_nominal	1020	26	823	37	8	
Freely dispersible organs of clonal growth	boolean	1025	26	828	37	8	*
Shoot life span (cyclicity)	enum_nominal	1890	49	1491	66	9	*
Branching type of stem-derived organs of clonal growth	enum_nominal	1258	32	1014	45	8	
Primary root	boolean	1986	51	1579	70	9	
Persistence of the clonal growth organ	interval_avg	998	26	807	36	8	*
Number of clonal offspring	interval_avg	1001	26	812	36	8	*
Lateral spreading distance by clonal growth	interval_avg	999	26	807	36	8	*
Clonal index	integer	984	25	797	35	8	*
Position of root buds	enum_nominal	345	9	267	12		
Role of root buds in the life-history of a plant	enum_nominal	345	9	267	12		
Number of buds per shoot at the soil surface (root buds excluded)	interval_avg	2112	54	1666	74		
Number of buds per shoot at a depth of 0–10 cm (root buds excluded)	interval_avg	2115	55	1668	74		
Number of buds per shoot at a depth greater than 10 cm (root buds excluded)	interval_avg	2113	54	1666	74		
Size of the belowground bud bank (root buds excluded)	interval_avg	2129	55	1673	74		
Depth of the belowground bud bank (root buds excluded)	interval_avg	1995	51	1584	71		
Number of buds per shoot at the soil surface (root buds included)	interval_avg	2112	54	1666	74		
Number of buds per shoot at a depth of 0–10 cm (root buds included)	interval_avg	2115	55	1668	74		
Number of buds per shoot at a depth greater than 10 cm (root buds included)	interval_avg	2113	54	1666	74		
Size of the belowground bud bank (root buds included)	interval_avg	2129	55	1673	74		*
Depth of the belowground bud bank (root buds included)	interval_avg	2031	52	1608	72		*

Plant characteristic	Data type	All species (n = 3878)	% of all 3878	Without cultivated, casual neophytes and apomicts (n = 2246)	% of 2246	Note	PCA
6. Trophic mode							
Parasitism and mycoheterotrophy	interval_avg	3848	99	2225	99		*
Carnivory	boolean	3867	100	2242	100		*
Symbiotic nitrogen fixation	interval_avg	3798	98	2210	98		*
7. Karyology							
Chromosome number (2n)	integer	1763	45	1458	65		
Ploidy level (x)	integer	1771	46	1457	65		
2C genome size	interval_avg	1775	46	1461	65		*
1Cx monoploid genome size	interval_avg	1771	46	1457	65		
Genomic GC content	percentage	1722	44	1423	63		*
8. Taxon origin							
Origin in the Czech Republic	enum_ordinal	3817	98	2209	98		
Invasion status	enum_ordinal	3540	91	2160	96		
Geographic origin	enum_nominal	1279	33	618	28	10	
Year of the first record in the wild	year	704	18	269	12	11	
Introduction pathway	enum_nominal	1258	32	603	27	10	
9. Ecological indicator values							
Light indicator value	enum_ordinal	2273	59	1845	82		
Temperature indicator value	enum_ordinal	2273	59	1845	82		
Moisture indicator value	enum_ordinal	2273	59	1845	82		
Reaction indicator value	enum_ordinal	2271	59	1843	82		
Nutrient indicator value	enum_ordinal	2271	59	1843	82		
Salinity indicator value	enum_ordinal	2271	59	1843	82		
Whole-community disturbance frequency indicator value	interval_avg	1159	30	992	44		
Herb-layer disturbance frequency indicator value	interval_avg	1159	30	992	44		
Whole-community disturbance severity indicator value	interval_avg	1159	30	992	44		
Herb-layer disturbance severity indicator value	interval_avg	1159	30	992	44		
Whole-community structure-based disturbance indicator value	interval_avg	1159	30	992	44		
Herb-layer structure-based disturbance indicator value	interval_avg	1159	30	992	44		
10. Habitat and sociology							
Occurrence in habitats	a set of 88 variables of enum_ordinal_single type	2236	58	1796	80		
Affinity to the forest environment in Thermophyticum	enum_nominal	3542	91	2062	92		
Affinity to the forest environment in Mesophyticum and Oreophyticum	enum_nominal	3658	94	2132	95		
Diagnostic taxon of classes	enum_syntaxons	450	12	391	17	12	
Diagnostic taxon of alliances	enum_syntaxons	925	24	798	36	12	
Diagnostic taxon of associations	enum_syntaxons	1258	32	1083	48	12	
Constant taxon of classes	enum_syntaxons	183	5	150	7	12	

Plant characteristic	Data type	All species (n = 3878)	% of all 3878	Without cultivated, casual neophytes and apomicts (n = 2246)	% of 2246	Note	PCA
Constant taxon of alliances	enum_syntaxons	497	13	430	19	12	
Constant taxon of associations	enum_syntaxons	992	26	854	38	12	
Dominant taxon of associations	enum_syntaxons	582	15	497	22	12	
Ecological specialization index for all vegetation types	real	1493	38	1268	56		
Ecological specialization index for non-forest vegetation	real	1427	37	1216	54		
Ecological specialization index for forest vegetation	real	809	21	691	31		
Index of colonization success (ICS)	real	1699	44	1675	75		
Index of colonization potential (ICP)	real	1154	30	1136	51		
Optimum successional age	real	938	24	920	41		
11. Distribution and frequency							
Floristic zone	enum_nominal	2148	55	1677	75		
Floristic region	enum_nominal	2196	57	1684	75		
Continentality degree	integer	1289	33	1057	47		
Distribution range extension along the continentality gradient	integer	1940	50	1606	72		
Elevational belt in the Czech Republic	enum_ordinal	2317	60	1814	81		
Occurrence frequency in the basic grid mapping cells	occurrence_frequency	3878	100	2246	100		
Occurrence frequency in quadrants of the basic grid mapping cells	occurrence_frequency	3878	100	2246	100		
Occurrence frequency in vegetation plots	percentage	1820	47	1500	67		
Occurrence frequency in vegetation plots with a cover above 5%	percentage	1820	47	1500	67		
Occurrence frequency in vegetation plots with a cover above 25%	percentage	1820	47	1500	67		
Occurrence frequency in vegetation plots with a cover above 50%	percentage	1820	47	1500	67		
Mean percentage cover in vegetation plots	percentage	1820	47	1500	67		
Maximum percentage cover in vegetation plots	percentage	1838	47	1517	68		
Number of narrow habitats in which the taxon occurs	integer	2234	58	1794	80		
Number of narrow habitats in which the taxon has its optimum	integer	2234	58	1794	80		
Number of broad habitats in which the taxon occurs	integer	2234	58	1794	80		
Number of broad habitats in which the taxon has its optimum	integer	2234	58	1794	80		
12. Threats and protection							
Red List 2017 (national categories)	enum_ordinal_single	3878	100	2246	100		
Red List 2017 (IUCN categories)	enum_ordinal_single	3878	100	2246	100		
Legal protection	enum_ordinal_single	3878	100	2246	100		

taken from the database of regional species pools for Czech habitats (Sádlo et al. 2007) and the database developed for the national vegetation classification (Chytrý 2007–2013). Data on eleven characteristics for which there was no original dataset based on information from the Czech Republic were provided by the BiolFlor database (Klotz et al. 2002), which contains plant characteristics of the German flora. Nevertheless, wherever available, we used data representing observations or measurements from the territory of the Czech Republic. The taxon lists used in all of these databases were converted to a single taxon list used in the Pladias Database. If the taxon concepts in the original source and the Pladias Database did not match perfectly, we were careful to correct the taxonomic interpretation in order to assign the values of plant characteristics to the correct taxon.

Several new datasets of plant characteristics were created for the Pladias Database. Some of these not only collated data for commonly used characteristics but also developed novel concepts, e.g. plant dispersal strategies (Sádlo et al. 2018) and disturbance indicator values (Herben et al. 2016). Others were compiled based on the study of plant material across large sets of species, e.g. the checklist of root sprouters of the Czech flora (Bartušková et al. 2017), genome sizes (Šmarda et al. 2019) and myrmecochory (Konečná et al. 2018). Several ecological variables were prepared based on various analyses of the national dataset of vegetation plots (Chytrý & Rafajová 2003), e.g. ecological specialization indices (Zelený & Chytrý 2019).

Mapping plant characteristics

We linked the species distribution data and species characteristics in the Pladias Database and mapped the spatial pattern of plant characteristics across the Czech Republic in a grid of 5 minutes of longitude × 3 minutes of latitude, i.e. approximately 6.0 × 5.5 km. The mapped values were either means for numerical data types or percentage representation of individual categories for categorical data types. The proportions are related to all the species with available data values (not to the whole flora). If a species had more than one value of a multistate categorical variable (e.g. the life form was both hemicryptophyte and therophyte), each value was counted with no weighting. Data values were transferred to the species according to the scheme described in Fig. 2. The maps are based exclusively on species, while other taxa were not considered.

The classes of the colour scale were defined separately for each characteristic using the k-means clustering (MacQueen 1967). The algorithm partitioned data into a given number of classes in an iterative way, maximizing the similarity of objects within the same class and minimizing their similarity between different classes. We deliberately did not use the same colour scale for different categories of the same trait, because in such a case, patterns for some categories, especially the rare ones, would not be visible. Nevertheless, it is essential to realize that the same colours of different categories relate to different absolute values. White colour is used for categorical characteristics if the mapped category is missing in the grid cell (i.e. its percentage value is 0%).

The maps are presented for those characteristics that show a remarkable non-random geographic pattern with putative ecological meaning. We emphasize that the maps should be understood merely as a part of the data description. The patterns shown are not phylogenetically corrected, and in some cases, they may result from a correlation of the displayed characteristic with other characteristics rather than from the direct effect of the environment on this characteristic. Still, we believe these maps can stimulate further research by suggesting hypotheses about the possible causes of the displayed patterns. For better insights, these maps can be compared with the country-scale maps of environmental variables relevant for plant distributions published by Chytrý (2017).

Description of individual plant characteristics[1]

1. Habitus and growth type

1.1 Height

Plant heights are relevant for the Czech Republic. They are measured in metres and relate to fully developed mature generative plants growing in the wild. Each taxon is characterized by two values: minimum (lower limit of the common range) and maximum (upper limit of the common range). The data were taken from the Key to the Flora of the Czech Republic (Kaplan et al. 2019a).

Data source and citation: Kaplan et al. (2019a).

1.2 Growth form (Fig. 3)

Growth form describes the potential life span of the plant and its parts (ramets), its reproductive strategy and durability of its aboveground parts (Klimešová et al. 2016, Ottaviani et al. 2017). Here the growth form is classified into nine categories, which also consider herbaceous vs woody nature of the stem. Annual herbs live for one season only and reproduce by seed usually in the same season in which they germinated. They may but need not be clonal; their clonality typically does not result in fragmentation. Perennial herbs are divided into three categories: (i) monocarpic perennial non-clonal herbs, which reproduce sexually only once in their life and do not possess woody aboveground parts or organs of clonal growth, (ii) polycarpic perennial non-clonal herbs, which reproduce sexually several times during their life and do not possess organs of clonal growth, and (iii) clonal herbs which possess organs of clonal growth enabling them to make fragments during their life and to form independent units (ramets) by vegetative reproduction; the whole plant reproduces sexually several times during its life, while individual ramets may reproduce once or several times during their life. The other categories include woody plants, which may but need not possess organs of clonal growth and may be able or not of fragmentation and vegetative reproduction. The woody plants are divided into dwarf shrubs (woody plants lower than 30 cm, also including suffruticose plants with erect, herbaceous shoots growing from woody stems at the base, which die out in autumn except for the lowest part with regenerative buds), shrubs (woody plants higher than 30 cm, branched at the base), trees (woody plants with trunk and crown), woody lianas and parasitic epiphytes, which include only two species of the Czech flora, *Loranthus europaeus* and *Viscum album*.

The data were partly taken from the aggregated CLO-PLA 3.4 database (Klimešová et al. 2017). The CLO-PLA categories were further divided into separate categories for herbaceous vs woody plants, and taxa not included in CLO-PLA were added.

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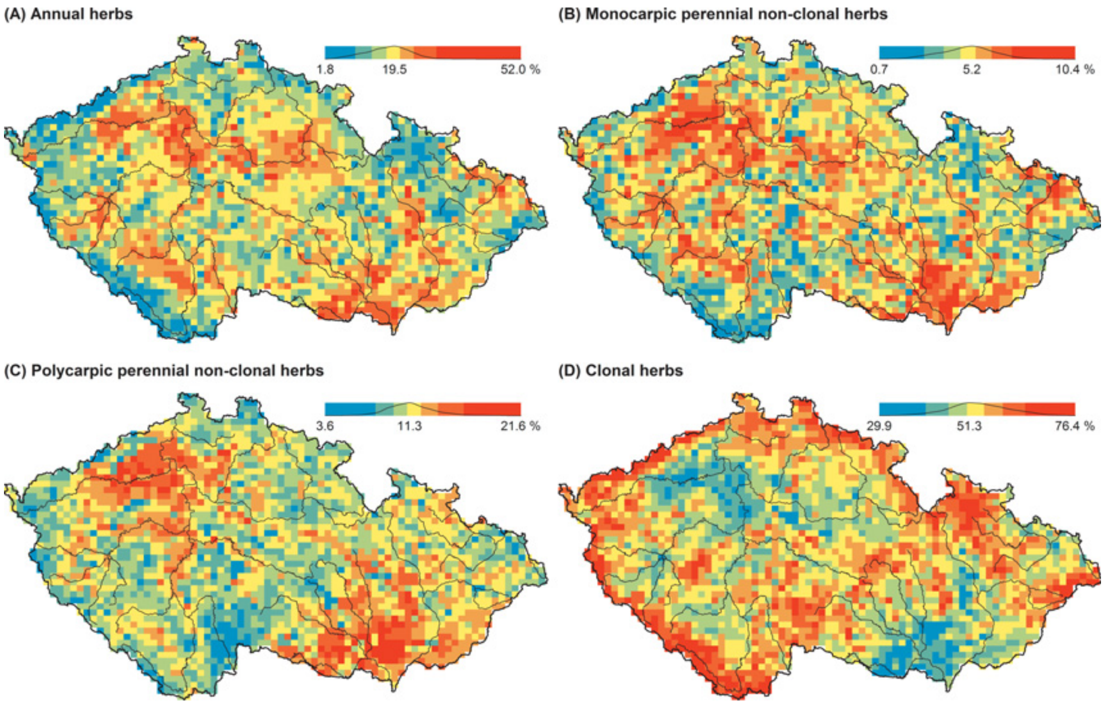
[1] See Electronic appendix 1 for a Czech version of these descriptions.


(A) Annual herbs

(B) Monocarpic perennial non-clonal herbs

(C) Polycarpic perennial non-clonal herbs

(D) Clonal herbs

Fig. 3. – Proportion of individual growth forms in the Czech flora. Annual and perennial non-clonal herbs are frequent in the lowlands, whereas clonal herbs are more common in the mountains. Woody growth forms did not reveal any distinct pattern and are not shown. All the maps in this paper are based on taxon lists recorded in quadrants of 5 × 3 minutes (approx. 6.0 × 5.5 km, i.e. 33 km^2). Only records of species (not other taxa) are mapped. Revised occurrence records marked as erroneous or uncertain were excluded.

Categories:

- annual herb
- monocarpic perennial non-clonal herb
- polycarpic perennial non-clonal herb
- clonal herb
- dwarf shrub
- shrub
- tree
- woody liana
- parasitic epiphyte

Citation: Dřevojan P. (2020) Growth form. – www.pladias.cz.

1.3 Life form (Fig. 4)

Life form classification follows the system of Raunkiaer (1934), which is based on the position of the buds that survive the unfavourable season. Macrophanerophytes are woody plants that bear the surviving buds at least 2 m above the ground, usually trees; nanophanerophytes are woody plants with surviving buds 0.3–2.0 m above the ground, usually shrubs; chamaephytes are herbs or low woody plants with surviving buds above the ground, but not more than 30 cm above it; hemicryptophytes are perennial or biennial herbs with surviving buds on aboveground shoots at the level of the ground; geophytes are perennial plants with surviving buds belowground, usually with bulbs, tubers or rhizomes; hydrophytes are plants with surviving buds in water, usually on the bottom of

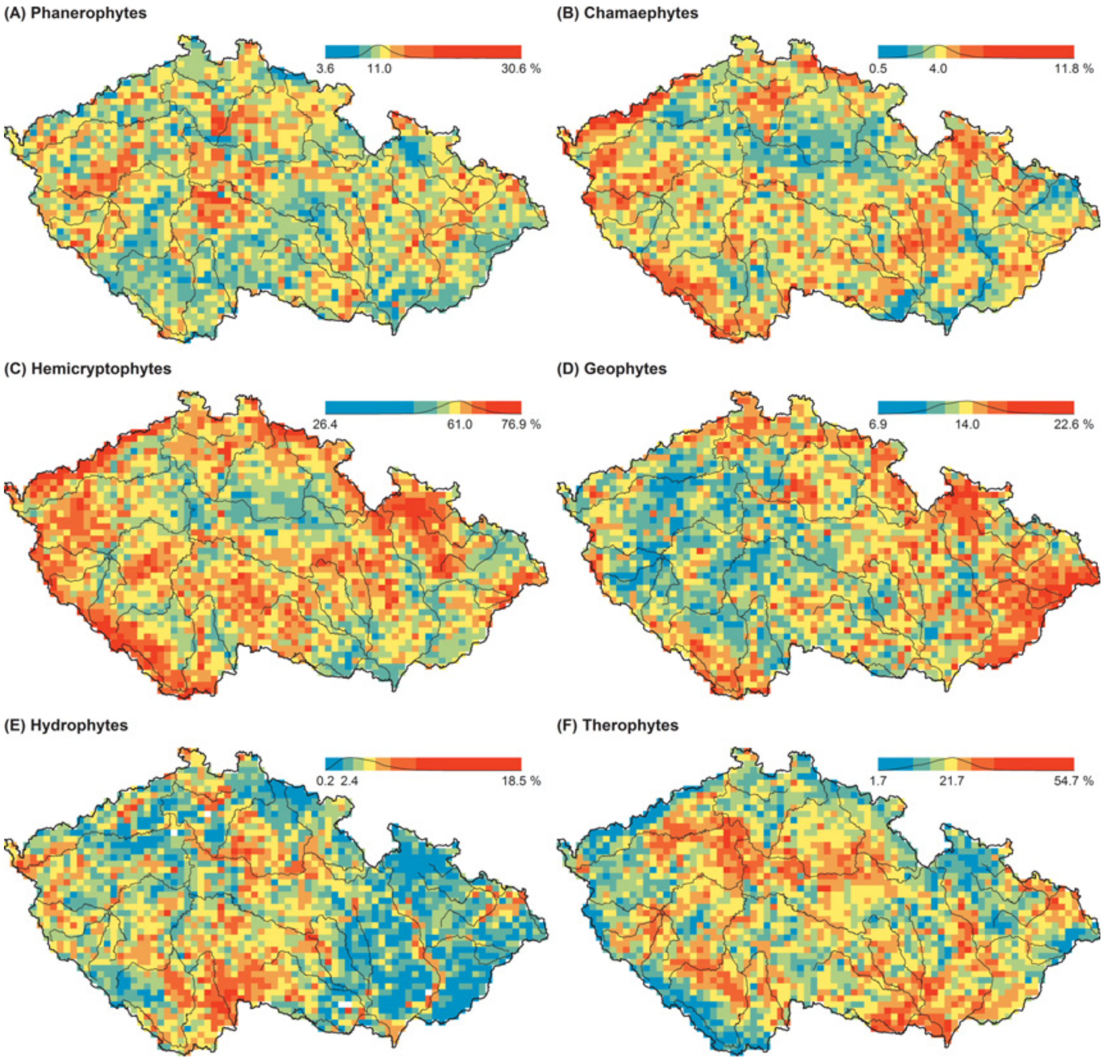


Fig. 4. – Proportion of individual life forms in the Czech flora. Chamaephytes and hemicryptophytes are more common in mid-elevation areas and the mountains, geophytes in submontane areas of the Bohemian Massif and especially in the flysch Carpathians in the eastern part of the country, hydrophytes along rivers and in pond basins, and therophytes in the lowlands. Macrophanerophytes and nanophanerophytes did not reveal any distinct pattern; all phanerophytes are shown together.

water bodies; therophytes are summer- or winter-annual herbs that survive the unfavourable season only as seeds germinating in autumn, winter or spring.

The data on life forms were taken from the Key to the Flora of the Czech Republic (Kaplan et al. 2019a). Some taxa can belong to more than one life form. In such cases, the dominant life form is listed first.

Categories:

- macrophanerophyte
- nanophanerophyte
- chamaephyte
- hemicryptophyte
- geophyte
- hydrophyte
- therophyte

Data source and citation: Kaplan et al. (2019a).

1.4 Life strategy (Fig. 5)

Grime (1974, 1979) distinguished three basic ecological strategies of plants: (i) competitive strategy (C), advantageous in stable habitats where resources are abundant, conditions not extreme and the disturbance level low; (ii) stress-tolerant strategy (S), advantageous where resources are scarce, conditions severe and highly variable, but disturbance is uncommon; and (iii) ruderal strategy (R), advantageous where resources are abundant and conditions not extreme, but the disturbance frequency is high.

Taxa of the Czech flora were assigned to life strategies based on the method proposed by Pierce et al. (2017). The life strategies calculated using this method represent the trade-off in resource investment between three key leaf traits: leaf area (LA; high in competitive taxa), leaf dry matter content (LDMC; high in stress-tolerant taxa) and specific leaf area (SLA; high in ruderal taxa). Scores that express the degree of C-, S- and R-selection are calculated from these traits. These scores are expressed on a percentage scale, and the sum of the three scores for individual taxa is 100%. Based on these scores, the taxa are assigned to the basic primary strategies C, S and R, intermediate strategies CS, CR, SR and CSR, and transitions between them, e.g. C/CS or SR/CSR (sensu Grime 1979). The data on leaf traits for these calculations or calculated values were taken from the LEDA database (Kleyer et al. 2008) and some other sources (Bjorkman et al. 2018, Dayrell et al. 2018, Findurová 2018, Tavşanoğlu & Pausas 2018, Wang et al. 2018, Guo et al. 2019). The Pladias Database contains both the score values for the three categories C, S, R and the categorized life strategies.

Categories:

- C
- C/CR
- C/CS
- C/CSR
- CR
- CR/CSR
- CS
- CS/CSR
- CSR
- R
- R/CR
- R/CSR
- R/SR
- S
- S/CS
- S/CSR
- S/SR
- SR
- SR/CSR

Citation: Guo W.-Y. & Pierce S. (2019) Life strategy. – www.pladias.cz.

2. Leaf

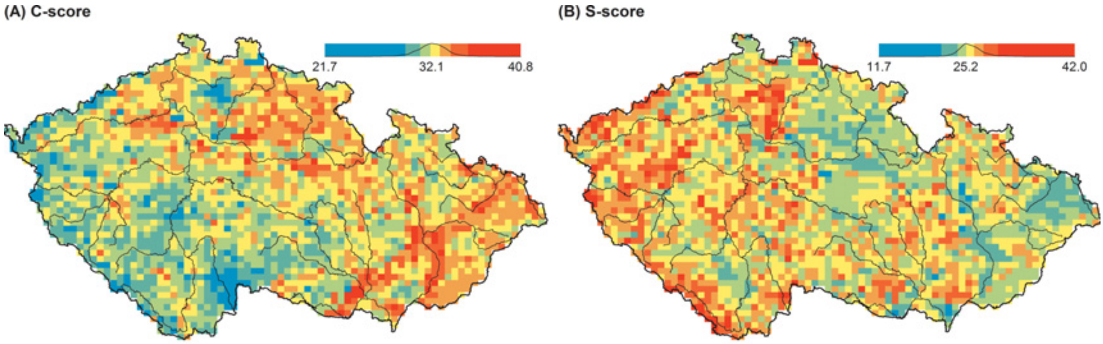
2.1 Leaf presence and metamorphosis

Data on the presence of leaves on the plant, their metamorphoses and reductions are based on the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards) and the Key to the Flora of the Czech Republic (Kaplan et al. 2019a).

Categories:

- leaves present, not modified
- leaves modified to spines
- leaves modified to tendrils
- leaves modified to phyllodes
- leaves modified to pitchers
- leaves reduced to collars
- leaves reduced to sheaths
- leaves reduced to scales
- leaves absent

Data source and citation: Hejný et al. (1988 onwards), Kaplan et al. (2019a).



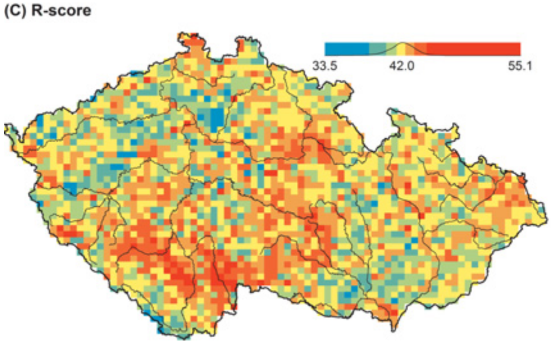


Fig. 5. – Life strategy scores for competitive (C), stress-tolerant (S) and ruderal strategy (R). C-strategists are most common in lowland agricultural areas with fertile soil, S-strategists on siliceous rocks in the Bohemian Massif, including both mountain areas and lowland sandstone areas, and R-strategists in wet basins and fishpond areas.

2.2 Leaf arrangement (phyllotaxis)

Four basic types of leaf arrangement are distinguished: alternate, opposite, verticillate (whorled) and rosulate (in the basal rosette). The character is assessed in well-developed plants, i.e. not in individuals re-sprouting after damage by mowing or grazing or those with teratological modifications. More than one character state may occur (e.g. *Hylotelephium jullianum* and *Salix purpurea*) in some taxa: all character states are recorded in such cases.

In some plants, the arrangement of frondose bracts in the inflorescence is assessed separately (e.g. true leaves in *Veronica persica* and *V. polita* are opposite, while bracts are alternate). Leaves with interpetiolar stipules found in the *Rubiaceae* family are considered as whorled. The leaves in *Rhamnus cathartica* are considered as opposite, although in most cases they are subopposite.

The information was extracted mainly from the descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). In cases of uncertainties, mainly for alien taxa, additional sources were consulted, including the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan).

Categories:

- alternate
- opposite
- verticillate
- rosulate

Citation: Grulich V., Holubová D., Štěpánková P. & Řezníčková M. (2017) Leaf arrangement. – www.pladias.cz.

2.3 Leaf shape (Fig. 6)

The primary distinction is made between simple and compound leaves. The simple leaves are categorized based on the leaf blade division associated with venation into palmately divided (e.g. *Alchemilla*), pinnately divided (e.g. *Achillea millefolium*), forked (e.g. *Batrachium*, *Ceratophyllum* and *Utricularia*) and pedate (e.g. *Helleborus*). The categorization is based on well-developed leaves. In many taxa, transitions occur between simple leaves with a dentate or serrate margin, and simple divided (pinnately or palmately lobed) leaves. Only the leaves with the lamina divided to at least one-quarter of their width are considered as divided. Many taxa with varying leaf division are assigned to more than one character state.

The compound leaves are divided into palmate and pinnate. The taxa that have both ternate and pinnate leaves, the latter with two pairs of leaflets (e.g. *Aegopodium podagraria* and some other species of the *Apiaceae* family), are assigned to both character states. The degree of division in pinnately compound leaves indicated here relates to well-developed leaves, especially to the basal part of the lamina. Taxa with multiple pinnately compound leaves are assigned to two or more character states based on the level of division, but very small leaves, which may correspond to simple leaves, are not considered.

In many cases, there are transitions between simple and compound leaves, especially between pinnatisect and pinnate leaves. Leaves with linear or filiform segments, including the bi-, tri- or even more-pinnatisect or palmatisect leaves (e.g. stem leaves in *Batrachium fluitans*, *Cardamine pratensis* and the genus *Seseli*) are classified as simple (dissected) leaves. In contrast, leaves with broader segments attached to the rachis by a distinct constriction or a petiolule (e.g. stem leaves in *Cardamine dentata* or ground leaves in *Pimpinella saxifraga*) are classified as compound.

In heterophyllous taxa, all types of leaves are assessed, and the taxon is assigned to two or more character states. However, less divided leaves found in juvenile plants of some taxa are not considered heterophyllous. The parasitic plants with rudimentary (vestigial) leaves (e.g. *Cuscuta*) or the plants with phylloclades replacing the vestigial leaves (e.g. *Asparagus*) are assigned the character state "reduced".

The information was extracted mainly from the descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). In uncertain cases, mainly for alien taxa, additional sources were consulted, including the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan).

Categories:
- simple – entire
- simple – palmately divided
- simple – pinnately divided
- simple – forked
- simple – pedate
- compound – ternate
- compound – palmate (5-foliate)
- compound – palmate (7-foliate)
- compound – palmate (8- and more-foliate)
- compound – imparipinnate
- compound – paripinnate
- compound – interruptedly pinnate
- compound – bipinnate
- compound – tripinnate
- compound – quadripinate
- reduced

Citation: Grulich V., Holubová D., Štěpánková P. & Řezníčková M. (2017) Leaf shape. – www.pladias.cz.

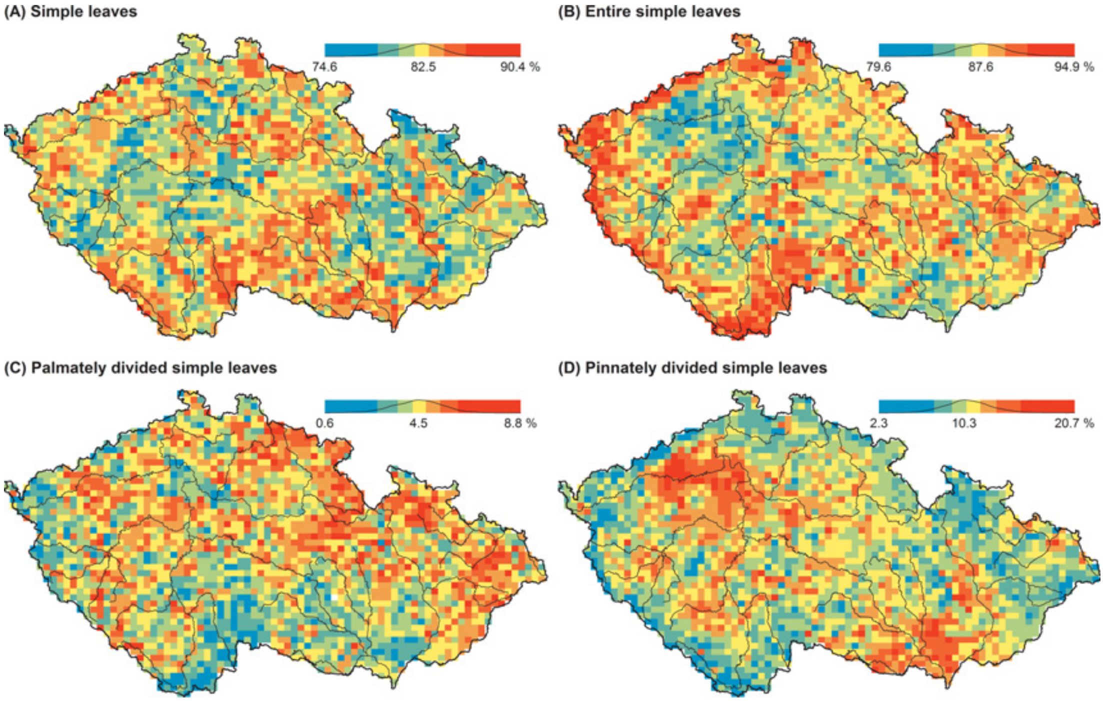


Fig. 6. – Proportion of species with different leaf shapes in the Czech flora. Simple leaves (A) are prevalent in wetland areas, both in pond basins and along large rivers. As the proportion of species with reduced leaves is insignificant in the Czech flora, the map for the proportion of species with compound leaves is essentially inverse to this map. The proportion of the most common types of simple leaves (B–D) is shown relative to all the species with simple leaves in the Czech flora. Entire leaves are more frequent in the western mountain areas of the Bohemian Massif and pond basins, palmately divided leaves in the mountain areas in the northeast, and pinnately divided leaves in dry lowlands.

2.4 Stipules

Stipules, i.e. paired leaflike appendages at the base of the petiole or sessile leaf blade, can be present or absent. Caducous stipules, i.e. those disappearing soon after the leaf blade has developed (e.g. *Prunus*), are considered as present. The interpetiolar stipules, morphologically indistinguishable from true leaves and together forming whorls (e.g. *Rubiaceae*), are considered as true stipules. In contrast, stipules modified into glands (e.g. *Lotus*) or hairs (e.g. *Portulacaceae*) are not considered as stipules here.

Information about the presence of stipules was extracted from the descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). In cases of uncertainties, mainly concerning alien taxa, descriptions in the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan) were consulted.

Categories:

- present
- absent

Citation: Grulich V., Holubová D., Štěpánková P. & Řezníčková M. (2017) Stipules. – www.pladias.cz.

2.5 Petiole

Leaf petiole can be present or absent. In some plants, it can be present in some leaves but absent in others. The data were extracted from the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards), the Key to the Flora of the Czech Republic (Kubát et al. 2002), the New Hungarian Herbal (Király et al. 2011) and the Excursion Flora of Germany (Jäger & Werner 2000).

Categories:
- present
- mainly present
- both present and absent
- mainly absent
- absent

Citation: Prokešová H. & Grulich V. (2017) Petiole. – www.pladias.cz.

2.6 Leaf life span (Fig. 7)

Leaf life span is a functional trait important for plant competitiveness. It depends on the climate in the distribution range of the taxon and microclimate, nutrient and light availability in typical habitats of the taxon. The data were taken from the BiolFlor database (Klotz & Kühn 2002a).

Categories:
- overwintering green – leaves developing in autumn, overwintering green and decaying in spring and summer
- spring green – leaves green from early spring to early summer, then usually decaying
- summer green – leaves green in the warm season
- evergreen – leaves green throughout the year, often living for more than one year (persistent-green)

Data source and citation: Klotz & Kühn (2002a).

2.7 Leaf deciduousness in woody plants

Leaves of different woody plant species have distinct phenological patterns. Most species of Central European woody plants have winter-deciduous leaves, while a small proportion has evergreen (persistent-green) leaves. Semi-deciduous leaves are rare, occurring mainly in cultivated species. The category of winter semi-deciduous leaves includes only the leaves that are at least partly green in winter, not marcescent leaves, which die out in autumn and remain attached, in a dry state, to the maternal plant over the winter (e.g. young individuals of *Quercus*).

Data on leaf deciduousness were extracted from the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards), Key to the Flora of the Czech Republic (Kaplan et al. 2019a), floras of some other countries, and complemented by original observations.

Categories:
- evergreen
- winter deciduous
- winter semi-deciduous
- drought semi-deciduous

Citation: Štěpánková P. & Grulich V. (2020) Leaf deciduousness in woody plants. – www.pladias.cz

2.8 Leaf anatomy (Fig. 8)

Leaf anatomy is an important ecological adaptation which helps plants to optimize photosynthesis under various environmental conditions. It reflects especially the availability of water (Klotz & Kühn 2002a). Succulent and scleromorphic leaves are adapted to dry

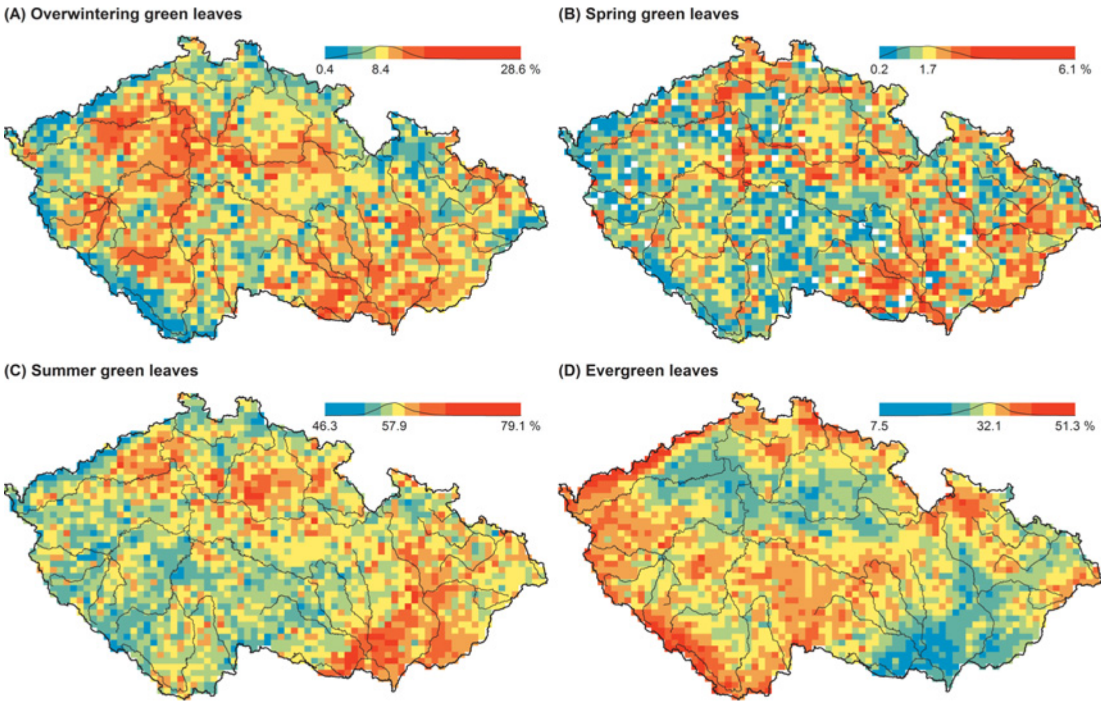


Fig. 7. – Proportion of species with different leaf life span in the Czech flora. Plants with overwintering-green leaves are more common in dry lowlands, those with spring-green leaves also in the lowlands, but especially in areas with rock outcrops, those with summer-green leaves in lowland areas with a large proportion of arable land, and those with evergreen leaves in the mountains.

conditions. Both of them have thickened epidermis and cuticle, but the former develop a water-storage tissue while the latter have mechanisms to promote water transport in periods of water availability. Mesomorphic leaves are adapted to less dry conditions; hygromorphic leaves to shady conditions that rarely suffer from drought; helomorphic leaves to oxygen deficiency in swampy soils; and hydromorphic leaves to gas exchange in the water. The most common type in the Czech flora is mesomorphic leaves. The data were taken from the BiolFlor database (Klotz & Kühn 2002a), which contains an extended and corrected version of the dataset published by Ellenberg (1979).

Categories:

- succulent
- scleromorphic
- mesomorphic
- hygromorphic
- helomorphic
- hydromorphic

Data source and citation: Klotz & Kühn (2002a).

2.9 Functional leaf type in woody plants

Functional leaf types in woody plants, often used for physiognomic classification of forest and scrub vegetation, are distinguished based on their morphology, anatomy and life span. Most angiosperm woody plants of the central-European flora have broad deciduous or semi-deciduous leaves, which have a large specific leaf area. The other leaf types are,

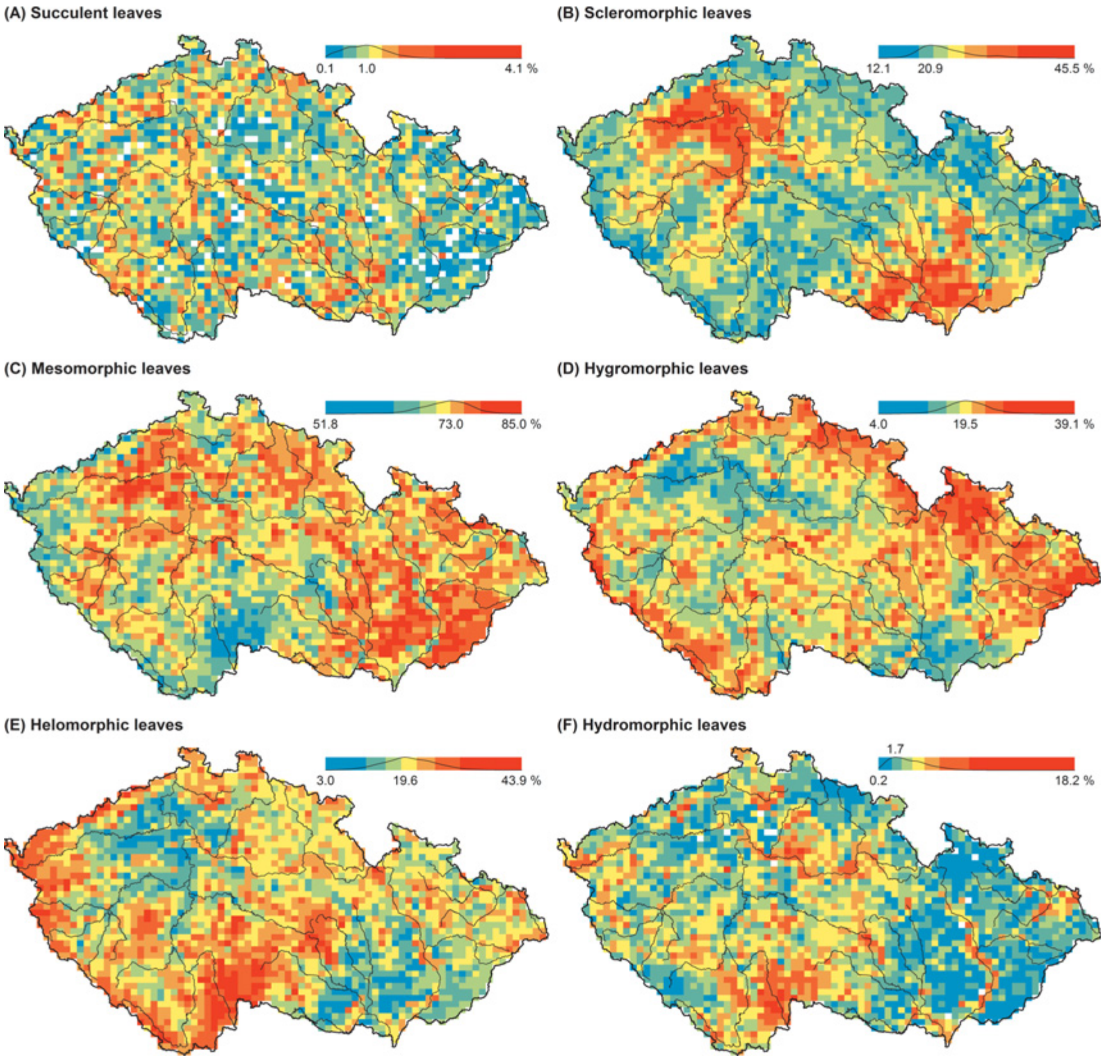


Fig. 8. – Proportion of species with different leaf anatomy in the Czech flora. Species with succulent leaves are common in areas with rock outcrops, those with scleromorphic leaves in dry lowlands, those with mesomorphic leaves in non-wetland lowland to submontane areas, those with hygromorphic leaves in the mountains, especially in the precipitation-rich northeast, those with helomorphic leaves in the western mountains of the Bohemian Massif and in the pond basins, and those with hydromorphic leaves in pond basins and riverine landscapes.

with rare exceptions (*Larix*), perennial and usually called evergreen. Needle-like and scale-like leaves occur in conifers and some species of *Ericaceae*. Sclerophyllous leaves are flat but have a strongly developed sclerenchyma, which causes their toughness. They are usually small coriaceous leaves with small specific leaf area, adapted to dry climate. Laurophyllous leaves are larger and thinner than sclerophyllous leaves and have a smaller amount of sclerenchyma. In most cases, they are dark green, smooth and shiny. These leaves are adapted to year-round wet climates with mild winters. A few species that are difficult to assign to these categories are classified as “special type”.

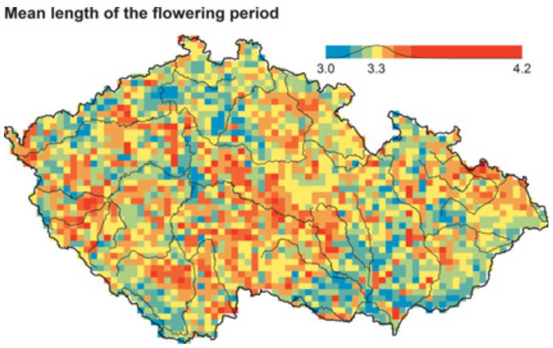


Fig. 9. – Mean length of the flowering period for the species of Czech flora (in months). On average, the most prolonged flowering period is found in mid-elevation areas that are neither too dry nor too cold.

The data on functional leaf types were taken from the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards), Key to the Flora of the Czech Republic (Kaplan et al. 2019a), floras of some other countries, and complemented by original observations.

Categories:
- needle-like
- scale-like
- broad deciduous or semi-deciduous
- sclerophyllous
- laurophyllous
- special type

Citation: Štěpánková P. & Grulich V. (2020) Functional leaf type in woody plants. – www.pladias.cz.

3. Flower

3.1 Flowering period (Fig. 9)

The months of the beginning and end of flowering in the Czech Republic are given. The data were taken from the Key to the Flora of the Czech Republic (Kaplan et al. 2019a).

Data source and citation: Kaplan et al. (2019a).

3.2 Flowering phase (Fig. 10)

The flowering period for plants is usually indicated in months. However, as the start and end of the flowering period depend on the weather, the exact time may change from year to year. Therefore, Dierschke (1995) classified plant taxa into symphenological groups, i.e. groups of taxa that usually bloom together. The data were taken from the BiolFlor database (Trefflich et al. 2002).

Categories:
- 1 *Corylus avellana-Leucojum vernum* (pre-spring)
- 2 *Acer platanoides-Anemone nemorosa* (start of early spring)
- 3 *Prunus avium-Ranunculus auricomus* (end of early spring)
- 4 *Fagus sylvatica-Galeobdolon* (start of mid-spring)
- 5 *Sorbus aucuparia-Galium odoratum* (end of mid-spring)
- 6 *Cornus sanguinea-Melica uniflora* (start of early summer)
- 7 *Ligustrum vulgare-Stachys sylvatica* (end of early summer)
- 8 *Clematis vitalba-Galium sylvaticum* (mid-summer)
- 9 *Hedera helix-Solidago* (early autumn)
- 10 Autumn-phase

Data source and citation: Trefflich et al. (2002).

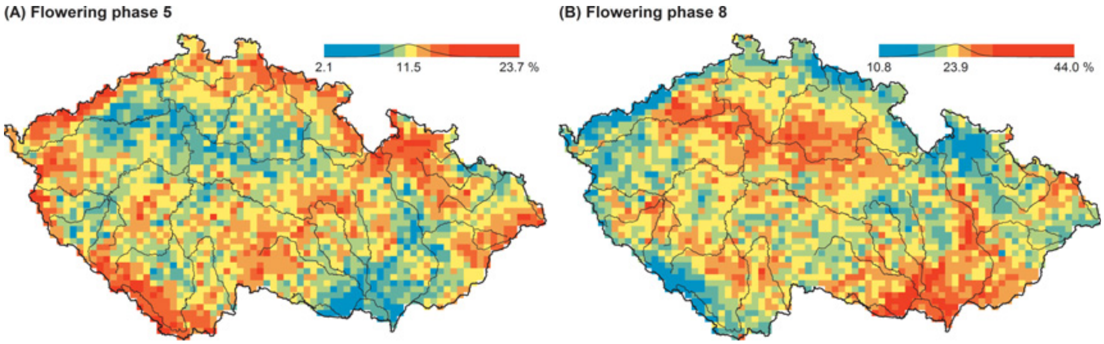


Fig. 10. – Proportion of species assigned to the flowering phases 5 *Sorbus aucuparia-Galium odoratum* (end of mid-spring) and 8 *Clematis vitalba-Galium sylvaticum* (mid-summer) in the Czech flora. The species belonging to phase 5 are remarkably concentrated in the mountains, while those belonging to phase 8 are frequent in the lowland areas with a high proportion of arable land. The other flowering phases do not show such distinct geographic patterns.

3.3 Flower colour (Fig. 11)

Flower colour is reported for nearly all angiosperms except duckweeds (*Araceae* p.p.) and some hybrids for which data on flower colour were not available.

If a species has more than one flower colour, all colours are reported irrespective of their frequency. This approach is used both for species that regularly form populations with different flower colours (e.g. *Corydalis cava* and *Iris pumila*) and for species with occasional occurrence of deviating flower colour (e.g. albinism in *Salvia pratensis* or pink flowers in *Ajuga reptans*). However, the whole range of variation is not fully reported in cultivated plants, for which some cultivars of different colour may be ignored (e.g. *Gladiolus hortulanus* and *Callistephus chinensis*). In plants with flowers of two colours (e.g. *Cypripedium calceolus*), both colours are reported. In plants with multi-coloured flowers (e.g. the variegated lip in *Ophrys apifera*) the predominant colour is reported.

If the flower has a well-developed perianth, the reported flower colour relates to the corolla or the tepals of the homochlamydeous perianth. If such a flower has bracts of a contrasting colour (e.g. *Melampyrum nemorosum*), their colour is not considered. If the corolla or the homochlamydeous perianth is not developed, the flower colour is based on the calyx (e.g. *Daphne mezereum*), bracts (e.g. *Aristolochia clematitis*), the system of bracts and bracteoles in the inflorescence (*Euphorbia*) or the involucre on secondary peduncles (*Bupleurum longifolium*). In species of *Araceae* with spadix and spathe of contrasting colours (e.g. *Calla palustris*) both colours are reported. The colour of the whole inflorescence is reported for some plants with reduced flowers (e.g. *Betula*, *Salix*, some *Cyperaceae* and *Typhaceae*). Spikelets in *Poaceae* are reported as green disregarding a possible violet tint; exceptions include the *Melica ciliata* agg. and *Cortaderia* that are reported as white. Also in other, rare cases, the inflorescence colour is reported as flower colour (e.g. green in *Ficus carica*). In *Asteraceae*, the colours of the disk flowers and ray flowers are reported separately if the ray flowers are developed and have a contrasting

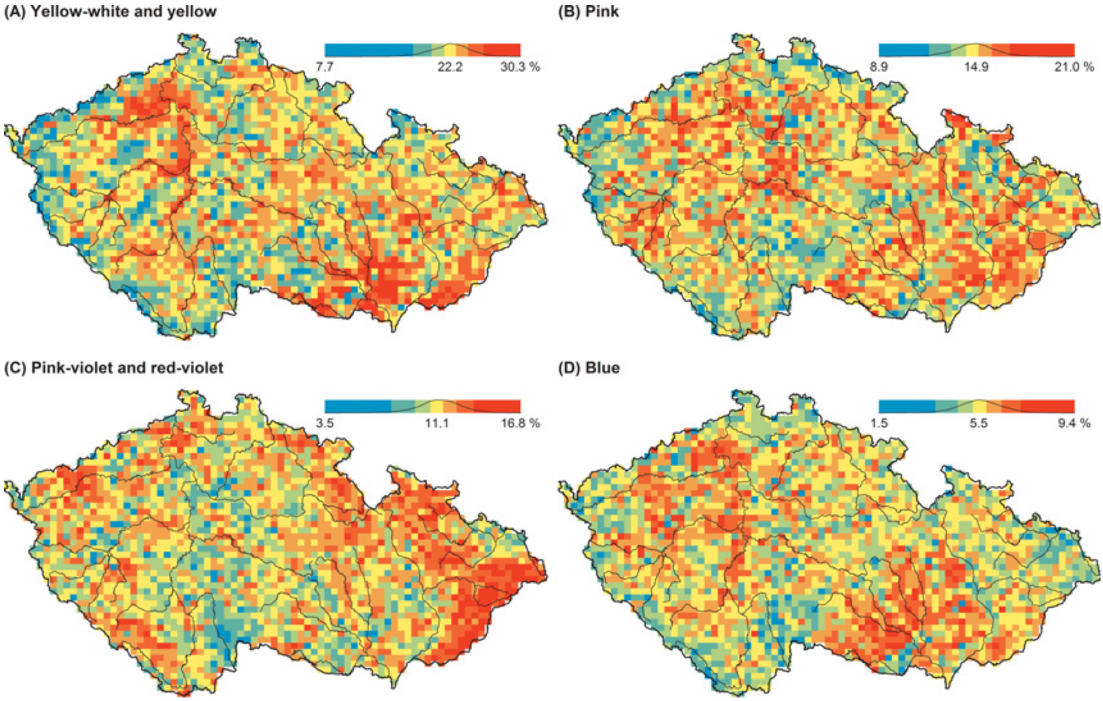


Fig. 11. – Proportion of species with selected colours in the Czech flora. In (A) and (C), two similar colours showing similar spatial patterns were merged. Yellow-white, yellow and blue colours tend to be frequent in dry and warm lowland areas, pink colours at lower elevations, and pink-violet and red-violet colours at higher elevations, especially in the flysch Carpathians. Most of the other flower colours show less clear geographic patterns.

colour (e.g. *Bellis perennis*). The colour of the involucrum is reported for species with tiny flower heads and indistinct flowers (e.g. *Artemisia campestris* and *Xanthium*) and for "immortelles" (e.g. *Helichrysum* and *Xeranthemum*).

Information on flower colour is partly based on the field knowledge, partly obtained from various photographs and descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). In the taxa that are not reported in the Flora of the Czech Republic, as well as in unclear cases (especially in alien species), other sources were used, especially the Flora of North America (Flora of North America Editorial Committee 1993), the Flora of China (Wu et al. 1994) and the Flora of Pakistan (http://www.tropicos.org/Project/Pakistan).

Categories:

- white (including grey and silvery, and rare cases of individuals with white colour) – e.g. ray flowers of *Leucanthemum vulgare*, albinotic plants of *Glechoma hederacea*, catkins of *Salix caprea*
- yellow-white (including white-yellow and cream) – e.g. *Scabiosa ochroleuca*
- green-white (including white-green and greenish) – e.g. *Orthilia secunda*
- green – e.g. *Poa pratensis* (the colour relates to the glumes and lemmas)
- yellow-green (including green-yellow) – e.g. *Acer pseudoplatanus*, *Rhamnus cathartica*
- yellow – e.g. *Taraxacum*
- orange – e.g. *Pilosella aurantiaca*
- pink (including white-pink, pink-white and dark pink) – e.g. *Malva alcea*, *Rosa canina*
- pink-violet – e.g. *Allium schoenoprasum*
- red – e.g. *Papaver rhoeas*
- red-violet (includes all the hues of purple, pink-red and violet-red) – e.g. *Astragalus onobrychis*, *Cirsium palustre*
- violet (including dark violet and black-violet) – e.g. *Bartsia alpina*, *Salvia verticillata*
- blue – e.g. *Centaurea cyanus*
- blue-violet – e.g. *Aconitum plicatum*
- brown (including yellow-brown, brown-yellow, beige and brown-violet) – e.g. *Euonymus verrucosus*, *Neottia nidus-avis*
- red-brown – e.g. *Asarum europaeum*, *Scrophularia nodosa*
- black – e.g. *Carex acuta* (the colour relates to the colour of bracts)

Citation: Štěpánková P. & Grulich V. (2019) Flower colour. – www.pladias.cz.

3.4 Flower symmetry (Fig. 12)

Flowers of angiosperms are either zygomorphic (with bilateral symmetry) or actinomorphic (with radial symmetry). This character is not reported for taxa with achlamydeous flowers and taxa with strongly reduced or rudimentary perianth or with a perianth modified into scale-like or setaceous structures. However, it is reported for taxa with the perianth reduced to a corolla-like calyx (e.g. *Aizoaceae* and *Daphne*) and in taxa with flowers surrounded by complex structures combining bracts with the proper perianth or petal-like staminodes and stamens (e.g. *Canna*). Spiral and spirocyclic flowers, though actually asymmetric, are classified as actinomorphic in *Nymphaeaceae* and most species of *Ranunculaceae*. In contrast, in some other members of *Ranunculaceae* (e.g. *Aconitum* and *Delphinium*), they are classified as zygomorphic. Bisymmetric flowers (in the *Brassicaceae* family and the genera *Dicentra* and *Lamprocapnos*) are consistently classified as actinomorphic. Both zygomorphic and actinomorphic flowers are reported for taxa with both symmetry types (e.g. *Succisa pratensis*).

The information about flower symmetry was extracted from the descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). If some uncertainty occurred, particularly in some alien taxa, the descriptions in the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan) were consulted.

Categories:

- zygomorphic
- actinomorphic

Citation: Grulich V., Holubová D., Štěpánková P. & Řezníčková M. (2017) Flower symmetry. – www.pladias.cz.

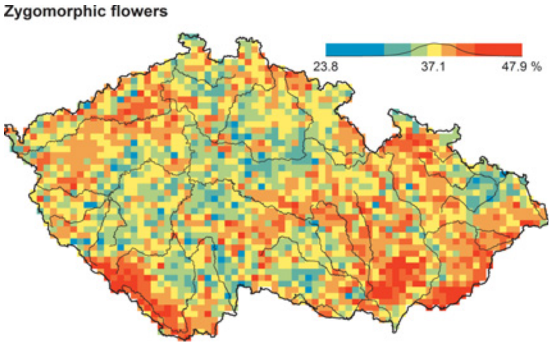


Fig. 12. – Proportion of species with zygomorphic flowers in the Czech flora. These species are frequent in the mountains and lowland non-wetland areas. Note that the proportion of actinomorphic flowers is the complement of the proportion of zygomorphic flowers.

3.5 Perianth type

Perianth (perigon), i.e. the non-reproductive part of the angiosperm flower, can be classified into heterochlamydeous and homochlamydeous. Heterochlamydeous flowers are divided into calyx and corolla. In homochlamydeous flowers, calyx and corolla are indistinguishable. Perianth or some of its parts can be reduced or absent; flowers with no perianth are called achlamydeous.

In *Apiaceae*, the presence of the calyx teeth is assessed as a reduced calyx; if these teeth are not visible, the calyx is considered as absent. In *Asteraceae*, the presence of a pappus, scales or a collar-like structure is considered as a reduced calyx; if no such structures are present, the calyx is considered as absent. In *Cyperaceae*, the presence of perianth bristles is assessed as a reduced perianth. All members of the *Poaceae* family are considered as plants with a reduced perianth. The perianth in the genus *Basella* is arbitrarily classified as a reduced calyx though it is also often considered as a reduced homochlamydeous perianth. The character states "homochlamydeous, sometimes absent" and "homochlamydeous, reduced or absent" mean that in one plant some flowers may have a well-developed or reduced perianth, while other flowers may be achlamydeous (e.g. *Atriplex*).

The information was extracted mainly from the descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). For the taxa not treated in that flora or if uncertainties occurred, mainly concerning some alien taxa, the descriptions in the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan) were consulted.

Categories:
- homochlamydeous
- homochlamydeous, sometimes reduced
- homochlamydeous, sometimes reduced or absent
- homochlamydeous, sometimes absent
- homochlamydeous, reduced or absent
- calyx and corolla
- calyx and corolla, corolla reduced or absent
- calyx and corolla, corolla sometimes absent
- calyx present, corolla sometimes reduced
- calyx present, corolla reduced
- calyx present, corolla reduced or absent
- calyx present, corolla sometimes absent
- calyx present, corolla absent
- calyx reduced, corolla present
- calyx sometimes absent, corolla present
- calyx absent, corolla present
- calyx absent, corolla sometimes present
- reduced
- reduced or absent
- flower achlamydeous

Citation: Grulich V., Prokešová H. & Štěpánková P. (2017) Perianth type. – www.pladias.cz.

3.6 Perianth fusion

This characteristic of angiosperm flowers is assessed either as a fusion of the corolla or, in homochlamydeous taxa (e.g. *Amaryllidaceae*, *Liliaceae* and *Orchidaceae*) as a fusion of the whole perianth. It is not assessed in achlamydeous groups (e.g. *Salix*) and plants with a strongly reduced or rudimentary perianth or with the perianth modified in scale-like or setaceous structures with a varying number of bristles, which may be free (e.g. in *Cyperaceae*) or partially fused (e.g. in most of *Poaceae*). The perianth of such plants is considered as reduced. The perianth in the genus *Aristolochia* is also classified as reduced (neither fused nor free): it is modified to scales situated at the bottom of a tube-like structure formed by fused bracts. Both primary character states are assigned to the taxa with unisexual male and female flowers that differ in the fusion of the perianth (e.g. *Cannabis*). A similar approach is used in the taxa in which some flowers are homochlamydeous while others are achlamydeous (e.g. *Atriplex*).

The basic information was extracted from the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). If some uncertainty occurred, especially for alien taxa, other sources were consulted, including the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan).

Categories:

- free
- fused
- reduced

Citation: Grulich V., Holubová D., Štěpánková P. & Řezníčková M. (2017) Perianth fusion. – www.pladias.cz.

3.7 Shape of the sympetalous corolla or syntepalous perianth

This characteristic of angiosperm flowers is not assessed for achlamydeous groups (e.g. *Salix*) and plants with a strongly reduced or rudimentary perianth or with the perianth modified in scale-like or setaceous structures (e.g. *Cyperaceae* and *Poaceae*). In *Amaranthaceae* and the genus *Cannabis*, the perianth is recognizable, and the degree of its fusion could be assessed, but not its shape. If the corolla or the perianth have an intermediate shape between two character states, the taxon is assigned to both of them. Many sympetalous corollas and syntepalous perianths have unique shapes that are difficult to match to general classification categories. The taxa with such shapes are classified to an auxiliary category “special type” (e.g. *Canna*, *Cyclamen*, *Dicentra*, *Gladiolus*, *Impatiens* and *Iris*).

The basic information was extracted from the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). In uncertain cases, especially in some alien taxa, other sources were consulted, including the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan).

Categories:

- urceolate
- bilabiate
- ligulate
- rotate
- funnel-shaped
- hypocrateriform
- personate
- labiate
- tubular
- campanulate
- filiform
- special type

Citation: Grulich V., Holubová D., Štěpánková P. & Řezníčková M. (2017) Shape of the sympetalous corolla or syntepalous perianth. – www.pladias.cz.

3.8 Calyx fusion

The calyx of angiosperm flowers can be fused into a calyx tube (synsepalous calyx) or composed of distinct sepals (aposepalous). In some plants (especially in *Asteraceae*) the calyx is modified into a ring of fine feathery hairs called the pappus. Taxa with both synsepalous and aposepalous calyx (e.g. *Platanus*) are classified as “synsepalous and aposepalous”. A cup-shaped tube formed of fused sepals, petals and stamens is called hypanthium. However, hypanthium may also be interpreted as a product of an intercalary growth of the floral axis (receptacle) up and around the carpels, forming a cup-shaped structure, sometimes even fusing with the outer walls of the carpels and making the ovary inferior. In most genera of the *Onagraceae* family, the hypanthium forms a floral tube fairly overtopping the apex of the ovary.

The data were taken from the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards), the Key to the Flora of the Czech Republic (Kubát et al. 2002), the New Hungarian Herbal (Király et al. 2011) and the Excursion Flora of Germany (Jäger & Werner 2000).

Categories:
- aposepalous
- fused at the base
- synsepalous and aposepalous
- synsepalous
- pappus
- hypanthium

Citation: Prokešová H. & Grulich V. (2017) Calyx fusion. – www.pladias.cz.

3.9 Inflorescence type

Inflorescence types follow the morphological system used in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). As the Czech terminology used for inflorescences does not match the English terminology, we use Latin terms in the English version of the Pladias Database. The exact identification of the inflorescence type is often equivocal because of varying interpretations of the same object. In species with unisexual flowers, male and female flowers can occur in different inflorescence types. In other cases, it is not possible to identify the inflorescence without detailed knowledge of evolutionary morphology, e.g. *umbella* vs *pseudumbella* in the genus *Butomus*. There are also compound inflorescences, in some cases with very different structure of their parts, especially in *Asteraceae*, which can have even triple inflorescences (e.g. *Echinops sphaerocephalus* often has an *anthella ex capitulis anthodiorum composita*).

The information was extracted mainly from the descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). For the taxa not treated in that flora or if some uncertainties occurred, mainly concerning some alien taxa, information was taken from the descriptions in the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards) and the Flora of Pakistan (www.tropicos.org/Project/Pakistan). In critical groups (e.g. *Rubus*), especially in recently described species, inflorescence type was taken from the original descriptions.

Categories:

- amentum
- amentum e floribus femineis
- amentum e floribus masculis
- anthella
- anthodium
- anthodium solitarium
- anthella e floribus masculis composita
- anthella e spiculis composita
- anthella ex capitulis anthodiorum composita
- anthella ex anthodiis composita
- panicula ex capitulis anthodiorum composita
- panicula ex anthodiis composita
- bostryx
- capitulum
- capitulum e floribus femineis compositum
- capitulum e floribus masculis compositum
- capitulum e spiculis compositum
- capitulum e verticillastris compositum
- capitulum ex anthodiis compositum
- cincinnus
- corymbothyrsus
- corymbothyrsus e fasciculis compositus
- corymbothyrsus ex anthodiis compositus
- corymbothyrsus ex fasciculis anthodiorum compositus
- corymbus
- corymbus ex anthodiis compositus
- dichasium
- dichasium e floribus femineis compositum
- dichasium ex anthodiis compositum
- fasciculus
- fasciculus e floribus femineis compositus
- fasciculus e floribus masculis compositus
- fasciculus ex anthodiis femineis compositus
- flores solitarii
- flores solitarii feminei
- flores solitarii masculi
- panicula
- panicula e bostrychibus composita
- panicula e capitulis composita
- panicula e cincinnis composita
- panicula e corymbis composita
- panicula e dichasiis composita
- panicula e fasciculis composita
- panicula e floribus masculis composita
- panicula e pseudospicis composita
- panicula e spiculis composita
- panicula e spiculis masculis composita
- pseudoracemus
- pseudospica
- pseudospica e capitulis composita
- pseudospica e floribus masculis composita
- pseudospica e spiculis composita
- pseudospica e verticillastris composita
- pseudospica ex anthodiis composita
- pseudumbella
- pseudumbella e cyathiis composita
- pseudumbella ex anthodiis composita
- racemus
- racemus e capitulis compositus
- racemus e cincinnis compositus
- racemus e fasciculis compositus
- racemus e floribus femineis compositus
- racemus e floribus masculis compositus
- racemus e spiculis compositus
- racemus e verticillastris compositus
- racemus ex anthodiis compositus
- racemus ex corymbis anthodiorum compositus
- racemus ex anthodiis masculis compositus
- racemus ex umbellis compositus
- rhipidium
- spadix
- spadix e floribus femineis compositus
- spica
- spica e floribus femineis composita
- spica e floribus masculis composita
- spica e spiculis composita
- spicula
- strobilus
- syconium
- umbella
- umbella composita
- umbella e spicis spicularum composita
- verticillastrum

Citation: Grulich V. & Štěpánková P. (2019) Inflorescence type. – www.pladias.cz.

3.10 Dicliny (Fig. 13)

Dicliny characterizes the level of spatial separation of male and female reproductive organs. Monoclinous (synoecious) plants, including most taxa of the central-European flora, have only bisexual (hermaphroditic) flowers. The plants with unisexual flowers are either monoecious (with both male and female flowers growing on the same individual) or dioecious (with male and female flowers growing on different individuals). Gynomonoecious plants have female and bisexual flowers on the same individuals, while andromonoecious plants have male and bisexual flowers on the same individuals. Gynodioecious plants have female and bisexual flowers on different individuals, or some individuals

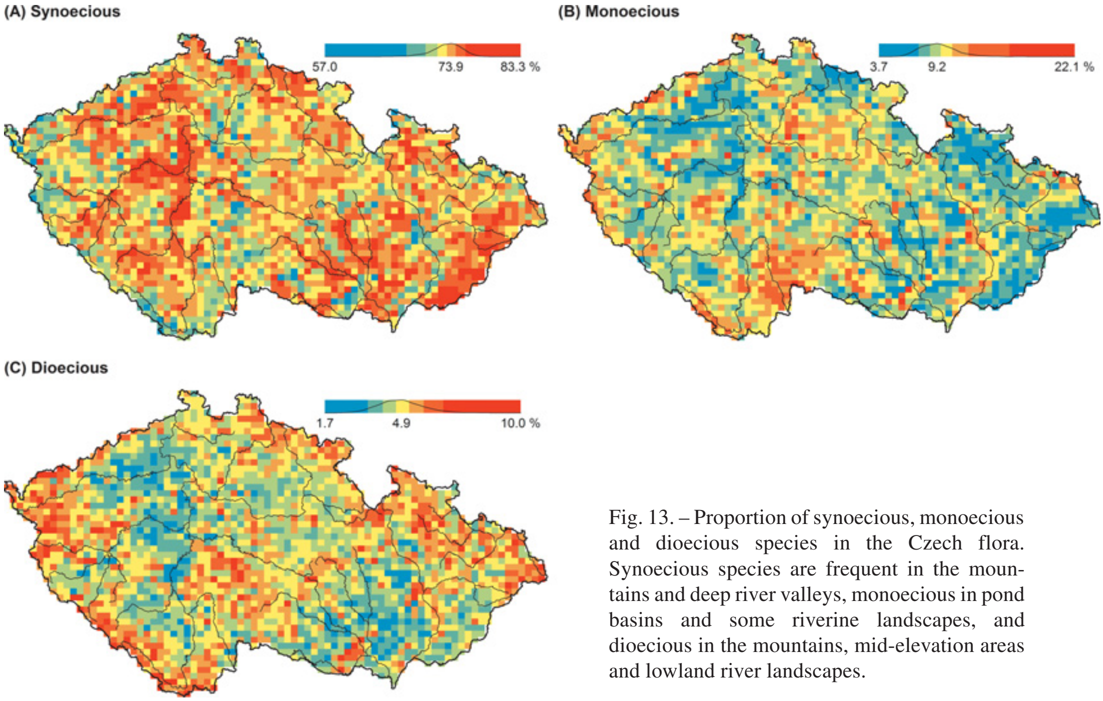


Fig. 13. – Proportion of synoecious, monoecious and dioecious species in the Czech flora. Synoecious species are frequent in the mountains and deep river valleys, monoecious in pond basins and some riverine landscapes, and dioecious in the mountains, mid-elevation areas and lowland river landscapes.

have only female flowers, and other individuals have both male and female flowers. Androdioecious plants have male and bisexual flowers on different individuals, or some individuals have only male flowers, and other individuals have both male and female flowers. Trioecious plants have individuals with male flowers, individuals with female flowers, and individuals with bisexual (or both male and female unisexual) flowers. Trimonoecious plants have a male, female and bisexual flowers on the same individual. Other plants can be male sterile. The data on dicliny were taken from the BiolFlor database (Durka 2002).

Categories:

- synoecious
- monoecious
- dioecious
- gynomonoecious
- andromonoecious
- gynodioecious
- androdioecious
- trimonoecious
- male-sterile
- trioecious

Data source and citation: Durka (2002).

3.11 Generative reproduction type (Fig. 14)

The type of generative reproduction (breeding system) is defined by the origin of gametes that fuse to form offspring. On the one hand, it includes obligate outcrossing, which can be controlled by genetic mechanisms of recognition and rejection of self-pollen before the fertilization of the egg cell (allogamy, self-incompatibility), sequential hermaphroditism (dichogamy) or unisexuality of plant individuals (dioecy). On the other hand, it includes obligate autogamy, which refers to the fusion of two gametes that both originate from one flower or one individual. However, various mixed strategies are common, including

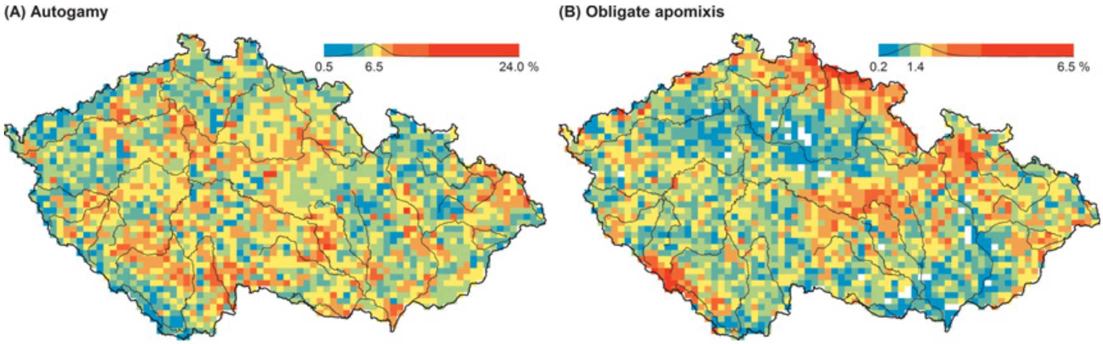


Fig. 14. – Proportion of autogamic and obligate apomictic species in the Czech flora. The former are frequent in pond basins and lowland riverine landscapes, the latter in the highest mountain areas.

reproduction by both self-fertilization and mating with other individuals. The degree of self-fertilization can be affected by both genetic and ecological factors, among others by frequency, diversity and foraging strategy of pollinators. Three categories are distinguished: (i) facultative allogamy (outcrossing prevails, but selfing is possible), (ii) facultative autogamy (mainly selfing, outcrossing is rare) and (iii) mixed mating, in which both outcrossing and selfing are common, sometimes with different frequencies among populations. The last main category, apomixis, includes seed production without fertilization. It can be either obligate (offspring is genetically identical with the maternal plant) or facultative (accompanied by residual sexuality, as a rule with a low frequency). Hybrid plants are often sterile, but can sometimes reproduce vegetatively and persist for a long time. In some cases (e.g. *Pilosella*), such sterile hybrids are considered as species and included in this list. Some morphologically well-defined and widely accepted taxa consist of populations with contrasting modes of reproduction (as a rule connected with ploidy levels). For example, some populations are sexual and allogamous while others are apomictic. Data on generative reproduction types of the taxa of Czech flora were obtained through a search of the available literature.

Categories:
- allogamy
- allogamy self-incompatibility
- facultative allogamy
- autogamy
- facultative autogamy
- mixed mating
- apomixis
- obligate apomixis
- facultative apomixis
- sterility

Citation: Chrtek J. Jr. (2018) Generative reproduction type. – www.pladias.cz.

3.12 Pollination syndrome (Fig. 15)

Pollen is transferred to stigma by different vectors, including abiotic vectors such as wind (anemophily) or water (hydrophily), or biotic vectors such as insects (entomophily). An alternative mechanism is selfing (autogamy), which can include special mechanisms such as cleistogamy (selfing in rudimentary, obligatorily autogamous flowers), pseudocleistogamy (selfing in flowers that do not open due to adverse environmental conditions) or geitonogamy (selfing by pollen from a neighbouring flower of the same

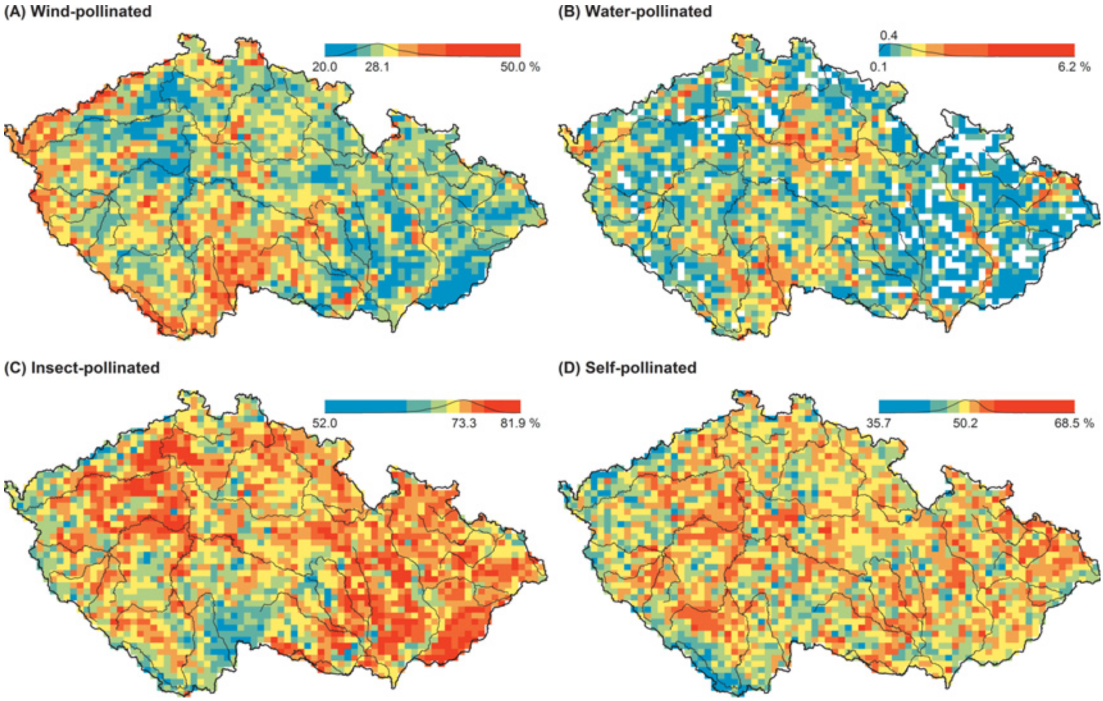


Fig. 15. – Proportion of wind-, water-, insect- and self-pollinated species in the Czech flora. Wind-pollinated plants are frequent in the western mountains of the Bohemian Massif and in pond basins, water-pollinated plants in the pond basins and lowland riverine landscapes, insect-pollinated plants in dry lowlands outside the large river floodplains and in the flysch Carpathians, and self-pollinated plants in lowlands and mid-elevation areas.

plant except the cases of pollen transfer by a vector). Pollination syndromes are adopted from the BiolFlor database (Durka 2002).

Categories:
- wind-pollination
- water-pollination
- insect-pollination
- selfing
- cleistogamy
- pseudocleistogamy
- geitonogamy

Data source and citation: Durka (2002).

3.13 Pollinator spectrum

The data describe the representation of abundances of pollinator functional groups for a given plant taxon. Pollinator taxa are divided into 13 functional groups (plus the category “unknown” for insufficiently identified pollinators). The delimitation of these groups reflects (i) similarity of pollination behaviour of the pollinator taxa included; (ii) precision of identification of the particular group by pollination biologists; and (iii) frequency of occurrence among visitors of Czech plant taxa (e.g. moths and hawkmoths constitute a well-defined functional group, but they were included among butterflies due to their rare occurrence in the dataset). Only a list of pollinator functional groups of a given plant taxon is shown on the Pladias Database public portal. Pollinator functional groups with less than 10% share on the total pollinator composition are listed in brackets.

The data are based predominantly (~80%) on European studies that quantitatively recorded all the pollinator functional groups visiting the focal plant species. The literature data were supplemented by original research (~20%). Pollinator spectra were established mainly for common non-forest herbs, based on approximately 240,000 recorded pollinator individuals. A plant taxon is included in the database if at least 25 pollinator individuals were recorded from it. Pollinator spectrum is based on the sum of all observed pollinator individuals from a given plant taxon. Pollinator records in percentages needed to be recalculated to abundances before summing up with pollinator abundances recorded from the same plant species. For such recalculation, it was conservatively assumed that the pollinator taxon with the lowest recorded percentage corresponds to one observed individual. The abundances of other pollinators were recalculated accordingly. In some studies, the pollinator percentages were calculated only after averaging data from several subplots, and the above-mentioned approach thus could not be employed because of obvious overestimation of abundances in such cases. Pollinator abundances were therefore estimated as one half of the back-transformed fitted value of the following regression equation: log(# individuals) ~ 0.461 × log(# taxa) + 0.815 ($F_{1,\,3774} = 1073$; $P < 0.001$; adj. $R^2 = 0.221$), computed from the data on site-by-plant taxon combinations from all studies with pollinator spectra reported as abundances.

Categories:

- honeybee – *Apis mellifera*
- bumblebees – *Bombus* spp. incl. *Psithyrus*
- solitary bees – anthophilous pollen-collecting taxa from *Apoidea* other than honeybees and bumblebees
- other *Hymenoptera* – *Hymenoptera* other than bumblebees, solitary bees and honeybee
- hoverflies – *Syrphidae* larger than 5 mm
- flies s.l. – flies, flower flies and similar (families *Muscidae*, *Anthomyiidae*, *Fanniidae*, *Scathophagidae*, *Sphaeroceridae*) larger than 5 mm
- meat flies s. l. – meat flies and blow flies (families *Sarcophagidae*, *Calliphoridae*, *Rhinophoridae*)
- other *Diptera* – *Diptera* other than flies, meat flies and hoverflies (or from those groups but smaller than 5 mm)
- butterflies – butterflies (*Lepidoptera*, including moths and sphingids)
- beetles – beetles (*Coleoptera*; except nitidulids)
- nitidulids – small floricolous beetles with aggregated distribution (families *Nitidulidae*, *Kateridae*, *Byturidae*, *Phalacridae*)
- thrips – *Thysanoptera*
- other pollinators – regular flower visitors presumably contributing to pollination (except for the orders *Diptera*, *Hymenoptera*, *Lepidoptera*, *Coleoptera* and *Thysanoptera*)
- unknown – pollinators without further identification by authors (or identification including more than one recognized pollinator functional group)

Citation: Janovský Z. (2020) Pollinator spectrum. – www.pladias.cz.

4. Fruit, seed and dispersal

4.1 Fruit type

The primary classification of fruit types is into dry and fleshy. Within each of these two groups, fruit types are further classified based on the scheme outlined in the first volume of the Flora of the Czech Republic (Slavíková 1988), which consistently uses the typological method. This means that fruits are classified based purely on their morphology following the formal definitions of the fruit type, regardless of the fruit type found in closely related species or genera.

One-seeded fruits in *Brassicaceae* (e.g. *Crambe*) are classified as achenes, not siliculas. Indehiscent two- and more-seeded fruits in the same family, breaking mainly in constrictions (e.g. in *Bunias* and *Raphanus*), are consistently classified as a loment, even if the fruit breaks into two distinct parts, of which one is one-seeded and the other, of strikingly different shape, two- or more-seeded and dehiscent, such as in *Rapistrum rugosum*. A similar approach is used for the classification of fruits in *Fabaceae*. Dehiscent fruits of most taxa are classified as legumes, while indehiscent two- and more-seeded fruits breaking into single-seeded parts (e.g. in *Hippocrepis* and *Securigera*) are classified as loments. One-seeded indehiscent fruits (e.g. in *Onobrychis* and *Trifolium*) are classified as achenes. Two- or more-seeded indehiscent fruits (e.g. in *Sophora japonica* and *Vicia faba*) are also classified as legumes. The fruits of all *Euphorbia* species are classified as capsules, although in some cases the seeds are not released. Fleshy false fruits of the genera *Basella*, *Ficus*, *Maclura*, *Morus*, *Nuphar* and *Nymphaea* are merged into a separate category.

The information about fruit type was extracted mainly from the descriptions in the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards). For the taxa not treated in that flora or in case of uncertainties, especially regarding alien taxa, descriptions in the Flora of North America (Flora of North America Editorial Committee 1993 onwards), the Flora of China (Wu et al. 1994 onwards), the Flora of Pakistan (www.tropicos.org/Project/Pakistan), and Flora Iberica (Castroviejo et al. 1986 onwards; mainly for the *Fabaceae* family) were consulted.

Categories:

- dry fruit – disciform breaking into mericarps
- dry fruit – pair of nutlets
- dry fruit – cremocarp
- dry fruit – double samara
- dry fruit – legume
- dry fruit – follicle
- dry fruit – achene/cypsela/samara
- dry fruit – nut enclosed in a utricle
- dry fruit – caryopsis
- dry fruit – nut
- dry fruit – schizocarp
- dry fruit – cluster of follicles
- dry fruit – head of achenes
- dry fruit – loment/transversely dehiscent siliqua
- dry fruit – siliqua
- dry fruit – silicula
- dry fruit – capsule
- dry fruit – cluster of four one-seeded nutlets
- dry fruit – dry schizocarp with an apical beak
- fleshy fruit – berry
- fleshy fruit – pome
- fleshy fruit – drupe
- fleshy fruit – head of one-seeded drupes
- fleshy fruit – hip
- fleshy fruit – special type

Citation: Grulich V., Holubová D., Štěpánková P. & Řezníčková M. (2017) Fruit type. – www.pladias.cz.

4.2 Fruit colour

Data on fruit colour according to the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards) and the Key to the Flora of the Czech Republic (Kubát et al. 2002). Fruit colours are standardized into ten colours. A single dominant colour of ripe fruit is reported for each taxon.

Categories:

- white
- green
- yellow
- orange
- violet
- red
- blue
- brown
- grey
- black

Data source and citation: Hejný et al. (1988 onwards), Kubát et al. (2002).

4.3 Reproduction type (Fig. 16)

Reproduction is the production of offspring that are physically separated from the parental plant. Plants reproduce either by seed (or spores) or vegetatively, while the combination of these two types of reproduction in the same taxon is common. Asexual seed production (apomixis) is not considered as vegetative reproduction. The data were taken from the BiolFlor database (Durka 2002).

Categories:

- only vegetatively
- mostly vegetatively, rarely by seed/spores
- by seed/spores and vegetatively
- mostly by seed/spores, rarely vegetatively
- only by seed/spores

Data source and citation: Durka (2002).

4.4 Dispersal unit (diaspore)

Diaspore, also called dispersule or propagule, is a generative or vegetative part of the plant body that is dispersed from the parental plant and can produce a new individual. Generative diaspores include spores, seeds and fruits or similar dispersal units (e.g. aggregate fruits in *Fragaria*, multiple fruits in *Morus*, gymnosperm cones, epimatium-bearing seed in *Taxus*, spikelets or their various fragments in *Poaceae*). If the seed is released from dehiscent fruit or decaying ripe fleshy fruit, both seed and fruit can be considered as diaspores. In plants with indehiscent fruits, only the fruit is considered as a diaspore. A specific category of generative diaspore is tumbleweeds, i.e. mature plant parts including stem branches and large inflorescence (e.g. *Crambe tataria* and *Falcaria vulgaris*).

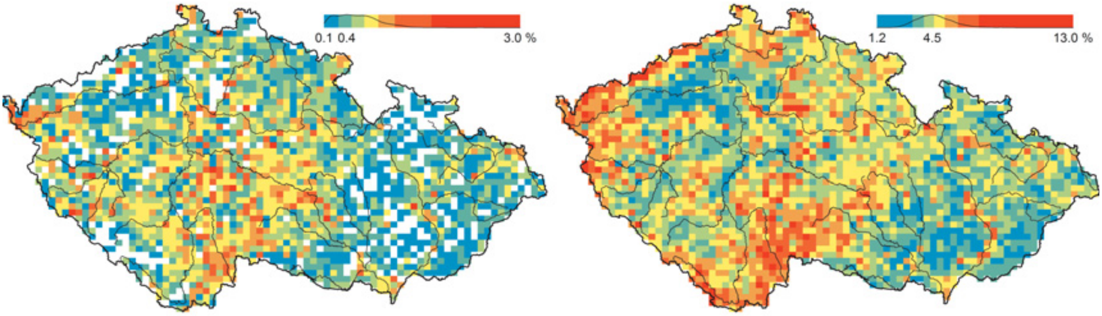
Vegetative diaspores are viable and movable parts of plants that originate above ground or in water and disconnect from the parent plant before sprouting. We did not consider as vegetative diaspores clonal organs connected with the maternal plant until the new plant becomes independent (e.g. stolons in *Fragaria*) and various types of below-ground organs or shoot bases embedded in soil (e.g. tubers of *Helianthus tuberosus* or grass tillers). Vegetative diaspores include (i) turions (e.g. *Myriophyllum* and *Utricularia*) and similar overwintering structures (detachable buds in *Elodea* and *Groenlandia* and shortened shoots of some pondweeds produced by rhizome or stolon, e.g. *Potamogeton alpinus*); (ii) bulbils and tubers of stem origin (e.g. *Allium oleraceum* and *Dentaria bulbifera*) or root origin (*Ficaria* only); (iii) plantlets born by pseudovivipary (e.g. *Poa alpina*); (iv) plantlets born from buds on leaves (e.g. *Cardamine pratensis*); (v) plantlets born on free ends of stolons, detachable before establishing (e.g. *Hydrocharis* and *Jovibarba*); (vi) unspecialized fragments of the shoot (e.g. *Sedum album* and many aquatic plants), shoot tips (e.g. *Ceratophyllum demersum*) or detachable offsprings born from axillary buds (e.g. *Agrostis canina*, *Arabidopsis halleri* and *Rorippa amphibia*); (vii) budding plants (*Lemnaceae* only); and (viii) gemmae produced by gametophytes (*Trichomanes speciosum* only).

Categories:

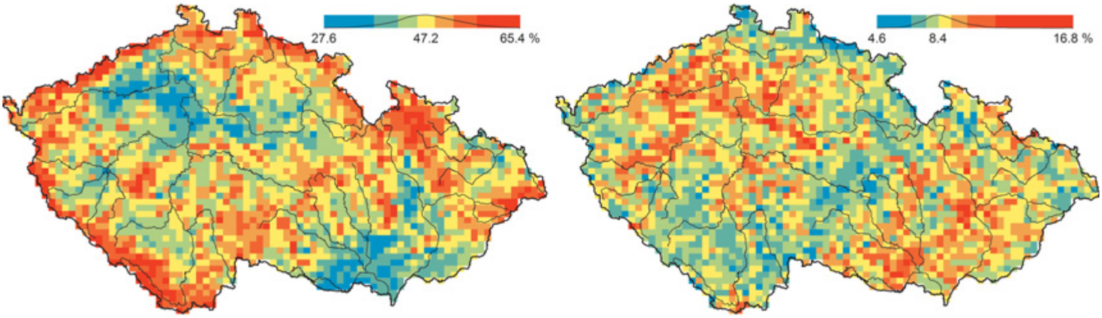
- spore
- seed
- fruit, infructescence or its part
- tumbleweed
- turion
- bulbil or tuber
- pseudovivipary
- leaf-born plantlet
- stolon-born plantlet
- shoot fragment
- budding
- gametophyte-gemma

Data source and citation: Sádlo et al. (2018).

(A) Reproduction only vegetatively **(B) Reproduction mostly vegetatively**



(C) Reproduction by seed-spores and vegetatively **(D) Reproduction mostly by seed-spores**



(E) Reproduction only by seed-spores

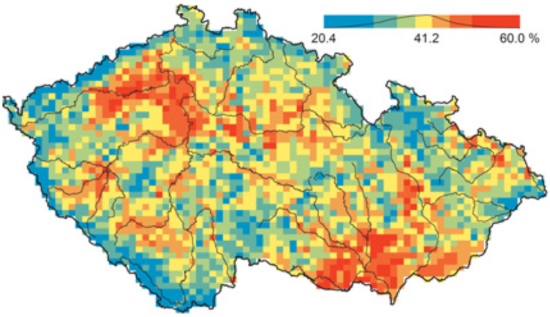
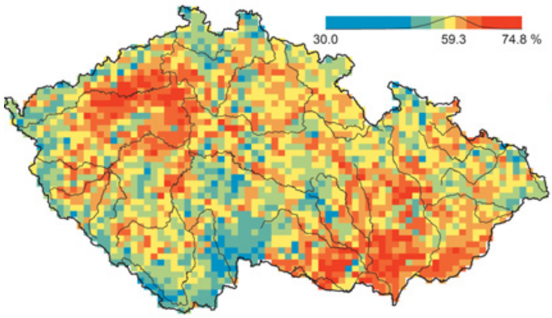


Fig. 16. – Proportion of species with different proportions of vegetative and generative reproduction in the Czech flora. Plants reproducing only vegetatively are more common in the mid-elevation areas of the Bohemian Massif, those reproducing mostly vegetatively in pond basins and lowland riverine landscapes, those reproducing by both seed/spores and vegetatively in the mountain area, those reproducing mostly by seed/spores in lowland areas and those reproducing only by seed/spores in dry lowland areas.

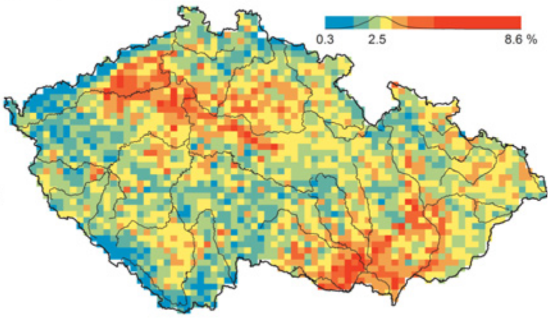
4.5 Dispersal strategy (Fig. 17)

Plants use different dispersal modes, also called dispersal syndromes, depending on different dispersal vectors. For example, anemochory is the dispersal by wind, hydrochory by water, epizoochory by attachment to an animal body and endozoochory by animals via ingestion. However, single plant species usually use a combination of several dispersal modes rather than a single mode. Distinct combinations of dispersal modes repeatedly occurring in different plant taxa are called dispersal strategies. Sádlo et al. (2018) distinguished nine dispersal strategies named for the genus names of typical representatives. Taxa of the Czech flora are assigned to individual strategies based on this source.

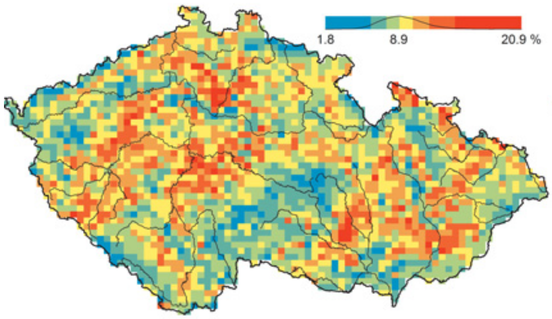
(A) Dispersal strategy Allium



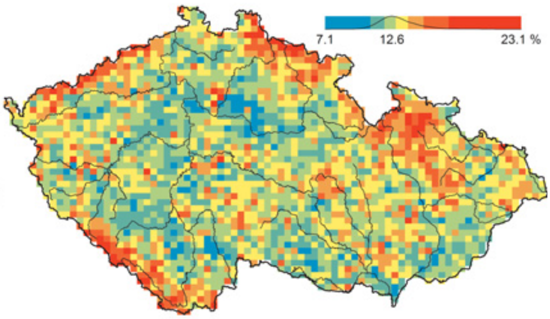
(B) Dispersal strategy Bidens



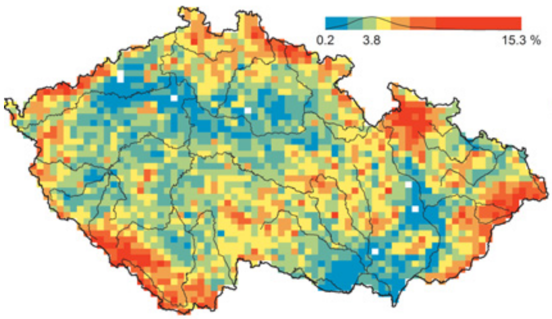
(C) Dispersal strategy Cornus



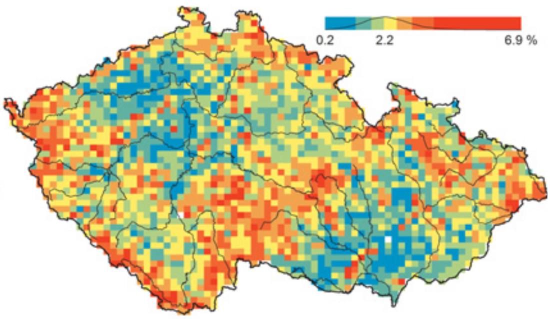
(D) Dispersal strategy Epilobium



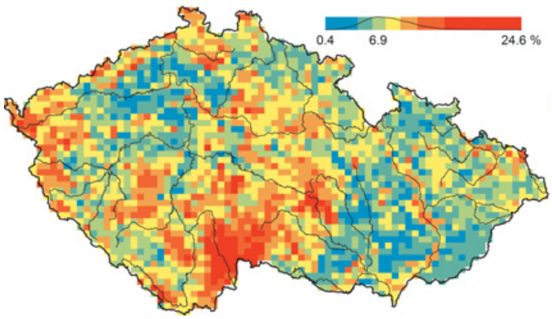
(E) Dispersal strategy Lycopodium



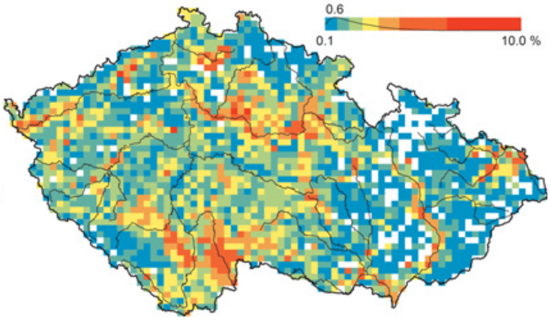
(F) Dispersal strategy Phragmites



(G) Dispersal strategy Sparganium



(H) Dispersal strategy Wolffia



◀ Fig. 17. – Proportion of species with different dispersal strategies in the Czech flora. The *Allium* dispersal strategy is frequent in dry lowlands, *Bidens* strategy in various lowland and mid-elevation areas, *Cornus* strategy also in various lowland and mid-elevation areas, but outside the pond basins and large river floodplains, *Epilobium* strategy in the high mountains of the Bohemian Massif, *Lycopodium* and *Phragmites* strategies in the mountain areas of both the Bohemian Massif and the Carpathians, and *Sparganium* and *Wolffia* strategies in pond basins and lowland riverine landscapes, the former being more common in pond basins and the latter in riverine landscapes.

Categories:

- *Allium* type – mainly autochory, less frequently anemochory, endozoochory and epizoochory. This is the most common dispersal strategy, including about 56% taxa of the Czech flora. About half of the included taxa are dispersal generalists lacking a clear morphological indication of anemochory or zoochory. Most myrmecochorous or probably myrmecochorous species are also assigned to this category.
- *Bidens* type – mainly autochory and epizoochory, less frequently endozoochory. This dispersal strategy is characterized by two essential dispersal modes, of which autochory is the more important, despite the presence of morphological structures indicating epizoochory.
- *Cornus* type – mainly autochory and endozoochory. Herbaceous plants, shrubs and small trees with fleshy fruit, often of the *Rosaceae* family, typically have this strategy. Furthermore, tall trees bearing large, heavy and nutrient-rich seeds are also included.
- *Epilobium* type – mainly anemochory and autochory, less frequently endozoochory and epizoochory. This dispersal strategy is typical of taxa growing in mesic and dry habitats.
- *Lycopodium* type – mainly anemochory, less frequently autochory, endozoochory, epizoochory and hydrochory. This dispersal strategy relies on light, very small spores and seeds that are dispersed, besides wind, by a wide range of vectors. Compared to other strategies, the role of autochory is small.
- *Phragmites* type – mainly anemochory and hydrochory, less frequently autochory, endozoochory and epizoochory. Wetland taxa with light diaspores (both seeds and fruits) equipped with a hairy flying apparatus. Most of the taxa with this dispersal strategy lack vegetative diaspores. Woody plants, stout clonal graminoids and herbaceous plants are typical growth forms associated with this dispersal strategy.
- *Sparganium* type – mainly autochory and hydrochory, less frequently endozoochory and epizoochory. This dispersal strategy is a wetland analogue of the *Wolffia* type, assigned to aquatic plants. It applies mainly to monocotyledonous taxa producing achenes with good buoyancy and with vegetative diaspores having an important role.
- *Wolffia* type – mainly hydrochory, less frequently endozoochory and epizoochory. This dispersal strategy is typical of aquatic macrophytes spread by fruit, seed or spores. However, vegetative reproduction dominates in most cases, including stem fragmentation, the formation of stolons or, in *Lemnaceae*, budding colonies.
- *Zea* type. Taxa with this dispersal strategy rarely or never disperse by generative diaspores and do not form vegetative aboveground diaspores.

Data source and citation: Sádlo et al. (2018).

4.6 Myrmecochory (Fig. 18)

Myrmecochorous plants, i.e. taxa dispersed by ants, possess an elaiosome, a nutrient-rich fleshy appendage of seed or fruit. However, in many taxa, the morphological indication or direct evidence of myrmecochory is equivocal. Removal experiments (seeds with and without elaiosome offered to ants) or chemical analysis (different nutrient content between seed and elaiosome; Konečná et al. 2018) would be needed to decide whether the appendage is elaiosome or not. Therefore, more categories than a simple binary distinction between myrmecochorous and non-myrmecochorous are recognized here: (i) myrmecochorous – an elaiosome (a conspicuous fleshy appendage of seed or fruit) is present; (ii) probably myrmecochorous – a fleshy structure resembling an elaiosome is present, but the appendage:seed size ratio is very small so that the possible advantage of seed transport for the ants would be small; (iii) probably non-myrmecochorous – seed or fruit bears a structure not similar to elaiosome, e.g. a non-fleshy appendage or rim; (iv) non-myrmecochorous (a) – an elaiosome is not present although the taxon is reported as myrmecochorous in the

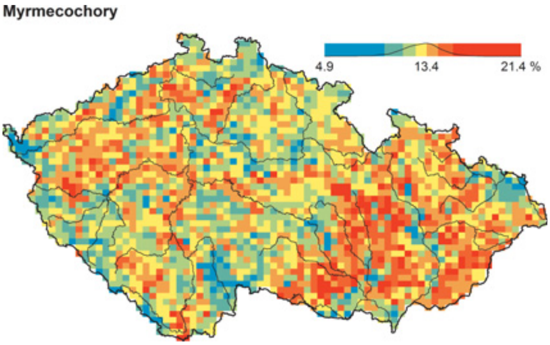


Fig. 18. – Proportion of species dispersed by ants in the Czech flora (merged categories 1 and 1nv). Myrmecochorous plants tend to avoid mountain ranges, river floodplains and pond basins, reflecting the fact that ants, in general, tend to avoid cold and flooded habitats.

literature or is a close relative of taxa considered as myrmecochorous; (v) non-myrmecochorous (b) – elaiosome is not present, and the taxon does not belong to a family reported as containing myrmecochorous species in the literature

Plant taxa that are often carried by ants to the nest although having no elaiosome (e.g. cheaters in this plant-ant mutualism or plant parts used as a building material for ant hills) are classified as non-myrmecochorous.

The data are based on the literature search and examination of seed samples of the taxa that are reported as myrmecochorous and their closely related congenerics. The list of these taxa with seed images is available at http://botanika.prf.jcu.cz/myrmekochorie. These taxa were selected from the families represented in the Czech flora that contain at least one taxon reported as myrmecochorous in the literature (Sernander 1906, Hejný et al. 1988 onwards, Fitter & Peat 1994, Klotz et al. 2002, Grime et al. 2007, Kleyer et al. 2008, Servigne 2008, Lengyel et al. 2010, Študent 2012). Such taxa were found in 37 families including *Amaryllidaceae*, *Apiaceae*, *Apocynaceae*, *Aristolochiaceae*, *Asparagaceae*, *Asteraceae*, *Boraginaceae*, *Campanulaceae*, *Caryophyllaceae*, *Celastraceae*, *Colchicaceae*, *Crassulaceae*, *Cyperaceae*, *Dipsacaceae*, *Euphorbiaceae*, *Fabaceae*, *Iridaceae*, *Juncaceae*, *Lamiaceae*, *Liliaceae*, *Linaceae*, *Montiaceae*, *Orobanchaceae*, *Oxalidaceae*, *Papaveraceae*, *Plantaginaceae*, *Poaceae*, *Polygalaceae*, *Polygonaceae*, *Portulacaceae*, *Primulaceae*, *Ranunculaceae,* *Resedaceae*, *Rosaceae*, *Santalaceae*, *Urticaceae* and *Violaceae*. All the taxa not belonging to these families were classified as non-myrmecochorous (b).

For each of the five categories, a subcategory nv (= non vidimus, i.e. not seen) is used in the taxa for which we found neither information in the literature nor a photograph of a seed, and failed to collect seeds from living plants, but the assignment to the category is likely based on the traits of closely related taxa. For example, we have no data for *Centaurea bruguiereana* but we classify it as myrmecochorous nv, because all the taxa of *Centaurea* for which we have data possess an elaiosome.

Categories:
- myrmecochorous
- myrmecochorous nv
- probably myrmecochorous
- probably myrmecochorous nv
- probably non-myrmecochorous
- probably non-myrmecochorous nv
- non-myrmecochorous (a)
- non-myrmecochorous (a) nv
- non-myrmecochorous (b)
- non-myrmecochorous (b) nv

Citation: Konečná M., Štech M. & Lepš J. (2018) Myrmecochory. – www.pladias.cz.

5. Belowground organs and clonality

5.1 Shoot metamorphosis

Shoot metamorphoses are modifications of the shoot that involve the development of different structures for special tasks such as vegetative spread or storage. Data about shoot metamorphoses are adopted from the BiolFlor database (Krumbiegel 2002).

Categories:

- stolon – lateral shoot (exceptionally the main shoot) with long thin internodes and adventitious roots; separation from the mother plant causes the formation of individual ramets
- stolon with tuberous tip – subterranean stolon with tuberous swelling of several internodes at the distal end, which mostly develops at the end of the growing season for storing nutrients; aboveground shoots develop from the tuber in the following season
- stolon with bulbous tip – subterranean stolon with a bulbous tip at the distal end; aboveground shoots develop from the bulb in the following season
- rhizome – subterranean or surface-close, mostly thickened shoot living for more than one year, bearing adventitious roots, buds and usually also cataphylls (tiny reduced leaves); it has both spreading and storing function
- stolon-like rhizome – rhizome with longer internodes that has mainly the spreading function
- pleiocorm – a system of compact, perennial shoots at the proximal end of the persistent primary root; the innovation shoots arise from the buds in the axils of basal leaves, and the connections between the shoots and the primary root are persistent
- rhizome-like pleiocorm – a pleoicorm in which the first innovation shoots arise from the basal leaf axils, but later shoots arise from rhizome-like, adventitiously rooted shoots, which later lose their connection with the primary root
- shoot tuber – thickened, mostly subterranean part of a shoot, living for less than one year and used for storage
- bulb – compressed part of a shoot with cataphyll leaves or leaf bases, used for storage or vegetative propagation
- bulbil – compressed aboveground lateral shoot with poorly developed or still absent organs, which develops into a new plant after separation from the mother plant
- brood shoot – spikelet of *Poaceae* transformed into a tiny shoot, which develops into a new plant after separation from the mother plant
- turion – compressed, mostly bud-like vegetative shoot, which hibernates with leaves or leaf parts and sprouts only after separation from the mother plant
- shoot thorn – prickly structure rich in strengthening tissue, mostly at the position of a lateral shoot
- shoot tendril – thread-like, ramified or non-ramified shoot used for plant attachment to supporting structures
- shoot succulence – the presence of a large amount of water-storing tissue causing fleshy thickening of shoots
- assimilating shoot – shoot used for assimilation instead of or in addition to leaves

Data source and citation: Krumbiegel (2002).

5.2 Root metamorphosis

Root metamorphoses are modifications of the root that involve the development of different structures for special tasks such as vegetative spread or storage. Types of root metamorphoses are adopted from the BiolFlor database (Krumbiegel 2002).

Categories:

- primary storage root – thickened primary root including the thickened hypocotyl and epicotyl, acting as a storage organ
- secondary storage root – partly thickened adventitious or lateral root acting as a storage organ; in contrast to root tuber, it has not lost the primary functions of roots such as anchoring and absorption of water and minerals
- root tuber – thickened, not ramified adventitious root formed from an innovation bud; it primarily acts as a storage organ, being rarely involved in absorption
- root shoot – adventitiously-rooted shoot growing from the primary or a lateral root; it is either leafless or has cataphyllary leaves during growth within the soil
- buttress root – the upper lateral root of trees; its thickened upper part forms buttresses that strengthen the trunk bases and increase trunk stability
- adhesive root – short aerial root attached to the substrate, trunk or wall without penetrating it
- rootless

Data source and citation: Krumbiegel (2002).

5.3 Storage organ

The occurrence of organs for storage of nutrients or water is usually associated with the ability of vegetative propagation and dispersal. The data on storage organs were taken from the BiolFlor database (Krumbiegel 2002).

Categories (see the definitions under Shoot metamorphosis and Root metamorphosis for the categories where no definition is provided):

- stolon
- stolon with tuberous tip
- stolon with bulbous tip
- rhizome
- stolon-like rhizome
- pleiocorm
- rhizome-like pleiocorm
- shoot tuber
- bulb
- bulbil
- turion
- succulence – the presence of special water-storing tissue
- primary storage root
- secondary storage root
- root tuber
- tuft – a cluster of more or less orthotropically growing shoots, which are tightly-packed because of numerous, spatially more or less regular ramification of the adventitiously rooting basal parts of the shoots
- hypocotyl bulb– thickened hypocotyl with storage function

Data source and citation: Krumbiegel (2002).

5.4 Type of clonal growth organ

The type of clonal growth is only reported for clonal herbs. Clonal growth is defined here as the growth of the plant body leading to the formation of physically independent asexual offspring. A morphological prerequisite for clonal growth is the formation of adventitious roots on stems or adventitious shoots from root buds that yield (potentially) physically independent individuals (Groff & Kaplan 1988).

The types of clonal growth organs are morphological categories that are defined based on three main parameters: (i) bud-bearing organ that gives rise to the clonal growth organ (shoot or root); (ii) position of the organ relative to the soil surface (aboveground, belowground, initially aboveground and later belowground, water); (iii) storage organ (shoot, root, leaf)

For each taxon, only one type of the clonal growth organ is reported, although some taxa possess several independent types of such organs (Klimešová & Klimeš 2006). The reported type is considered as the most important for the life cycle of the taxon, producing the highest number of offspring or permitting the individual to spread its offspring over large distances. Some of these types are vegetative diaspores, while others are used for local spread but not long-distance dispersal. The clonal growth organs are divided into

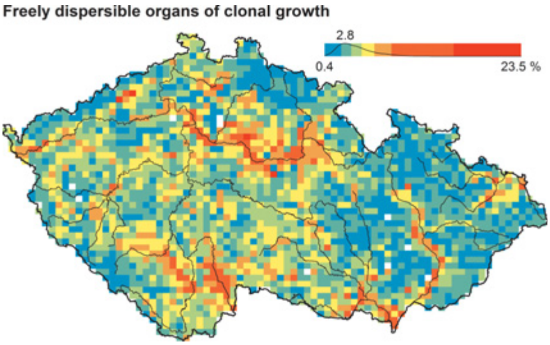


Fig. 19. – Proportion of species with freely dispersible organs of clonal growth among the clonal species in the Czech flora. Such species are frequent along large lowland rivers.

aboveground and belowground and sorted within each category by their decreasing frequency in the Czech flora.

Categories:
Aboveground organs

- stolon – a horizontal aboveground shoot rooting in the soil and providing connection between offspring plants and the mother plant or formed by a creeping main shoot
- turion – a detachable over-wintering bud of aquatic plants composed of tightly arranged leaves filled by storage compounds
- stem fragment – a detached part of the shoot with rooting ability
- budding plant – an extremely reduced body of aquatic plants formed by a small frond (e.g. *Lemna*)

Belowground organs

- epigeogenous rhizome – a perennial clonal organ of stem origin growing horizontally at the soil surface; its distal part is covered by soil and litter or pulled into the soil by the contraction of roots; nodes bear green leaves, the internodes are usually short
- hypogeogenous rhizome – a perennial clonal organ of stem origin usually growing horizontally at a species-specific depth belowground; after some time its tip turns up, becoming orthotropic and forming aboveground shoots; the horizontal part of the rhizome has long internodes and bears bracts and roots (usually only on the nodes)
- belowground stem tuber – a belowground, usually short-lived storage and regenerative organ of shoot origin
- bulb – a storage organ consisting of storage leaves and a shortened stem base
- root with adventitious buds – primary root including the hypocotyl or adventitious root forming adventitious buds spontaneously or after an injury
- root tuber – a belowground storage organ of root origin growing from a bud-bearing stem
- stolon with tuber – a stolon with a belowground, usually short-lived storage and regenerative organ developing at its distal end

Data source and citation: Klimešová & Klimeš (2006).

5.5 Freely dispersible organs of clonal growth (Fig. 19)

This trait is defined only for clonal herbs. Clonality of herbs can be realized by the formation of freely dispersible clonal offspring, i.e. new individuals that are separated from the mother shoots very shortly after their formation and before they develop roots attaching them to the soil. They are dispersed by water or other agents. Typical examples are plantlets, bulbils, turions or stem fragments of aquatic plants. The data reported here are based on individual observations in the CLO-PLA 3.4 database (Klimešová & Klimeš 2006, Klimešová et al. 2017).

Categories:

- present
- absent

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

5.6 Shoot life span (cyclicity) (Fig. 20A)

This trait, defined for herbs, is measured as the number of years from the emergence of the aboveground part of the shoot till its flowering and fruiting (Serebryakov 1952). Based on the analysis of morphological traits, we distinguish shoots with cyclicity of one year (monocyclic) from those that live longer (di- and polycyclic). In plants with sympodial branching, cyclicity refers to all shoots, while in plants with monopodial branching, it refers only to flowering shoots, although flowering and sterile shoots can be present simultaneously. Monocyclic plants usually do not possess a leaf rosette, and all shoots in a population can flower. In contrast, di- and polycyclic shoots possess a basal leaf rosette and shoot populations contain flowering and sterile shoots at the same time.

The data are based on individual observations in the CLO-PLA 3.4 database (Klimešová & Klimeš 2006). If more types are reported for one taxon, the most frequently observed type is given (Klimešová et al. 2017).

Categories:

- monocyclic shoots prevailing
- dicyclic or polycyclic shoots prevailing

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

5.7 Branching type of stem-derived organs of clonal growth (Fig. 20B–D)

Branching type is defined for clonal herbs. It determines whether individuals possess two different shoot types (flowering and sterile) or only one shoot type (which can potentially flower). In plants with sympodial branching, all shoots are identical in their construction, replacing each other during ontogeny of the individual; all of them can potentially flower. In contrast, plants with monopodial branching possess two shoot types, one of which never flowers, whereas the flowering shoots arise from axillary buds of the non-flowering shoot. Finally, ferns and lycophytes can possess dichotomous branching that is functionally similar to monopodial branching.

The data reported here are based on individual observations in the CLO-PLA 3.4 database (Klimešová & Klimeš 2006). If more types are reported for one taxon, the most frequently observed type is given here (Klimešová et al. 2017).

Categories:

- monopodial
- sympodial
- dichotomous

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

5.8 Primary root (Fig. 21A)

The presence of the primary root is only defined for herbs. The primary root can be either present for the whole life of a plant or replaced during the ontogeny by adventitious roots. If the primary root is the only root for the whole life of a plant, the plant is not capable of forming adventitious roots on stems; therefore it is not clonal (unless it is able to form adventitious buds on roots; Groff & Kaplan 1988). In contrast, if the primary root is existing only in an early ontogenetic stage and later replaced by adventitious roots formed on belowground parts of the stem, the plant can grow clonally. In older individuals of some taxa that preserve the primary root, this root can split into parts, giving rise to several independent plant individuals. Some taxa only form adventitious roots under specific conditions (soil moisture, root injury or old age).

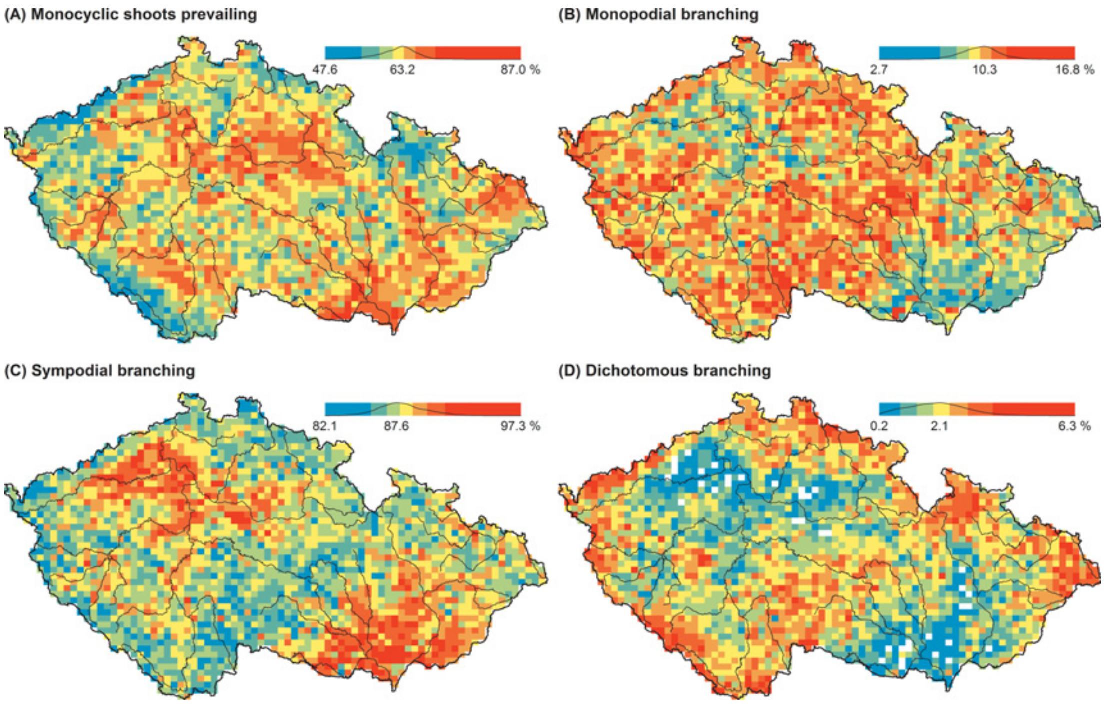


Fig. 20. – Proportion of species with prevailing monocyclic (annual) shoots (A) and proportion of species with monopodial, sympodial and dichotomous branching (B–D) in the Czech flora. The species with monocyclic shoots are frequent in lowland areas with a large proportion of arable land. The species with monopodial branching are most frequent in mid-elevation areas and basins of the Bohemian Massif, those with sympodial branching in dry lowland areas and those with dichotomous branching in higher mountain areas.

The data reported here are based on individual observations stored in the CLO-PLA 3.4 database (Klimešová & Klimeš 2006). If more types are reported for one taxon, the most frequently observed type is given (Klimešová et al. 2017).

Categories:

- present
- absent

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

5.9 Persistence of the clonal growth organ

Persistence of the clonal growth organ, defined for clonal herbs, determines the life span of the physical connection between the parent and offspring shoots. Because morphological analysis does not permit the identification of such life span beyond a period of few years, the persistence of the connection is assessed in categories (< 1, 1–2, > 2 years; Klimešová & Klimeš 2006). From those categories, mean values of their ranges (0.5, 1.5 and 4.0 years) are used, and the final value is the mean of all records for the given taxon and the given type of the clonal growth organ in the CLO-PLA 3.4 database (Klimešová et al. 2017).

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

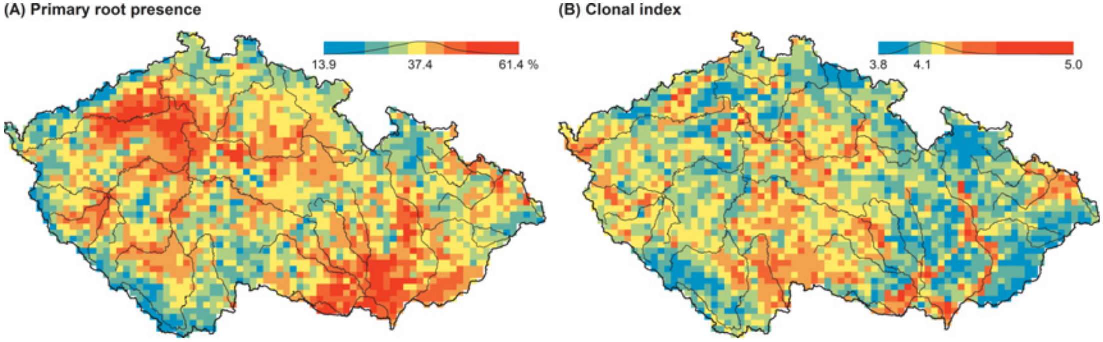


Fig. 21. – Proportion of species with a primary root (A) and mean clonal index for the clonal herbs (B). The species with the primary root are frequent in dry lowland areas, which is partly due to the prevalence of primary root in therophytes. The clonal index tends to be higher in wetland areas, both in pond basins and along large lowland rivers. The two variables that are combined in this index, Number of clonal offspring and Lateral spreading distance by clonal growth, both display a similar geographic pattern (not shown).

5.10 Number of clonal offspring

This trait is only defined for clonal herbs. The number of offspring shoots produced per parent shoot of a clonal herb per year is estimated in categories (< 1, 1, 2–10, > 10; Klimešová & Klimeš 2006), which are represented by the mean values of their ranges (0.5, 1, 6, and 15). The reported value is the mean of these values across all the available measurements for individuals of the given taxon and type of clonal growth organ in the CLO-PLA 3.4 database (Klimešová et al. 2017).

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

5.11 Lateral spreading distance by clonal growth

The lateral spreading distance by clonal growth is defined for clonal herbs as the distance between parental and offspring shoots. Freely dispersible vegetative diaspores are not considered. Lateral spreading distances were estimated in categories (< 0.01 m, 0.01–0.25 m, > 0.25 m; Klimešová & Klimeš 2006), which are represented by the mean values of their ranges (0.005 m, 0.13 m, 0.50 m). The reported value is the mean of these values across all records for the given taxon and the given type of clonal growth organ in the CLO-PLA 3.4 database (Klimešová et al. 2017).

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

5.12 Clonal index (Fig. 21B)

The Clonal index (Johansson et al. 2011) is a measure of taxon's clonal ability. It is defined for clonal herbs as the sum of the ranks of the four categories of "Number of clonal offspring" (coded as 1, 2, 3, 4) and the three categories of "Lateral spreading distance by clonal growth" (coded as 1, 2, 3) with the presence of freely dispersible vegetative diaspores added as the fourth category (4). The index values range from 2 to 8, with higher values indicating better clonal ability. The index is defined for clonal herbs.

The data reported here are based on the categories of “Number of clonal offspring” and “Lateral spreading distance by clonal growth” aggregated from individual records in the CLO-PLA 3.4 database (Klimešová & Klimeš 2006, Klimešová et al. 2017).

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

5.13 Position of root buds

In contrast to stem buds, which are always located in a leaf axil, adventitious buds on roots (or hypocotyl) are not located at specific positions of the roots. They occur only in some root types or may only appear after the individual is injured. Root buds are found in approximately 10% of species in the Czech flora. Adventitious buds may be located on the hypocotyl, on the primary root, or on lateral roots. We list the hypocotyl only if the roots are found exclusively on it. We report the primary root if the buds are never formed on lateral roots, and we report the lateral roots if root buds are potentially found on all three types of bud-bearing organs. The data were taken from Bartušková et al. (2017).

Categories:

- hypocotyl
- primary root
- lateral roots

Data source and citation: Bartušková et al. (2017).

5.14 Role of root buds in the life-history of a plant

Adventitious buds on roots or hypocotyl occur in only about 10% species of the Czech flora and have different roles in individual taxa. In some taxa, they occur only after the plant is injured and play a role in regeneration after such injury (regenerative role). In other taxa, these buds are formed without such an external stimulus. Consequently, they increase the number of shoots and thereby the number of offspring, both clonally and by seed. In most taxa, such buds occur only in some individuals and are not necessary for completing the life cycle; we denote them as additive (or accessory) root buds. In a few taxa, the formation of root buds is necessary for completing the life cycle and flowering. They develop in all individuals, and survival/flowering or overwintering of an individual is dependent on them (Rauh 1937, Klimešová 2007). The data were taken from Bartušková et al. (2017).

Categories:

- regenerative
- additive
- necessary

Data source and citation: Bartušková et al. (2017).

5.15 Bud bank (Fig. 22)

Bud bank denotes all inactive (dormant) buds on the plant body that can give rise to new shoots, including both shoot buds and root buds (Klimešová & Klimeš 2007). The most important part of the bud bank is located at the soil surface or belowground, out of the reach of disturbance or seasonal frost or drought (Raunkiaer 1934). Consequently, only data on buds located at the soil surface or in the soil are reported here.

The number of buds on plant organs located at different soil depths was assessed according to morphological characters (Klimešová & Klimeš 2007). The assessment was based on the assumption that each leaf (or leaf scale) axil contains a bud. Assessment of

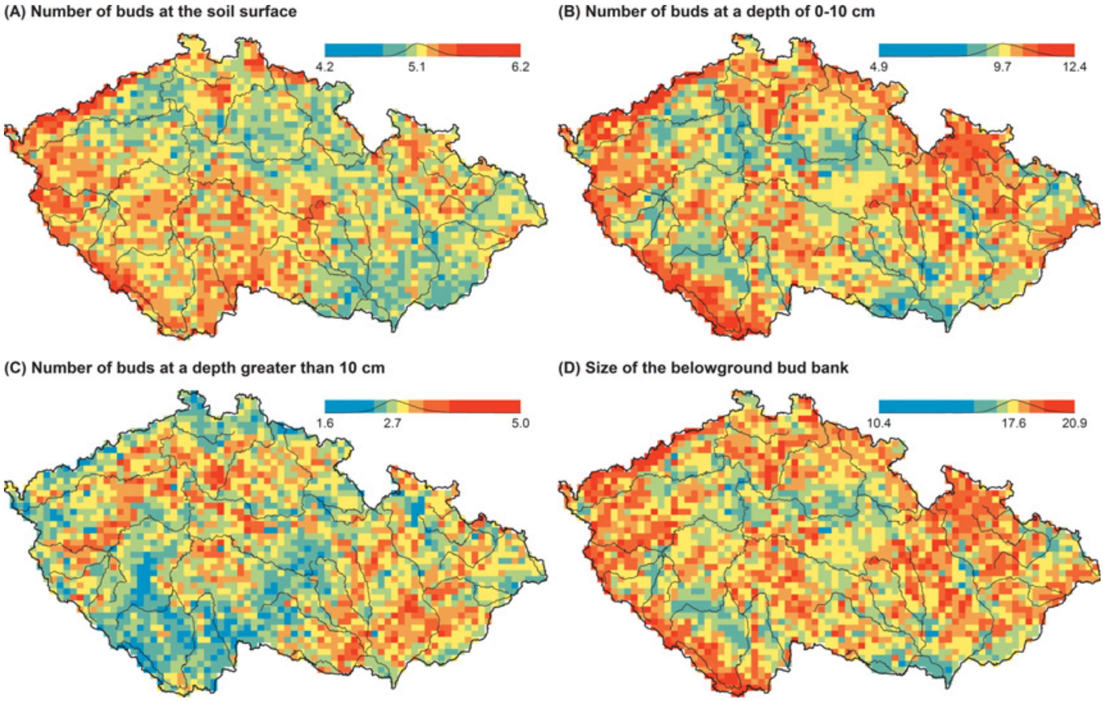


Fig. 22. – Mean number of buds per shoot (including root buds) at different depths and the size of the belowground bud bank for species of the Czech flora that form a bud bank. Higher numbers of buds at the soil surface are typical of middle and higher elevations of the Bohemian Massif. Higher numbers at a depth of 0–10 cm are typical of all mountain areas, and higher numbers at a depth greater than 10 cm are typical of low-elevation non-wetland areas. The size of the belowground bud bank is largest in mountain areas and mid-elevation non-wetland areas.

bud numbers in individual plants was done in three categories (0, 0–10, > 10 buds per shoot; Klimešová & Klimeš 2006). These categories were respectively represented by values of 0, 5, 15 buds per shoot. The value for the taxon was calculated as the mean of these values across the individuals of this taxon and particular soil depth as reported in the CLO-PLA 3.4 database (Klimešová et al. 2017). The size of the belowground bud bank was determined as the sum of bud numbers per shoot summed over the soil profile. The depth of the belowground bud bank was determined as the average depth of the buds in the soil. In addition to stem-derived buds, around 10% of taxa in the Czech flora possess the ability to form adventitious buds on the root or hypocotyl (here collectively called root buds). As root buds cannot be counted (they are formed freely along the root), 15 buds were arbitrarily added per each 10 cm of depth for categories that include root buds. All the bud-bank characteristics are given for stem-derived buds only (root buds excluded) and all the buds (root buds included):

- Number of buds per shoot at the soil surface (root buds excluded)
- Number of buds per shoot at a depth of 0–10 cm (root buds excluded)
- Number of buds per shoot at a depth greater than 10 cm (root buds excluded)
- Size of the belowground bud bank (root buds excluded)

- Depth of the belowground bud bank (root buds excluded)
- Number of buds per shoot at the soil surface (root buds included)
- Number of buds per shoot at a depth of 0–10 cm (root buds included)
- Number of buds per shoot at a depth greater than 10 cm (root buds included)
- Size of the belowground bud bank (root buds included)
- Depth of the belowground bud bank (root buds included)

Data source and citation: Klimešová & Klimeš (2006), Klimešová et al. (2017).

6. Trophic mode

6.1 Parasitism and mycoheterotrophy (Fig. 23A, B)

Plant parasitism is based on either of two mechanisms. The first group of parasitic plants involves those parasitizing directly on another plant. These plants are called haustorial parasites. They take resources from the host's vascular bundles using a specialized organ, the haustorium. The second group comprises mycoheterotrophic plants, which parasitize fungi via mycorrhizal interaction and gain organic carbon from them.

Plants in both groups display variable dependence on their host organism. The haustorial parasites include two distinct functional groups: green hemiparasites and holoparasites. Green hemiparasites are partial parasites that retain photosynthetic ability but obtain all mineral resources and a part of the organic carbon from the host. Holoparasites are non-green full parasites unable to photosynthesize. Location of the haustorial attachment to the host (root or stem) is another essential functional trait. The distinction between partial and full parasitism in haustorial parasites may not be straightforward. In the Czech flora, it is nevertheless possible to distinguish between stem hemi- and holoparasites, which are difficult to separate on the global scale (Těšitel 2016). Consequently, we use a traditional classification here and classify as holoparasites those plants that are in adulthood mostly without chlorophyll, even though some of them might have some chlorophyll and perform residual photosynthesis (e.g. *Cuscuta*).

In mycoheterotrophic plants, there is a continuum from initial mycoheterotrophs through partial mycoheterotrophs to full mycoheterotrophs. In the initial mycoheterotrophs, only initial stages, i.e. gametophytes or seedlings, are dependent on the fungus, whereas adult plants are autotrophic, while still depending on mycorrhizal symbiosis as a source of water and mineral nutrients. In the partial mycoheterotrophs, photosynthesizing adults obtain from their mycorrhizal fungi not only water and mineral nutrients but also different amounts of organic carbon. The full mycoheterotrophs lost their chlorophyll and are thus fully parasitic. In some partial mycoheterotrophs (e.g. the genus *Cephalanthera*), chlorotic individuals can be found, which lack chlorophyll and fully depend on their hosts.

Classification of haustorial parasites follows Těšitel (2016) with a further distinction of stem hemi- and holoparasites, and identification of mycoheterotrophs follows Merckx (2012).

Categories:

- autotrophic
- root hemiparasite
- stem hemiparasite
- root holoparasite
- stem holoparasite
- partial or initial mycoheterotroph
- full mycoheterotroph

Citation: Těšitel J., Těšitelová T., Blažek P. & Lepš J. (2016) Parasitism and mycoheterotrophy. – www.pladias.cz.

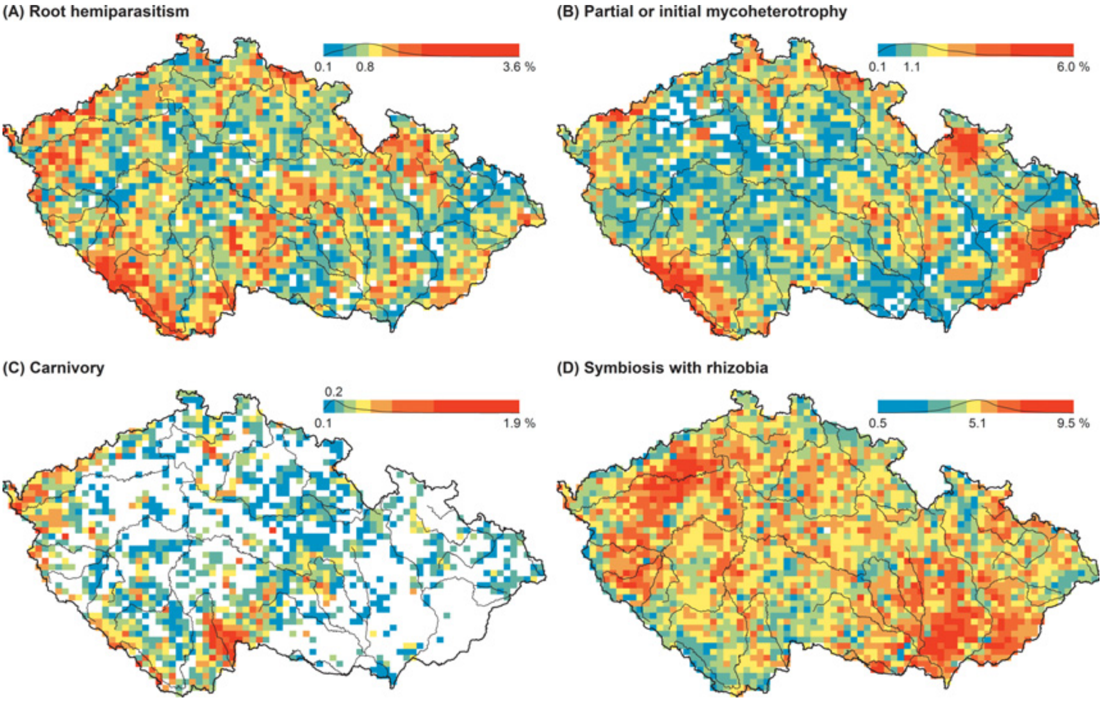


Fig. 23. – Proportion of species with alternative trophic strategies in the Czech flora. Root-hemiparasitic species are more common at middle and higher elevations (A), partially or initially mycoheterotrophic species in the highest mountains of the Bohemian Massif and in the flysch Carpathians (B), while the other categories of parasitism and mycoheterotrophy are represented by very few species. Carnivorous species are most common in areas with mires, both on flat mountain plateaus in the western Bohemian Massif and in pond basins (C). Species forming a symbiosis with rhizobia are concentrated in dry lowland areas outside river floodplains (D); this pattern is identical with the pattern of proportional representation of *Fabaceae* species.

6.2 Carnivory (Fig. 23C)

Carnivorous plants attract, trap and kill their prey, animals (mainly insects and small crustaceans) and protozoans, and subsequently absorb the nutrients from their dead bodies.

Categories:

- carnivorous
- non-carnivorous

Data source and citation: Hejný et al. (1988 onwards).

6.3 Symbiotic nitrogen fixation (Fig. 23D)

Plants are classified into those without symbiotic nitrogen fixers and those that form a symbiosis with nitrogen-fixing bacteria. The latter are further divided into those forming symbiosis with rhizobia (e.g. *Allorhizobium*, *Bradyrhizobium*, *Mesorhizobium*, *Rhizobium* and *Sinorhizobium*) and those forming the symbiosis with the genus *Frankia*, the latter called actinorhizal plants (Bond 1983, Pawlowski & Sprent 2007, Sprent 2008, Benson 2016).

Categories:

- symbiosis with rhizobia
- symbiosis with *Frankia*
- no nitrogen-fixing symbionts

Citation: Blažek P. & Lepš J. (2016) Symbiotic nitrogen fixation. – www.pladias.cz.

7. Karyology

7.1 Chromosome number (2n)

Chromosome number is the somatic number of chromosomes in the zygotic stage, i.e. without possible endopolyploidy of somatic tissues. If different chromosome numbers are known for a taxon, the database contains primarily the number reported from the Czech Republic or the number that is the most common in this country or can be expected to be the most common based on the data from neighbouring countries. Other existing and less common chromosome numbers are reported in brackets. The survey does not take into account odd chromosome numbers of individual, aneuploid, euploid, haploid or autopolyploid plants, which may rarely originate in natural or experimental populations. It also disregards the numbers reported in early studies or from geographically distant areas for which the taxonomic identity with Czech plants is unclear.

The data compilation is based mainly on the Flora of the Czech Republic (vols 1–8; Hejný et al. 1988 onwards) and the Chromosome Count Database (Rice et al. 2015; http://ccdb.tau.ac.il). If only information about ploidy level is available from flow cytometry measurements, but no chromosome number is known, the number typical of the given ploidy in closely related taxa is indicated.

Citation: Šmarda P. (2018) Chromosome number (2n). – www.pladias.cz.

7.2 Ploidy level (x) (Fig. 24A, B)

Ploidy level is the number of somatic chromosomal sets in the zygotic stage, i.e. without the possible endopolyploidy of somatic tissues. Ploidy level determines the minimum copy number of most genes, influences minimal cell size and other morphological and ecological properties of the taxon (Stebbins 1950, Levin 2002, Tate et al. 2005). The data presented here are based on the traits Chromosome number and 2C genome size, and to a lesser extent also on a literature search of flow cytometry studies related to the area of the Czech Republic. The reported values are especially those reported from the Czech Republic or those ploidy levels that are most frequent in this country or at least are assumed to be the most frequent based on the data from neighbouring countries. The other existing (minor) ploidy levels (cytotypes) that are documented from the Czech Republic or that may be expected to occur here based on the records from neighbouring countries are indicated in brackets. The survey does not take into account the observations of individual haploid or autopolyploid plants which may rarely originate in natural or experimental populations. It also disregards the ploidy levels derived from the numbers of chromosomes reported in early studies or from geographically distant areas, where taxonomic identity with Czech plants is uncertain.

The size of one chromosomal set (x) or the “base chromosome number” for calculating the ploidy level is derived here from the lowest chromosome number known in the given genus or the group of closely related genera (e.g. Raven 1975). This minimum

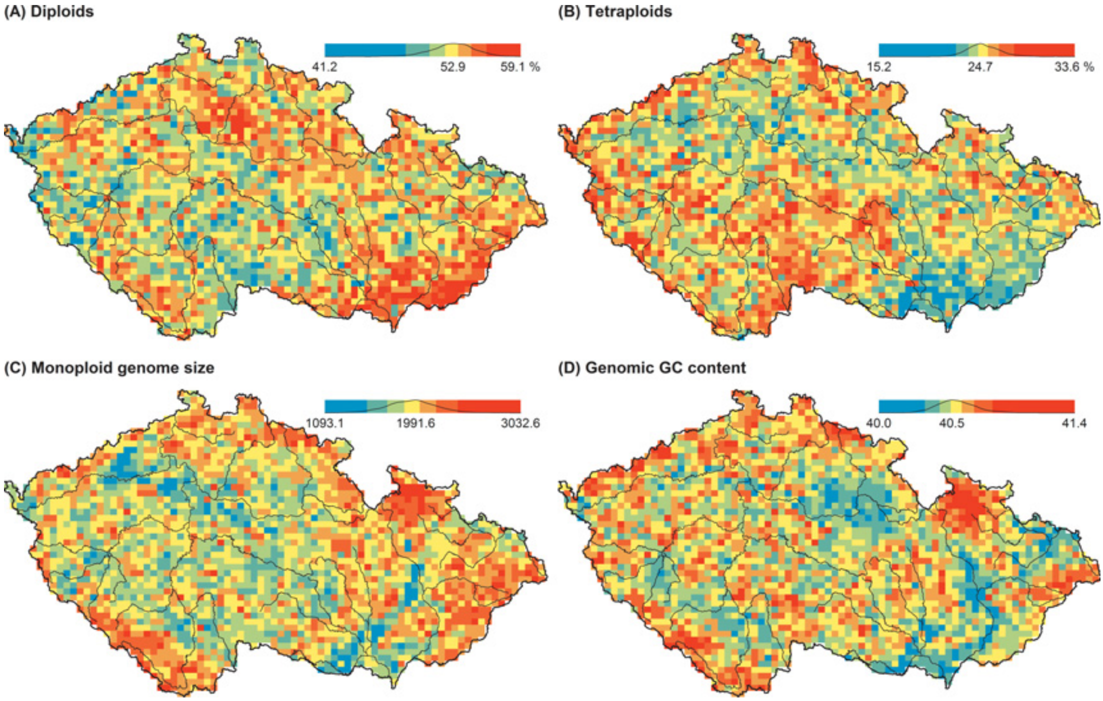


Fig. 24. – Patterns of genomic characteristics in the Czech flora, including the proportion of diploid and tetraploid species (A, B), mean 1Cx monoploid genome size in DNA base pairs (C) and mean percentage of genomic guanine and cytosine (GC) bases in nuclear DNA (D). Diploids are frequent at low elevations and in the flysch Carpathians, while tetraploids have a complementary distribution pattern. Both the monoploid genome size and genomic CG content attain larger values in the mountains and partly in submontane areas, and small in wetland areas, especially in the floodplains of lowland rivers. This pattern partly reflects the fact that ferns and gymnosperms, i.e. taxa with on average larger genomes than angiosperms, account for a larger proportion of the total flora in the mountains. The geographic pattern of the somatic (2C) genome size is very similar to that of the 1Cx genome size (not shown).

chromosome number is generally considered to correspond to diploids (i.e. two chromosomal sets). A taxon is considered as polyploid whenever its chromosome number and genome size are jointly ± doubled (or otherwise multiplied) compared to the diploid taxa of related genera. It may therefore sometimes happen that no diploid taxa are known in some genera. The absence of diploids in a given genus may result from (i) the lack of karyological data, (ii) the extinction of the diploid relative(s), or (iii) a polyploidy event that predated the origin of the whole genus, with the current genomes still showing little signs of backward "diploidization". The joint usage of the chromosome number and genome size enables estimation of ploidy levels also for the taxa with holocentric chromosomes (*Cyperaceae*, *Drosera*, *Juncaceae*, *Cuscuta* sect. *Cuscuta* and *C.* sect. *Gramica*). In these taxa, the chromosome number does not need to be positively correlated with the ploidy level due to possible chromosomal fissions and fusions (agmatoploidy and symploidy, respectively; Bureš et al. 2013). To handle the chromosomal fusions in *Luzula*, chromosome size categories as defined by Nordeskiöld (1951) were further considered to estimate the actual ploidy level. Ploidy level estimates in highly polyploid genomes of *Viola* follow Marcussen et al. (2015).

Citation: Šmarda P. (2018) Ploidy level (x). – www.pladias.cz.

7.3 2C genome size

2C genome size is the somatic nuclear DNA content in a zygotic cell measured in megabase pairs (Mbp). This measure can vary among taxa due to both polyploidy and the variability in the content of non-coding DNA (Leitch & Greilhuber 2013). Genome size influences minimum cell size, duration of the cell cycle and cell division, and nutrient requirements. Therefore, it may have a considerable influence on ecological strategies of plants (Bennett 1987, Veselý et al. 2012, Greilhuber & Leitch 2013). Most values were measured in plants collected in the Czech Republic (Šmarda et al. 2019). The data always refer to the dominant chromosome number and the dominant ploidy level of the given taxon.

Data source and citation: Šmarda et al. (2019).

7.4 1Cx monoploid genome size (Fig. 24C)

1Cx monoploid genome size is the amount of DNA contained in one set of chromosomes measured in megabase pairs (Mbp). The values were obtained for each taxon by dividing its 2C genome size by the respective ploidy level (Greilhuber et al. 2005). Differences in 1Cx values among taxa are therefore virtually free of the polyploidy effect (i.e. only due to amplification of non-coding DNA). However, the 1Cx values in polyploids are usually slightly smaller due to the increased tendency to eliminate the duplicated, redundant DNA (Leitch & Bennett 2004). Because the 1Cx values tend to be similar in related taxa, they can be used to roughly estimate the 2C genome size in related taxa for which only the ploidy level is known so far. Conversely, they can be used to estimate the ploidy levels based on the known 2C genome size. The data were taken from Šmarda et al. (2019).

Data source and citation: Šmarda et al. (2019).

7.5 Genomic GC content (Fig. 24D)

Genomic GC content is the percentage of guanine and cytosine bases in nuclear DNA. It influences the thermal stability of DNA, packing of condensed DNA within the nucleus, the energetic cost of DNA synthesis or cell sensitivity to desiccation (Šmarda & Bureš 2012, Šmarda et al. 2014). For the vast majority of taxa, these data were measured in plants collected in the Czech Republic (Šmarda et al. 2019). The data always refer to the dominant chromosome number and dominant ploidy of the given taxon. Differences up to 1% in closely related taxa or up to 2% in unrelated taxa may be considered insignificant because of possible method errors (Šmarda et al. 2012).

Data source and citation: Šmarda et al. (2019).

8. Taxon origin

8.1 Origin in the Czech Republic (Fig. 25A–C)

Taxa are classified according to whether they are native or alien to the Czech Republic. Following the definitions used in invasion ecology, native taxa are those that have evolved in the area of the Czech Republic or immigrated there without human assistance from the area where they had evolved. Alien taxa are those whose presence is a result of intentional or unintentional introduction by human activity and can be divided based on their residence time. The alien taxa are divided based on their residence time into archaeophytes and neophytes. Archaeophytes are taxa occurring in the wild that were introduced between the beginning of Neolithic agriculture and the year 1500, i.e. the beginning of intercontinental overseas trade after the discovery of the Americas. Neophytes are taxa occurring in the wild that were introduced after 1500 (see Pyšek et al. 2004 for detailed definitions). Additionally, some frequently cultivated taxa that are not known to have escaped from cultivation are listed as a separated category.

The data included in the database follow the 2nd edition of the Catalogue of alien plants of the Czech Republic (Pyšek et al. 2012 and references related to individual taxa therein) with the addition of recent records.

Categories:

- native
- archaeophyte
- neophyte
- cultivated only

Data source and citation: Pyšek et al. (2012).

8.2 Invasion status (Fig. 25D–F)

Invasion status is a classification of alien taxa into three categories reflecting their position in the invasion process. Alien taxa that only occasionally reproduce in the wild in the Czech Republic, do not form self-replacing populations, and rely on repeated introductions for their persistence are termed casual. Naturalized taxa are alien plants that reproduce in the wild and sustain populations over many life cycles without direct intervention by humans (or despite human intervention). Invasive plants are naturalized plants that produce reproductive offspring, often in large numbers, at considerable distances from parent plants and thus have the potential to spread over an extensive area (Richardson et al. 2000, 2011). This classification does not apply to native taxa, which are reported as separate categories. The data were taken from the 2nd edition of the Catalogue of alien plants of the Czech Republic (Pyšek et al. 2012 and references related to individual taxa therein).

Categories:

- casual
- naturalized
- invasive
- native

Data source and citation: Pyšek et al. (2012).

8.3 Geographic origin (Fig. 26)

This information is given for alien taxa only. These taxa are classified according to their geographic origin (native range) at the level of continents; those with a native range encompassing more than one continent are assigned to two or more categories. Origin in

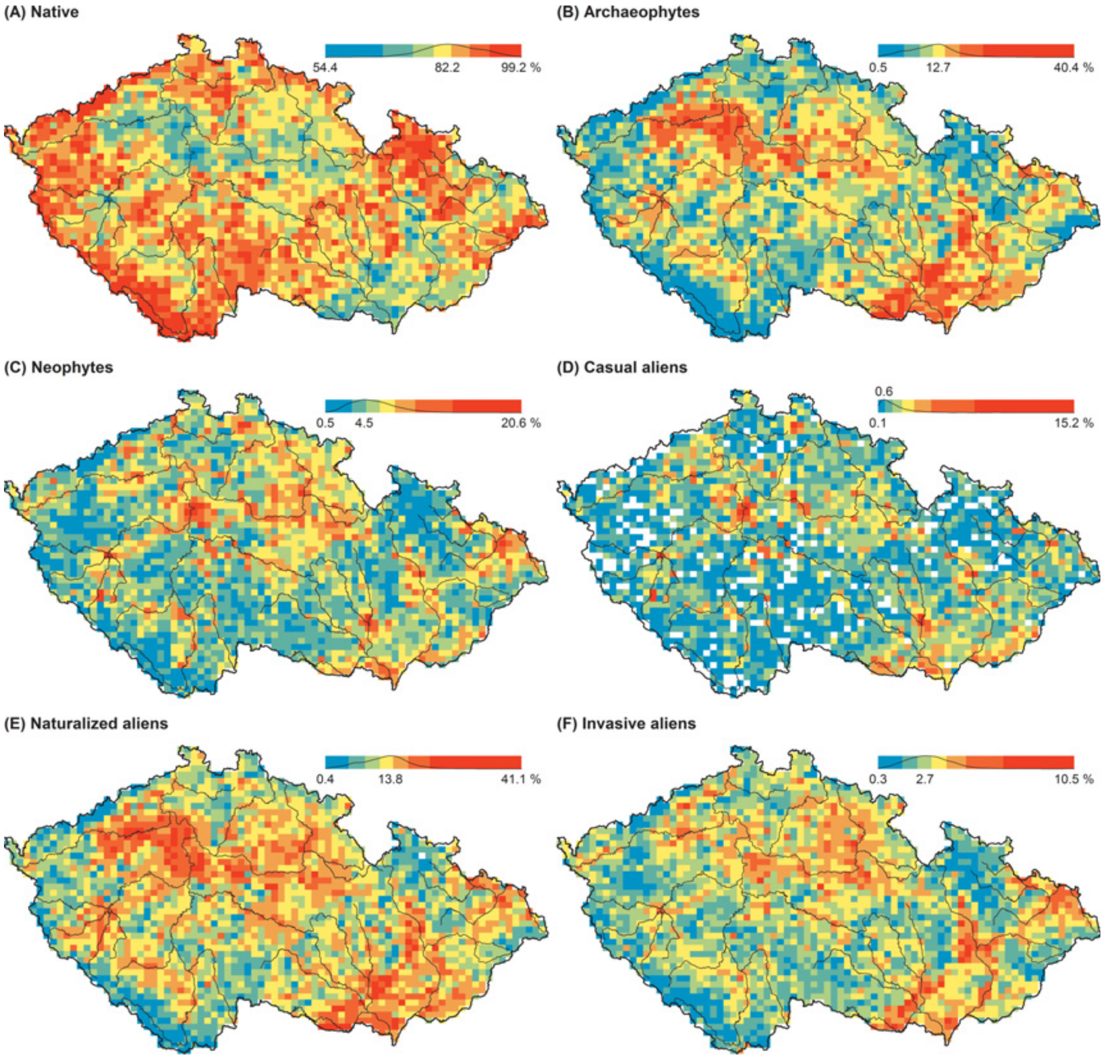


Fig. 25. – Patterns of the origin and invasive status in the Czech flora. Native species are frequent in mountain areas, while both groups of aliens are more common in the lowlands. Archaeophytes are widespread mainly in warm and dry lowland agricultural areas, whereas neophytes are more common in urban areas and along lowland rivers. Casual species are found mostly in urban areas, naturalized species are common across lowland areas, while invasive species show a distinct concentration of occurrence along lowland rivers.

Europe refers to the non-Mediterranean parts of this continent other than the Czech Republic. The Mediterranean region comprises parts of southern Europe, northern Africa and western Asia from Turkey and Israel to Afghanistan, which are characterized by the Mediterranean-type climate and corresponding evergreen vegetation. Conversely, records of origin in Africa, Asia and Europe do not relate to the Mediterranean part of these continents. Hybrids and species that originated through recent hybridization are listed as a separate category. Anecophytes are taxa for which native range is unknown or

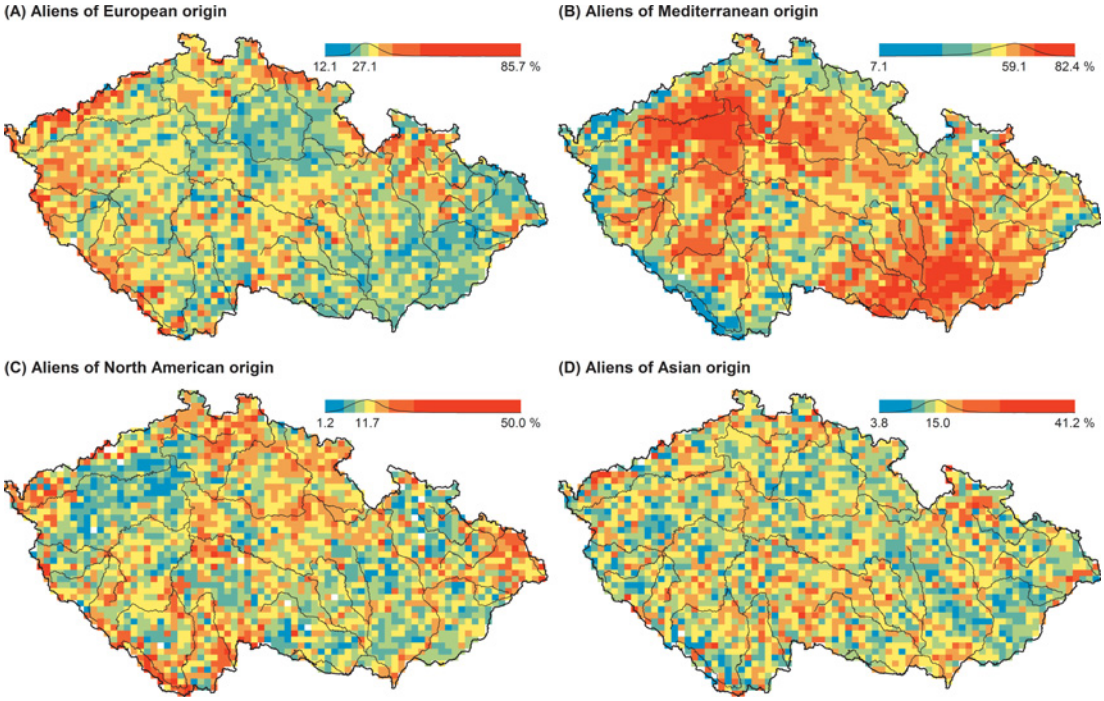


Fig. 26. – Proportion of European, Mediterranean, North American and Asian species in the Czech alien flora (native species are not considered). Species originating on other continents are rare and do not display distinct patterns. The species introduced from other parts of non-Mediterranean Europe are frequent in the mountain and submontane areas. Mediterranean species are frequent in the dry and warm lowlands. North American species tend to be more common in wetter areas, both in the precipitation-rich mountains and in the lowland pond basins or riverine landscapes. Asian species do not display any distinct pattern.

highly uncertain. The data were taken from the 2nd edition of the Catalogue of alien plants of the Czech Republic (Pyšek et al. 2012 and references related to individual taxa therein).

Categories:
- Europe
- Mediterranean
- North America
- Central America
- South America
- Asia
- Africa
- Australia
- hybrid origin
- anecophyte

Data source and citation: Pyšek et al. (2012).

8.4 Year of the first record in the wild

The year of the first reported occurrence in the wild in the Czech Republic is given for neophytes. Data were extracted from the 2nd edition of the Catalogue of alien plants of the Czech Republic (Pyšek et al. 2012); however, for many species, this information is not available.

Data source and citation: Pyšek et al. (2012).

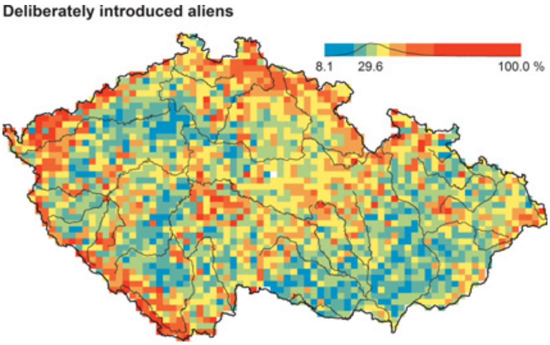


Fig. 27. – Proportion of the deliberately introduced alien species in the Czech alien flora (native species are not considered). Deliberately introduced aliens are particularly frequent in the mountain areas of the Bohemian Massif, whereas accidentally introduced aliens prevail in the lowlands. Note that the absolute number of alien species in the mountain areas is low.

8.5 Introduction pathway (Fig. 27)

This information is available for alien taxa only. Taxa were classified according to the mode of introduction, with the distinction made between an accidental or deliberate pathway (Hulme et al. 2008). The deliberate introduction refers to the direct release into the wild for landscaping purposes, as well as planting in horticulture, forestry and agriculture and subsequent escape from cultivation. The accidental introductions include import through contamination of a commodity, a stowaway on a transport vector or spread via an infrastructure corridor without which the spread would be impossible (Hulme et al. 2008). A taxon can be assigned to more than one introduction pathway. The data included in the database follow the 2nd edition of the Catalogue of alien plants of the Czech Republic (Pyšek et al. 2012 and references related to individual taxa therein).

Categories:

- accidental introduction
- deliberate introduction

Data source and citation: Pyšek et al. (2012).

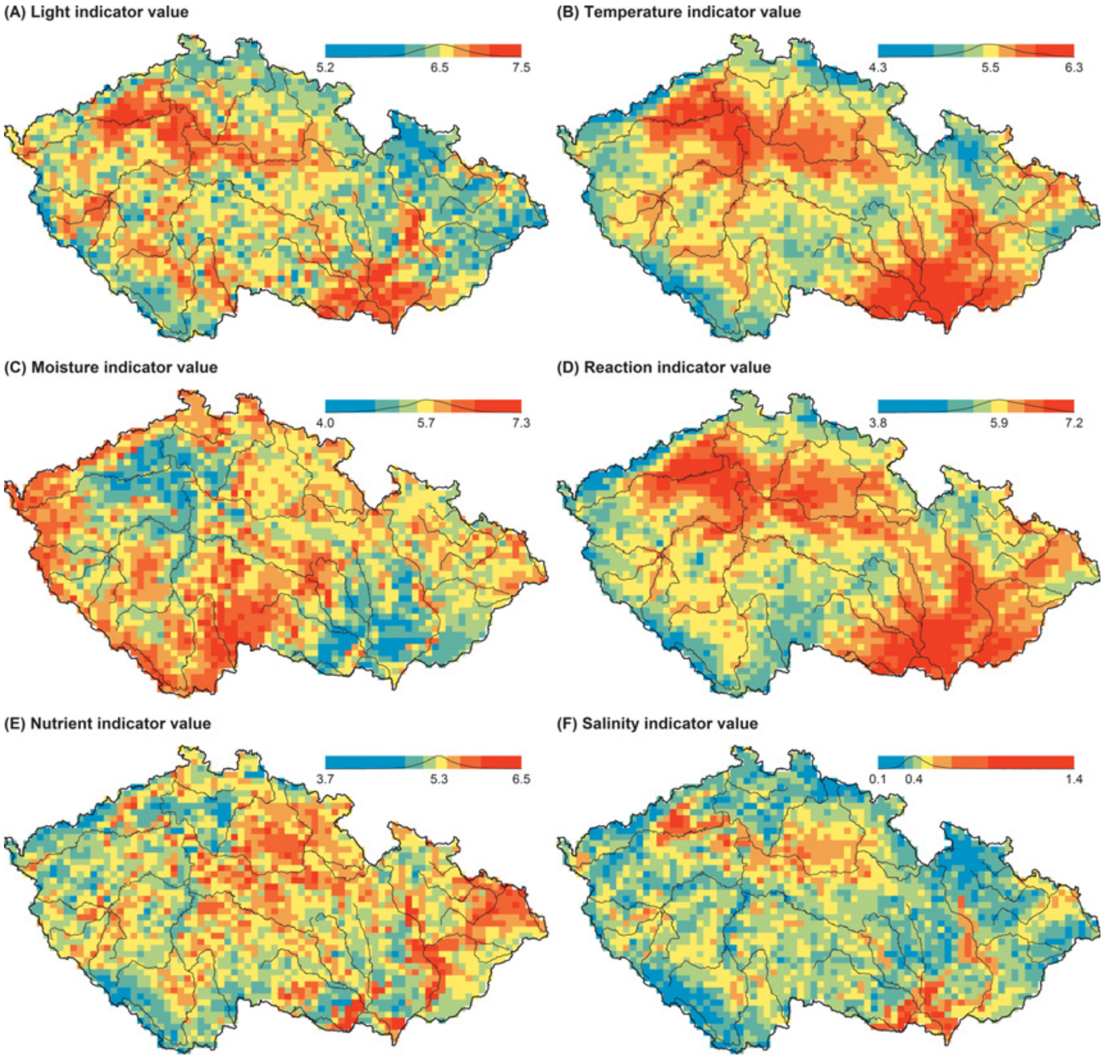
9. Ecological indicator values

9.1 Ellenberg-type indicator values (Fig. 28)

Indicator values for the main environmental factors affecting plant occurrence are expressed on ordinal scales defined by Ellenberg et al. (1991). The values for individual taxa were modified and extended for the Czech flora by Chytrý et al. (2018). The following indicator values were defined:

- Light indicator value
- Temperature indicator value
- Moisture indicator value
- Reaction indicator value
- Nutrient indicator value
- Salinity indicator value

These scales range from 1 to 9 except for moisture (1–12) and salinity (0–9). The values with “x” indicate generalists, i.e. taxa with broad ecological range for the given factor. For light, a value of 1 indicates deep-shade plants, while a value of 9 indicates the


(A) Light indicator value

(B) Temperature indicator value

(C) Moisture indicator value

(D) Reaction indicator value

(E) Nutrient indicator value

(F) Salinity indicator value

Fig. 28. – Mean Ellenberg-type indicator values for light, temperature, moisture, reaction, nutrients and salinity in the Czech flora. Light-demanding species (A) are frequent in open areas with a low proportion of forest, thermophilous (B) and basiphilous (D) species in the warm and dry lowlands, moisture-demanding species (C) in the western oceanic mountains, basins, fishpond areas and along large rivers, nutrient-demanding species (E) in the lowland areas with deeps soils on soft sediments, and halophytes and subhalophytes (F) in the dry areas of northern Bohemia and southern Moravia.

full-light plants (indicator values for trees relate to juvenile individuals in herb and shrub layers). For temperature, a value of 1 indicates plants of cold areas, occurring only in high mountain areas, while a value of 9 indicates plants of the warmest sites of southern central Europe. For moisture, the taxa with a value of 1 are strong drought indicators, while the taxa with a value of 12 are permanently or almost permanently submerged aquatic plants. The reaction value is a proxy for the pH of soil or water, especially in acidic environments.

In near-neutral or alkaline environments, it is more a proxy for calcium concentration. A reaction value of 1 is assigned to indicators of strong acidity, never occurring in slightly acidic to alkaline soil or water. In contrast, a value of 9 is assigned to base and lime indicators that always occur in calcium-rich conditions. The nutrient value is a proxy for the availability of nitrogen or phosphorus and to some extent, also a proxy for site primary productivity. A nutrient value of 1 is assigned to the taxa occurring at nutrient-poorest sites, while a value of 9 belongs to the taxa concentrated at nutrient-richest sites. The salinity value is a proxy for concentration in the environment of soluble salts, including sulphates, chlorides and carbonates of sodium, potassium, calcium and magnesium. The taxa with a value of 0 are glycophytes, i.e. non-salt-tolerant plants. In contrast, the taxa with a value of 9 are euhaline to hypersaline, occurring on soils with a very high and in dry periods extremely high salt content.

Data source and citation: Chytrý et al. (2018).

9.2 Indicator values for disturbance (Fig. 29)

Indicator values for disturbance express relationships of common taxa of the Czech flora separately to the frequency and severity of disturbance. Individual disturbance agents are not distinguished, but a wide range of factors is considered including logging, cutting, mowing, herbivory, trampling, damage by herbicides, burning, wind-throws, soil erosion, ploughing, hoeing or burrowing, wave and current action, and flooding. There are three types of indicator values for disturbance: (i) Disturbance frequency indicator values are expressed as the inverse of the disturbance return time on a logarithmic scale (in years, common logarithms). For example, a value of –2 refers to the return time of a century, a value of –1 to the return time of ten years, and a value of 0 to a disturbance occurring every year. One unit of the index corresponds to a tenfold change in disturbance frequency. (ii) Disturbance severity indicator values are expressed using an arbitrary scale from 0 (least severe disturbance) to 1 (most severe disturbance). They are based on the assessment of the proportion of above-ground biomass removed and degree of soil disturbance (proportional change in cover of the bare ground) in a single disturbance event. Indicator values for frequency and severity of disturbance are correlated, but still sufficiently independent to express separate components of the taxon's disturbance niche. (iii) Structure-based disturbance indicator values express disturbance regime based on structural parameters of vegetation plots in which the taxon occurs. These values are normalized to the 0–1 range, where higher values indicate a higher level of disturbance.

Each of these three types of indicator values is provided separately for the whole-community disturbance events and for smaller disturbance events that affect the herb layer but not the tree layer in forests. Both indicator values are identical for taxa of open habitats. The following indicator values for disturbance are provided:

- Whole-community disturbance frequency indicator value
- Herb-layer disturbance frequency indicator value
- Whole-community disturbance severity indicator value
- Herb-layer disturbance severity indicator value
- Whole-community structure-based disturbance indicator value
- Herb-layer structure-based disturbance indicator value

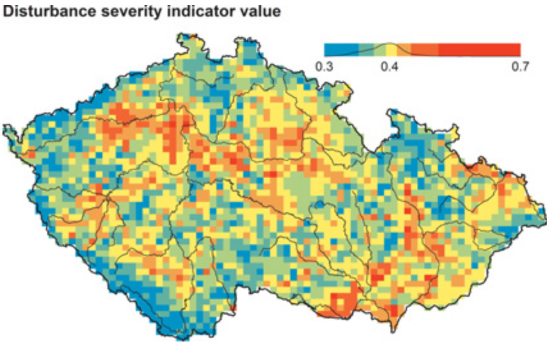


Fig. 29. – Mean whole-community disturbance frequency indicator value. The geographic patterns for the other disturbance indicator values were found to be similar (not shown). The highest frequency and severity of disturbance is indicated in agricultural areas, especially in dry lowlands.

Indicator values for disturbance were calculated by Herben et al. (2016) based on an analysis of a stratified subset of 30,115 vegetation plots from the Czech National Phytosociological Database (Chytrý & Rafajová 2003). Only taxa occurring in at least 20 plots were used. These plots were classified by an expert system into 39 phytosociological vegetation classes as defined in Vegetation of the Czech Republic (Chytrý 2007–2013). For each of these classes, the mean frequency and severity of disturbance were assessed based on field observations. The disturbance indicator value for each taxon was calculated as the average disturbance frequency or severity weighted by the frequency of occurrence of that taxon in the plots assigned to these vegetation classes. The structure-based disturbance indicator values were calculated based on the variation in plant height at maturity and variation in summed covers of all taxa recorded in the vegetation plots where the target taxon occurs.

Data source and citation: Herben et al. (2016).

10. Habitat and sociology

10.1 Occurrence in habitats

Data on taxon occurrence in habitats of the Czech Republic are based on the analysis of vegetation plots from the Czech National Phytosociological Database (Chytrý & Rafajová 2003) and its expert revision and completion based on the literature and field experience, especially for rare and taxonomically problematic taxa. The classification recognizes 88 basic habitats aggregated to 13 broader habitats that are defined by Sádlo et al. (2007: their Appendix 1):

1 Vegetation of cliffs, screes and walls
- 1A Calcareous cliffs
- 1B Siliceous cliffs and block fields
- 1C Walls
- 1D Mobile calcareous screes

2 Alpine and subalpine grasslands
- 2A Alpine grasslands on siliceous bedrock
- 2B Subalpine tall-forb and tall-grass vegetation

3 Aquatic vegetation
- 3A Macrophytic vegetation of eutrophic and mesotrophic still waters
- 3B Macrophytic vegetation of water streams
- 3C Macrophytic vegetation of oligotrophic lakes and pools

4 Wetland and riverine herbaceous vegetation
- 4A Reed-beds of eutrophic still waters
- 4B Halophilous reed and sedge beds
- 4C Eutrophic vegetation of muddy substrata
- 4D Riverine reed vegetation
- 4E Reed vegetation of brooks
- 4F Mesotrophic vegetation of muddy substrata
- 4G Tall-sedge beds
- 4H Vegetation of low annual hygrophilous herbs
- 4I Vegetation of nitrophilous annual hygrophilous herbs
- 4J River gravel banks
- 4K *Petasites* fringes of montane brooks
- 4L Nitrophilous herbaceous fringes of lowland rivers

5 Vegetation of springs and mires
- 5A Hard-water springs with tufa formation
- 5B Lowland to montane soft-water springs
- 5C Alpine and subalpine soft-water springs
- 5D Calcareous fens
- 5E Acidic moss-rich fens and peatland meadows
- 5F Transitional mires
- 5G Raised bogs
- 5H Wet peat soils and bog hollows

6 Meadows and mesic pastures
- 6A Mesic *Arrhenatherum* meadows
- 6B Montane mesic meadows
- 6C Pastures and park grasslands
- 6D Alluvial meadows of lowland rivers
- 6E Wet *Cirsium* meadows
- 6F Intermittently wet *Molinia* meadows
- 6G Vegetation of wet disturbed soils

7 Acidophilous grasslands
- 7A Subalpine and montane acidophilous grasslands
- 7B Submontane *Nardus* grasslands

8 Dry grasslands
- 8A Hercynian dry grasslands on rock outcrops
- 8B Submediterranean dry grasslands on rock outcrops
- 8C Narrow-leaved sub-continental steppes
- 8D Broad-leaved dry grasslands
- 8E Acidophilous dry grasslands
- 8F Thermophilous forest fringe vegetation

9 Sand grasslands and rockoutcrop vegetation
- 9B Open vegetation of acidic sands vegetation
- 9C Festuca grasslands on acidic sands
- 9D Pannonian sand steppes
- 9E Acidophilous vegetation of spring therophytes and succulents
- 9F Basiphilous vegetation of spring therophytes and succulents

10 Saline vegetation
- 10G Continental vegetation of annual halophilous grasses
- 10H Inland vegetation of succulent halophytes
- 10I Inland saline meadows
- 10J Saline steppes

11 Heathlands and scrub
- 11A Dry lowland to subalpine heathlands
- 11D Subalpine acidophilous *Pinus mugo* scrub
- 11H Subalpine deciduous scrub
- 11I Willow carrs
- 11J Willow galleries of loamy and sandy river banks
- 11L Tall mesic and xeric shrub
- 11N Low xeric scrub
- 11R Scrub and pioneer woodland of forests clearings

12 Forests
- 12A Alder carrs
- 12B Alluvial forests
- 12C Oak-hornbeam forests
- 12D Ravine forests
- 12E Herb-rich beech forests
- 12F Limestone beech forests
- 12G Acidophilous beech forests
- 12H Peri-Alpidic basiphilous thermophilous oak forests
- 12I Subcontinental thermophilous oak forests
- 12J Acidophilous thermophilous oak forests
- 12K Acidophilous oak forests
- 12L Boreo-continental pine forests
- 12O Peri-Alpidic pine forests
- 12P Peatland pine forests
- 12Q Peatland birch forests
- 12R Acidophilous spruce forests
- 12S Basiphilous spruce forests
- 12T *Robinia pseudoacacia* plantations
- 12U Plantations of broad-leaved non-native trees
- 12V *Picea* plantations
- 12W *Pinus* and *Larix* plantations

13 Anthropogenic vegetation
- 13A Annual vegetation of ruderal habitats
- 13B Annual vegetation of arable land
- 13C Annual vegetation of trampled habitats
- 13D Perennial thermophilous ruderal vegetation
- 13E Perennial nitrophilous herbaceous of mesic sites
- 13F Herbaceous vegetation of forests clearings and *Rubus* scrub

Taxon occurrence in each habitat is assessed, based on expert judgement, on a four-degree scale: 1 – occurrence = the taxon can grow in the habitat, but it tends to be rare there, and the habitat is not its ecological optimum; 2 – optimum = the habitat or a part of it is the ecological optimum for this taxon; 3 – dominant = the taxon can be assigned to the previous category, and at the same time it frequently attains a cover above 25% in areas of 10–100 m^2 or 100–1000 m^2 in herbaceous or woody vegetation, respectively; 4 – constant dominant = same as for the previous category but the taxon also determines the general appearance of the habitat (e.g. *Calluna vulgaris* in heathlands), occurring in ≥ 40% of the localities of the habitat.

Data source and citation: Sádlo et al. (2007).

10.2 Affinity to the forest environment

The affinity of taxa to the forest environment is assessed using the categories of the German national list of forest taxa (Schmidt et al. 2011). Each taxon is assessed separately for the region of Thermophyticum (lowlands with thermophilous and drought-adapted flora) and merged regions of Mesophyticum and Oreophyticum (mid-elevations and mountains with mesophilous and mountain flora; Skalický 1988). The compilation was based on the list of regional species pools of Czech habitats (Sádlo et al. 2007), expert knowledge and various literature sources. It has been integrated into the European forest plant species list (Heinken et al. 2019).

Categories:

- 0 – taxon does not spontaneously occur in Czech forests
- 1.1 – taxon occurring mainly in closed forests
- 1.2 – taxon occurring mainly along forest edges and in forest openings, including forest roads and paths, windthrow sites, burnt sites and forest clearings
- 2.1 – taxon occurring both in forest and open vegetation
- 2.2 – taxon occurring partly in forest but mainly in open vegetation

Citation: Dřevojan P., Chytrý M., Sádlo J. & Pyšek P. (2016) Affinity to the forest environment. – www.pladias.cz.

10.3 Diagnostic taxon

Diagnostic taxa are characterized by a concentration of their occurrence in the stands belonging to the target vegetation unit while being rare or absent in other vegetation units. They were determined based on the calculation of fidelity of each taxon to a group of vegetation plots representing the target vegetation unit in a geographically and ecologically stratified selection of plots of all vegetation types from the Czech National Phytosociological Database (Chytrý & Rafajová 2003). Fidelity was measured using the phi coefficient of association after the sizes of plot groups were virtually standardized to 1% of the total size of the data set following Tichý & Chytrý (2006). The taxa with a value of phi higher than 0.25 and significant concentration in the vegetation unit according to Fisher's exact test ($P < 0.001$) were considered as diagnostic taxa. The data on the diagnostic status of taxa for individual phytosociological classes, alliances or associations were taken from the monograph Vegetation of the Czech Republic (Chytrý 2007–2013). The numbers of vegetation plots used for the calculations are given in respective volumes of this monograph.

Data source and citation: Chytrý (2007–2013).

10.4 Constant taxon

Constant taxa are characterized by frequent occurrences in stands belonging to the target vegetation unit, but unlike diagnostic taxa, they can also commonly occur in other vegetation units. They were determined based on the calculation of percentage frequency (constancy) of each taxon in a group of vegetation plots representing the target vegetation unit in a geographically and ecologically stratified selection of plots of all vegetation types extracted from the Czech National Phytosociological Database (Chytrý & Rafajová 2003). The taxa with an occurrence frequency in the vegetation unit higher than 40% were considered as constant taxa. The data on the constant status of taxa for individual phytosociological classes, alliances or associations were taken from the monograph Vegetation of the Czech Republic (Chytrý 2007–2013). The numbers of vegetation plots used for the calculations are given in respective volumes of this monograph.

Data source and citation: Chytrý (2007–2013).

10.5 Dominant taxon

Dominant taxa are defined here as those occurring with a cover higher than 25% in more than 5% of vegetation plots belonging to the target association. They do not need to be the taxa with the highest cover in particular stands. These taxa were determined based on the group of vegetation plots representing the target vegetation unit in a geographically and ecologically stratified selection of plots of all vegetation types extracted from the Czech National Phytosociological Database (Chytrý & Rafajová 2003). The data on the dominant status of taxa for individual associations were taken from the monograph Vegetation of the Czech Republic (Chytrý 2007–2013). The numbers of vegetation plots used for the calculations are given in respective volumes of this monograph.

Data source and citation: Chytrý (2007–2013).

10.6 Ecological specialization indices (Fig. 30)

The degree of ecological specialization for individual taxa is estimated based on their co-occurrence with other taxa. The underlying assumption is that variation in the composition of co-occurring taxa indicates the range of habitat conditions suitable to this taxon (Fridley et al. 2007). A taxon repeatedly co-occurring with a similar set of taxa across different sites is more likely to be a specialist with a preference for a specific habitat. Conversely, a taxon co-occurring with various taxa across different sites is more likely to be a generalist tolerating a wide range of habitats. The ecological specialization index (ESI) of a taxon is inversely related to beta diversity calculated for the set of sites at which this taxon occurs.

The ecological specialization indices were calculated based on the vegetation plots from the Czech National Phytosociological Database (Chytrý & Rafajová 2003). Three vegetation datasets were selected from a geographically stratified subset of plots from the database: (i) a dataset including all the vegetation types (30,115 plots, 1935 taxa), (ii) a dataset including only non-forest vegetation (24,712 plots, 1875 taxa) and (iii) a dataset including only forest vegetation (5403 plots, 1264 taxa). Whittaker's multiplicative measure of beta diversity (Whittaker 1960) rarefied to 10 vegetation plots randomly selected

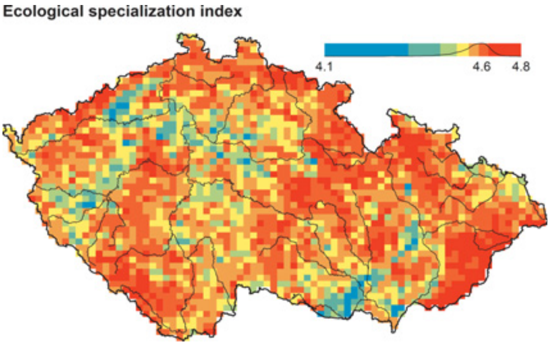


Fig. 30. – Weighted mean ecological specialization index for all vegetation types. Ecologically specialized species are frequent in the mountains and hilly landscapes, while generalist species are most common in the lowland agricultural areas.

from a subset of plots containing the target taxon (β_{10}) was computed for each taxon (Zelený 2009). Outlier plots with very different species composition were removed from the subset before rarefaction, following a recommendation of Botta-Dukát (2012). Because the calculated value of beta diversity decreases with increasing value of taxon specialization, the value of ESI was calculated as ESI = 10 – β_{10}. This value theoretically ranges from 0 to 9, with high values indicating specialists and low values indicating generalists.

Each ESI value is accompanied by a taxon weight, which represents the total number of plots in which this taxon occurs within a particular dataset. The weights can be used as a measure of the reliability of the calculated ESI value for given taxon, which increases with increasing frequency of the taxon in the dataset. Minimum weight is 10, corresponding to the minimum number of occurrences for which ESI was calculated. The theoretical maximum weight is the number of plots in the given dataset.

The following specialization indices and corresponding taxon weights are available (with ranges of values in brackets):

- Ecological specialization index for all vegetation types (2.69–7.95)
- Ecological specialization index for non-forest vegetation (2.63–7.49)
- Ecological specialization index for forest vegetation (2.61–7.95)
- Taxon weights of ESI for all vegetation types (10–5020; theoretical maximum 30,115)
- Taxon weights of ESI for non-forest vegetation: (10–4542; theoretical maximum 24,712)
- Taxon weights of ESI for forest vegetation: (10–2032; theoretical maximum 5403)

Data source and citation: Zelený & Chytrý (2019).

10.7 Colonization ability

The indices characterizing plant colonization ability were published by Prach et al. (2017). The authors derived the index values for individual taxa from a database of 21 succession series (both primary and secondary succession) starting on the bare substrate. This database (Database of Successional Series, DaSS; Prach et al. 2014) contains 1013 taxa of vascular plants recorded in 2817 vegetation plots from the Czech Republic sampled in various habitats and successional stages of different age from 1 to 150 years. The following indices are defined:

- Index of colonization success (ICS) expresses taxon frequency in the Database of Successional Series. It was calculated as: ICS* = log ((SF + EGSSF)/2) + 1, where SF is the total taxon frequency in the DaSS database, and EGSSF is the taxon frequency in a geographically stratified selection from DaSS. Values of ICS* were subsequently transformed to the range from 1 (absence) to 9 (high frequency of the taxon across successional stages).

- Index of colonization potential (ICP) accounts for the fact that taxon occurrence in successional series is influenced not only by taxon traits but also by the taxon occurrence frequency in the landscape. Therefore, the frequency in successional series was corrected by the frequency of the same taxon within a geographically stratified subset of the Czech National Phytosociological Database (CNPD; 30,115 vegetation plots and 1935 taxa; Chytrý & Rafajová 2003). The index was calculated as: ICP = 0.5 + arctg (relEGSSF/relCNPD) / 10, where relEGSSF is taxon frequency in a geographically stratified plot selection from DaSS and relCNPD is taxon frequency in a geographically stratified plot selection from CNPD. The index ranges from 1 (low) to 9 (high colonization ability). Values below five indicate underrepresentation of the taxon occurrence in DaSS with respect to CNPD, while values above five indicate overrepresentation in DaSS.
- Optimum successional age is the median of the time in years from the disturbance when the taxon occurs during succession. It ranges from 1 to 50 years. When the calculated median was higher, the value was arbitrarily set to 75 years due to the low number of old successional stages.

Data source and citation: Prach et al. (2017).

11. Distribution and frequency

11.1 Floristic zone (Fig. 31)

The floristic zones of the Earth in which the taxon occurs are defined according to Meusel et al. (1965, 1978) and Meusel & Jäger (1992). Data were taken from the BiolFlor database (Kühn & Klotz 2002).

Categories:

- arctic – zone of tundra north of the arctic treeline
- boreal – zone of northern coniferous forests (taiga)
- northern temperate – northern zone of summer-green deciduous forests
- southern temperate – southern zone of summer-green deciduous forests
- submeridional – zone of summer-green dry forests and steppes
- meridional – zone of evergreen broad-leaved and coniferous forests, steppes and deserts
- subtropical – winter-dry zone with savannas and dry forests
- tropical – humid zone with evergreen broad-leaved forests
- austral or antarctic – floristic zones of the southern hemisphere corresponding to the temperate to arctic zones of the northern hemisphere

Data source and citation: Kühn & Klotz (2002).

11.2 Floristic region

The floristic region is reported as the continent or its part in which the taxon occurs according to the taxon range maps (Meusel et al. 1965, 1978, Meusel & Jäger 1992). The categories are not discrete, and some of the regions can be included within broader regions (e.g. Western Siberia – Siberia – Asia). From a set of overlapping categories, the one that best matches the taxon geographic range or its part is reported. Data were taken from the BiolFlor database (Kühn & Klotz 2002).

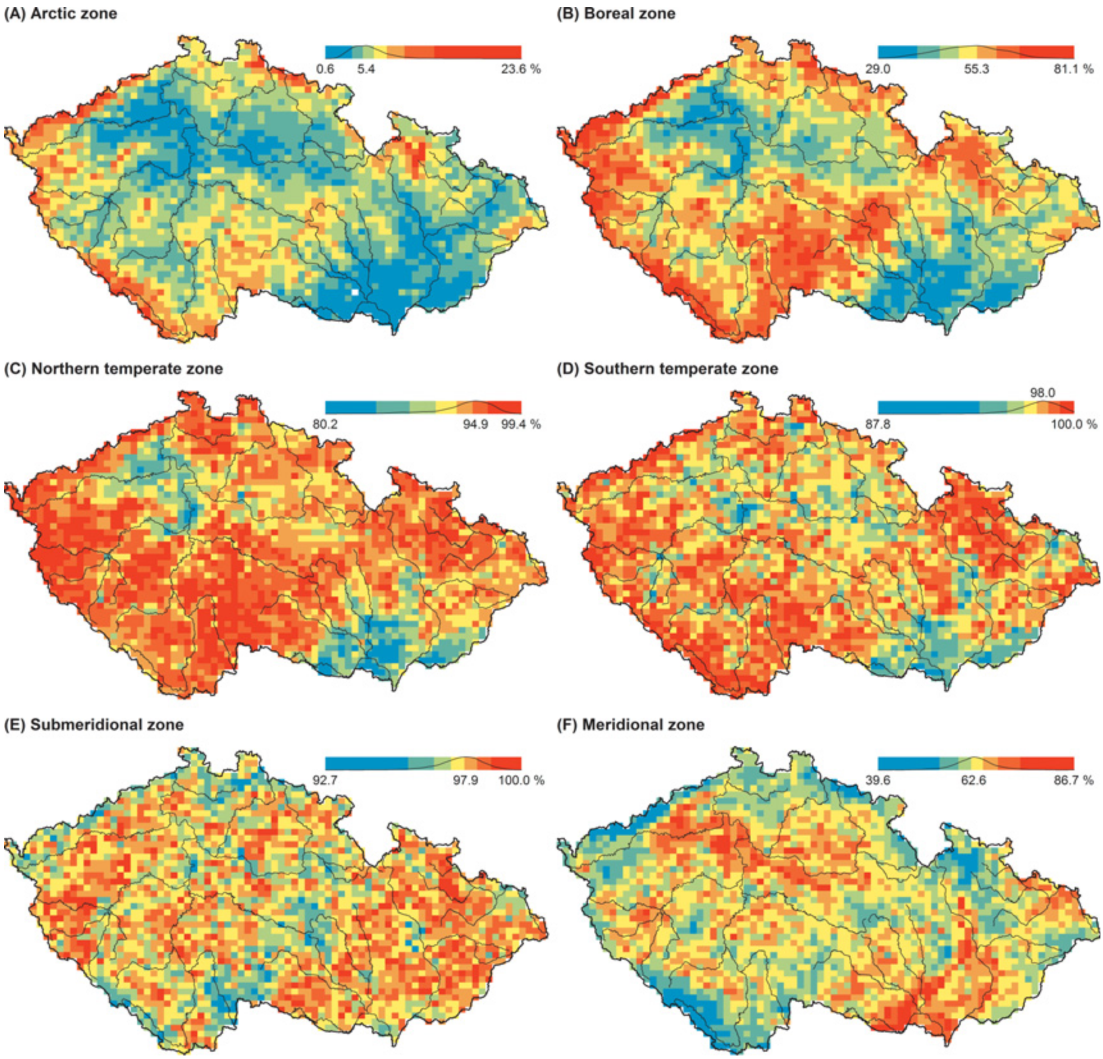


Fig. 31. – Proportion of species from different floristic zones in the Czech flora. Species from more northern zones tend to be concentrated at higher elevations, and vice versa.

Categories:

- Europe
- Europe-Western Asia
- Western Europe
- Eastern Europe
- Alps
- Carpathians
- Caucasus
- Asia
- Western Asia
- Asia Minor
- Near East
- Middle Asia
- Central Asia
- Siberia
- Western Siberia
- Eastern Asia
- Africa
- Eastern Africa
- Americas
- North America
- Eastern America
- Western America
- Greenland
- Australia, New Zealand
- circumpolar

Data source and citation: Kühn & Klotz (2002).

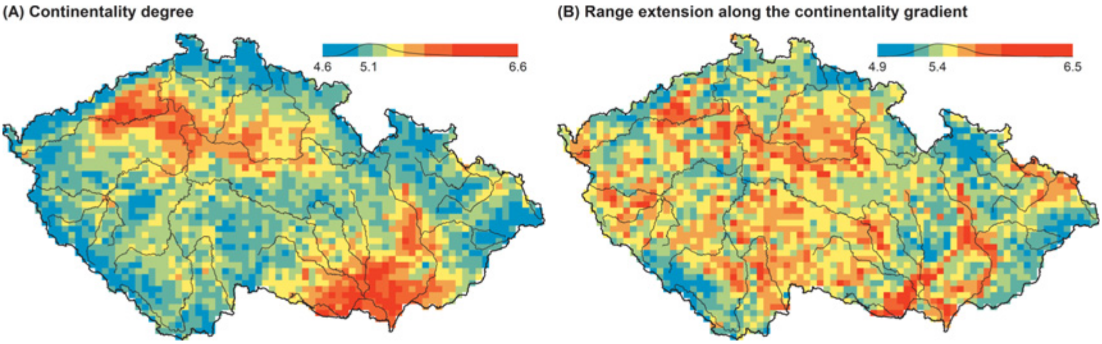


Fig. 32. – Mean continentality degree and mean range extension along the continentality gradient (number of adjacent regions) of species of the Czech flora. The highest mean degree of continentality is found in dry and warm forest-steppe regions of northern and central Bohemia and southern Moravia. The highest range extension along the continentality gradient is encountered in the flora along lowland rivers.

11.3 Continentality degree (Fig. 32A)

Continentality degree is derived from the position of taxon distribution range on the gradient from oceanic Western Europe to continental Middle Asia. The concept and data were taken from Berg et al. (2017), who revised and corrected a previous system of indicator values for continentality developed by Ellenberg et al. (1991). Higher values on the ordinal scale from 1 to 9 indicate taxa distributed in more continental areas. The taxa that extend over more than four regions assigned to different continentality classes as defined by Jäger (1968) are considered to be indifferent unless their lower continentality border is located in the regions assigned to continentality class 2 or higher.

Data source and citation: Berg et al. (2017).

11.4 Distribution range extension along the continentality gradient (Fig. 32B)

Extension of the taxon distribution range along the gradient of continentality from oceanic Western Europe to continental Middle Asia is expressed using the continentality classes defined for the Holarctic floristic kingdom by Jäger (1968). The value, ranging from 1 to 10, is the number of adjacent regions assigned to different continentality classes overlapping with the taxon range. The data were taken from Berg et al. (2017).

Data source and citation: Berg et al. (2017).

11.5 Elevational belt in the Czech Republic

The lowest and the highest elevational vegetation belt in which the taxon commonly occurs in the Czech Republic. For some taxa, also extremes are shown, i.e. elevational belts in which the taxon rarely occurs outside its main elevational range. The submontane belt comprises merged supracolline and submontane belts, and the montane belt comprises merged montane and supramontane belts according to the classification of elevational vegetation belts used in the Flora of the Czech Republic (Skalický 1988). The data were taken from the Key to the Flora of the Czech Republic (Kaplan et al. 2019a)

Categories:

- lowlands
- colline belt
- submontane belt
- montane belt
- subalpine belt

Data source and citation: Kaplan et al. (2019a).

11.6 Occurrence frequency in the basic grid mapping cells and quadrants of the basic grid mapping cells

The number of basic grid mapping cells (Central European Basic Area, CEBA) and the number of quadrants of the Central European flora mapping in that the taxon has been recorded within the territory of the Czech Republic are generated dynamically from the current occurrence records in the species distribution module of the Pladias Database. The basic grid cells measure 10 minutes in the west–east direction and 6 minutes in the south–north direction, which corresponds to approximately 12.0 × 11.1 km (133.2 km^2) on the 50th parallel. The Czech Republic comprises 679 basic cells, including incomplete cells on the state borders. The quadrants are the basic grid cells divided into four. They measure 5 minutes in the west–east direction and 3 minutes in the south–north direction, which corresponds to approximately 6.0 × 5.55 km (33.3 km^2) on the 50th parallel. Revised occurrence records marked as erroneous or uncertain are not counted.

Citation: Pladias. Database of the Czech flora and vegetation. – www.pladias.cz.

11.7 Commonness in vegetation plots from the Czech Republic

Measures of commonness in vegetation plots indicate taxon frequency in individual vegetation stands and the cover it attains. All these measures were quantified based on a set of vegetation plots representing all vegetation types of the Czech Republic, extracted from the Czech National Phytosociological Database (Chytrý & Rafajová 2003) in March 2013. These plots were classified to phytosociological associations using the expert system developed in the project Vegetation of the Czech Republic (Chytrý 2007–2013). The plots not assigned to any association were deleted, and a subset of plots of each association was selected based on a geographic stratification that reduced the unbalanced numbers of plots from different regions. The following measures of commonness were computed from the resulting set of 30,115 vegetation plots classified to 496 associations:

- Occurrence frequency in vegetation plots – percentage occurrence frequency calculated from all plots
- Occurrence frequency in vegetation plots with a cover above 5% – percentage frequency of occurrence with a cover above 5% calculated from all taxon occurrences (plots in which the taxon was absent were not considered)
- Occurrence frequency in vegetation plots with a cover above 25% – percentage frequency of occurrence with a cover above 25% calculated from all taxon occurrences (plots in which the taxon was absent were not considered)
- Occurrence frequency in vegetation plots with a cover above 50% – percentage frequency of occurrence with a cover above 50% calculated from all taxon occurrences (plots in which the taxon was absent were not considered)
- Mean percentage cover in vegetation plots (plots in which the taxon was absent were not considered)
- Maximum percentage cover in vegetation plots

Citation: Chytrý M. (2016) Commonness in vegetation plots. – www.pladias.cz.

11.8 Number of habitats with taxon occurrence in the Czech Republic

The number of habitat types (habitats) in which the taxon occurs was counted based on the data from the Czech National Phytosociological Database (Chytrý & Rafajová 2003) and their expert revision and completion, especially for rare and taxonomically problematic taxa. This number is a measure of the taxon's ecological range. The classification recognizes 88 basic habitats aggregated into 13 broader habitats that are defined by Sádlo et al. (2007: their Appendix 1). The number of habitats is defined in four ways:

- Number of narrow habitats in which the taxon occurs – the number of habitats of the total number of 88 in which the taxon occurs; the taxon may or may not have its ecological optimum in these habitats
- Number of narrow habitats in which the taxon has its optimum – the number of habitats of the total number of 88 in which the taxon occurs and at the same time has its ecological optimum there (it may also be a dominant or constant dominant)
- Number of broad habitats in which the taxon occurs – the number of habitats of the total number of 13 in which the taxon occurs; the taxon may but does not necessarily have its ecological optimum in these habitats
- Number of broad habitats in which the taxon has its optimum – the number of habitats of the total number of 13 in which the taxon occurs and at the same time has its ecological optimum there (it may also be a dominant or constant dominant)

Data source and citation: Sádlo et al. (2007).

12. Threats and protection

12.1 Red List 2017 (national categories) (Fig. 33)

National Red List categories were taken from the 2017 edition of the Red List of Vascular Plants of the Czech Republic (Grulich 2017). These categories, introduced in the previous editions of the Czech Red List, are different from the IUCN Red List categories. The main category "A" includes extinct or missing taxa, while the main category "C" includes endangered, near threatened and data deficient taxa.

Categories:

- A1 – extinct taxon
- A2 – missing taxon
- A3 – extinct or missing taxon (uncertain case)
- C1r – critically threatened taxon, rare
- C1t – critically threatened taxon, declining
- C1b – critically threatened taxon, rare and declining
- C2r – endangered taxon, rare
- C2t – endangered taxon, declining
- C2b – endangered taxon, rare and declining
- C3 – vulnerable taxon
- C4a – lower risk, near-threatened
- C4b – lower risk, data deficient
- taxon is not on the Red List

Data source and citation: Grulich (2017).

12.2 Red List 2017 (IUCN categories)

International Red List categories defined by the IUCN were taken from the 2017 edition of the Red List of Vascular Plants of the Czech Republic (Grulich 2017). Taxon assignments to these categories follow the internationally accepted rules (IUCN 2012, 2014). To some extent, the definitions of these categories differ from the national categories used in the previous Czech Red Lists. The national Red List included only threatened or possibly threatened taxa, implying that the non-included taxa are not threatened. Therefore, the non-included taxa are classified here as LC(NA) – least concern (taxon is not on the Red List).

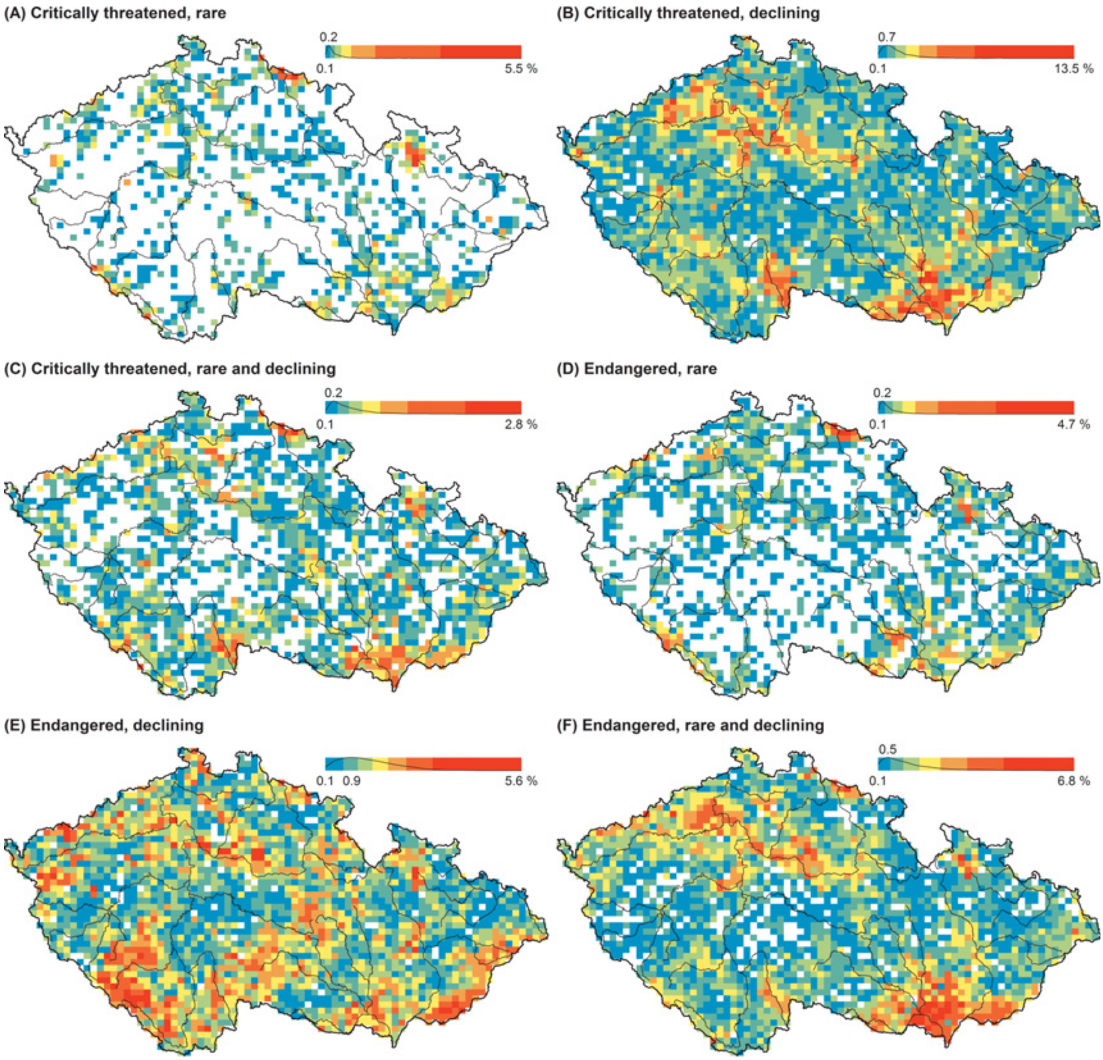


Fig. 33. – Proportion of the species in the national Red List that are critically threatened (C1 category) and endangered (C2 category) relative to the whole Czech flora. The species in both categories are divided into those threatened by being rare (A, D), declining (B, E) or both rare and declining (C, F). The species threatened due to rarity are found mainly in the highest mountain groups of the Sudetes (Krkonoše and Hrubý Jeseník Mountains). The critically threatened declining species are mainly found in dry lowland areas and wet basins, whereas the endangered declining species are found in mid-elevation areas. The species threatened by both rarity and decline do not display any distinct pattern for critically threatened species but are remarkably concentrated in dry lowland areas for the endangered species.

Categories:

- EX – extinct
- RE – regionally extinct
- CR – critically endangered
- EN – endangered
- VU – vulnerable
- NT – near threatened
- LC – least concern
- LC(NA) – least concern (taxon is not on the Red List)
- DD – data deficient
- NA – not applicable
- NE – not evaluated

Data source and citation: Grulich (2017).

12.3 Legal protection

Legal protection in the Czech Republic concerns the specifically protected species, i.e. rare taxa, threatened taxa and taxa significant from a cultural or scientific point of view that are listed in Annex II of the Decree of the Ministry of the Environment no. 395/1992. They comprise 487 taxa of vascular plants divided into three categories according to their vulnerability: critically threatened, endangered and vulnerable.

Categories:
● critically threatened taxon
● endangered taxon
● vulnerable taxon
● not protected by law

Data source and citation: Decree no. 395/1992 of the Ministry of the Environment of the Czech Republic.

Summary of the patterns of plant traits in the Czech flora

The geographic patterns of plant characteristics presented in the maps show a high degree of similarity among different characteristics. This may reflect correlations between the values of different characteristics across species, which suggest the existence of a limited number of viable combinations of plant traits, as indicated in an analysis of global plant trait spectra (Díaz et al. 2016). Here we provide a preliminary analysis of the main axes of trait variation in the Czech flora using ordination of the functional traits from the Pladias Database.

We used the data for species, disregarding the other taxonomic ranks, except for the genera *Rubus* and *Taraxacum*, in which we merged groups of numerous closely related species into sections. We selected the traits that are potentially functional, disregarding some morphological traits that have no apparent relationship to plant function, environmental associations and other characteristics. To obtain a more comprehensive picture, we added four traits from the LEDA database (Kleyer et al. 2008) that are not included in the Pladias Database but are often used in functional plant ecology (Westoby 1998): Leaf size, Specific leaf area (SLA), Leaf dry matter content (LDMC) and Seed mass. Data on the first two of these traits were supplemented by new measurements (Findurová 2018). Multi-state categorical variables were transformed into sets of variables with values ranging from 0 to 1 indicating to which extent a taxon exhibits each category (fuzzy coding). For some of those categorical traits, we merged detailed categories into broader descriptors (e.g. for Pollination syndrome, we merged the categories Selfing, Cleistogamy, Pseudocleistogamy and Geitonogamy into Autogamy). We excluded the species that are extinct from the Czech flora, casual aliens and the species that are only present in cultivation in the country. The resulting matrix, used for the analysis, contained 2356 species and 69 numerical traits or individual binary variables representing the categories of multistate traits (Table 1).

To summarize trait values and their correlations, we computed a principal component analysis (PCA). The values of Height, Leaf size and 2C genome size were log-transformed before the analysis to improve normality and homogeneity of variances. Each fuzzy-coded variable was standardized by the margin total (i.e. divided by the row sum of corresponding columns) to ensure the equal weight of individual species in the analysis. The PCA was based on centred and normalized data resulting in an equal weight of each trait (or column in fuzzy-coded variables) in the analysis. As PCA cannot handle missing

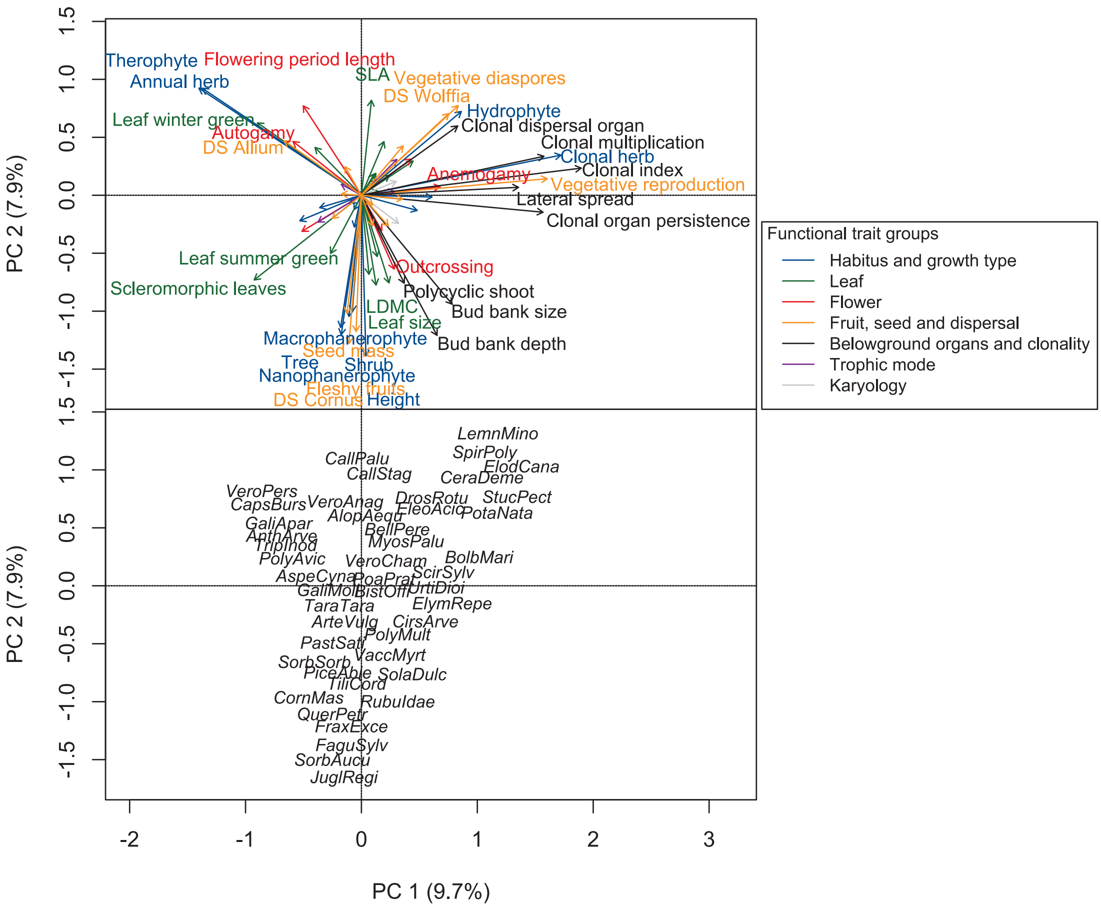


Fig. 34. – Principal component analysis (PCA) of species traits from the Pladias Database. Arrows represent the relation between the traits and the axes (PC 1 and PC 2). Traits reaching $r^2 \geq 0.1$ when regressed against the first two axes are labelled with their names. Species are represented based on their scores defined by the “orditorp” function which prevents illegibility by displaying only some of overlapping labels. Label priority was set according to the frequency of the given species in the species occurrence records of the Pladias Database. Species codes: *AlopAequ* = *Alopecurus aequalis*, *AnthArve* = *Anthemis arvensis*, *ArteVulg* = *Artemisia vulgaris*, *AspeCyna* = *Asperula cynanchica*, *BellPere* = *Bellis perennis*, *BistOffi* = *Bistorta officinalis*, *BolbMari* = *Bolboschoenus maritimus*, *CallPalu* = *Callitriche palustris*, *CallStag* = *Callitriche stagnalis*, *CapsBurs* = *Capsella bursa-pastoris*, *CeraDeme* = *Ceratophyllum demersum*, *CirsArve* = *Cirsium arvense*, *CornMas* = *Cornus mas*, *DrosRotu* = *Drosera rotundifolia*, *EleoAcic* = *Eleocharis acicularis*, *ElodCana* = *Elodea canadensis*, *ElymRepe* = *Elymus repens*, *FaguSylv* = *Fagus sylvatica*, *FraxExce* = *Fraxinus excelsior*, *GaliApar* = *Galium aparine*, *GaliMoll* = *Galium mollugo* agg., *JuglRegi* = *Juglans regia*, *LemnMino* = *Lemna minor*, *MyosPalu* = *Myosotis palustris*, *PastSati* = *Pastinaca sativa*, *PiceAbie* = *Picea abies*, *PoaPrat* = *Poa pratensis*, *PolyMult* = *Polygonatum multiflorum*, *PolyAvic* = *Polygonum aviculare*, *PotaNata* = *Potamogeton natans*, *QuerPetr* = *Quercus petraea*, *RubuIdae* = *Rubus idaeus*, *ScirSylv* = *Scirpus sylvaticus*, *SolaDulc* = *Solanum dulcamara*, *SorbSorb* = *Sorbaria sorbifolia*, *SorbAucu* = *Sorbus aucuparia*, *SpirPoly* = *Spirodela polyrhiza*, *StucPect* = *Stuckenia pectinata*, *TiliCord* = *Tilia cordata*, *TripInod* = *Tripleurospermum inodorum*, *UrtiDioi* = *Urtica dioica*, *VaccMyrt* = *Vaccinium myrtillus*, *VeroAnag* = *Veronica anagallis-aquatica*, *VeroCham* = *Veronica chamaedrys*, *VeroPers* = *Veronica persica*, *TaraTara* = *Taraxacum* sect. *Taraxacum*.

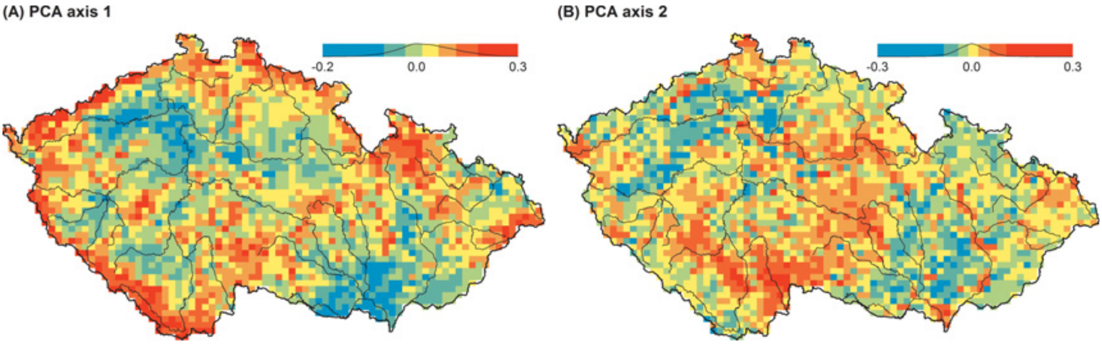


Fig. 35. – Mean scores of species on the first two axes of principal component analysis (PC1 and PC2, compare Fig. 34). The first axis shows mainly the contrast between annual herbs vs perennial clonal herbs (compare Fig. 3), the former being frequent in dry and warm lowlands (blue) and the latter prevalent in the mountains (red). The second axis shows the contrast between large species, often woody plants with large leaves and heavy seeds, which are more common in non-wetland landscapes (blue) vs small species with large specific leaf area (often annuals and aquatic plants), which are more common in wetland landscapes (both large river floodplains and pond basins; red).

data, missing values in the trait data matrix were replaced by the overall mean of the given trait. Although this approach involves artificial data imputation, it does not affect the correlation structure among traits. The PCA was computed using the "rda" function in the vegan package (version 2.5-6; Oksanen et al. 2019) in the R software (www.r-project.org). To visualize the main functional pattern in the Czech flora on the map, we used species composition within each geographic grid cell to calculate the average of species scores on the first two axes and plotted them on the map.

The main axis of trait variation (PC 1, Fig. 34) is associated with clonality: clonal herbs including hydrophytes are located on the positive side of the axis while annual non-clonal herbs occupy the negative side. The second axis (PC 2) is associated with plant size. Its negative side is associated with tall species, often trees and shrubs with large leaves and large seeds. In contrast, the positive side is characterized by herbaceous species with large specific leaf area, most of them annual terrestrial herbs or hydrophytes. Both PCA axes also show distinct geographic patterns (Fig. 35). Three contrasting specialized functional groups of the Czech flora can be recognized in the species graph of the first two PCA axes: (i) annual herbs located in the upper left part of the ordination space, (ii) trees and shrubs in the lower part and (iii) aquatic plants in the upper right part. Perennial herbs typically displaying trait values in between these specialized groups are located in the centre of the ordination space.

This analysis shows that the main pattern in functional trait variation across the Czech flora shares some features with the global flora analysis (Díaz et al. 2016), but there are also significant differences. The main axis of variation in the global dataset was related to the size of the whole plants and their parts, which we identified as the second trait axis. In the herb-dominated flora of the Czech Republic, we identified the importance of clonality and life span, which calls for more emphasis on these relatively understudied traits. Díaz et al. (2016) also identified the leaf economic spectrum as an important axis largely independent of plant size. By contrast, our analysis identified a strong correlation between leaf traits and plant size. Nevertheless, these patterns can be influenced by a different set of traits entered in the analysis and phylogenetic relationships. They require further research.

Outlook

The Pladias Database is the first comprehensive compilation of critically revised botanical data for the Czech Republic. It is internationally unique in that it integrates huge amounts of very detailed data on distributions, traits, and environmental associations of vascular plant taxa. The database has facilitated systematic mapping of plant distributions in the country (Kaplan et al. 2015, 2016a, b, 2017a, b, 2018a, b, 2019b, 2020) and numerous studies analysing biological and ecological plant traits performed within the Pladias project. Although the Pladias project was finished on 31 December 2018, the database infrastructure is further maintained and improved by the three institutions involved in its development. New data continue to be added and critically revised by experts, including external collaborators. The Pladias project also stimulated the development of the Database of Lichens and Bryophytes – DaLiBor, which has already integrated almost 600,000 occurrence records from the Czech Republic. DaLiBor uses the Pladias Database infrastructure but is further developed separately to fulfil the specific requirements of lichenologists and bryologists. Nevertheless, shared database structure and software routines allow future integration and joint analyses.

Integration of various data on plant distributions, traits, plant environmental associations and vegetation types in a single platform provides unique opportunities for testing ecological hypotheses that could not be tested earlier and addressing entirely new research questions. The database also has enormous potential for applications, especially in biodiversity conservation. Last but not least, the data are also available for international collaboration.

See www.preslia.cz for Electronic Appendix 1

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Author contributions

MC, PPy and JL coordinated the Pladias project at the three partner institutions. JW coordinated programming and database software management, ZK and JD coordinated taxonomic backbone and distribution mapping, with contributions from JW. MC coordinated the preparation of the data on plant characteristics, vegetation data and the public portal. PN and MR programmed the database software and the website. DH designed the first version of the website and collected and managed the image database. MŘ technically managed the preparation of the trait data and the public portal. IA, AB, PB, JC, MC, PD, VG, WYG, TH, DH, ZJ, MK, IK, JK, JL, ZL, LM, JP, SP, KP, HP, PPy, MŘ, JS, PŠm, PŠt, MŠ, JT, TT, LT and DZ prepared different parts of the data on plant characteristics. LT developed the identification key for vegetation types. JK provided original drawings of belowground plant organs. JD and PŠt prepared the electronic version of the Flora of the Czech Republic. JD and PPe prepared bibliographies. MV prepared the maps used in this paper. JT, FMF and IA performed the PCA analysis.

Souhrn

Databáze české flóry a vegetace byla vyvinuta týmem projektu Pladias v letech 2014–2018 a od té doby je průběžně aktualizována. V sekci Druhy tato databáze obsahuje kriticky revidované informace o flóře cévnatých rostlin včetně 13,6 milionů záznamů o výskytu rostlin na území ČR, které jsou dynamicky zobrazovány v mapách, a údaje o 120 charakteristikách rostlin (funkční vlastnosti, ekologické vazby a další informace). Charakteristiky rostlin jsou rozděleny do sekcí (1) Habitus a typ růstu, (2) List, (3) Květ, (4) Plod, semeno a šíření, (5) Podzemní orgány a klonalita, (6) Způsob výživy, (7) Karyologie, (8) Původ taxonu, (9) Ekologické indikační hodnoty, (10) Stanoviště a sociologie, (11) Rozšíření a hojnost a (12) Ohrožení a ochrana. V sekci Vegetace databáze obsahuje informace o vegetačních typech přejaté z monografie Vegetace České republiky. Údaje jsou doplněny národními botanickými bibliografiemi, elektronickými verzemi standardních národních monografií flóry a vegetace, databází více než 19 000 fotografií rostlinných taxonů a typů vegetace a digitálními mapami s botanickými informacemi. Údaje z databáze jsou dostupné na veřejném portálu www.pladias.cz, který také poskytuje možnosti stahování různých datových souborů a interaktivní určovací klíče druhů a vegetačních typů České republiky. V tomto článku popisujeme obecné zaměření, strukturu a obsah databáze a podrobnosti k údajům o vlastnostech rostlin. Detailní popisy všech vlastností v češtině jsou uvedeny v elektronické příloze. Abychom ilustrovali data a popsali hlavní trendy v geografickém rozšíření vybraných charakteristik flóry na území ČR, připravili jsme mapy středních hodnot numerických charakteristik nebo podílů kategorií u kategoriálních charakteristik v síti 5 × 3 zeměpisných minut (přibližně 6 km × 5,5 km). Variabilitu v různých funkčních vlastnostech rostlin jsme shrnuli pomocí analýzy hlavních komponent.

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