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Distributions of vascular plants in the Czech Republic. Part 11

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Abstract: The eleventh part of the series on the distributions of vascular plants in the Czech Republic includes grid maps of 85 taxa in the genera *Agrostemma*, *Berula*, *Bromus*, *Carex*, *Corydalis*, *Echinocystis*, *Festuca*, *Himantoglossum*, *Lychnis*, *Ophrys*, *Ornithopus*, *Pseudofumaria*, *Quercus*, *Salix*, *Sium* and *Vaccaria*. These maps were produced by taxonomic experts based on examined herbarium specimens, literature and field records. Most of the studied species are on the national Red List. *Agrostemma githago*, previously a noxious weed in cereal fields throughout this country, has virtually been eliminated from arable land and is now only rarely recorded in ruderal habitats. The recently described *Festuca albensis* is a species endemic to three sandy areas in Germany and the Czech Republic. It is threatened due to its restricted distribution, hybridization and habitat eutrophication. In contrast to the majority of orchids, *Ophrys apifera* has expanded its range and colonized secondary habitats in central Europe. In the Czech Republic it was for the first time recorded in 1980. However, in spite of the increase in the number of records, most of the populations are small. *Himantoglossum calcaratum* subsp. *rumelicum* and *Salix starkeana* have been extirpated from this country and are classified as nationally extinct. *Vaccaria hispanica* has not been observed for more than three decades and is classified as missing. Besides numerous archaeophytes and neophytes, mainly of the genus *Bromus*, two invasive species are discussed: *Echinocystis lobata* has become widespread along lowland rivers and streams, whereas *Quercus rubra* has become naturalized in forests mainly in the lowlands and at middle elevations. Spatial distributions and often also temporal dynamics of individual taxa are shown in maps and documented by records included in the Pladias database and available in the Supplementary materials. The maps are accompanied by comments that include additional information on the distribution, habitats, taxonomy and biology of the taxa.

Keywords: alien species, central Europe, chorology, Czech Republic, distribution atlas, distribution patterns, endangered species, endemic, flora, grid maps, herbaria, phytogeography, plant records, vascular plants

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Introduction

The mapping of the distributions of plants in the Czech Republic, initiated within the PLADIAS project in 2014, has recently yielded the tenth anniversary paper (Kaplan et al. 2021). Together with the previous instalments (Kaplan et al. 2015, 2016a, b, 2017a, b, 2018a, b, 2019b, 2020), the team of taxonomic experts has produced grid-based distribution maps of 907 taxa of vascular plants, based on examined herbarium specimens as well as critically evaluated and sorted literature, database and field records. Since the publication of the previous instalment, maps for a further 85 taxa have been finished and are included in this paper.

The taxonomically difficult genera *Bromus*, *Carex*, *Festuca*, *Himantoglossum*, *Ophrys*, *Quercus* and *Salix* are represented. The distribution maps of *Bromus*, *Carex* and *Festuca* resulted from expert revisions for the Flora of the Czech Republic, with its 9th volume, containing the treatments of these genera, now being prepared for publication. The maps of *Salix* were produced during studies of genetic diversity and hybridization of willow species. Although the genera *Himantoglossum* and *Ophrys* are taxonomically difficult particularly in southern Europe, their diversity in the Czech Republic is rather low. The recent taxonomic and nomenclatural revisions in *Himantoglossum* require updates in the national plant nomenclature (cf. Kaplan et al. 2019a): the Czech population previously referred to as *H. caprinum* and *H. jankae*, should instead be referred to as *H. calcaratum* subsp. *rumelicum* (Niketić et al. 2018, Lorenz 2019).

More than a half the mapped taxa are on the national Red List (Grulich 2012). The category of critically threatened plants is particularly heavily represented, comprising 23 taxa, with the ecological groups of these taxa mainly consisting of montane plants (e.g. *Carex capillaris*, *Festuca versicolor*, *Salix appendiculata*, *S. bicolor*, *S. hastata* and *S. herbacea*), followed by psammophytes (*Festuca albensis*, *F. psammophila* and *Ornithopus perpusillus*) and weeds of arable land (*Agrostemma githago*, *Bromus arvensis* and *B. secalinus*). Not surprisingly, orchids (*Himantoglossum adriaticum* and all *Ophrys* species) also are critically threatened. Two species, namely *Himantoglossum calcaratum* subsp. *rumelicum* and *Salix starkeana*, have been extirpated from the Czech Republic and are classified as nationally extinct. *Vaccaria hispanica* has not been observed for more than three decades and is classified as missing.

Alien species are represented by archaeophytes and neophytes. The genus with the most introduced species covered here is *Bromus*, with four archaeophytes and nine neophytes. Invasive species are occasionally recruited from aliens. Two invasive species are included in this paper. *Echinocystis lobata* has become widespread along lowland rivers and streams throughout this country, whereas *Quercus rubra* has become naturalized in forests mainly in the lowlands and at middle elevations.

Materials and methods

Taxonomic scope

The following groups of vascular plants are mapped: native taxa, naturalized aliens, most casuals and certain hybrids. Distribution maps are produced for species and subspecies, and in exceptional cases also for varieties or infrageneric taxa (e.g. sections). Plants of

species groups that are difficult to assign to species may be mapped as species aggregates. Field crops and plants deliberately cultivated in gardens and parks are not included in the mapping project. Nomenclature, taxonomic concepts and delimitation of species aggregates mostly follow Kaplan et al. (2019a), with differences indicated where necessary. For taxa not included in that source, a taxonomic reference is given. Publication of maps does not follow any alphabetical or systematic order, but mainly the maps resulting from recent revisions are included.

Data sources

All relevant floristic data sources are used. Major national herbaria and some local and foreign collections, incl. BRA, BRNL, BRNM, BRNU, CB, CBFS, CESK, CHEB, CHOM, FMM, GM, HOMP, HR, KHMS, LIM, LIT, MJ, MMI, MP, MZ, NJM, OL, OLM, OMJ, OMP, OP, OSM, OVMB, PL, PR, PRA, PRC, ROZ, SAV, SOB, SOKO, SUM, VM, VYM, WU and ZMT (acronyms follow Thiers 2022), were consulted as the main sources of taxonomically examined records. Most records for maps of common and easy-to-identify taxa came from the Pladias database (Wild et al. 2019, Chytrý et al. 2021), which has integrated data from five large national databases, several regional projects and unpublished field records from the maps' authors and regional contributors.

Mapping procedure

All records used for mapping are entered into the Pladias database and geographically sorted according to the traditionally used CEBA (Central European Basic Area) grid template (Niklfeld 1999) divided into quadrants of 5 × 3 arc minutes (corresponding to approximately 5.5 × 5.9 km). The territory of the Czech Republic is covered by 2551 quadrants, of which 2181 are completely within the borders of this country. Individual records and the whole distribution of each taxon are checked and evaluated by the author of a particular map in a web-based mapping interface of the Pladias database. Maps of taxonomically critical groups are based solely or mainly on herbarium specimens examined by taxonomic experts; these cases are indicated in the text accompanying the particular map. Maps of all other taxa are based on records from databases, literature and herbaria, which were scrutinized by the authors of the respective maps. Records used for producing maps are listed in Supplementary Data S1–S85. In selected maps, native versus introduced occurrences are distinguished, and corresponding records in the database classified accordingly. Draft distribution maps and the background records are released in a web-based review process for scrutiny by field botanists, regional collaborators and members of the Czech Botanical Society. Their comments and additional records are collected in the database and returned to the responsible specialists for consideration before producing the distribution maps.

Final maps and comments

The treatment of each taxon consists of a grid distribution map and accompanying text; the maps' authors, indicated in the figure captions, also had major roles in writing the first drafts of the texts for the subject taxa. Maps are displayed using a spherical Mercator projection (EPSG:3857) in which meridians and parallels appear as straight lines, and the

fields of the mapping grid are thus displayed as squares. The background relief was derived from SRTM data (http://www2.jpl.nasa.gov/srtm/, the version provided by http://srtm.csi.cgiar.org) and the river network was adapted from data provided by CENIA (www.cenia.cz). When appropriate, different symbols are used on the maps to distinguish between the following alternative attribute states: (i) recent versus old records, (ii) native occurrences versus introductions, and (iii) records based on examined herbarium specimens versus all other records. These classifications of records are used only for those taxa where such distinction provides important information and the amount and quality of records are sufficient. The mapping symbols used to indicate the different attributes of the records in particular grid cells are shown in Table 1. Symbols specific to individual maps are explained in their captions. In the caption for each map, the counts of occupied quadrants are indicated according to the symbols used in the map; uncertain occurrences are not included in the counts. The accompanying text includes the accepted scientific name, a brief outline of the total distribution, information on habitats occupied by the species and a description of its distribution in the Czech Republic. Where appropriate, comments on taxonomy, biology and details of the spatial and temporal dynamics of the distribution are given.

Table 1. – The symbols used in the distribution maps to indicate the different attributes of occurrence in particular grid cells.

Attribute distinguished	Symbol	Attribute state
None	●	All records
Time	●	Recent occurrence (at least one record since 2000)
	●	Old occurrence (all records before 2000, or demonstrably extirpated from all localities after 2000, or all records undated)
Origin	●	Native (at least one record)
	×	Alien
Source of data	●	Examined herbarium specimen (at least one record)
	▲	All other
All	?	Only record(s) uncertain regarding identification and/or locality

Distribution maps and comments

Agrostemma githago (Fig. 1)

Agrostemma githago is probably native to the eastern Mediterranean area. It has been introduced into most of Europe, the temperate zone in Asia, northernmost Africa, eastern and southern Africa, Australia, New Zealand, North America and southern South America (Meusel et al. 1965, Hultén & Fries 1986). In Europe it has considerably fewer records in its eastern and northernmost parts and is absent from Iceland. The occurrences in the northern parts of the continent have mostly been casual; however, *A. githago* has also declined in more southern areas (Jalas & Suominen 1986). In the Czech Republic it used to be a noxious weed in cereal fields, most frequently in rye fields (*Secale cereale*), growing apparently on all types of soil. *Agrostemma githago* has also been recorded on

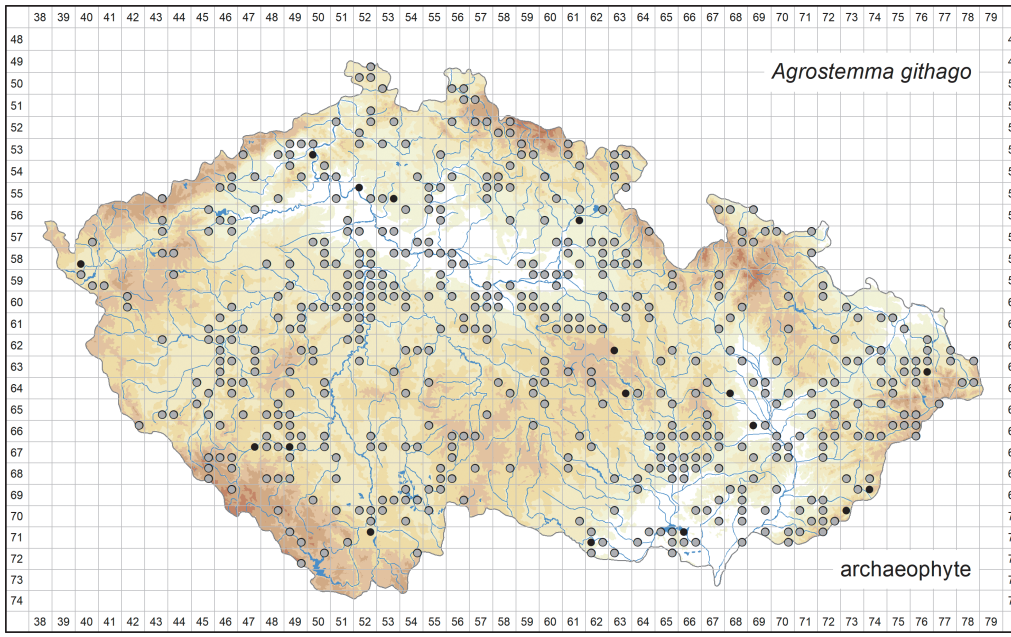

Fig. 1. Distribution of *Agrostemma githago* in the Czech Republic: ● at least one record in 2000–2021 (17 quadrants), ● pre 2000 records only (509 quadrants). Prepared by Zdeněk Kaplan & Jiří Danihelka.

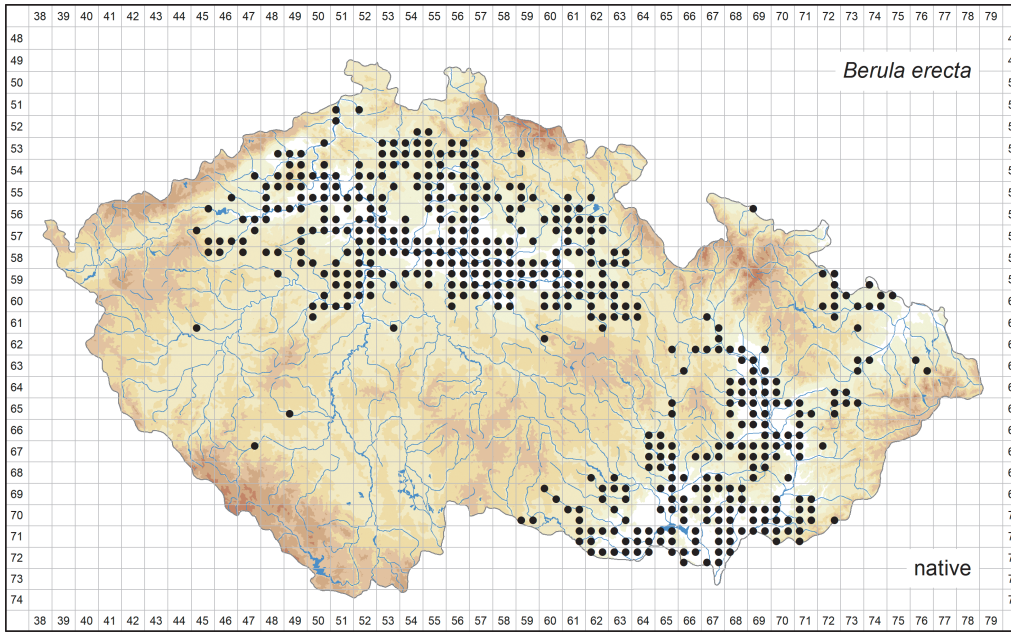

Fig. 2. Distribution of *Berula erecta* in the Czech Republic (515 occupied quadrants). Prepared by Jan Prančl.

fallow land, in disturbed places along roads and other ruderal habitats. Earlier literature (e.g. Čelakovský 1877) indicated that it was a widespread and frequent weed throughout this country. Approximately in the 1950s–1970s *A. githago* strongly declined mainly due to improved methods of seed cleaning and later probably also due to use of herbicides. By the 1980s it was virtually eliminated from arable land and only grown intentionally in small fields in a few open-air folk museums in eastern Moravia. During the past decade the number of recorded occurrences has somewhat increased with the growing popularity of annual flower mixtures, which are sown not only in gardens but also in public spaces, around shopping centres and even along paths outside settlements. *Agrostemma githago* is now rarely recorded on waste disturbed ground and in other ruderal habitats in villages and towns, and exceptionally also in the countryside in disturbed grasslands along paths and in edges of small fields. Probably all recent occurrences outside of gardens originated from intentional sowing or escapes from cultivation. *Agrostemma githago* is classified as a casual archaeophyte (Pyšek et al. 2012) and as critically threatened (Grulich 2012). As this species was known to earlier botanists as a common weed, its individual localities were often not recorded. Čeřovský (1999) in his map assumed previous occurrence of *A. githago* almost throughout this country wherever arable land was present. Although this was likely close to the actual former distribution of this species, the map presented here is based solely on standard records, not on general information in local floras about this species' presence in the areas covered; however, this limitation renders it inevitably incomplete.

Berula erecta (Fig. 2)

The distribution of *Berula erecta* s. str. includes Europe, northernmost Africa, the Middle East and central Asia eastwards as far as eastern Kazakhstan and western Nepal; it is also naturalized in Australia (Pu & Watson 2005, Spalik & Downie 2006). The populations in North America, distributed from southernmost Canada to Guatemala, are often classified as a separate species, *B. incisa*, or as a subspecies or variety of *B. erecta*. The populations from eastern and southern Africa have recently been considered a separate species, *B. thunbergii* (Spalik et al. 2009). *Berula erecta* is distributed throughout most of Europe except for Iceland, most of Scandinavia and northern Russia (Hultén & Fries 1986, Hand 2011). In the Czech Republic it occurs mainly in small streams, channels and ditches with muddy or sandy bottom, less often in springs, alluvial pools, oxbows and edges of fishponds. It is found in both sunny and shady places. The species prefers slowly flowing to almost still, shallow waters rich in nutrients, calcium and dissolved oxygen (at least in the top layer of the substrate), while it avoids strongly anaerobic sapropelic mud. It tolerates short-term drops in water level (Hegedüšová et al. 2009, Sádlo 2011). The dense, often monodominant stands of the species significantly contribute to the terrestrialization of aquatic habitats. In this country, *B. erecta* grows mainly in lowlands, reaching its elevational maximum at 570 m near the village of Vyškovec in the Bílé Karpaty Mts in south-eastern Moravia. It is relatively frequent in the northern half of Bohemia as well as in central and southern Moravia. In contrast, the species rarely occurs in northern Moravia and Silesia and it is almost absent from westernmost and southern Bohemia, where its occurrence was recently confirmed at a single locality in the limestone area between the towns of Sušice and Horažďovice. *Berula erecta* is relatively well tolerant of

water pollution and dredging, yet it has declined somewhat due to strong eutrophication and stream channelization. Therefore, it is classified as of lower risk – near threatened (Grulich 2012).

Bromus arvensis (Fig. 3)

Bromus arvensis is a predominantly European species, native to southern, south-eastern and southern-central Europe, and introduced northwards as far as Iceland and northern Scandinavia. Somewhat isolated occurrences are in Anatolia, Iran, central Asia and Siberia. It has been also introduced into southern Africa, North America, Argentina and New Zealand (Hultén & Fries 1986, Pavlick & Anderton 2007). In the Czech Republic *B. arvensis* occurs as a weed on arable land, less frequently on road verges, embankments, in river ports, on fallow land, at dumpsites, along railways and near mills. In the past, it was locally scattered to rare, but fully established in warm and moderately warm areas in the northern half of Bohemia and in central, southern and south-eastern Moravia, and very rare and probably also as a casual species elsewhere. After World War II *B. arvensis* suffered a considerable decline in the Czech Republic mostly due to improved methods of grain cleaning and later also due to deep tillage. Since the 1980s this species has been recorded at only a few sites in western and southern Bohemia, and southern, eastern and northern Moravia. Most of these records are from ruderal sites and only the two most recent ones from cereal fields. They represent recent accidental introductions with low-quality grain or as a contaminant of commercial seed. Due to an enormous number of misidentifications we have seen in herbaria, the map is based mainly on examined herbarium specimens. *Bromus arvensis* has often been confused with *B. japonicus* and less frequently even with *B. commutatus* and *B. secalinus*. *Bromus arvensis* is classified as a casual archaeophyte (Pyšek et al. 2012) and as critically threatened due to its decline (Grulich 2012).

Bromus briziformis (Fig. 4)

Bromus briziformis is native to the Caucasus Mts, Transcaucasia, northern Iran and Middle Asia (Conert 1998a). It has been introduced to some European countries and North America and has become naturalized mainly in the western USA (Conert 1998a, Pavlick & Anderton 2007). In its native range it occurs on stony and loamy slopes, screes, and gravel bars and also as a weed on roadsides and in arable fields. In Europe this species is sometimes cultivated as an ornamental, mainly for use in dried flower bouquets. The earliest record of cultivated plants in Bohemia dates back to 1845 when *B. briziformis* was collected in Prague. It was cultivated also in the old botanical garden in Smíchov, now one of Prague's city districts, as documented by a specimen from 1860. The earliest records of escaped plants are from around 1900: in 1895 *B. briziformis* was collected in the city of Brno in Moravia and in 1901 in the town of Mělník in central Bohemia, in both cases from vineyards. Several records of escaped plants followed in various parts of the country, the latest in 1959. Most finds are from settlements and represent garden escapes or plants that may have germinated from thrown-away dried flower bouquets; only the latest record near the village of Bezděkov in northern-central Moravia originated from a field margin. *Bromus briziformis* is considered a casual neophyte (Pyšek et al. 2012).

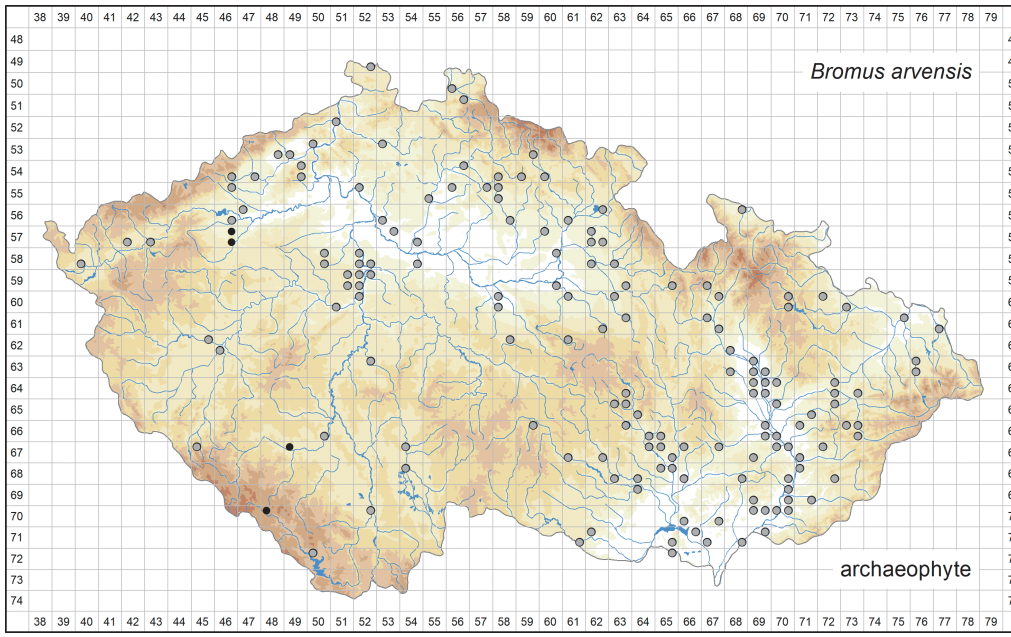

Fig. 3. Distribution of *Bromus arvensis* in the Czech Republic: ● at least one record in 2000–2021 (4 quadrants), ● pre 2000 records only (159 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

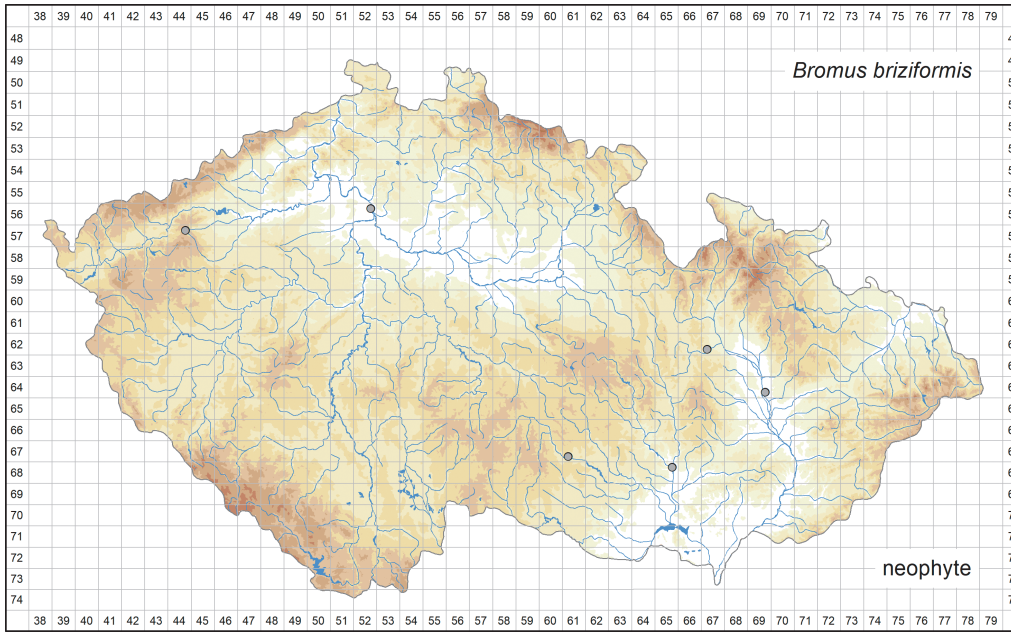

Fig. 4. Distribution of *Bromus briziformis* in the Czech Republic: ● pre 2000 records only (6 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

Bromus bromoideus (Fig. 5)

Bromus bromoideus is a highly specialized weed of spelt (*Triticum aestivum* Spelta group) fields on dry calcareous soils, endemic to the provinces of Liège and Luxemburg in Belgium and the adjacent French department of Ardennes (Tournay 1968). It is most closely related to the western European *B. grossus* (Koch et al. 2016), also a weed of spelt fields. From the mid-1930s *B. bromoideus* was considered extirpated in the wild and two decades later even extinct (Tournay 1968). However, in 2005 viable seeds of this species were found in the botanical garden in the town of Meise in Belgium. Nowadays, it is cultivated in several botanical gardens in Europe (Koch et al. 2016). In the Czech Republic *B. bromoideus* was collected in 1889 in the city of Olomouc on a rubble heap (Danihelka 2014). The mode of introduction is unknown; however, Olomouc was an important garrison town at that time, and seeds of *B. bromoideus* may have been introduced with forage grain for horses.

Bromus carinatus (Fig. 6)

Bromus carinatus is a member of a taxonomically difficult group native to North America. Of this group, *B. carinatus* (incl. *B. marginatus*), *B. polyanthus* and *B. sitchensis* have been reported to occur in Europe (Verloove 2012); all plants collected in the Czech Republic belong to *B. carinatus*, mainly or even exclusively to its morph with long awns, *B. carinatus* var. *marginatus*. *Bromus carinatus* is native to western North America from British Columbia and Saskatchewan south to Mexico (Pavlick & Anderton 2007). It has been introduced into Europe, south-western Asia, China, South America and New Zealand (Valdés et al. 2009, GBIF 2021). The earliest record of *B. carinatus* from cultivation in the Czech Republic is from the village of Sloupnice in eastern Bohemia and dates back to 1907. In the 1930s it was cultivated in the botanical garden in Olomouc and some private gardens; the first escapes were recorded in the cities of Brno and Olomouc and date to 1934 and 1942, respectively. Probably soon after World War I it was cultivated as a fodder crop in the surroundings of the town of Veselí nad Lužnicí in southern Bohemia and already by then may have escaped from cultivation but no records are available. Since the 1960s *B. carinatus* started to spread, especially in towns and their surroundings, although it still appeared to be very rare. The more rapid spread in the past 25 years was associated with the frequent use of commercial grass-seed mixtures for slope and soil stabilization and has been accelerated by both road and rail traffic. *Bromus carinatus* occurs on lawns and at various ruderal sites in settlements, along roads and railways, on riverbanks, sometimes also in disturbed grasslands. The grass is noted for its good soil stabilizing capabilities, which makes it valuable for revegetation and erosion control, and is also a palatable forage. *Bromus carinatus* is considered a naturalized neophyte (Pyšek et al. 2012).

Bromus catharticus (Fig. 7)

Bromus catharticus is native to South America and it has been introduced into and become naturalized in tropical and warmer temperate regions of Asia, Africa and Australia, and also in North America northwards to the northern USA (Pavlick & Anderton 2007). The distribution in Europe is still insufficiently known, due to confusion with species of

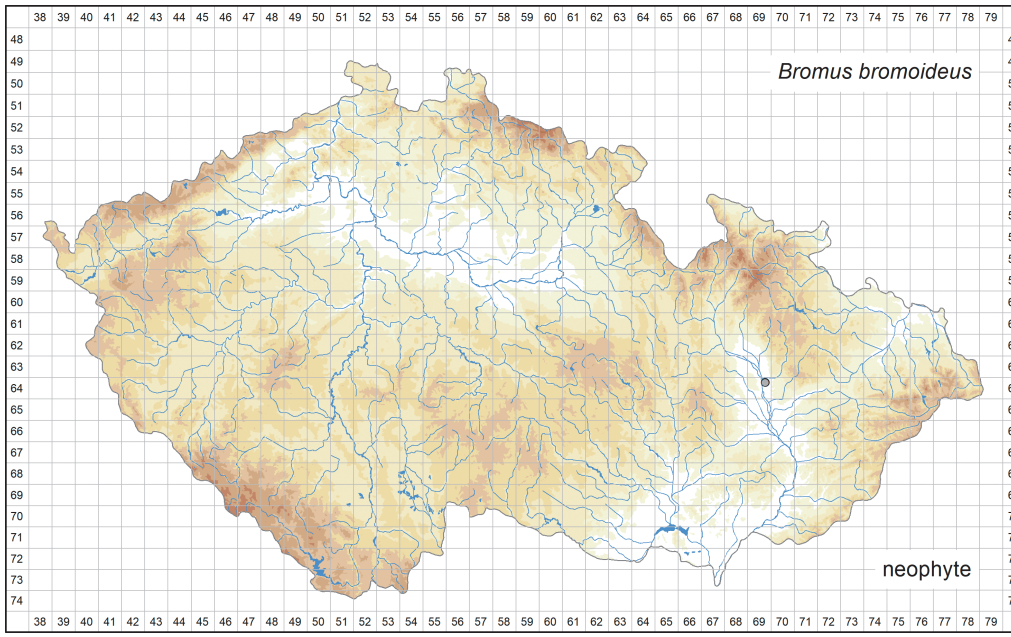

Fig. 5. Distribution of *Bromus bromoideus* in the Czech Republic: ● pre 2000 records only (1 quadrant). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

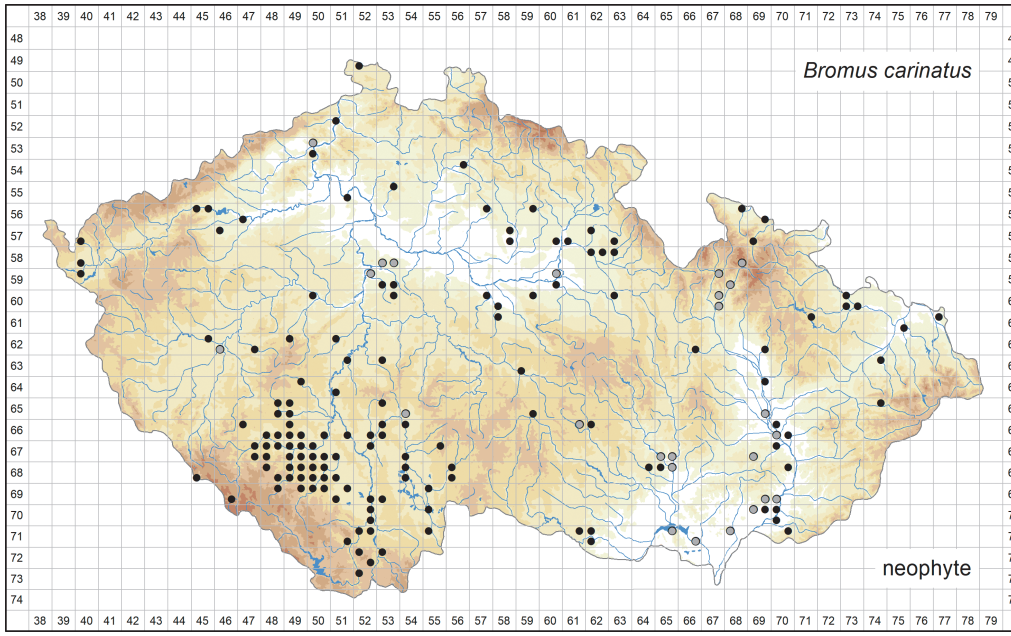

Fig. 6. Distribution of *Bromus carinatus* in the Czech Republic: ● at least one record in 2000–2021 (142 quadrants), ● pre 2000 records only (25 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

the *B. carinatus* agg. It is rare to scattered in the Mediterranean basin and rare in Europe's western, central and south-eastern parts; occasionally it is found in Norway and the northern part of Russia, mostly as a grain and wool alien, and winter forage (rescue grass; Valdés et al. 2009, GBIF 2021). The earliest herbarium specimen from the Czech Republic, collected from the town of Kolín in central Bohemia in 1853, may have originated from cultivation. The record from the town of Písek in southern Bohemia in 1873, from a beer garden, refers to escaped or accidentally introduced plants. Unclear is also the status of plants collected in the town of Česká Lípa in northern Bohemia (1880) and in the village of Roudno in northern Moravia (1904); all the other plants collected until the half of the 20th century are specimens from cultivation or escapes within gardens. In 1957, *B. catharticus* was collected in a disused limestone quarry near the village of Raspenava in northern Bohemia; the seeds were introduced there with wool waste. In the 1960s and 1970s it was also introduced with wool to the city of Brno, but the two available herbarium specimens collected in the towns of Vyškov (1965) and Kuřim (1974) are plants grown deliberately in experimental fields fertilized with wool waste. The latest records from 1998–2004 in the village of Průhonice near Prague are from ruderal lawns along streets and most likely represent escapes from cultivation. Due to taxonomic and nomenclatural confusion, most of the records in the Czech botanical literature are erroneous, based on misidentifications of *B. carinatus*. Therefore, the map is based exclusively on examined herbarium specimens. *Bromus catharticus* is classified as a casual neophyte of the Czech flora (Pyšek et al. 2012).

Bromus commutatus (Fig. 8)

Bromus commutatus is closely allied to *B. racemosus* and easily confused with it. Some authors (e.g. Stace 1997) suggest it might be better treated as a subspecies of the latter. *Bromus commutatus* is native to Eurasia and northernmost Africa. In Europe it is distributed from northern Portugal and Spain in the west to the Volga river basin and the Caucasus Mts in the east; northwards its more or less continuous distribution reaches northern Germany, Poland and northern Belarus, and it has been introduced to Scandinavia, Finland and north-western Russia; in the south it is absent from southern Italy, Sardinia and Sicily. In Asia it is rare, found only in Anatolia, Transcaucasia, Israel, Iran, Iraq, central Asia and as a casual in the Russian Far East. It has been further introduced into southern Africa, North and South America, Australia and New Zealand (Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007, Wilson 2009). In the Czech Republic *B. commutatus* occurs mainly as a weed on arable land including especially that used for forage crops (*Medicago sativa* and *Trifolium pratense*), recently mostly winter cereals, as well as fallow land, but has also been found along roads and paths, in dump places, disturbed grasslands, and less often also in meadows and railway stations. Soils are usually loamy to clayey, moderately humid, slightly acidic to slightly basic, moderately supplied with nutrients, usually poor in calcium. *Bromus commutatus* was scattered to locally common in warm, mainly hilly landscapes of north-western, west-central and eastern Bohemia and southern and central Moravia, from which it extended to the middle elevations in areas with moderately warm climates, such as in the foothills of the Českomoravská vrchovina highlands, Orlické hory Mts and Bílé Karpaty Mts, and the surroundings of the town of Vsetín; casual occurrences were reported elsewhere. In the second half of the

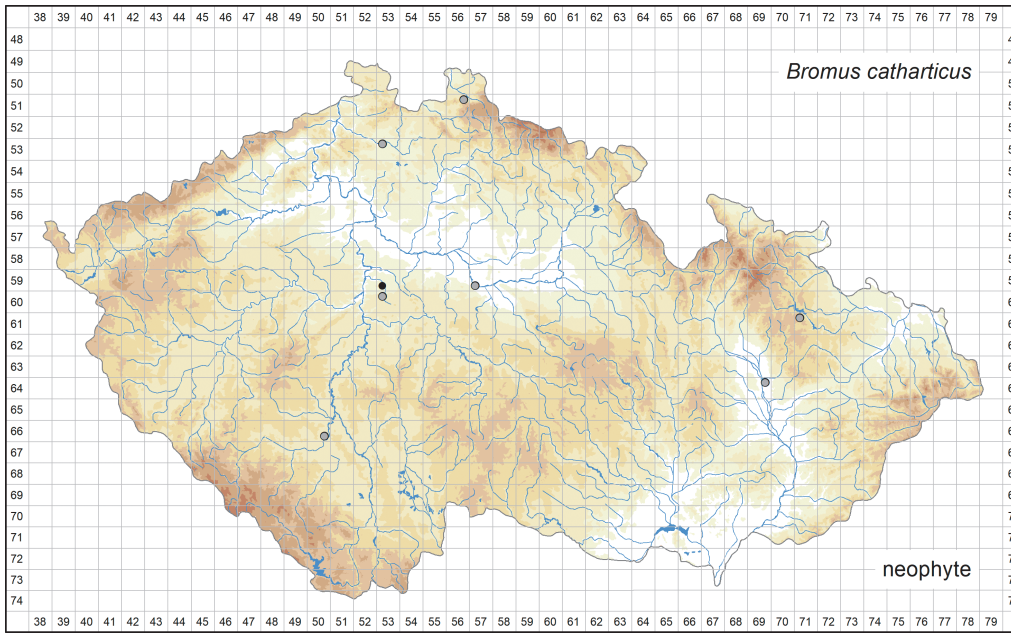

Fig. 7. Distribution of *Bromus catharticus* in the Czech Republic: ● at least one record in 2000–2021 (1 quadrant), ● pre 2000 records only (7 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

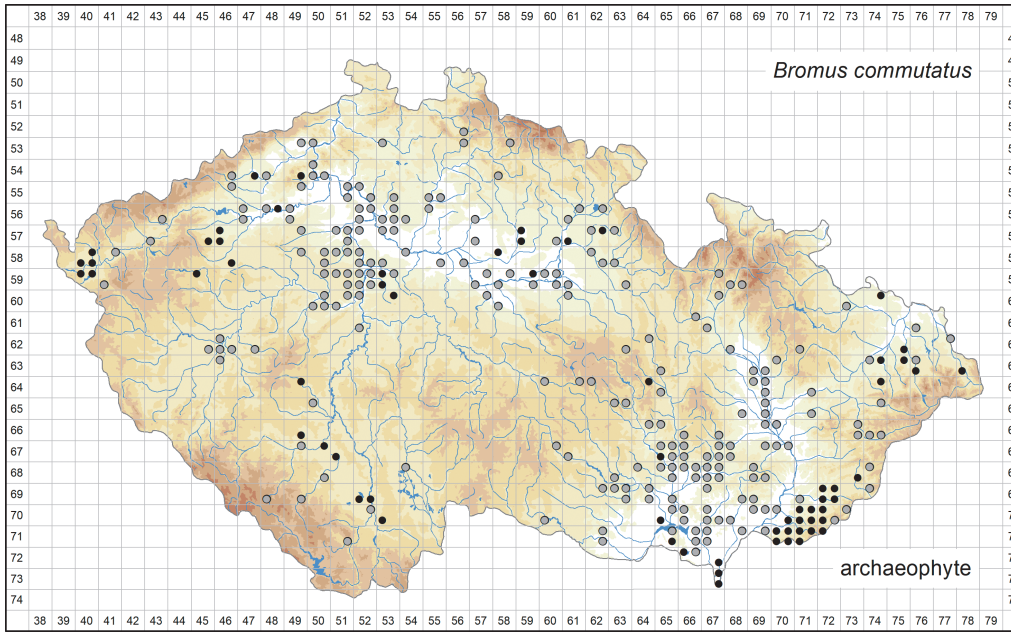

Fig. 8. Distribution of *Bromus commutatus* in the Czech Republic: ● at least one record in 2000–2021 (64 quadrants), ● pre 2000 records only (221 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

20th century it declined considerably in arable fields due to improved methods of grain cleaning, deep tillage and use of herbicides; however, due to less intense agriculture and land use it survived in areas such as the Bílé Karpaty Mts in south-eastern Moravia. During the 1990s *B. commutatus* was very rare, likely confined to the city of Brno and its surroundings, south-eastern Moravia and a few sites in northern Moravia and southern (and possibly also north-western) Bohemia. Since then it has been recorded in various parts of the country, namely near the town of Cheb in western Bohemia, in south-western and eastern Bohemia, northern and north-eastern Moravia and Silesia. Most of these recent records in Bohemia and northern Moravia are from arable land and represent introductions with contaminated commercial seed, most likely from abroad. The map is based mainly on examined specimens because of frequent confusion, mainly with *B. japonicus*, less frequently also with *B. racemosus* and *B. secalinus*. *Bromus commutatus* is classified as a naturalized archaeophyte and as vulnerable (Grulich 2012, Pyšek et al. 2012).

Bromus diandrus (Fig. 9)

Bromus diandrus is a taxonomically disputed species. In our circumscription it comprises two varieties: plants with lax, spreading panicles are classified as var. *diandrus*, while those with contracted, stiffly erect panicles are classified as var. *rigidus* (Sales 1993). These taxa are often distinguished at the subspecies or even species level (e.g. Conert 1998a). However, their morphological differentiation is weak, and the few distinguishing characters are not correlated with the two ploidy levels (hexaploid and octoploid) found within this species (Oja & Laarmann 2002). In the Czech Republic only a small number of specimens were collected, with most corresponding to var. *diandrus*. However, a few of them have a contracted panicle, whereas others cannot be assigned to either of the two taxa with certainty. This may be due to continuous variation or may just reflect atypical environments. *Bromus diandrus* is native to Macaronesia, the Mediterranean area, the Middle East, towards the east reaching as far as Middle Asia. It has been introduced into and has become at least partly naturalized in eastern Asia, the Americas, southern Africa, southern Australia and New Zealand (Conert 1998a, Pavlick & Anderton 2007, Jessop et al. 2018). In its native range it occurs in phrygana, disturbed dry grasslands, margins of cultivated fields and on waste ground and roadsides. In the Czech Republic it was first collected in 1929 in ruderal places in Prague's city district of Zlíchov. During the 1950s–1970s it was introduced with wool waste into several sites in northern Bohemia, such as in 1957 a disused limestone quarry near the village of Raspenava, in 1967 a dump site near a wool spinning factory in the city of Liberec, and in 1971 in Brno, where it occurred in garden allotments in cultivated beds fertilized with waste from wool cleaning and also in a dump site in the city district of Brněnské Ivanovice. The latest record in this country dates back to 1977 when *B. diandrus* was collected on a railway near the town of Kadaň in northern Bohemia. It is classified as a casual neophyte (Pyšek et al. 2012).

Bromus hordeaceus (Fig. 10)

The range of *Bromus hordeaceus* spans Europe except for its northern parts (towards the north rarely exceeding 60°N), being rather rare in the Mediterranean islands. In Asia it extends to Anatolia, the Caucasus Mts and Transcaucasia, Iran, Pakistan and China. It also occurs in northern Africa. It has been introduced into and has become locally

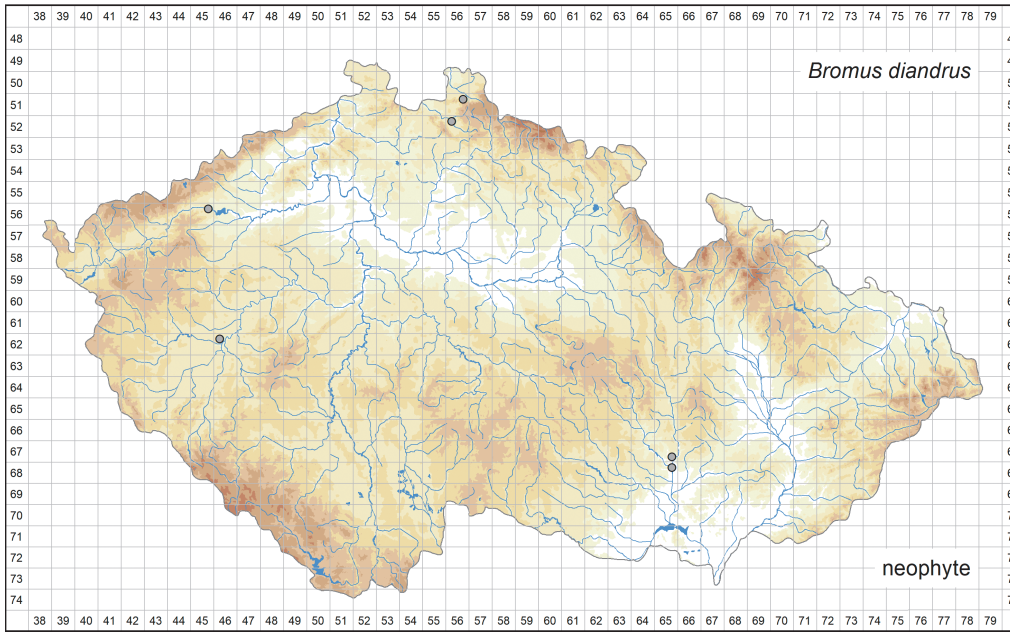

Fig. 9. Distribution of *Bromus diandrus* in the Czech Republic: ● pre 2000 records only (6 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

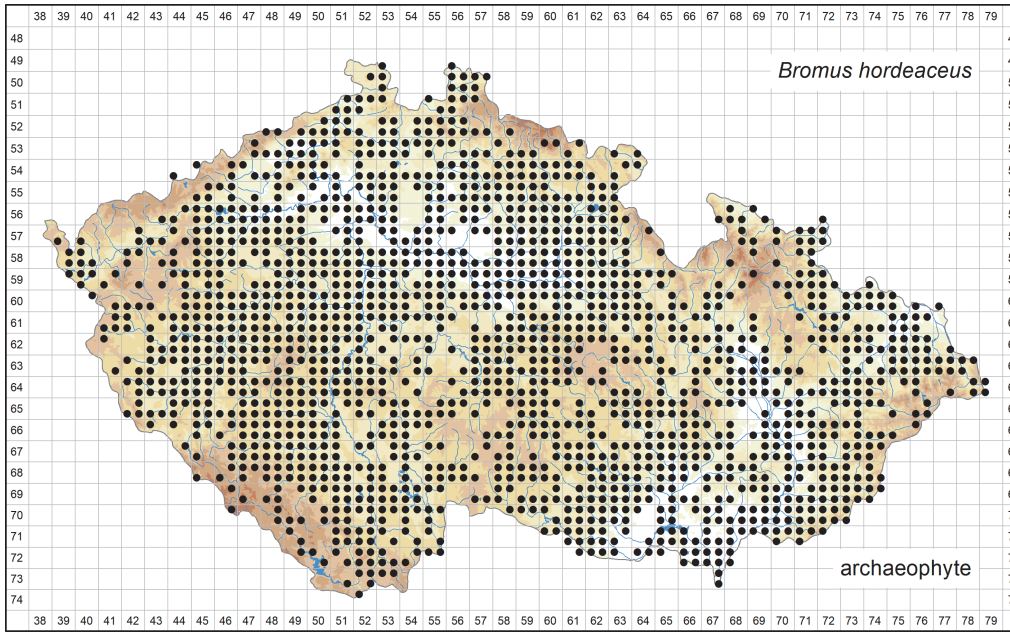

Fig. 10. Distribution of *Bromus hordeaceus* in the Czech Republic (1669 occupied quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

naturalized in the Korean Peninsula, Japan, southern Africa, North America (from Alaska to northern Mexico), Australia, New Zealand and the southern half of South America (Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007, Jessop et al. 2018). *Bromus hordeaceus* is a polymorphic species. Several subspecies are recognized, of which only subsp. *hordeaceus* has been recorded from the Czech Republic with certainty. Plants morphologically intermediate between *B. hordeaceus* and *B. lepidus* are sometimes considered as hybrids between these species (*B.* ×*pseudothominei*) or classified as a subspecies of the former, *B. hordeaceus* subsp. *pseudothominei* (e.g. Kubát 2002). Such plants, occasionally collected also in this country, are included here in *B. hordeaceus* and require further study. In the Czech Republic *B. hordeaceus* grows in various ruderal and semi-ruderal sites, namely on road verges and embankments, along walking paths, at railway stations and at dump sites and on fallow land. It also enters ruderal grasslands in settlements and human-influenced types of semi-natural vegetation, such as abandoned or disturbed meadows and pastures, and (especially recently) margins of arable fields. Soils are usually loamy, moderately humid to dry, slightly acidic to slightly basic, moderately to well supplied with nutrients and rather rich in humus. *Bromus hordeaceus* is common in the lowlands and at middle elevations, i.e. in areas with warm and moderately warm climates, reaching its current elevational maximum at about 1480 m in the Hrubý Jeseník Mts. The occurrences in man-made habitats at high elevations are usually temporary. It is classified as a naturalized archaeophyte in this country (Pyšek et al. 2012).

Bromus japonicus (Fig. 11)

Bromus japonicus is continuously distributed from the southern part of central Europe and Italy through the Balkan Peninsula and the Black Sea region to the Caucasus Mts; beyond this range it has sporadic occurrences westwards as far as France, England and southern Scotland, and northwards to central Norway and Finland. The distribution in Asia is rather discontinuous, encompassing its south-western part from Anatolia to Afghanistan, Middle Asia (northwards extending to Siberia, southwards to Pakistan and north-western India), China, Mongolia, the Korean Peninsula and Japan. It has also been introduced into North America, Australia, New Zealand and the southern part of South America (Meusel et al. 1965, Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007). In the Czech Republic *B. japonicus* occurs in margins of arable fields, on fallow land, in vineyards, disturbed places in dry grasslands and open shrub communities, and also at railway stations and on roadsides and railway embankments, and in yards of industrial facilities. It prefers loamy, less often clayey or sandy, moderately humid, permeable, neutral to basic soils, moderately supplied with nutrients and often well supplied with calcium. *Bromus japonicus* is scattered to locally common in warm and dry hilly areas of north-western Bohemia and north-west and south-west of Prague, and locally also in eastern Bohemia and on limestone outcrops in southern and south-western Bohemia. In Moravia it is scattered to locally common in its southern part, with an almost continuous distribution south-west, south and south-east of the city of Brno. Elsewhere in this country it is absent or rare. At middle elevations and in areas with moderately humid climates it is found as introduced and locally established in railway stations and on railway embankments, while from higher elevations only temporary occurrences are reported. In the second half of the 20th century it declined due to changes in farming methods;

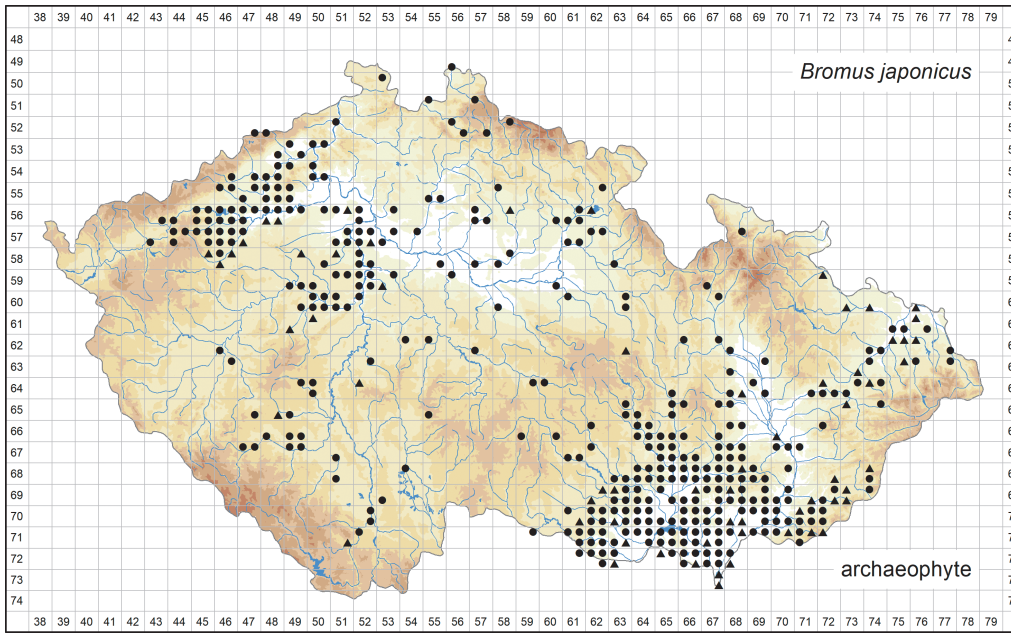

Fig. 11. Distribution of *Bromus japonicus* in the Czech Republic: ● occurrence documented by herbarium specimens (354 quadrants), ▲ occurrence based on other records (63 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

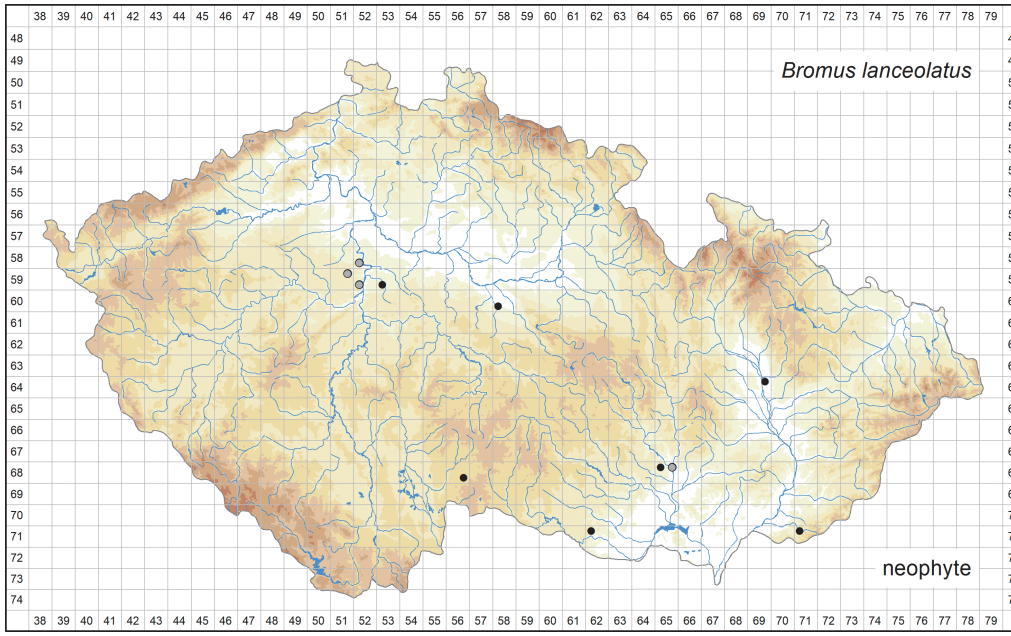

Fig. 12. Distribution of *Bromus lanceolatus* in the Czech Republic: ● at least one record in 2000–2021 (7 quadrants), ● pre 2000 records only (4 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

however, recently it has tended to spread both on arable land and in ruderal habitats. In the Czech Republic this species is considered a naturalized archaeophyte (Pyšek et al. 2012) and at lower risk – near threatened (Grulich 2012).

Bromus lanceolatus (Fig. 12)

Bromus lanceolatus is native to the Mediterranean area and adjacent parts of south-western Asia, the Caucasus Mts, Transcaucasia and Middle Asia as far as China (Conert 1998a). It has been introduced to central Europe and North America (Conert 1998a, Pavlick & Anderton 2007). In its native range it occurs on dry slopes, waste ground, in open woodland and field margins. In the Czech Republic it is rarely cultivated as an ornamental plant and is also used sometimes in dried flower bouquets. As an escaped species, it was first collected in the outskirts of Prague in 1848 and again in Prague's district of Zlíchov in 1929. As a wool-associated alien, it was observed in the city of Brno in 1958–1961 in strawberry beds fertilized with waste from wool cleaning. There have been seven records since 2000 in different parts of the country, all in settlements; they refer to plants escaped from cultivation or plants that may have germinated from garden or flower shop waste or that were accidentally introduced directly from southern Europe. *Bromus lanceolatus* is considered a casual neophyte (Pyšek et al. 2012).

Bromus lepidus (Fig. 13)

Bromus lepidus is distributed mainly in north-western Europe from the British Isles in the west to central Scandinavia and southern Finland in the east; southwards, as a rare casual, it reaches southern Germany, Switzerland, northern Italy, Austria and north-western Hungary. It has also been recorded from the Canary Islands, Egypt, western North America and Uruguay (Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007). The native range is unknown: it may have evolved quite recently in man-made habitats. *Bromus lepidus* has been temporarily introduced into the Czech Republic, mainly as a contaminant of grass-seed mixtures from western and north-western Europe. It was first found in 1883 in a park lawn in the town of Sedlčany in central Bohemia. In 1898–1969 it was repeatedly recorded from ruderal grasslands as well as dump places in Prague; numerous records from the 1950s and 1960s reflect targeted searches at that time. There are also several records from other parts of the country, most of them from lawns along streets as well as gardens, the latest from the city of Brno in 1976. *Bromus lepidus* may easily be overlooked due to confusion with small plants of *B. hordeaceus*, and further search may result in new records. It is classified as a casual neophyte of the Czech flora (Pyšek et al. 2012).

Bromus madritensis (Fig. 14)

Bromus madritensis is native to Macaronesia, the Mediterranean area, the Middle East and eastwards as far as Afghanistan, while also being found in southern Crimea. Casual introductions are known from several countries of northern, western and central Europe (Conert 1998a). Outside Europe *B. madritensis* has been introduced into North America, where it has become established in the south-western USA (Pavlick & Anderton 2007), and to Australia (Jessop et al. 2018), where it has become invasive; it has also been intro-

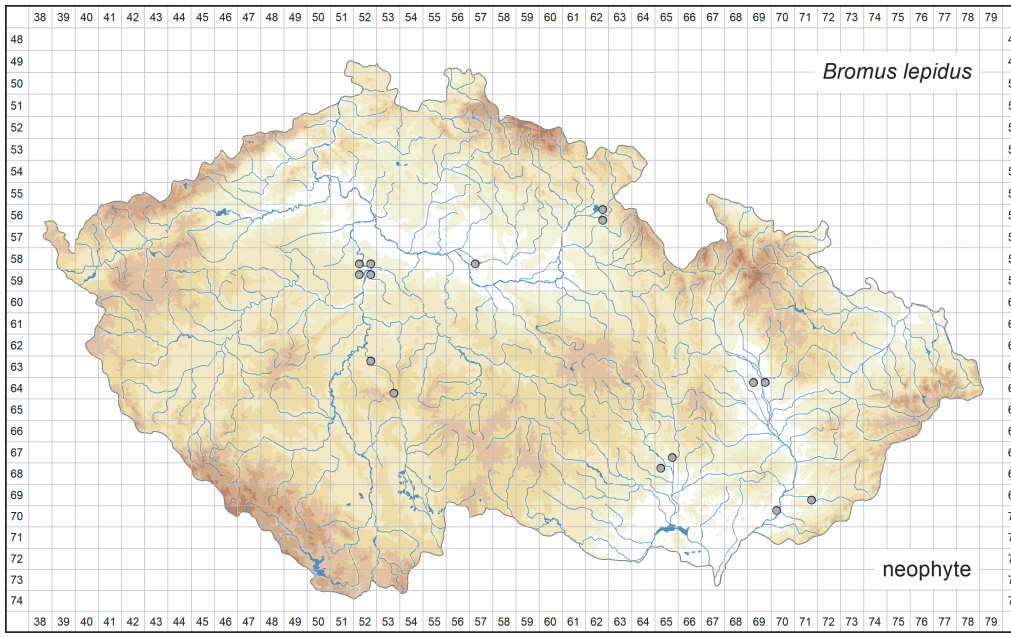

Fig. 13. Distribution of *Bromus lepidus* in the Czech Republic: ● pre 2000 records only (15 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

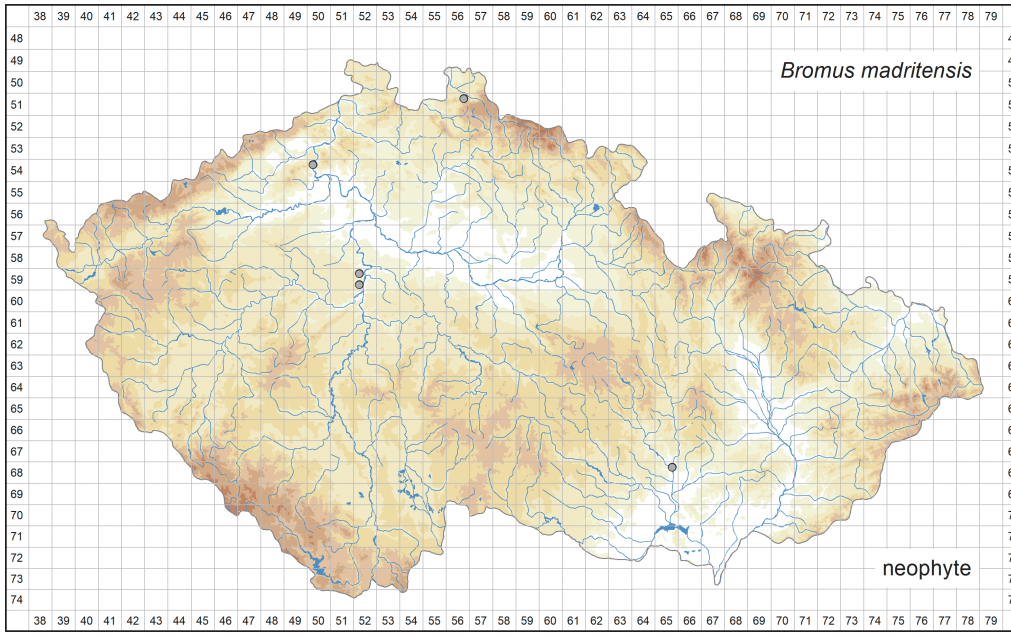

Fig. 14. Distribution of *Bromus madritensis* in the Czech Republic: ● pre 2000 records only (5 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

duced to South America, southern Africa and New Zealand (Conert 1998a). In its native range it occurs along pathways, in margins of arable fields and at waste places. In the Czech Republic it was first recorded in 1926 and 1927 on the railway in Prague's city district of Smíchov and in 1929 in ruderal places in the city district of Zlíchov nearby. Roughly at the same time, *B. madritensis* was collected also in the village of Dolní Zálezly in northern Bohemia. In 1957 it was collected in a disused limestone quarry near the village of Raspenava in northern Bohemia; the plants were introduced there with wool waste. In 1958–1961 *B. madritensis* was introduced to the city of Brno as a contaminant of wool and collected in strawberry beds fertilized with waste from wool cleaning. There exists also an undated record (from the 1950s to the 1990s) from the former freight railway station Žižkov in Prague. *Bromus madritensis* is considered a casual neophyte (Pyšek et al. 2012).

Bromus racemosus (Fig. 15)

Bromus racemosus is native to Europe, Anatolia, the Caucasus Mts, Transcaucasia, northern Iran and central Asia. The more or less continuous European range extends from southern France and England in the west to northern coast of the Caspian Sea and lower Volga river basin in the east; northwards it reaches Denmark and southern Sweden; isolated occurrences are known in Portugal, Spain, Ireland, Scotland, Island, central Sweden, Baltic countries and north-western Russia. It has been introduced into North America, South America (Chile, Argentina), Australia and New Zealand (Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007, Wilson 2009). In the Czech Republic *B. racemosus* grows in wet meadows and pastures, rarely also in wet places in arable fields (especially of *Trifolium pratense*) and in semi-ruderal habitats. It prefers loamy to clayey, moderately humid, intermittently wet to wet, slightly acidic to neutral soils, moderately supplied with nutrients and as a rule poor in calcium. In the past, *B. racemosus* was scattered over warm and moderately warm parts of north-western, central, south-western, southern and eastern Bohemia and southern and central Moravia, and rare or absent elsewhere, reaching its elevational maximum at about 600 m near the village of Horní Moravice in northern Moravia. After World War II it almost disappeared due to drainage, conversion of meadows to arable land and eutrophication. Nowadays is it known only from the vicinity of the town of Chudenice in south-western Bohemia, the meadows along the Botič stream near the village of Průhonice near Prague, the Bílé Karpaty Mts in south-eastern Moravia and probably also the village of Dobré Pole in southernmost Moravia. Due to the enormous amount of misidentifications seen in herbaria, the map is based on examined specimens and selected reliable literature and database records. Still, it may be contaminated by misidentified slender specimens of *B. commutatus* because these two closely related species differ only in a few, partly modifiable characters, and some individuals are difficult to assign unequivocally to either of the two. Further studies are necessary to clarify the relationships between *B. racemosus*, *B. commutatus* and *B. secalinus*. *Bromus racemosus* is classified as critically threatened in this country due to its decline (Grulich 2012).

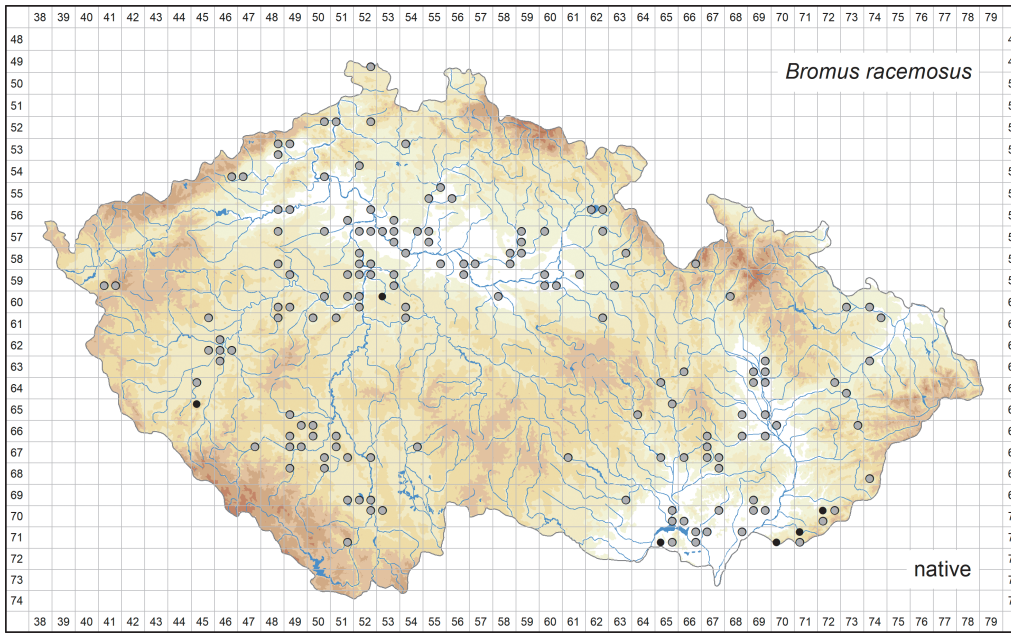

Fig. 15. Distribution of *Bromus racemosus* in the Czech Republic: ● at least one record in 2000–2021 (6 quadrants), ● pre 2000 records only (152 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

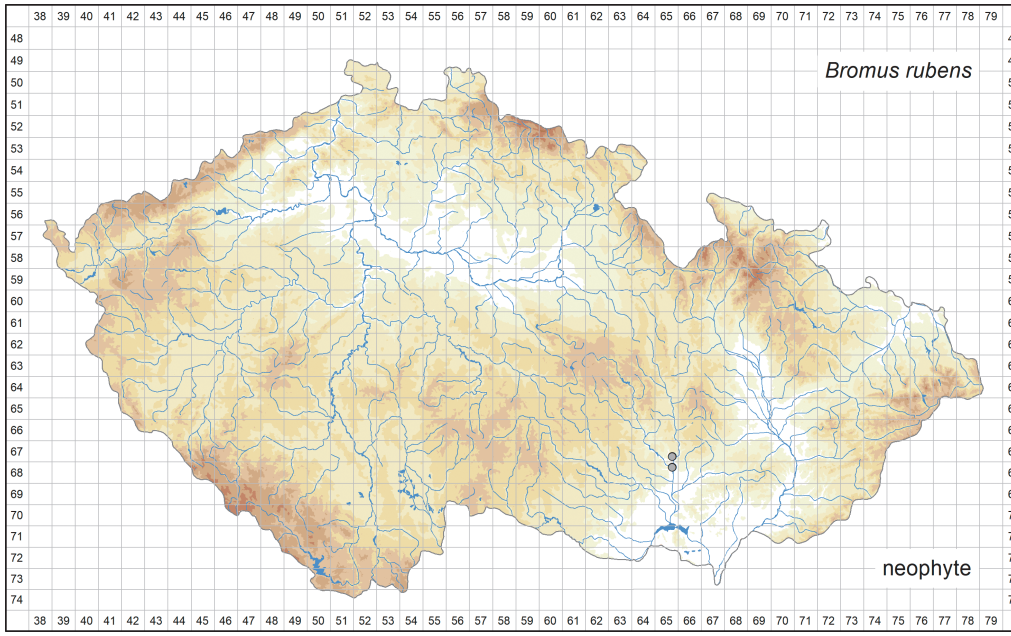

Fig. 16. Distribution of *Bromus rubens* in the Czech Republic: ● pre 2000 records only (2 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

Bromus rubens (Fig. 16)

Bromus rubens is native from Macaronesia across the Mediterranean area as far as Middle Asia (Conert 1998a). It has been introduced to several countries of Europe, the Americas, Australia, and New Zealand. It has become established in the eastern USA (Pavlick & Anderton 2007) and southern Australia (Jessop et al. 2018). In its native range it occurs mainly in dry pastures, disturbed grasslands, waste places, scrub and on roadsides. It was formerly introduced into the Czech Republic as a wool contaminant and was observed in the city of Brno in 1958–1961 as a weed in strawberry beds and in 1968 as a weed in garden allotments fertilized with waste from wool cleaning. *Bromus rubens* is classified as a casual neophyte (Pyšek et al. 2012).

Bromus scoparius (Fig. 17)

Bromus scoparius is native to the Mediterranean area, towards the east reaching as far as Middle Asia. It has been introduced into several countries in western, central and eastern Europe, as well as into North America (now established in California), Chile and Australia (Conert 1998a, Pavlick & Anderton 2007). In the Czech Republic it was first collected in 1927 in the former freight railway station Praha-Smíchov in the western part of Prague. It was also introduced as a contaminant of wool into the city of Brno where it was observed in 1958–1961 as a weed in strawberry beds fertilized with waste from wool cleaning. *Bromus scoparius* is considered a casual neophyte (Pyšek et al. 2012).

Bromus secalinus (Fig. 18)

Bromus secalinus is more or less continuously distributed throughout Europe, except for southernmost Italy, the southern part of the Balkan Peninsula and the meadow-steppe zone in Ukraine and the southern part of Russia. It is markedly rarer in Asia, where it occurs in western Anatolia, northern Iran, in some parts of central Asia, in Siberia, China, the Russian Far East and Japan; it is also known from northern Africa. It has been introduced into North America (and has become naturalized and widespread especially in its temperate zone), South America (Argentina, Chile), southern Africa, Australia and New Zealand (Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007, Wilson 2009). The species' native range is unknown; the speirochoric *B. secalinus* spread as a weed, with its similarity to rye likely inhibiting its detection as a seed contaminant. In the Czech Republic it occurs as a weed in winter cereals, rarely also on fallow land, roadsides, fishpond dams and in various ruderal habitats; in the past it also occurred around mills. Soils are usually loamy to sandy, permeable, moderately humid, acidic to neutral, moderately supplied with nutrients, poor in humus and calcium. Over the whole 19th century and in the first half of the 20th century, *B. secalinus* was reported as a widespread weed of winter crops, especially of rye, frequent at middle elevations in areas with humid climates, and also extending into the mountains. However, it was rather rare in warm and dry lowlands and hilly landscapes. It strongly declined after World War II (in some areas the decline started already in the 1930s) due to changes in farming methods, especially improved methods of grain cleaning, and later also deep tillage and the use of herbicides. By the 1980s it vanished from most of its former sites in this country, except for several sites in western, south-western and southern Bohemia, in the Bílé Karpaty Mts, near the

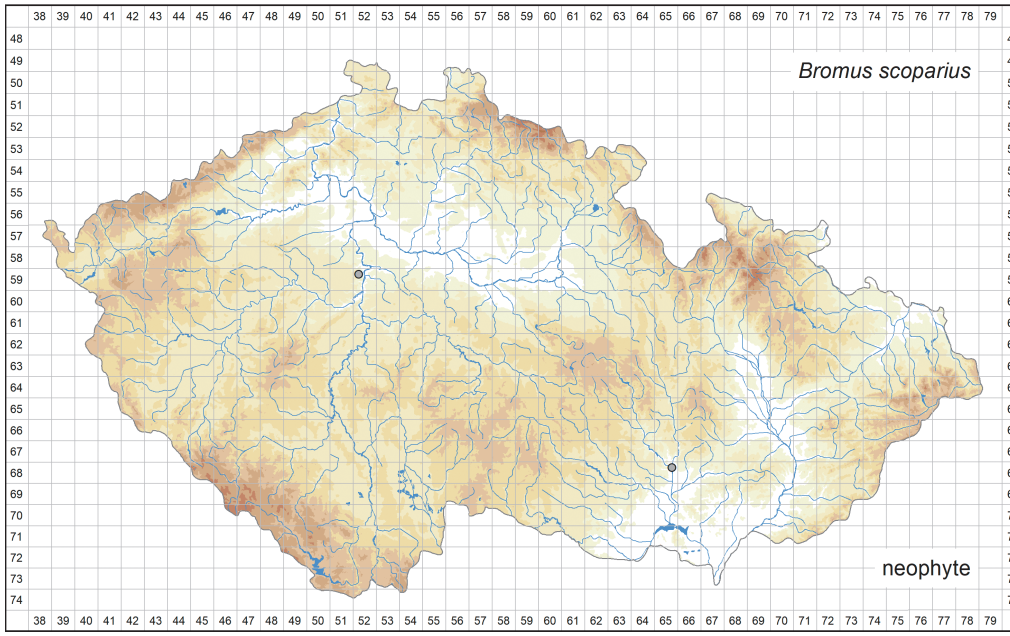

Fig. 17. Distribution of *Bromus scoparius* in the Czech Republic: ● pre 2000 records only (2 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

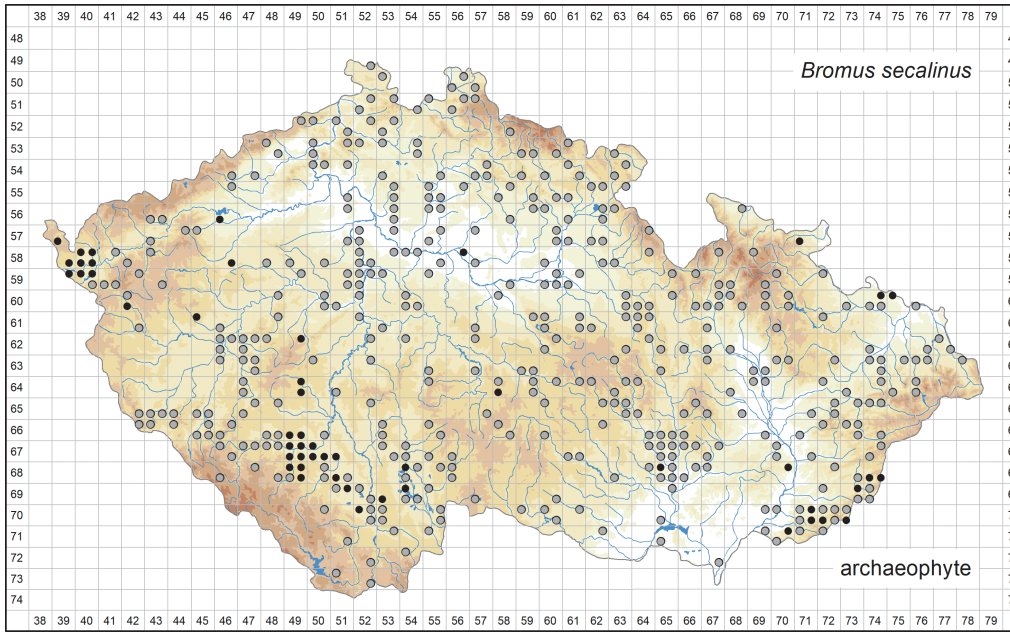

Fig. 18. Distribution of *Bromus secalinus* in the Czech Republic: ● at least one record in 2000–2021 (50 quadrants), ● pre 2000 records only (415 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

city of Brno and towns of Moravská Třebová, Opava and Vsetín in Moravia. During the past two decades new sites have been discovered, and the species has become locally common around the towns of Cheb and Strakonice in western and south-western Bohemia, respectively. The occurrences in cereal fields are due to accidental introductions with contaminated grain seed, those around fishponds due to introductions with low quality grain or waste from grain cleaning used for feeding fish, and those on roadsides due to the use of *B. secalinus* in commercial grass-seed mixtures employed for soil stabilisation. It is likely that the number of records will slightly increase. The species' former distribution is greatly underestimated because it was once locally so common that early local and regional floras contain only general information about its presence and/or mass occurrence in cereals. *Bromus secalinus* is classified as a casual archaeophyte (Pyšek et al. 2012) and as critically threatened due to its decline (Grulich 2012).

Bromus squarrosus (Fig. 19)

Bromus squarrosus is native to southern and south-eastern Europe, Anatolia, the Caucasus Mts, Transcaucasia, northern Iran, central Asia (as a casual alien in Siberia), north-western China, northern Africa and the Canary Islands. In Europe it extends continuously northwards as far as central France, north-eastern Austria, Moravia, Slovakia and central part of European Russia (as a casual alien as far as Nordic countries and north-western Russia). It has been introduced to southern Canada, the northern USA, Chile and Australia (Meusel et al. 1965, Conert 1998a, Pavlick & Anderton 2007). In the Czech Republic *B. squarrosus* is considered native only to the vicinity of the town of Znojmo in south-western Moravia and perhaps also to Kotouč hill near the town of Štramberk in north-eastern Moravia. It occurs at moderately disturbed sites on rock outcrops within a mosaic of dry grasslands and scrub, less frequently on fallow land and in vineyards, preferably on dry, permeable, neutral to basic soils. Temporary occurrences of introduced plants have been recorded from about 15 sites throughout this country; the earliest record is from the Josefov fortress (now a part of the town of Jaroměř) in eastern Bohemia and dates back to 1879. Further records followed during the 1950–1970s. At that time the seeds were introduced with iron ore mainly from southern Ukraine (occurrences in the industrial region in north-eastern Moravia and Silesia), and as wool (northern Bohemia) and cereal contaminants. During the past two decades *B. squarrosus* has been discovered on the railway bridge in the city district of Braník in Prague (2009), in the village of Biskupice in south-eastern Moravia (2006) and in an abandoned limestone quarry near the village of Kurovice in eastern Moravia (2015). The native populations of *B. squarrosus* are considered as critically threatened due to the species' rarity (Grulich 2012).

Bromus sterilis (Fig. 20)

Bromus sterilis occurs in Europe, northwards to southern Scandinavia (with outposts up to the Arctic Circle) and eastwards from the Atlantic coast continuously to the Dnieper river basin, northern coast of the Black Sea and the Caucasus Mts; it is also found in south-western and central Asia, China, Japan, northern Africa and Macaronesia. It has been introduced into and has become naturalized in North America, southern South America, Australia and New Zealand (Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007, Wilson 2009). In the Czech Republic *B. sterilis* is found in ruderalized

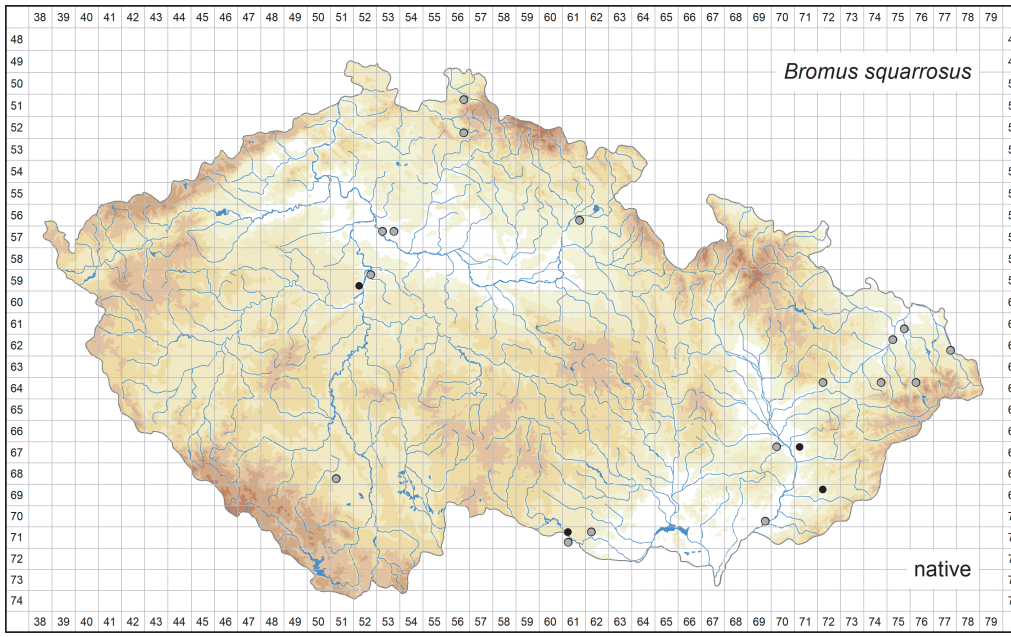

Fig. 19. Distribution of *Bromus squarrosus* in the Czech Republic: ● at least one record in 2000–2021 (4 quadrants), ● pre 2000 records only (17 quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

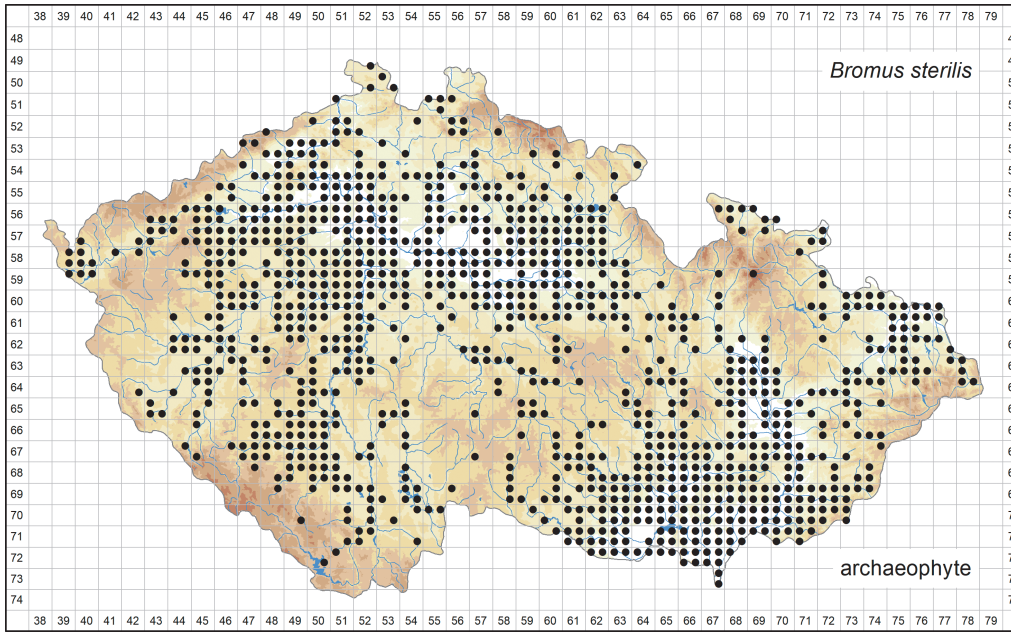

Fig. 20. Distribution of *Bromus sterilis* in the Czech Republic (1078 occupied quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

shrub communities, *Robinia pseudoacacia* woodlands, at ruderalized forest edges, on walls, in gardens, waste places, along railways including railway stations, on road verges and along paths, in ruderalized disturbed grasslands and dump places, most frequently in settlements and their surroundings, with growing frequency also as a weed on arable land in winter crops. Its rather recent spread on arable land is enhanced by reduced soil cultivation. *Bromus sterilis* occurs on loamy to sandy, moderately humid to dry, permeable, slightly acidic to basic soils, usually rich in nutrients and often well supplied with calcium. It is scattered to common in the lowlands and at middle elevations, i.e. in areas with warm and moderately warm climates, in the latter predominantly in areas strongly influenced by agriculture and/or industrial production. Locally it spreads into higher elevations, reaching its elevational maximum at about 860 m near the village of Cínovec in the Krušné hory Mts. This species is probably under-recorded, and some gaps in the lowlands indicate lack of records rather than true absences. *Bromus sterilis* is considered a naturalized archaeophyte (Pyšek et al. 2012).

Bromus tectorum (Fig. 21)

Bromus tectorum is a mainly Eurasian species distributed from the Iberian Peninsula and British Isles in the west to central Asia (and introduced to the Russian Far East and Japan) in the east, extending northwards continuously to southern Scandinavia (with occasional occurrences in northern Scandinavia and Island) and to about 55°N in Belarus and Russia; it also occurs in northern Africa and in the Canary Islands. It has been introduced into southern Africa, North America, South America (Chile and Argentina), Australia and New Zealand (Meusel et al. 1965, Hultén & Fries 1986, Conert 1998a, Pavlick & Anderton 2007, Wilson 2009). In western North America it has become a dominant species of rangelands and arable fields, displaying invasive behaviour, and is now listed as a noxious weed (Mack 1981, Schachner et al. 2008). In the Czech Republic *B. tectorum* occurs in dry ruderal sites in settlements and their surroundings, in railway stations and embankments, along roads, in ruderalized disturbed grassland (especially on sand), margins of arable fields, sparsely vegetated stone quarries and castle ruins. Soils are usually sandy to loamy, shallow, permeable, rather dry, slightly acidic to basic, poor in humus and nutrients. *Bromus tectorum* is frequent in warm and moderately warm parts of this country, especially in areas strongly influenced by human activities, such as industrial grounds, large towns and traffic hubs. It has been accidentally introduced to higher elevations, especially to railway stations and railway embankments, and reaches its elevational maximum at about 990 m in the village of Kubova Huť in the Šumava Mts. This species is considered a naturalized archaeophyte (Pyšek et al. 2012).

Carex capillaris (Fig. 22)

Carex capillaris is a circumpolar species, with a widely patchy distribution in the mountains of the temperate to subtropical zone. In Europe it occurs in Iceland, Scotland and Scandinavia, and throughout the northern part of Russia; it is also found at higher elevations of the European mountains, including the Sierra Nevada Mts, Pyrenees, Alps, Krkonoše Mts, Carpathians and Dinaric Mts. Isolated occurrences are located in the Atlas Mts in Morocco and the Caucasus. In North America, it occurs in its northern half, towards the south extending to California and New Mexico. Closely related species are

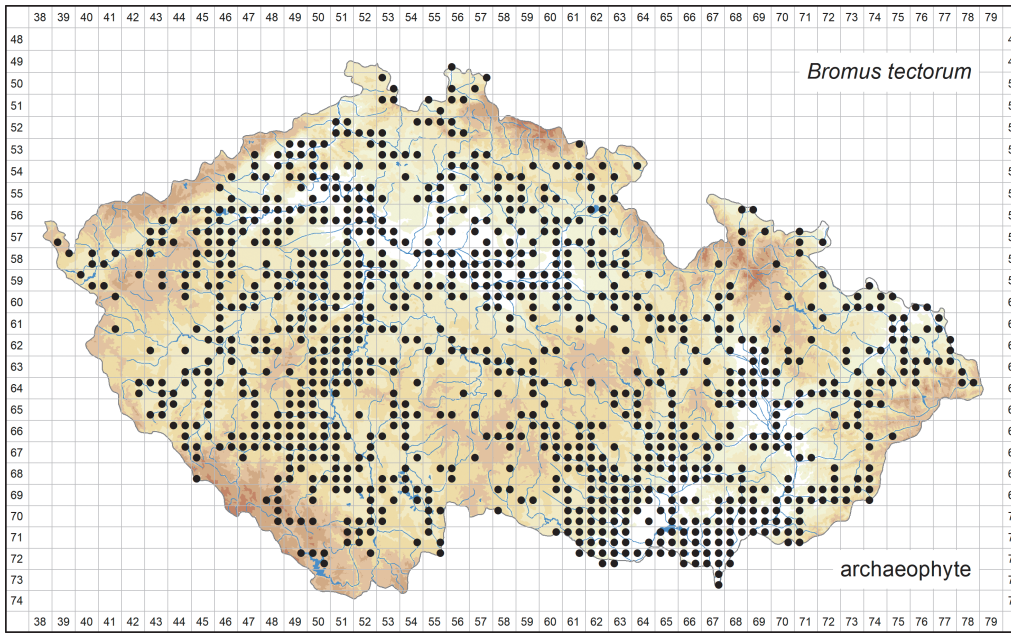

Fig. 21. Distribution of *Bromus tectorum* in the Czech Republic (1038 occupied quadrants). Prepared by Jindřich Chrtek Jr. & Jiří Danihelka.

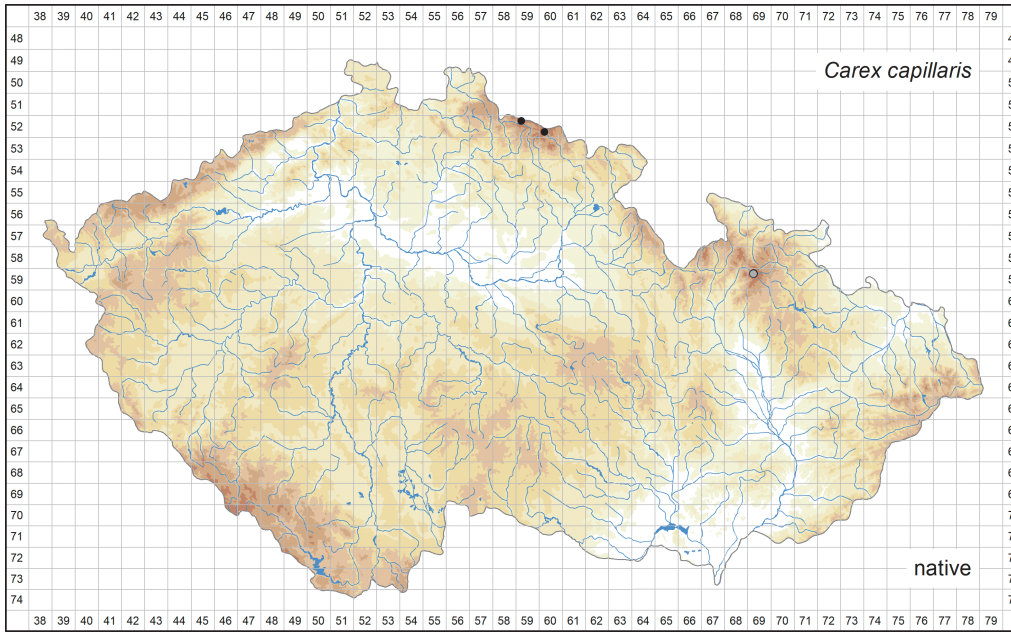

Fig. 22. Distribution of *Carex capillaris* in the Czech Republic: ● at least one record in 2000–2021 (2 quadrants), ● pre 2000 records only (1 quadrant). Prepared by Vít Grulich & Radomír Řepka.

found in the mountains of central and eastern Asia and of North America (Egorova 1999, Ball 2002a). In the Czech Republic *C. capillaris* grows in rock crevices and around springs in glacial cirques. It prefers shallow soils on basic substrates such as limestone, porphyry and graphitic phyllite. It is a very rare species found in the Krkonoše Mts at elevations 1100–1300 m. Previously it also occurred in the Velká kotlina glacial cirque in the Hrubý Jeseník Mts, with the last record dating back to 1950. It is classified as a critically threatened species due to its rarity (Grulich 2012).

Carex ericetorum (Fig. 23)

Carex ericetorum occurs from the Pyrenees in northern Spain and England across central and northern Europe (here reaching beyond the Arctic Circle) as far as North Macedonia and Bulgaria. Towards the east, it extends across European Russia as far as central Siberia and northern Mongolia in Asia (Meusel et al. 1965, Egorova 1999). Slightly different plants from high elevations in the Alps and Carpathians, distinguished by narrower perigynia and a broad hyaline margin of the glumes, are sometimes (e.g. Bernátová & Kliment 2000) regarded as an independent species, *C. approximata*. However, these differences probably fall within the variation of *C. ericetorum* in its entire range. In the Czech Republic *C. ericetorum* occurs mainly in open-canopy thermophilous oak and pine forests, rarely in some types of dry grasslands. It prefers light soils on acidic crystalline bedrock, sandstone and sands. The species is rare throughout the Czech Republic, present at just a few isolated groups of localities. Some occurrences are situated in the lowlands and hills in central, northern and eastern Bohemia, especially along the Labe river and in the vicinity of the town of Doksy. Other occurrences are in the vicinity of Prague, in the Džbán hills north-west of the city, the surrounding of the town of Teplá, the city of Plzeň and the Třeboňská pánev basin in southern Bohemia. In Moravia *C. ericetorum* occurs on the eastern margin of the Bohemian Massif in south-western Moravia and near the town of Hodonín. It reaches its elevational maximum of ca 650 m near the town of Teplá in western Bohemia. *Carex ericetorum* is classified as endangered due to its rarity (Grulich 2012).

Carex fritschii (Fig. 24)

Carex fritschii is a European species with a rather small range confined to the foothills of the Alps and adjacent areas in France, Switzerland, Italy, Slovenia, Austria, Hungary, Slovakia and the Czech Republic (Schultze-Motel 1980, Koopman 2011). It prefers moderately warm and dry climates, and slightly acidic soils on sand or crystalline bedrock with thermophilous oak forests, especially in semi-shady habitats. In the Czech Republic *C. fritschii* is known from southern Moravia, where most occurrences are concentrated in the sandy areas of the Dúbrava forest near the town of Hodonín and the Boří les forest near the town of Břeclav. In addition, one population occurs on a sand hummock in a floodplain forest near the confluence of the Morava and Dyje rivers and one on granite bedrock near the town of Moravský Krumlov. The isolated occurrence in the valley of the Sázava river near the village of Sázava in central Bohemia was found only in 2013 (Grulich et al. 2017). *Carex fritschii* is classified as endangered due to its rarity (Grulich 2012); some of the populations suffer from contemporary forestry practices.

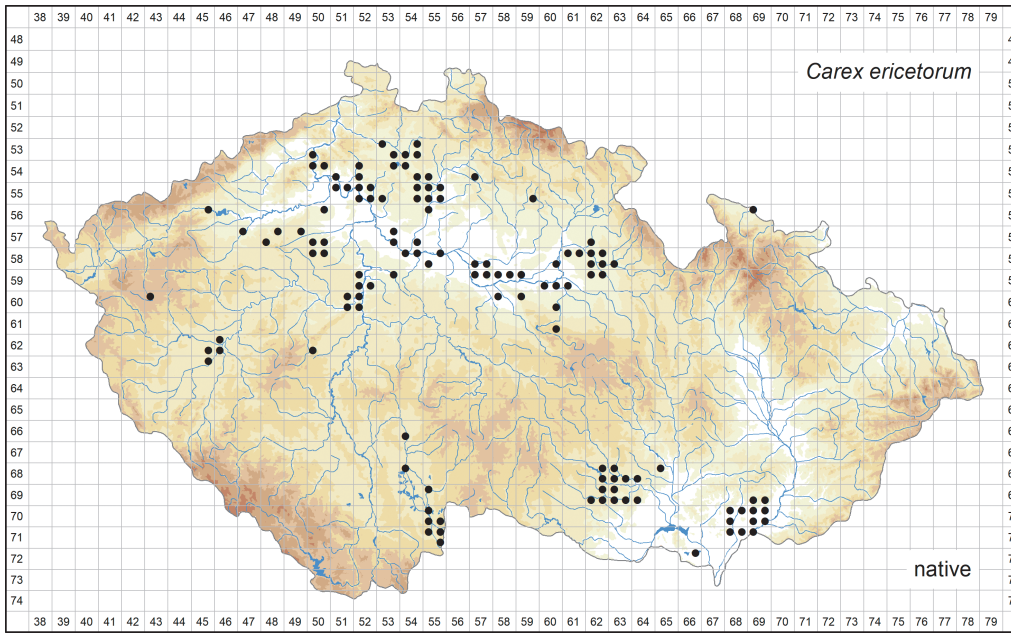

Fig. 23. Distribution of *Carex ericetorum* in the Czech Republic (124 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

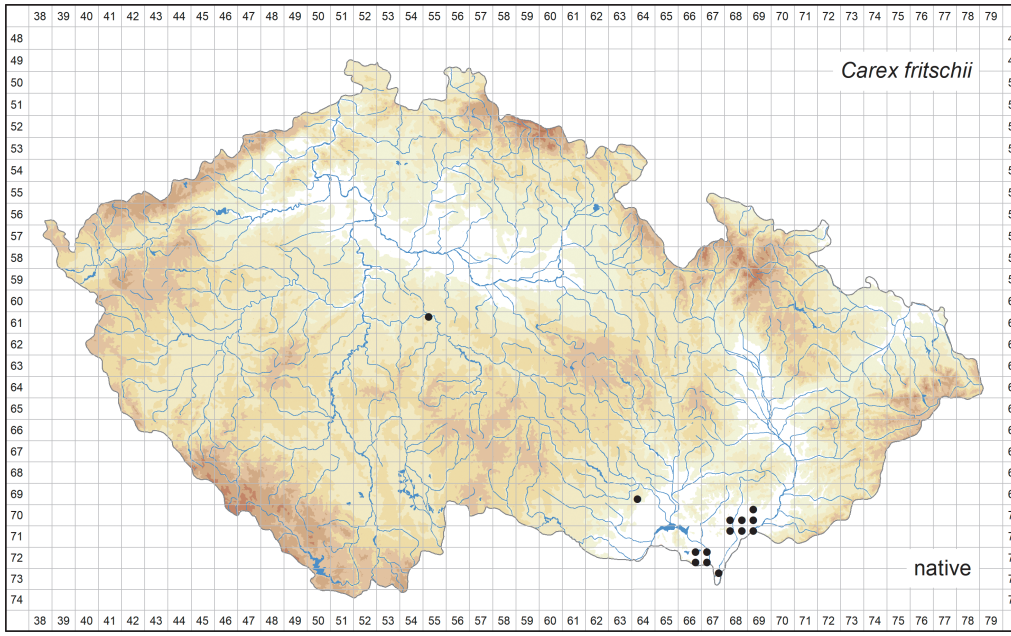

Fig. 24. Distribution of *Carex fritschii* in the Czech Republic (14 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

Carex grayi (Fig. 25)

Carex grayi is a morphologically distinct species of the section *Lupulinae*. It occurs in the eastern part of North America from the Canadian provinces of Ontario and Quebec in the north to the US state of Florida in the south, towards the west extending to Oklahoma and Kansas. It grows in mesic to wet places in deciduous forests, forest clearings, mostly on fine alluvial and lake sediments or in the littoral zone of rivers at elevations of 0–500 m (Reznicek 2002). In Europe *C. grayi* is cultivated as an ornamental plant. It has escaped in Austria (Tintner 2016), Belgium (Koopman 2011), Denmark (Koopman 2011) and the Netherlands (Koopman 2015). In the Czech Republic *C. grayi* rarely escapes and only a few individuals are usually found. The exception was the occurrence in the castle park in the town of Klášterec nad Ohří, where several dozen tussocks were observed. Aside from this occurrence, there are records from the vicinity of the cities of Prague, Pardubice, Brno and Olomouc. *Carex grayi* is classified as a casual neophyte (Pyšek et al. 2012).

Carex limosa (Fig. 26)

Carex limosa is a Holarctic species. Its distribution area includes northern Europe and Asia; in Europe it reaches southwards to the Pyrenees, Alps and mountains in the Balkan Peninsula. It occurs also in the Caucasus Mts and northern Anatolia (Hultén & Fries 1986, Egorova 1999). In North America it is found from Alaska in the west to Newfoundland in the east, extending southwards to Kansas (Ball 2002b). *Carex limosa* occurs in fens, mires and peat bogs. It prefers organic substrates with low or medium mineral content and acidic soil reaction; it is usually found in very wet conditions, such as bog hollows. In the Czech Republic *C. limosa* is found mainly in the mountains along the country's border, e.g. in the Šumava Mts, Krušné hory Mts, Jizerské hory Mts, Krkonoše Mts and Hrubý Jeseník Mts. It rarely occurs also at low elevations, e.g. near the town of Doksy, the city of Plzeň, in the basins in southern Bohemia and in the Českomoravská vrchovina highlands. Isolated populations once existed near the city of Pardubice in eastern Bohemia and near the town of Bzenec in southern Moravia. It reaches its elevational maximum at ca 1450 m in the Čertova louka peat bog in the Krkonoše Mts, whereas its former occurrence near the town of Bzenec was at ca 190 m a.s.l. Most occurrences at low elevations have been destroyed or are threatened. Therefore, this species is classified as endangered (Grulich 2012).

Carex magellanica subsp. *irrigua* (Fig. 27)

Carex magellanica is a species with a bipolar disjunction. It was described from South America, where subsp. *magellanica* grows in southern Chile and Argentina and on the Falkland Islands (Moore & Chater 1971). Subsp. *irrigua* is confined to Arctic and boreal Eurasia as well as North America. It is also found in the mountains of central and central-eastern Europe, including the Sudetes, Alps and Carpathians (Hultén & Fries 1986, Egorova 1999). In the Czech Republic *C. magellanica* grows on wet acidic organic substrates with a low content of minerals, preferring rather elevated positions in peat bogs (hummocks). It is a rare species in the Czech flora with two groups of localities: there are about 20 populations in the Krkonoše Mts and about 30 in the Šumava Mts. Formerly it also occurred in the peat bogs around Mt Klínovec in the Krušné hory Mts. Another specimen

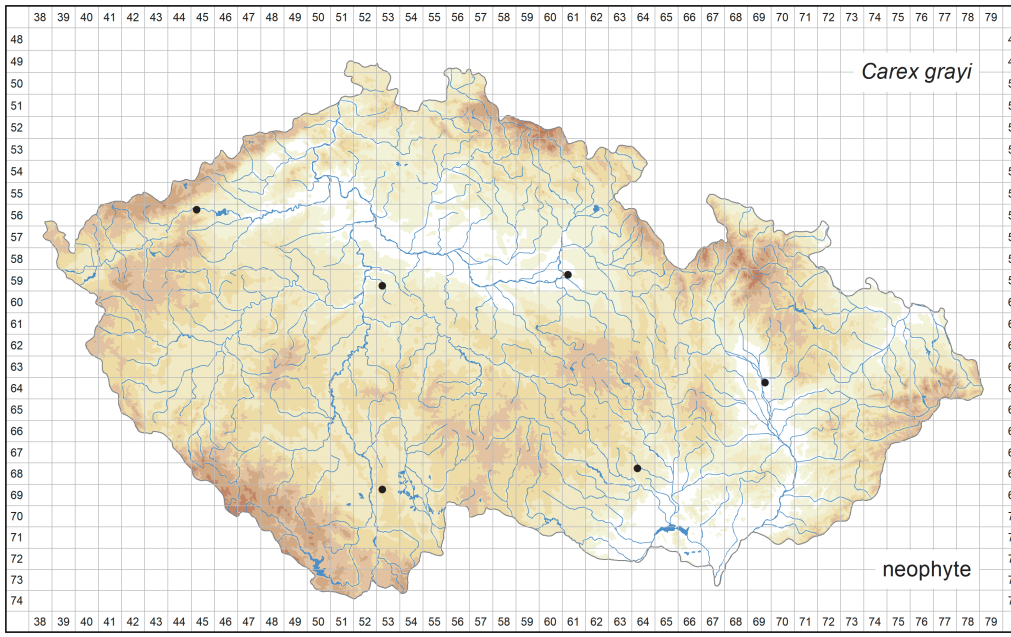

Fig. 25. Distribution of *Carex grayi* in the Czech Republic (6 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

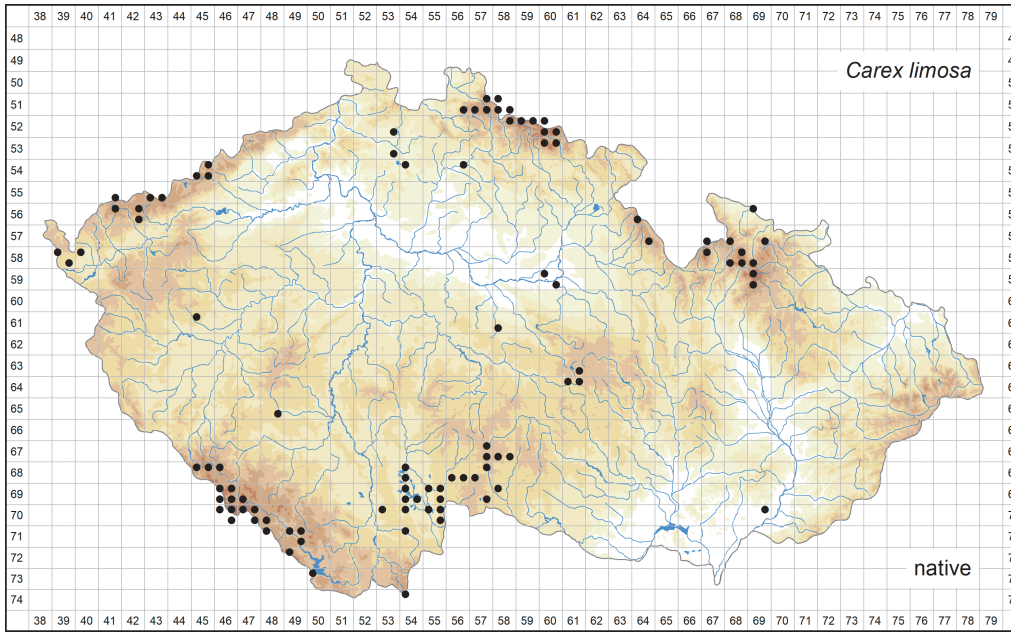

Fig. 26. Distribution of *Carex limosa* in the Czech Republic (99 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

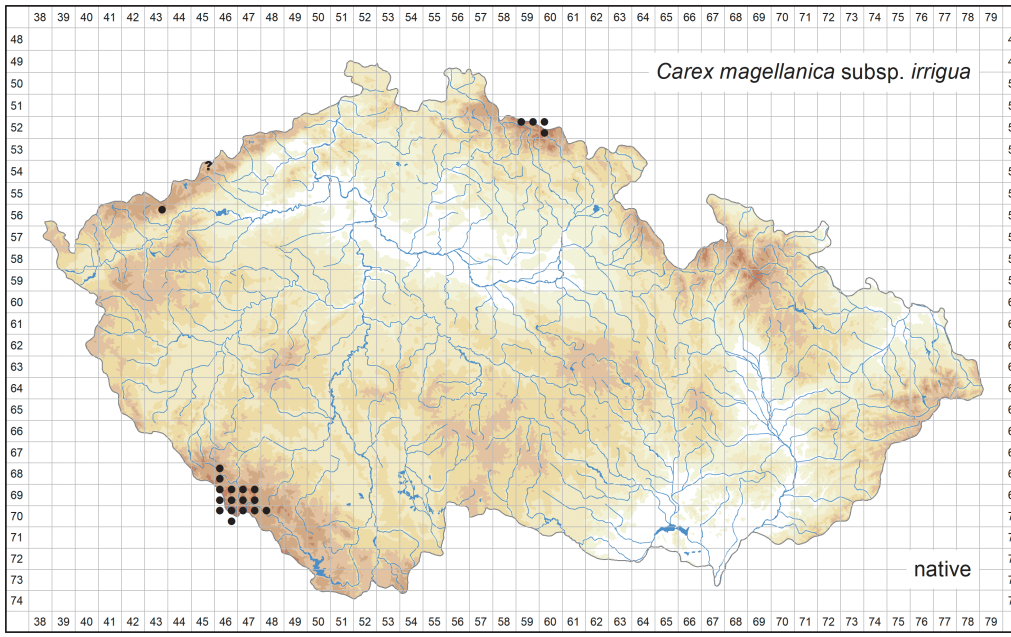

Fig. 27. Distribution of *Carex magellanica* subsp. *irrigua* in the Czech Republic (22 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

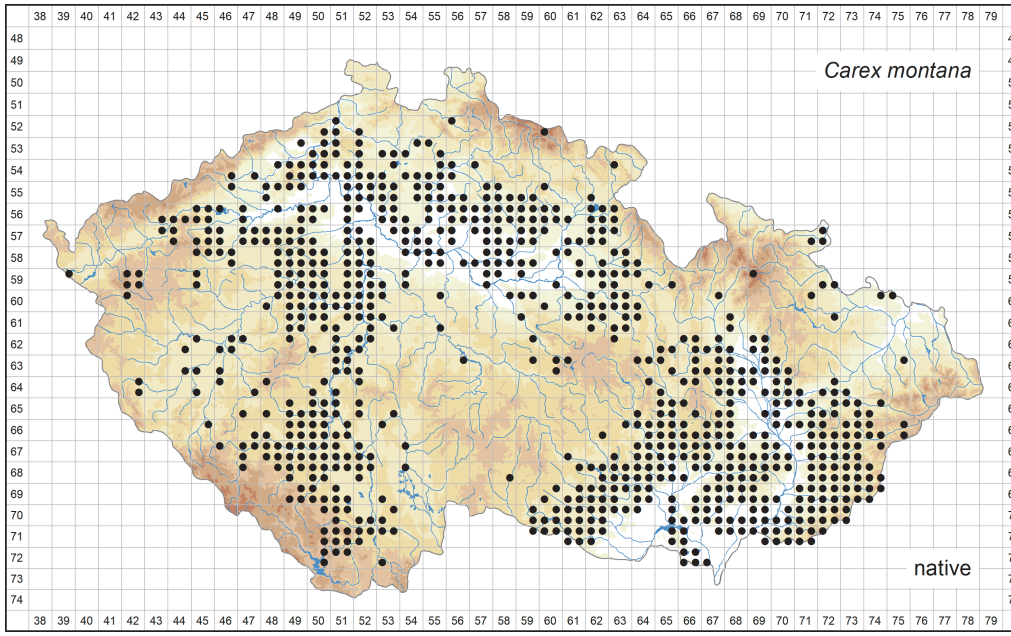

Fig. 28. Distribution of *Carex montana* in the Czech Republic (809 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

from that area, collected near the village of Načetín, is probably a hybrid with *C. limosa*. The Czech sites of this species are situated at elevations of 800–1400 m. Due to its rarity, *C. magellanica* subsp. *irrigua* is classified as endangered (Grulich 2012).

Carex montana (Fig. 28)

The distribution of *Carex montana* in Europe stretches from northern Spain to the Ural Mts in Russia, northwards to central Sweden and southern Finland and southwards to northern Italy and the Balkan Peninsula. Isolated occurrences are known from the northern foothills of the Caucasus and western Siberia (Meusel et al. 1965, Egorova 1999). In the Czech Republic *C. montana* occurs mainly in open-canopy thermophilous oak and pine forests and in broad-leaved dry grasslands. It prefers basic to moderately acidic, often rather heavy soils. Most of the occurrences lie in rather warm, dry parts in central, northern and eastern Bohemia, and in southern, central and eastern Moravia. It is also rather frequent in some parts of southern Bohemia and scattered to rare in western Bohemia, the central part of the Českomoravská vrchovina highlands and Silesia. It reaches its elevational maximum at ca 800 m near the village of Polná na Šumavě, but an isolated occurrence exists in the glacial cirque of Velká kotlina in the Hrubý Jeseník Mts at ca 1200 m.

Carex pallescens (Fig. 29)

Carex pallescens is an amphi-atlantic species. Its range encompasses almost all of Europe except most of the Iberian Peninsula and the southernmost parts of the Mediterranean area. The Asian part of its range includes Siberia as far as Lake Baikal; rather isolated occurrences are located in Kazakhstan and China, but the species avoids steppe areas. In addition, it is reported to occur in Tunisia, Turkey, Syria, Lebanon, the Caucasus Mts, Transcaucasia and northern Iran. The North American part of its range is located in the eastern part of southern Canada and the north-east of the USA. It has been introduced into New Zealand (Meusel et al. 1965, Ball 2002c). *Carex pallescens* has a wide ecological amplitude, growing in various forest and non-forest habitats from lowlands up to the subalpine belt on mesophilous and damp meadows and pastures, in peat bogs, heaths, alpine grasslands, deciduous and coniferous forests, usually on neutral to acidic soils. In the Czech Republic *C. pallescens* is scattered to common almost over the entire country, especially at medium and high elevations. It is relatively rare in or locally absent from deforested landscapes only in warm areas, e.g. in central and northern Bohemia and southern Moravia. Its absence may be due to long-term agricultural use, but also due to its intolerance to warm and dry climates. It reaches its elevational maximum at 1360 m in the Krkonoše Mts.

Carex pilulifera (Fig. 30)

Carex pilulifera is a European suboceanic species growing throughout Europe except its south-eastern part and the Mediterranean area. Isolated occurrences are in Iceland, northern Portugal, Corsica and the Balkan Peninsula. The continuous distribution reaches eastwards into the Baltic countries, Belarus and western Ukraine; in Russia the species is found around the cities of St. Petersburg and Moscow (Meusel et al. 1965, Hultén & Fries

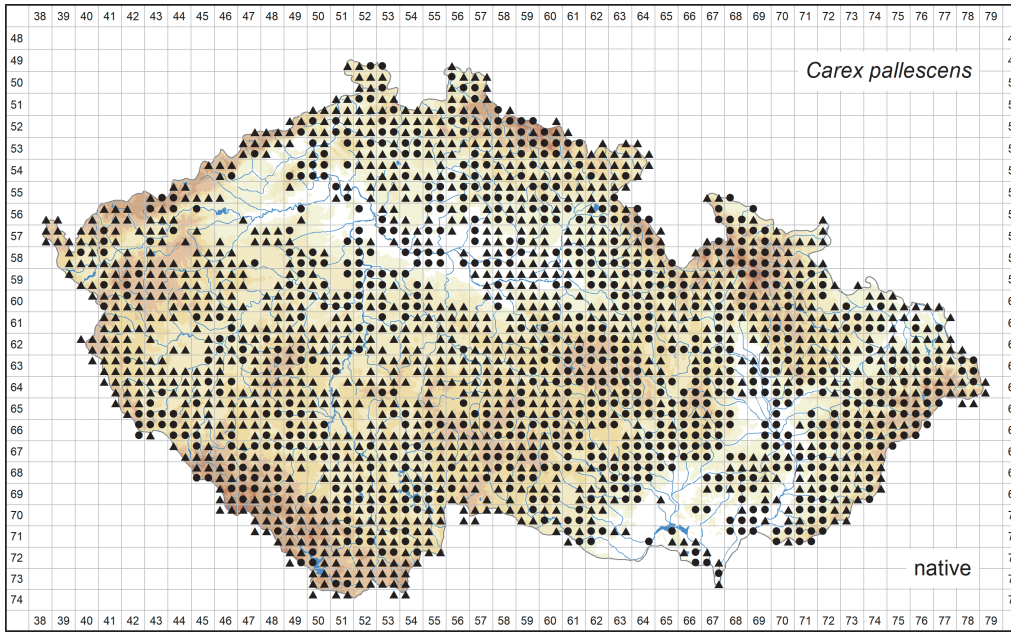

Fig. 29. Distribution of *Carex pallescens* in the Czech Republic: ● occurrence documented by herbarium specimens (779 quadrants), ▲ occurrence based on other records (1235 quadrants). Prepared by Vít Grulich & Radomír Řepka.

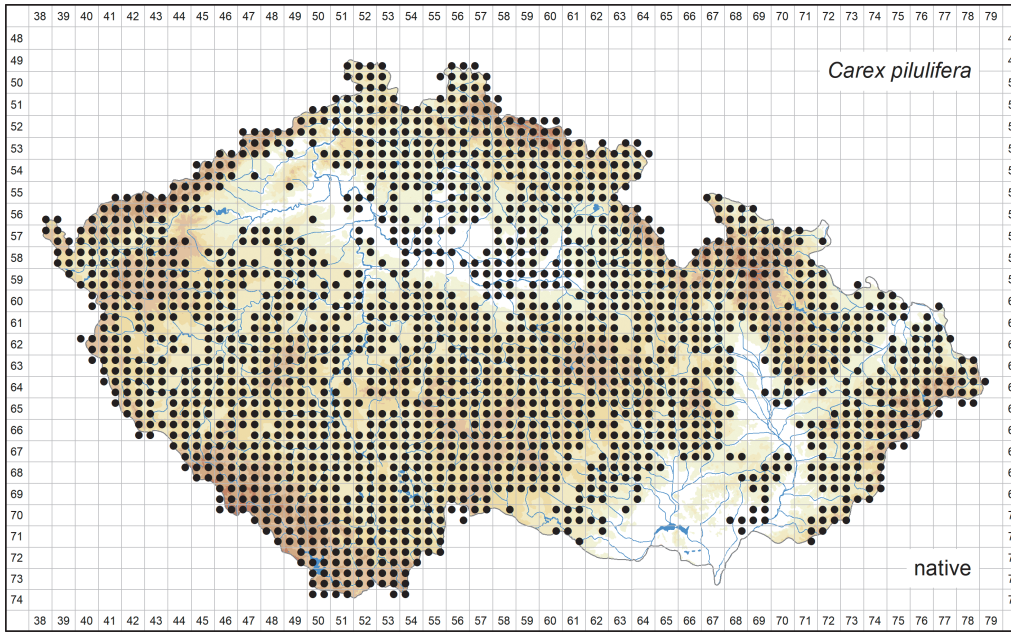

Fig. 30. Distribution of *Carex pilulifera* in the Czech Republic (1923 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

1986). In the Czech Republic *C. pilulifera* grows in dry meadows, pastures, margins of peat bogs, clearings and light to semi-shady deciduous and coniferous forests, including pine and spruce plantations. The substrates underlying the soil on which this species occur include acidic crystalline rock, slate, conglomerates, flysch, sand and peat. *Carex pilulifera* most often occurs on light soils with a strongly acidic reaction, in dry to humid places (more often on podzol soils), in open to semi-shady habitats. It is scattered to frequent from middle to high elevations in most of this country. In contrast, it is rather rare in the lowlands and absent from warm, dry and deforested areas with predominantly basic bedrock in northern and north-western Bohemia and in southern Moravia, especially in the area between the city of Brno and the towns of Znojmo and Hodonín, and in the western part of the Bílé Karpaty Mts. It is also absent from or rare in river basins with a high groundwater level and clayey sediments, i.e. the Ostravská pánev basin and the river floodplains in central and southern Moravia. *Carex pilulifera* reaches its elevational maximum at 1300 m in the Šumava Mts.

Carex tomentosa (Fig. 31)

Carex tomentosa is a Eurasian species widespread in Europe from north-eastern Spain in the west to the Ural Mts in the east. The northern limit of its distribution runs through central Sweden and Estonia; towards the south it extends into central Italy, central Greece and the European part of Turkey. In Asia, it occurs in a strip from the Ural Mts to the Altai Mts, with isolated occurrences in northern Kazakhstan, Buryatia and near Lake Baikal; in addition, it is found in the Caucasus Mts and Transcaucasia, north-eastern Turkey and northern Iran (Meusel et al. 1965, Egorova 1999). In the Czech Republic *C. tomentosa* grows in damp to intermittently wet meadows, dry grasslands, occasionally also in the understory of open-canopy forests, mainly on neutral to basic substrates such as calcareous sandstone, siltstone, claystone and loess. It is a good indicator of heavy, neutral to basic soils that are wet in spring but dry out in summer; they are usually well supplied with nutrients; *C. tomentosa* often grows with *C. flacca* at these sites. *Carex tomentosa* occurs mainly in warm areas in northern and eastern Bohemia on heavy calcareous soils developed on Cretaceous sediments and other calcareous rocks such as limestone and marl. In Moravia, it is common on Tertiary sediments (flysch) in its southern and eastern part, elsewhere being rare to absent. It occurs from the lowlands to the middle elevations, reaching its elevational maximum at 690 m on Mt Lesná in the Bílé Karpaty Mts.

Corydalis cava (Fig. 32)

Corydalis cava is mainly a European species, with a continuous range extending from eastern France in the west to European Russia in the east. It is absent from western Europe except for a few sites in the north of the Iberian Peninsula and in southern France, and from most of Scandinavia except for its southernmost part. In Asia it is restricted to Anatolia, the Caucasus and the Alborz Mts. The species is considered an alien in Belgium and the Netherlands (Hultén & Fries 1986, Verloove 2006, Lidén 2011). The species is divided into two subspecies: subsp. *cava* occurs in most of Europe, whereas subsp. *marschalliana* grows in southern and eastern Europe and in the Asian part of the species' range (Lidén 2011). *Corydalis cava* is a self-incompatible, myrmecochorous spring geophyte. In the Czech Republic it grows in various types of open-canopy deciduous

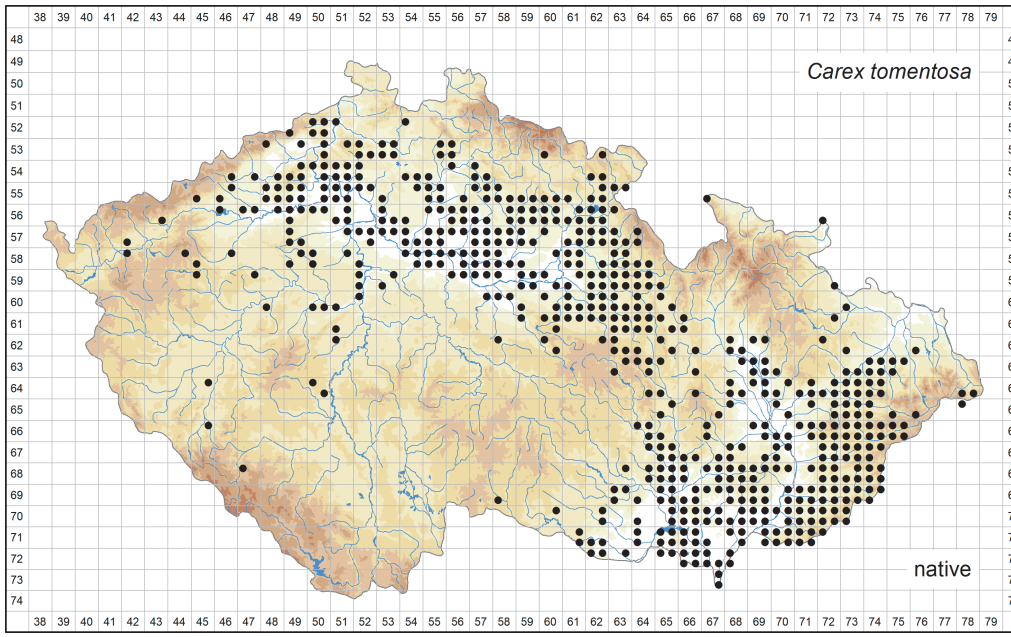

Fig. 31. Distribution of *Carex tomentosa* in the Czech Republic (601 occupied quadrants). Prepared by Vít Grulich & Radomír Řepka.

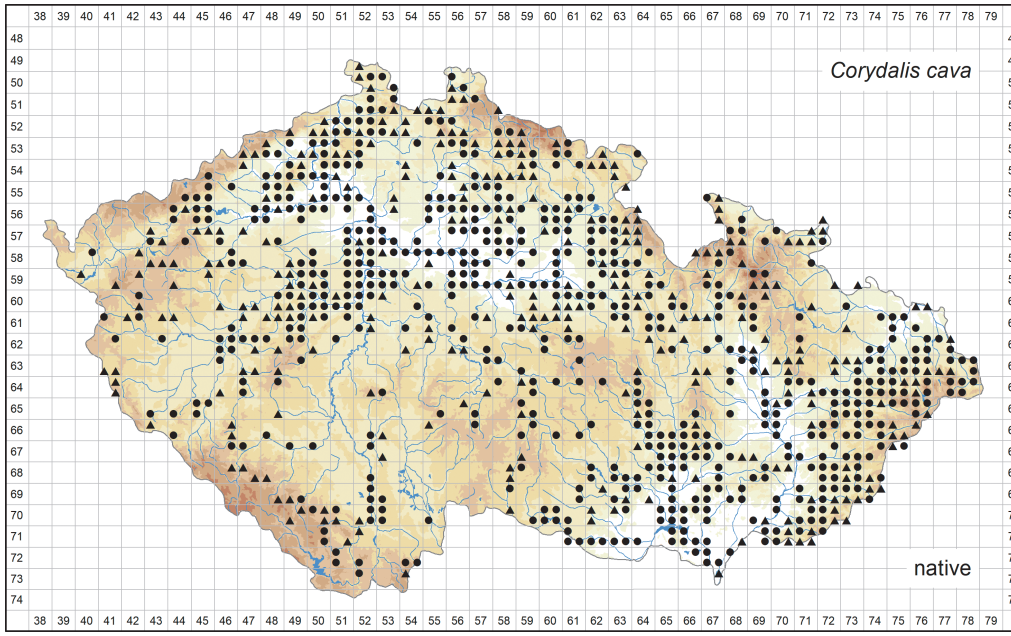

Fig. 32. Distribution of *Corydalis cava* in the Czech Republic: ● occurrence documented by herbarium specimens (602 quadrants), ▲ occurrence based on other records (313 quadrants). Prepared by Jan Prančl.

forests, such as floodplain, ravine, oak-hornbeam and beech forests, and shrub communities (especially that dominated by *Corylus avellana*), and it also often spreads spontaneously in parks and gardens. It prefers moderately dry to moist, loose soils rich in nutrients and humus. In this country *C. cava* occurs mainly in the lowlands and at middle elevations. It is relatively common in the northern half of Bohemia and in Moravia, whereas it is much less frequent in the areas with a predominance of hard acidic substrates such as western Bohemia and the Českomoravská vrchovina highlands. It rarely grows in the mountains, reaching its elevational maximum at 1200 m in the Velká kotlina glacial cirque in the Hrubý Jeseník Mts.

Corydalis cheilanthifolia (Fig. 33)

Corydalis cheilanthifolia is native to south-western and central China, where it grows in rocky gorges, on shaded slopes and in stone crevices, usually at elevations of 800–1700 m (Zhang et al. 2008). In Europe it was first recorded escaped in 1918 in Brussels, but this occurrence soon disappeared (Verloove 2006). It was not recorded again until 1981, when it was found escaped in Hampshire, England. Currently, it occurs throughout England, having been naturalized in the southern parts of the country (Stace 2010). In mainland Europe this species has been recently reported from a number of localities in the Netherlands and rarely from Belgium, France and the Czech Republic; it has also been introduced to the USA and New Zealand (Uher 2016, GBIF 2021, Sparrius 2021). In its secondary range *C. cheilanthifolia* most often grows in joints of walls, near the bases of tree trunks and along channels and roads where it has been introduced with stones and gravel. In the Czech Republic this species was for the first time found escaped in 2012 in the town of Boskovice in southern Moravia. In recent years it has been further recorded at several sites on the outskirts of the town of Břeclav in southernmost Moravia (2015) and in the town of Krupka in northern Bohemia (2021).

Corydalis intermedia (Fig. 34)

Corydalis intermedia grows mainly in central and northern Europe, whereas it is absent from the British Isles and only rarely occurs in western, southern and eastern parts of the continent. In Scandinavia this species extends beyond the Arctic Circle (Meusel et al. 1965, Hultén & Fries 1986, Lidén 2011). It is a predominantly self-pollinated spring geophyte with very short-lived above-ground organs. In the Czech Republic *C. intermedia* grows in a range of deciduous woodland habitats, including ravine, floodplain, oak-hornbeam and beech forests, various shrub communities and pioneer woods, parks and gardens. It prefers moderately dry to moist soils rich in nutrients and humus, but it also occurs on shallow, stony, nutrient-poor substrates (unlike *C. cava* and *C. solida*). The species is scattered over most of this country except for its easternmost parts, where it is very rare. The larger clusters of localities are situated in areas with frequent ravine and alluvial forests. It occurs mainly in lowlands and at middle elevations, being rare in mountains, reaching its elevational maximum at 1300 m in the Velká kotelní jáma glacial cirque in the Krkonoše Mts. *Corydalis intermedia* is classified as of lower risk – near threatened (Grulich 2012). Due to its inconspicuous appearance and short life cycle, it may be easily overlooked, and its actual distribution is probably somewhat wider than shown on the map.

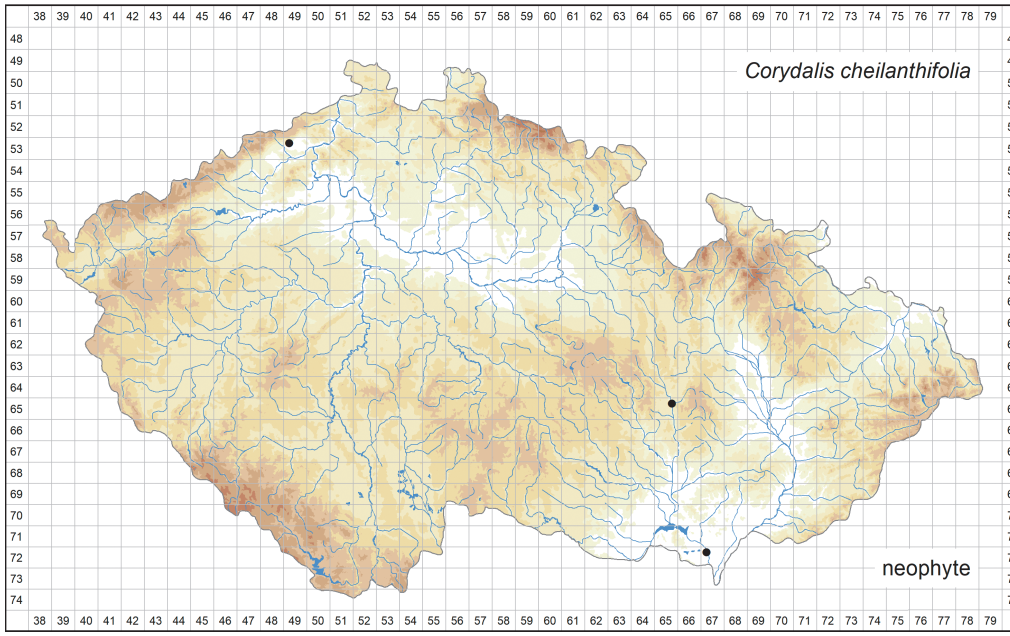

Fig. 33. Distribution of *Corydalis cheilanthifolia* in the Czech Republic (3 occupied quadrants). Prepared by Jan Prančl.

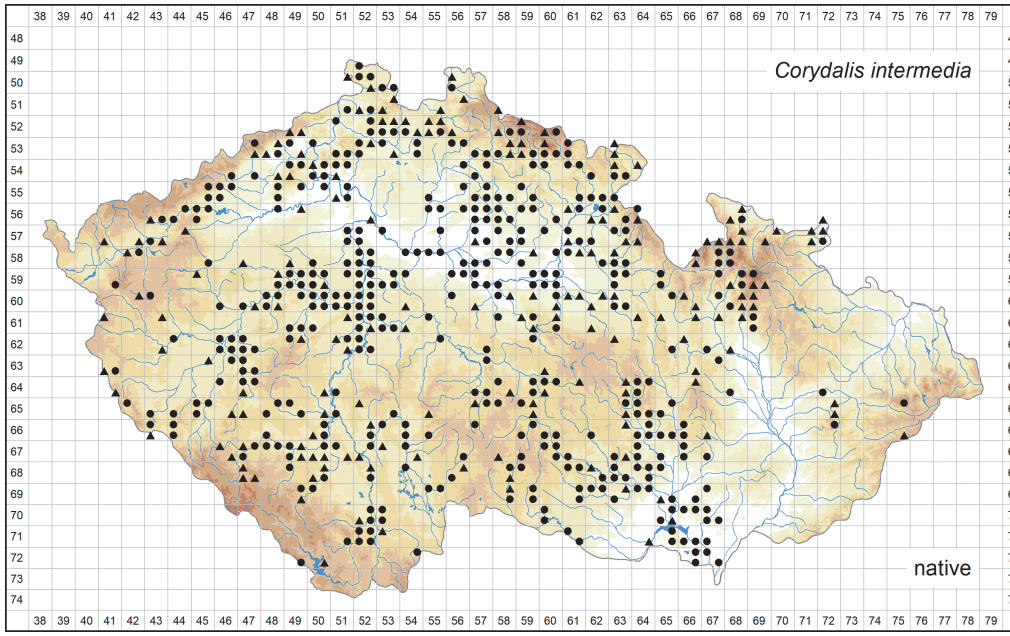

Fig. 34. Distribution of *Corydalis intermedia* in the Czech Republic: ● occurrence documented by herbarium specimens (411 quadrants), ▲ occurrence based on other records (187 quadrants). Prepared by Jan Prančl.

Corydalis pumila (Fig. 35)

Corydalis pumila is a European species. It shows a more or less meridional distribution extending from the southern Scandinavia in the north as far as Corsica, Sicily, Italy and Greece in the south, being absent from western and eastern Europe except for a few outposts in Romania and Ukraine (Stolle 2004, Lidén 2011). Its distribution is scattered and disjunct; it probably occurs only in warm, dry regions with moderate precipitation during summer and without humid conditions during winter (Stolle 2004). The species is a predominantly self-pollinated, myrmecochorous spring geophyte. In the Czech Republic *C. pumila* grows mainly in open-canopy oak and oak-hornbeam thermophilous forests, but also in the plantations of *Robinia pseudoacacia* and *Acer platanoides* that replaced them as well as in park woods. It occurs on moderately dry soils rich in humus and nutrients (but not hypertrophic), on both acidic and basic substrates. The species does not tolerate even occasional flooding; it is therefore rare in floodplain forests, where it grows only on raised, rather dry sites. Despite its occasional presence in secondary habitats, it probably represents a more or less relict, ancient forest plant species, occurring exclusively or predominantly in areas where forest has never been converted to arable land (Prančl 2021). *Corydalis pumila* is an uncommon species, confined to the warmest, driest parts of this country, including north-western and central Bohemia and southern Moravia, with the highest number of sites being situated in southernmost Moravia. Its occurrence at a single locality in central Moravia has been destroyed. The species is surprisingly rare in or absent from some areas that are rich in thermophilic flora, such as the České středohoří Mts, the Džbán hills, the Křivoklátsko area and the Český kras karst area. It is classified as vulnerable (Grulich 2012), being threatened by forestry practices that cause soil erosion and lead to dense and shady undergrowth, as well as by spread of early-growing neophytes such as *Allium paradoxum* and *Smyrnium perfoliatum*. *Corydalis pumila* is a somewhat neglected species, often being overlooked or confused with *C. solida*; therefore, its actual distribution may be somewhat wider than shown on the map.

Corydalis solida (Fig. 36)

The native distribution of *Corydalis solida* includes most of Europe except the British Isles, northern half of Scandinavia and the driest parts of the Mediterranean area. It has also been recorded from northernmost Africa, Anatolia, the Caucasus Mts and southwestern and southern Siberia (Hultén & Fries 1986, Lidén 2011). The species is variable and taxonomically complex, being divided into several subspecies, of which only subsp. *solida* occurs in central Europe. Also, a number of garden cultivars obtained by crossing plants from different parts of the species' range are frequently cultivated. These plants often escape from cultivation (especially from garden waste) or are deliberately planted in the countryside; this has led to this species occurring as an alien in Norway and Great Britain (Stace 2010, Lidén 2011). *Corydalis solida* is a self-incompatible, myrmecochorous spring geophyte. In the Czech Republic it grows in various communities of open-canopy deciduous woodlands, including ravine, floodplain, oak-hornbeam and beech forests, shrub communities, parks and stream banks; it is particularly abundant on the slopes of deep river valleys and old river terraces. It prefers moderately dry to moist, loose soils rich in nutrients and humus. The species is relatively common throughout the eastern part of this country; however, it is absent from southernmost Moravia. The

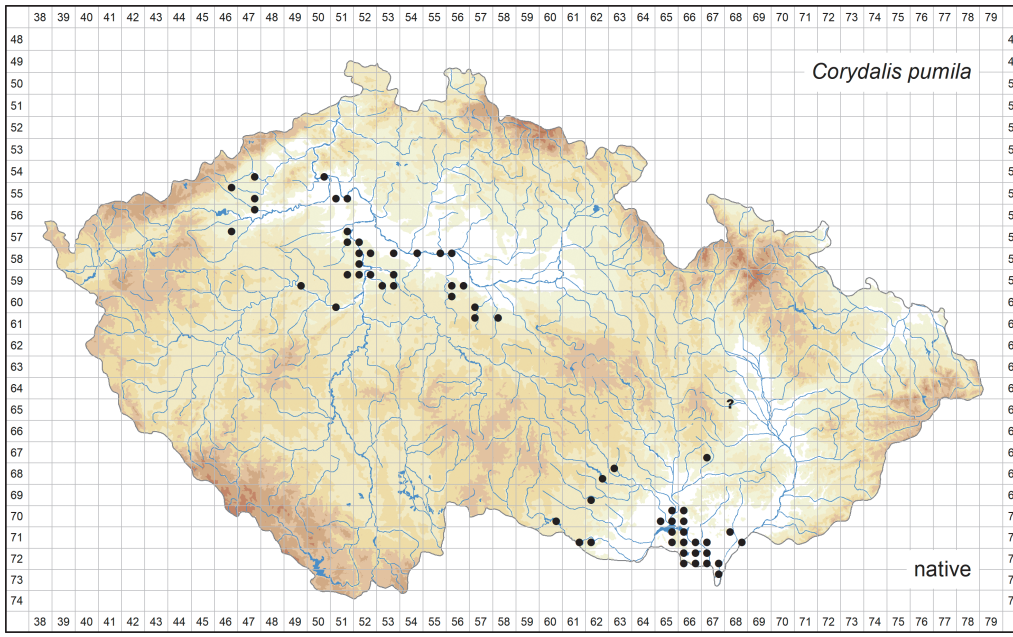

Fig. 35. Distribution of *Corydalis pumila* in the Czech Republic (60 occupied quadrants). Prepared by Jan Prančl.

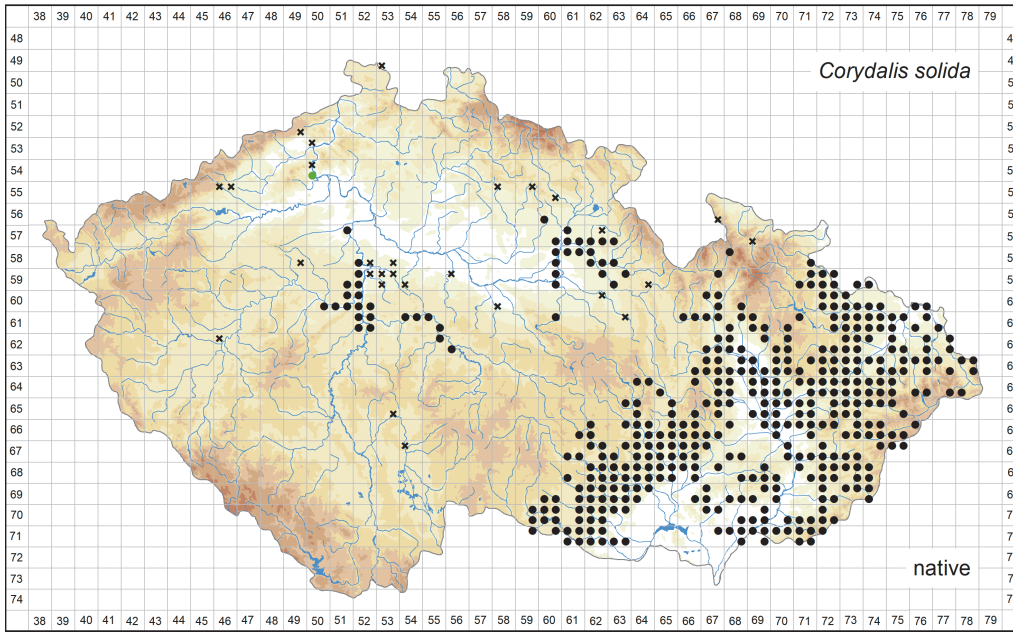

Fig. 36. Distribution of *Corydalis solida* in the Czech Republic (● native: 418 quadrants, × alien: 28 quadrants) and the hybrid swarm of *C. pumila* × *C. solida* (*C.* ×*laxa*; ● , 1 quadrant) on Lovoš hill in the České Středohoří Mts. Prepared by Jan Prančl.

current distribution in Moravia may be connected with the postglacial spread of *Fagus sylvatica* (Grulich 1985). In Bohemia *C. solida* is restricted to two isolated outposts: the first includes the Sázava river valley and the adjacent parts of the Vltava and Berounka river valleys in central Bohemia; the second is situated in the floodplain of the Orlice river and adjacent parts of Labe river floodplain and Chrudimka river valley in eastern Bohemia. It mostly occurs at low and middle elevations, and only rarely grows in the mountains, reaching its elevational maximum at 1020 m in the Beskydy Mts. In the Czech Republic *C. solida* is almost completely a vicariant of *C. pumila*. Recently, a hybrid swarm of *C. pumila* × *C. solida* (*C.* ×*laxa*) has been recognized on the top of Lovoš hill in the České středohoří Mts in northern Bohemia. This population may be related to the indigenous occurrence of *C. solida* in Saxony (Hardtke & Ihl 2000). In recent years, the species has also been repeatedly found escaped from cultivation, especially in parks and forests adjacent to garden allotments and graveyards. Such plants are often morphologically different from the indigenous central-European populations, being markedly tufted and possessing flowers of various colours. *Corydalis solida* is classified as of lower risk – near threatened (Grulich 2012).

Echinocystis lobata (Fig. 37)

Echinocystis lobata is native to temperate regions of eastern and central North America, occurring widely mainly in the area of Great Lakes. It is a climbing, monoecious annual, in its native range growing on riverine and lacustrine banks, and in thickets and edges of floodplain forests. It is cultivated as an ornamental species and has become naturalized in the western part of North America and in a large part of Eurasia, with its first escape in Europe recorded in 1904 in southern Transylvania, Romania. In Eurasia this species' range now extends from France in the west throughout Europe and southern Siberia to the Russian Far East (Slavík & Lhotská 1967, Lambdon et al. 2008, Vinogradova et al. 2018). *Echinocystis lobata* is currently widespread in most of central Europe and temperate areas of eastern Europe, but is absent from the western part of the continent and extends only marginally into Scandinavia and the Mediterranean area (Lambdon et al. 2008, Henning et al. 2017). In the Czech Republic *E. lobata* mostly occurs in tall herbaceous, nutrient demanding vegetation in regularly flooded habitats on the banks of rivers and streams and alluvial pools, especially in floodplains of large lowland rivers. Less often it is also found around fishponds, in landfills and ruderal places in settlements. In this country cultivation of *E. lobata* has been documented since 1869. The date of the first escape outside gardens is not entirely clear. The first unequivocal case of spontaneous occurrence in the countryside dates back to 1941, when it was found near the village of Říčky, north-west of the town of Ústí nad Orlicí in eastern Bohemia. In Moravia the earliest herbarium specimen dates back to 1930, but it cannot be ruled out that these were plants from cultivation; escaped plants were documented for the first time in 1946 in the town of Hodonín in southern Moravia. The species began to spread rapidly in the 1990s, when it became widespread along many rivers. The spread of *E. lobata* in river corridors is facilitated by floods and probably also by river regulation (Šumberová 2009). On the other hand, floods in the first half of the growing season can also eliminate its seedlings (Kabátová et al. 2014). *Echinocystis lobata* is classified as an invasive neophyte (Pyšek et al. 2012). The distribution map includes only clear cases of escapes. Despite its striking

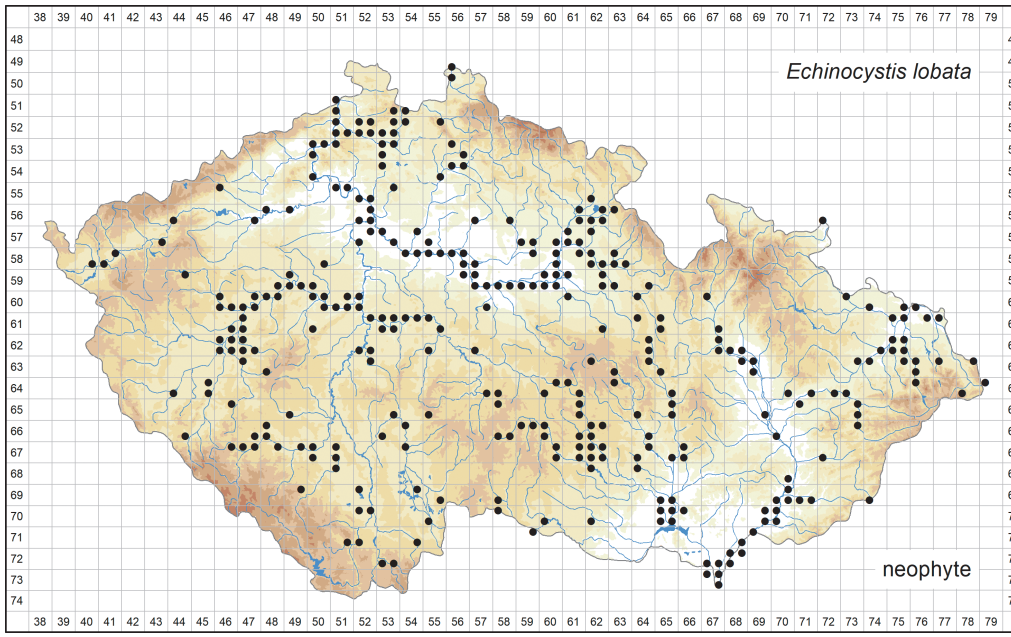

Fig. 37. Distribution of *Echinocystis lobata* in the Czech Republic (323 occupied quadrants). Prepared by Jan Prančl.

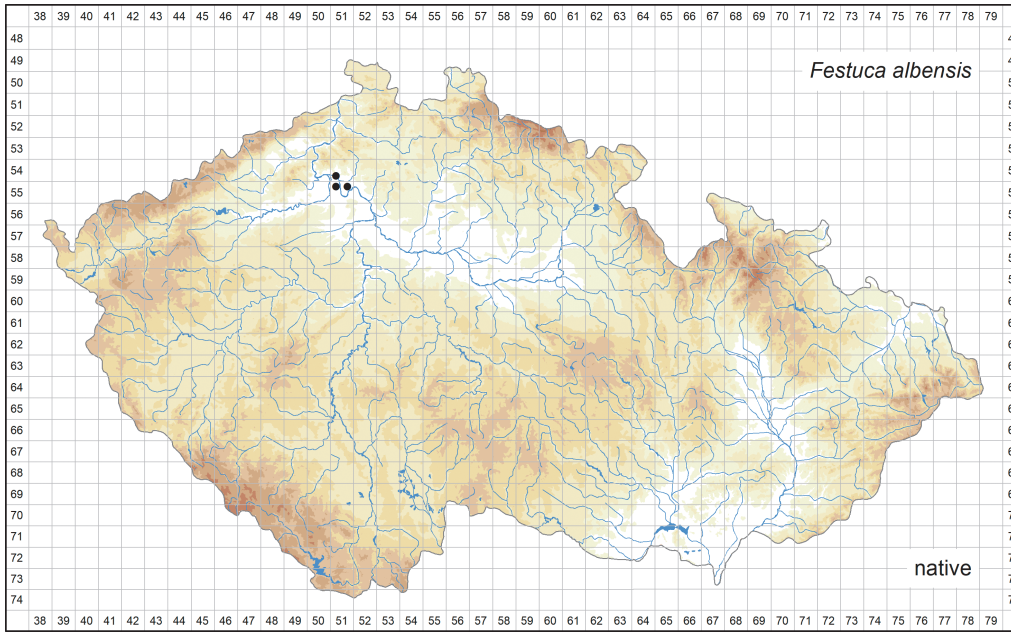

Fig. 38. Distribution of *Festuca albensis* in the Czech Republic (3 occupied quadrants). Prepared by Vít Grulich & Petr Šmarda.

appearance, this species is poorly recorded and collected, as it grows mainly in hard-to-reach tall coastal vegetation, and the map is thus incomplete.

Festuca albensis (Fig. 38)

Festuca albensis is a central-European tetraploid species that has only recently been described from sands along the Labe rive near the village of Oleško in northern Bohemia (Toman 2008). It occurs also in two sandy areas in Germany: the central Rhine river valley between the cities of Mannheim and Mainz, and the Main river valley near the village of Volkach near the city of Würzburg, from where it was later redescribed as *F. tomanii* (Korneck & Gregor 2015). *Festuca albensis* grows on acidic to slightly basic sands in open-canopy pine forests, their margins and surrounding secondary sandy grasslands. In the Czech Republic it is known only from a small sandy area between the villages of Travčice, Hrdly, Oleško, Libotenice and Nunčičky in northern Bohemia. There it tends to hybridize with the co-occuring *F. ovina*, and these hybrids likely prevail at some sites (Toman 2008, Šmarda 2017). Due to its local distribution, the threat by hybridization and habitat eutrophication, we recommend classifying it as critically threatened (Šmarda 2017). The distribution map is based only on examined herbarium specimens, whereas apparent or potential hybrid plants were excluded.

Festuca altissima (Fig. 39)

The distribution of *F. altissima* in Europe stretches from northern Spain and the British Isles to the Ural Mts in Russia, northwards to Norway and central Sweden and southwards to southern Italy and the Balkan Peninsula. Isolated occurrences are known from the Caucasus Mts, north-eastern Anatolia, north-western Iran and the Altai Mts in western Siberia (Meusel et al. 1965, Hultén & Fries 1986). In the Czech Republic *F. altissima* occurs in beech and fir forests. It prefers shady and semi-shady places with neutral to acidic soils, found preferably in areas with oceanic climates. The majority of localities in this country are in the upper hilly landscapes and in the mountains, but this species is rather rare in some parts of western and southern Bohemia, the southern part of the Českomoravská vrchovina highlands and the Bílé Karpaty Mts. It is absent from warm, dry parts of central and northern Bohemia and southern and central Moravia. It reaches its elevational maximum at about 1220 m near the village of Horní Planá in the Šumava Mts.

Festuca drymeja (Fig. 40)

Festuca drymeja is distributed mainly in the Balkan Peninsula and the south-eastern part of central Europe; its north-western distribution limit passes through Austria and the Czech Republic (Meusel et al. 1965, Conert 1998b). Populations from southern Italy and Sicily are distinguished as *F. exaltata* or as *F. drymeja* subsp. *exaltata*. In the Czech Republic *F. drymeja* occurs mainly on screes in shady beech and oak-hornbeam forests on neutral to slightly acidic soils. There are only three isolated localities known in this country, situated in its eastern part. This species was first collected in 1950 in the Hostýnské vrchy Mts. The other two populations were found in the surroundings of the city of Brno (Řepka 1987, 1997). The three known sites are at elevations of 260–500 m. *Festuca drymeja* is listed as critically threatened due to its rarity (Grulich 2012).

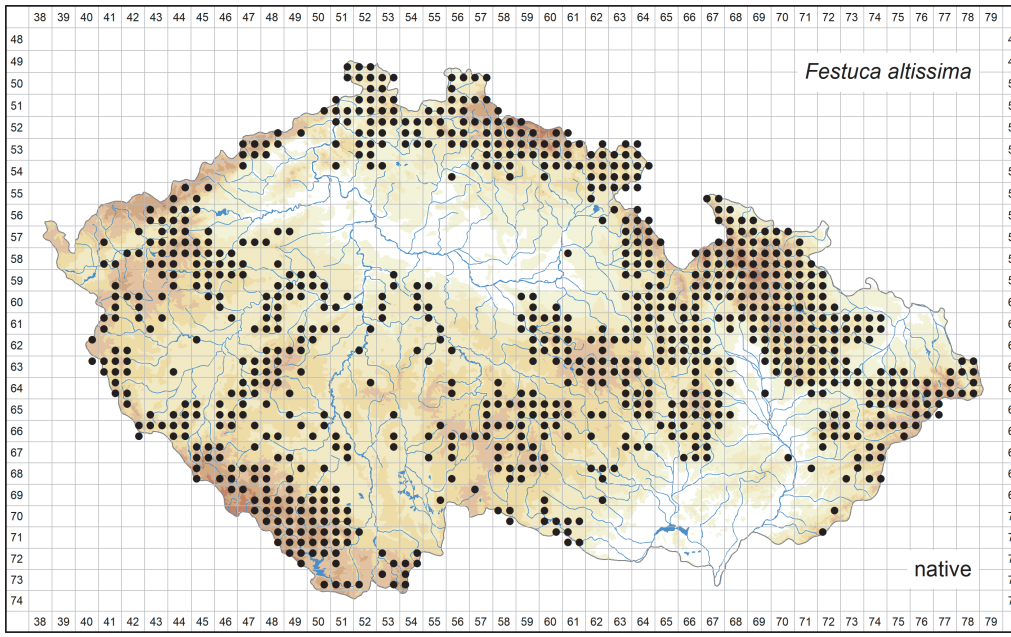

Fig. 39. Distribution of *Festuca altissima* in the Czech Republic (895 occupied quadrants). Prepared by Vít Grulich & Petr Šmarda.

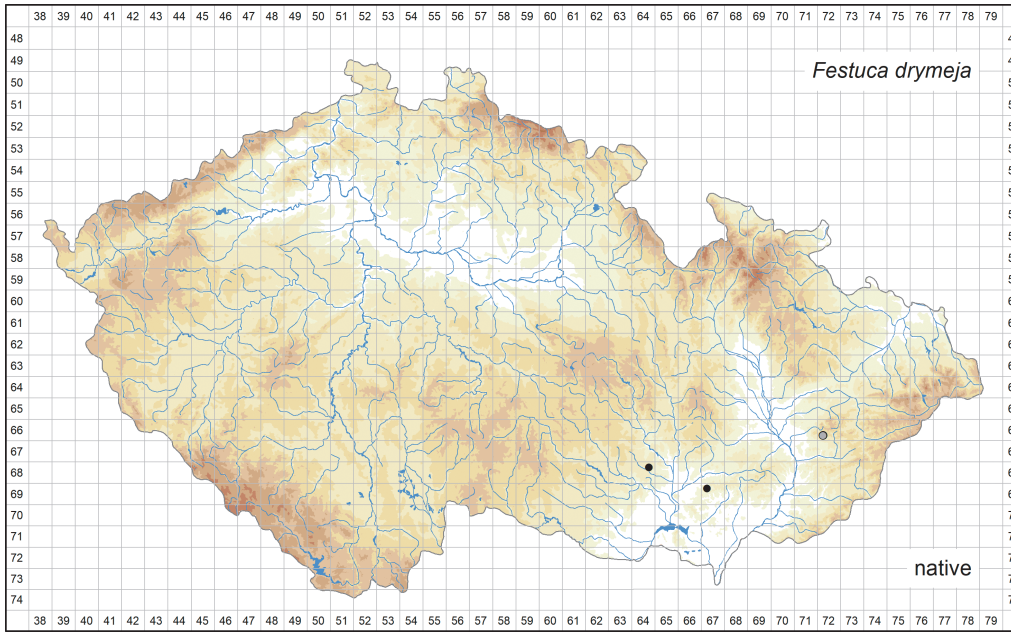

Fig. 40. Distribution of *Festuca drymeja* in the Czech Republic: ● at least one record in 2000–2021 (2 quadrants), ● pre 2000 records only (1 quadrant). Prepared by Vít Grulich & Petr Šmarda.

Festuca pallens s. l. (Figs 41–43)

The taxonomy of this species complex was discussed by Šmarda et al. (2007). Individuals of the diploid *Festuca pallens* are sometimes difficult to distinguish morphologically from its tetraploid relative *F. csikhegyensis*. Hence the maps of these two species are based only on the records supported by chromosome counting or flow cytometry, and on unequivocal herbarium specimens. The records used for these maps as well as all other herbarium specimens and reliable literature and database records were summarized to produce a map for the entire group here designated as *F. pallens* s. l. (Fig. 41).

Festuca csikhegyensis is a central-European tetraploid relative of *F. pallens* s. str., which is distributed from Alsace in France to northern Hungary (Šmarda et al. 2007). This species was divided into several forms with parapatric distribution (Tracey 1980). However, distinguishing these forms based on morphological grounds is problematic and mostly impossible (Šmarda et al. 2007). In the Czech Republic *F. csikhegyensis* grows in sparse, sun-exposed vegetation, mostly in primary open habitats on various types of acidic to base-rich rocks (granite, gneiss, basalt, phonolite, limestone and serpentinite), very rarely also on sand. Most of the occurrences are in central, western and northern Bohemia, mainly in the valleys of the Ohře, Berounka, Sázava and Vltava rivers and in the České středohoří Mts. Another cluster of localities is found in western and southern Moravia, mainly in the valleys of the Dyje and Jihlava rivers as well as in the Pavlovské vrchy hills. In contrast, *F. csikhegyensis* is very rare in southern and eastern Bohemia, and absent from the Českomoravská vrchovina highlands and from most of central, northern and eastern Moravia (Fig. 42). It reaches its elevational maximum at about 550 m in the Pavlovské vrchy hills. The species is probably allotetraploid, and plants or local populations corresponding morphologically to *F. csikhegyensis* are perhaps recurrently produced. These new individuals or local populations are included in the map, as it is practically impossible to distinguish them from established populations of *F. csikhegyensis* based on morphology and without knowledge of the population context.

Festuca pallens is a central-European diploid species, which is distributed from Belgium and north-eastern France northwards to southern Poland and north-western Ukraine, and southwards to Switzerland, Slovenia and Romania (Šmarda et al. 2007). In the Czech Republic it grows on rock outcrops without a clear substrate preference (e.g. on limestone, serpentinite, granite, basalt, phonolite and gneiss, very rarely on sandstone), in sunny places and sparse vegetation, usually in primary open habitats. It occurs mainly in river valleys in central, western and southern Bohemia, and in western and central Moravia, as well as in hilly landscapes with abundant exposed rock surfaces, such as the České středohoří Mts. Elsewhere, especially in areas with predominantly soft bedrock, such as in eastern Bohemia, northern Moravia and Silesia, it is very rare (Fig. 43). *Festuca pallens* occurs at low and middle elevations, with the maximum at about 700 m in the valley of the Otava river in the Šumava Mts. It is classified as of lower risk – near threatened (Grulich 2012).

Festuca psammophila subsp. *dominii* (Fig. 44)

Festuca psammophila subsp. *dominii* is a diploid taxon and an eastern and south-eastern vicariant of subsp. *psammophila*. It is distributed on sands along the lower stretches of the Morava river in south-eastern Moravia, south-western Slovakia (namely the Záhorská

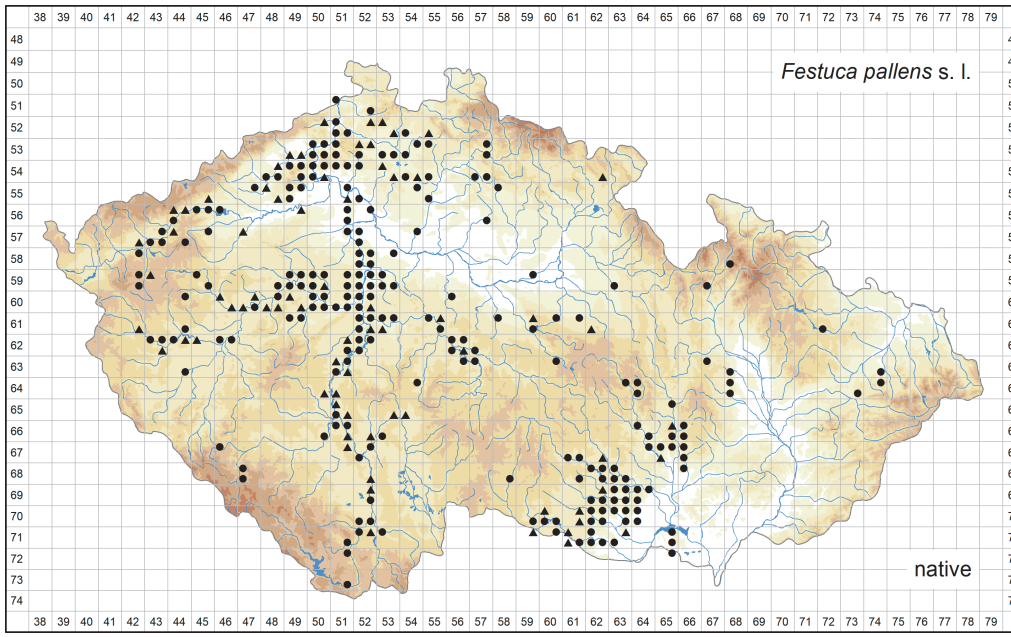

Fig. 41. Distribution of *Festuca pallens* s. l. in the Czech Republic: ● occurrence documented by herbarium specimens (221 quadrants), ▲ occurrence based on other records (72 quadrants). Prepared by Vít Grulich & Petr Šmarda.

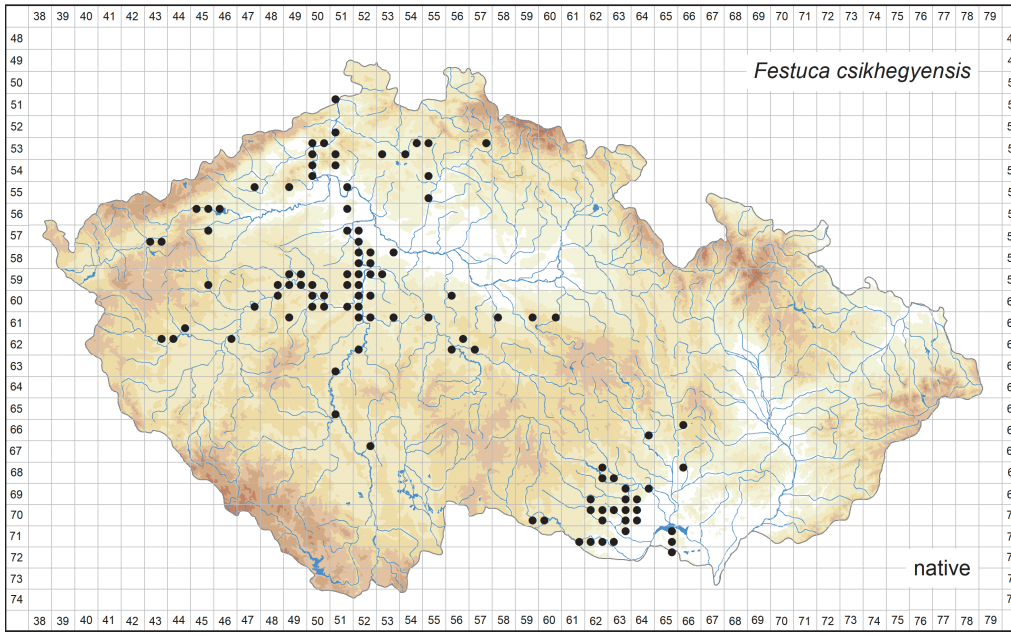

Fig. 42. Distribution of *Festuca csikhegyensis* in the Czech Republic (106 occupied quadrants). Prepared by Vít Grulich & Petr Šmarda.

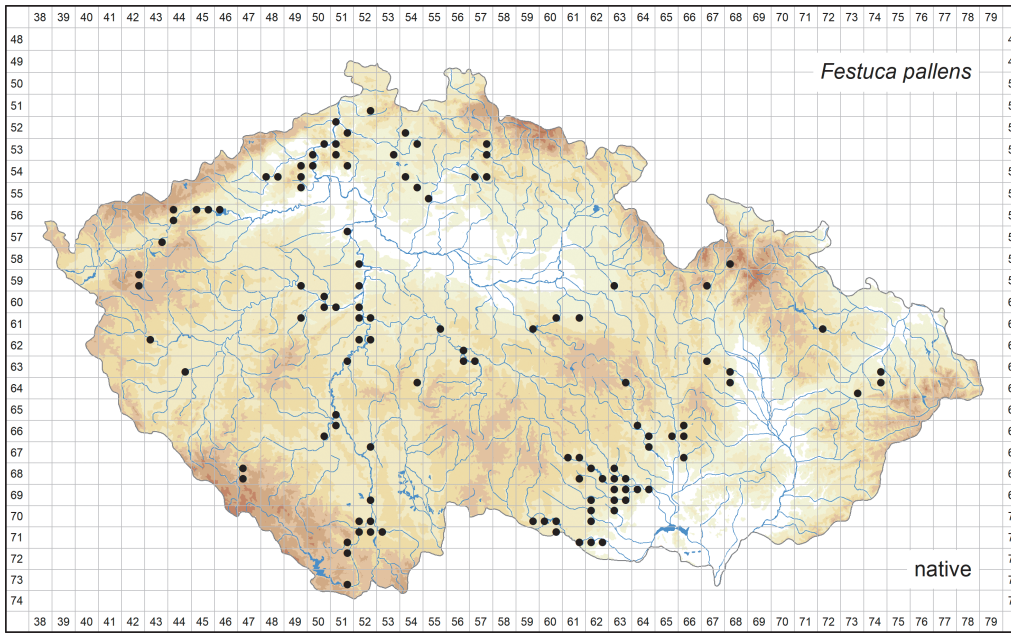

Fig. 43. Distribution of *Festuca pallens* in the Czech Republic (114 occupied quadrants). Prepared by Vít Grulich & Petr Šmarda.

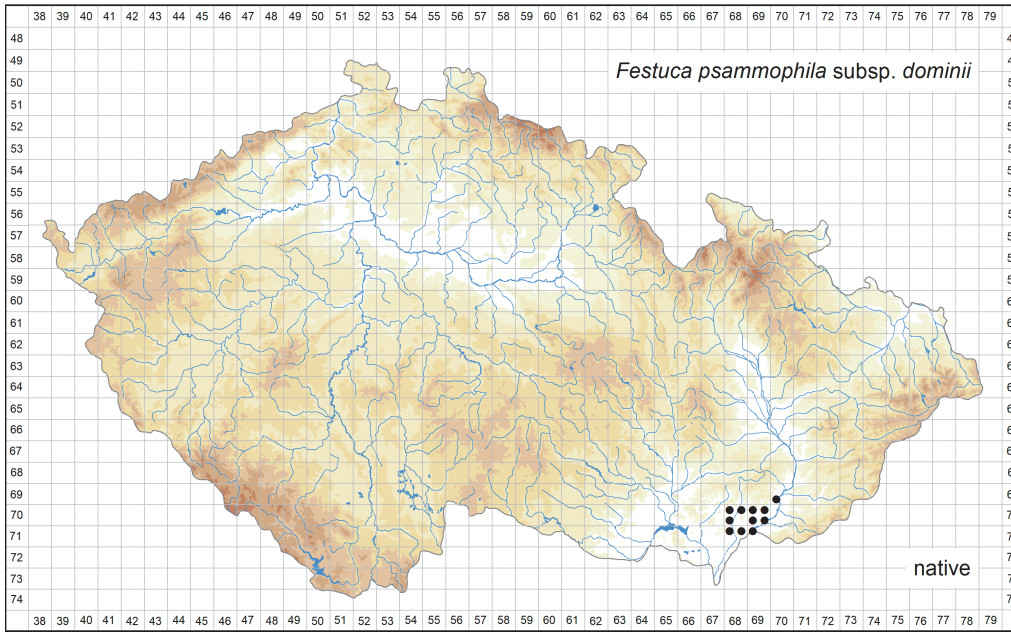

Fig. 44. Distribution of *Festuca psammophila* subsp. *dominii* in the Czech Republic (11 occupied quadrants). Prepared by Vít Grulich & Petr Šmarda.

nížina basin) and north-western Austria (the Marchfeld lowland). Some localities are also known from south-eastern Poland, where the taxon tends to form transitions to subsp. *psammophila* (Šmarda et al. 2007). In the Czech Republic *F. psammophila* subsp. *dominii* grows on acidic sands in open-canopy pine forests and sparse sandy grasslands. Moravian localities are scattered throughout the large sandy area in the Dúbrava forest between the towns of Hodonín, Kyjov and Bzenec in the basin of the Morava river, at elevations of about 200 m. Due to its local distribution, *F. psammophila* subsp. *dominii* is classified as critically threatened (Grulich 2012). The distribution map is based only on examined herbarium specimens.

Festuca psammophila subsp. *psammophila* (Fig. 45)

Festuca psammophila subsp. *psammophila* is a diploid taxon with a relatively small, central-European distribution, comprising central and northern parts of Germany, Poland, Lithuania and the Czech Republic (Šmarda et al. 2007). It occurs only on acidic sands in open-canopy pine forests, their margins and sparse sand grasslands. In the Czech Republic it is distributed in the Labe river basin, specifically between the towns of Roudnice nad Labem, Týnec nad Labem and Chlumec nad Cidlinou in central Bohemia. An isolated group of populations is known from sandstones near the town of Bělá pod Bezdězem (Klika 1933, Toman 1990). Many populations have already disappeared, while those extant are endangered by eutrophication and succession. Consequently, *F. psammophila* subsp. *psammophila* is critically threatened (Grulich 2012). Because of frequent confusion with other glaucous grass species occurring in sandy habitats, such as *Festuca brevipila*, *F. ovina* s. l. and even *Corynephorus canescens*, the distribution map is based only on examined herbarium specimens.

Festuca versicolor (Fig. 46)

The small range of *Festuca versicolor* stretches from the eastern and north-eastern Alps in Austria (distinguished there as subsp. *pallidula* and subsp. *brachystachys*), northwards to the Sudetes and eastwards to the Carpathians in Slovakia, Poland, Ukraine and Romania (plants from the Eastern Carpathians in Romania are recognized as subsp. *dominii*; Krajina 1930, Markgraf-Dannenberg 1980). Only subsp. *versicolor* is present in the Czech Republic. It occurs only in subalpine cliff vegetation in glacial cirques, where it grows on basic rocks (marble and porphyry) in sunny or semi-shady places. Only four small populations occur on the Czech side of the Krkonoše Mts (another is known on the Polish side) at elevations of 1100–1300 m. Wimmer (1841) recorded this species also from the Velká kotlina glacial cirque in the Hrubý Jeseník Mts. However, no specimen of *F. versicolor* from this site was found in herbaria, while later attempts to find it there again failed (cf. Fiek & Uechtritz 1881). *Festuca versicolor* is classified as critically threatened due to its rarity (Grulich 2012).

Himantoglossum adriaticum (Fig. 47)

Himantoglossum adriaticum has a rather small range extending from central and northern Italy through eastern Austria, Slovenia and western Croatia to the Czech Republic, western Hungary and western Slovakia (Bateman et al. 2017). In the Czech Republic it

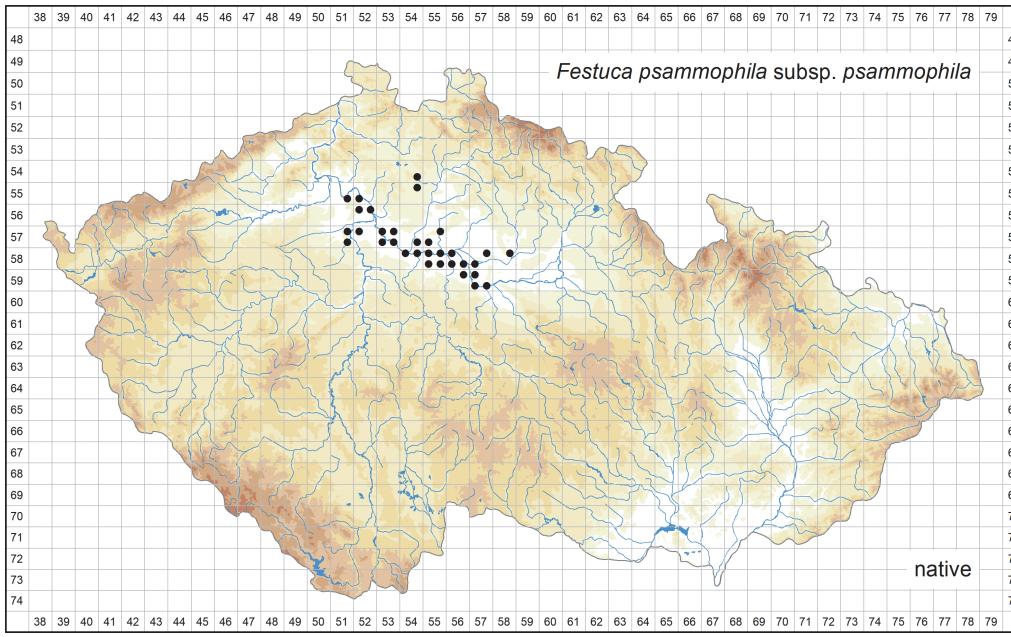

Fig. 45. Distribution of *Festuca psammophila* subsp. *psammophila* in the Czech Republic (32 occupied quadrants). Prepared by Vít Grulich & Petr Šmarda.

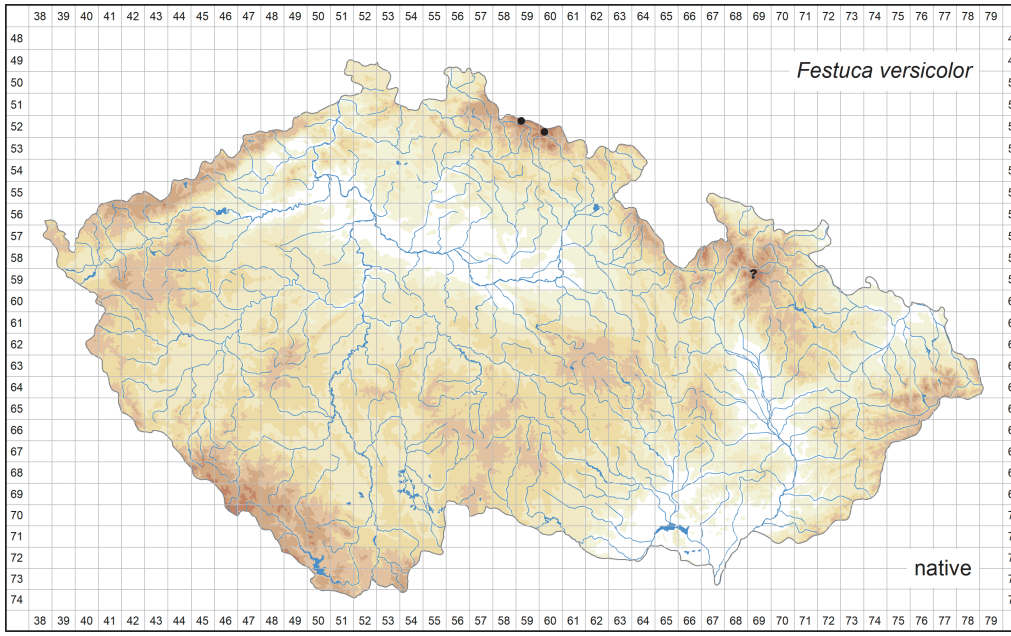

Fig. 46. Distribution of *Festuca versicolor* in the Czech Republic (2 occupied quadrants). Prepared by Vít Grulich & Petr Šmarda.

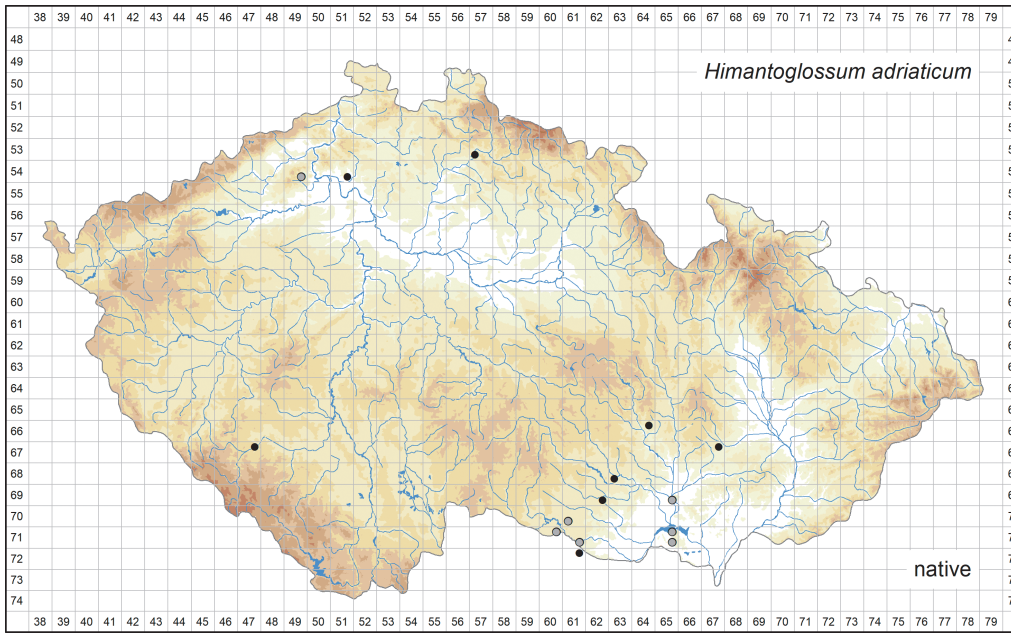

Fig. 47. Distribution of *Himantoglossum adriaticum* in the Czech Republic: ● at least one record in 2000–2021 (8 quadrants), ● pre 2000 records only (7 quadrants). Prepared by Zdeněk Kaplan.

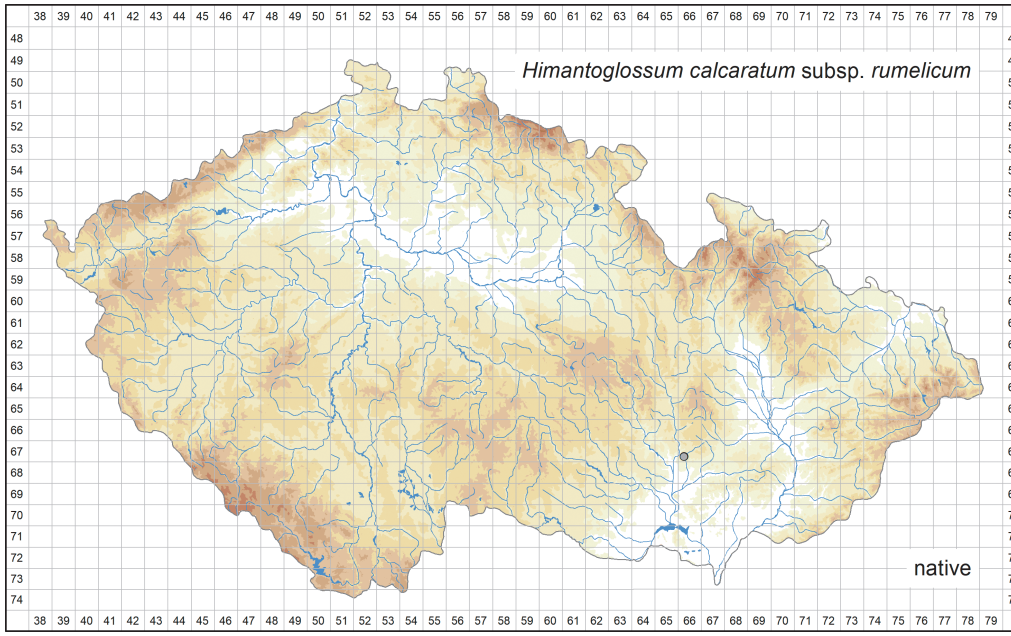

Fig. 48. Distribution of *Himantoglossum calcaratum* subsp. *rumelicum* in the Czech Republic: ● pre 2000 records only (1 quadrant). Prepared by Zdeněk Kaplan.

grows in forest-steppes, open-canopy oak forests, forest fringes and grasslands, on rather dry, basic soils that are rich in nutrients. Until recently it has been known from about eight sites in southern Moravia, of which only one is extant, and one site in the České středohoří Mts in northern Bohemia, where *H. adriaticum* was recorded only in 1874. Rather surprisingly, in 2008–2021 this species was discovered at four new sites in southern Moravia and three new sites in Bohemia. With one exception, each of the occurrences included a single plant. It is unclear whether these new occurrences all resulted from long-distance seed dispersal with establishment facilitated by the warmth of the past two decades, or the plants were intentionally planted there. Most of the earlier populations vanished probably due to abandonment of low-intensity grazing, succession of grasslands to shrub communities and intensification of land use. *Himantoglossum adriaticum* is therefore classified as critically threatened (Grulich 2012).

Himantoglossum calcaratum subsp. *rumelicum* (Fig. 48)

Himantoglossum calcaratum in its broadened circumscription recently proposed by Bateman et al. (2017) is distributed mainly in the Balkan Peninsula, extending northwards to Slovakia and eastwards to northern Turkey (Molnár et al. 2012 as *H. jankae*, Bateman et al. 2017). It includes two subspecies, of which subsp. *rumelicum* (previously as subsp. *jankae*, the correct name established by Niketić & Djordjević in Niketić et al. 2018) occurs almost throughout the range of this species, whereas subsp. *calcaratum* is confined to Bosnia and Herzegovina, Serbia, Montenegro, Kosovo and North Macedonia (Delforge 2006, Bateman et al. 2017, Fekete et al. 2017, Niketić et al. 2018). Development of the understanding of *Himantoglossum* taxonomy was associated with frequent recent changes in the name for the widespread taxon of this group: from *H. caprinum* to (among others) *H. jankae*, *H. calcaratum* subsp. *jankae* and *H. calcaratum* subsp. *rumelicum* (e.g. Baumann & Lorenz 2005, Molnár et al. 2012, Sramkó et al. 2012, 2014, Bateman et al. 2017, Niketić et al. 2018, Lorenz 2019). In the Czech Republic *H. calcaratum* subsp. *rumelicum* was recorded at a single site, namely Hády hill near the city of Brno, southern Moravia, in 1832–1855. Due to taxonomic difficulties, this population was previously treated as various other *Himantoglossum* taxa but was assigned to this taxon by Šmiták (2006, as *H. caprinum*), based on re-evaluation of herbarium vouchers. The single population vanished probably in the late 1850s due to opening of the limestone quarry in Hády hill. *Himantoglossum calcaratum* subsp. *rumelicum* is therefore classified as nationally extinct (Grulich 2012, as *H. caprinum*).

Lychnis chalcedonica (Fig. 49)

Lychnis chalcedonica is native to southern parts of western and central Siberia, central Asia, north-western China and Mongolia, in the west extending from Asia to the adjacent part of European Russia (Friedrich 1979, Jalas & Suominen 1986, Zuev 1993). It is cultivated as an ornamental species in Europe, China and North America, and sporadically escapes, but these occurrences are usually only ephemeral (Jalas & Suominen 1986, Kurtto 2001a, Lu et al. 2001, Morton 2005, Verloove 2014a). In the Czech Republic *L. chalcedonica* is grown in gardens ornamentally and seldom is found escaped or introduced with garden waste in meadows, grasslands, on road verges and waste ground, where it probably does not persist for a long time. The earliest record of escaped plants, in

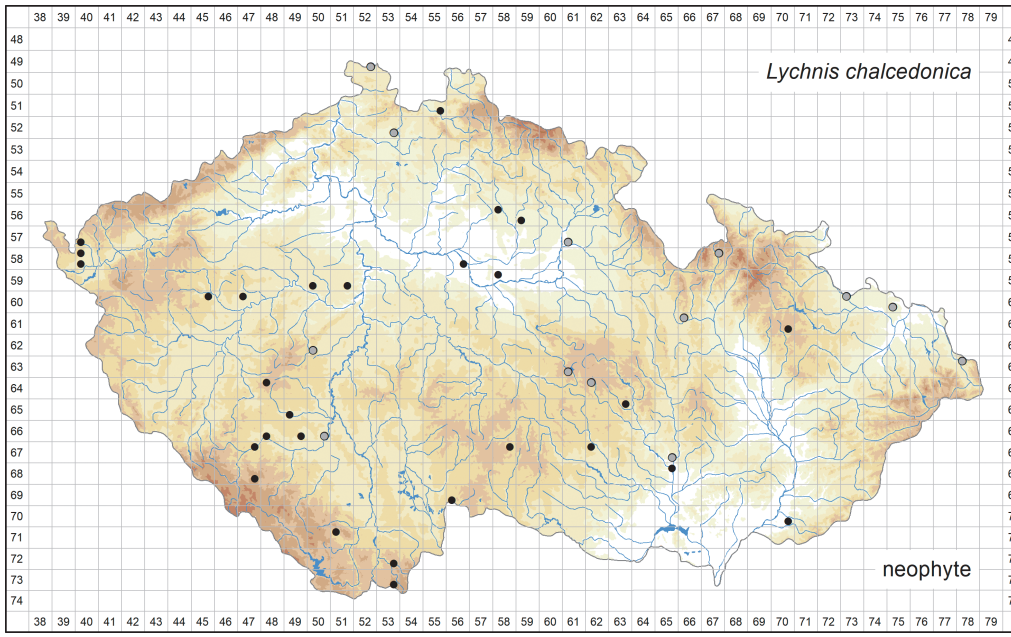

Fig. 49. Distribution of *Lychnis chalcedonica* in the Czech Republic: ● at least one record in 2000–2021 (28 quadrants), ● pre 2000 records only (13 quadrants). Prepared by Zdeněk Kaplan & Jiří Danihelka.

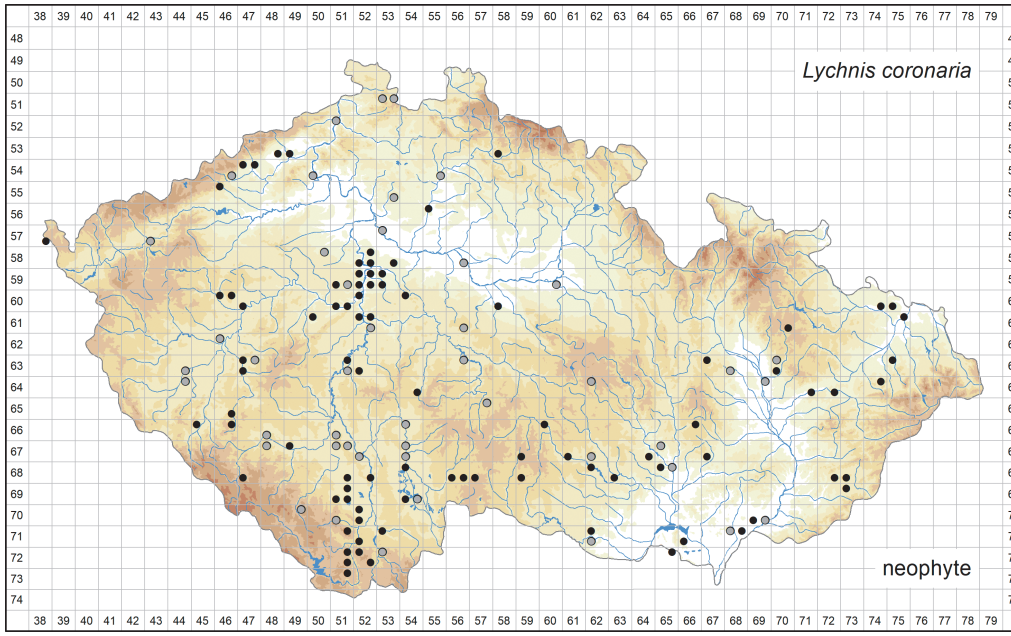

Fig. 50. Distribution of *Lychnis coronaria* in the Czech Republic: ● at least one record in 2000–2021 (88 quadrants), ● pre 2000 records only (45 quadrants). Prepared by Zdeněk Kaplan & Jiří Danihelka.

the village of Malšovice (now a suburb of the city of Hradec Králové) in eastern Bohemia, dates back to 1884. It is classified as a casual neophyte (Pyšek et al. 2012). Only records explicitly referring to escaped plants or plants found outside of gardens were included in the map.

Lychnis coronaria (Fig. 50)

Lychnis coronaria is considered native to southern Europe, extending westwards to the Iberian Peninsula, northwards to southern Slovakia and western Ukraine, and eastwards to the Balkan Peninsula and Crimea, and the continuous range reaches the Asian continent in northern Anatolia. Isolated occurrences are in northern Iran, the western Pamir Mts and the western Tian Shan Mts (Friedrich 1979, Jalas & Suominen 1986). Secondary occurrences in Europe are recorded from more northern areas, including northern France, Belgium, Denmark, southern Norway, southern Sweden and southern Finland (Jalas & Suominen 1986, Kurtto 2001a, Verloove 2014b), with plants escaped from cultivation reported also from China, Japan and North America (Lu et al. 2001, Morton 2005). In the Czech Republic *L. coronaria* is cultivated in gardens as an ornamental species and sometimes it escapes or is intentionally planted in meadows, dry grasslands, along paths and roads and in forest fringes, often close to gardens or chalets. The earliest record of escaped plants in this country dates back to 1845 when *L. coronaria* was observed in the chateau park in Červený Hrádek near the town of Chomutov in western Bohemia. The number of records has been increasing recently as this species has become more popular in gardens. Populations at some of the sites are known to have persisted for decades already, and *L. coronaria* is therefore classified as a naturalized neophyte (Pyšek et al. 2012).

Lychnis flos-cuculi (Fig. 51)

Lychnis flos-cuculi occurs in most of Europe except for the southern Iberian Peninsula, Sicily, the southern Balkan Peninsula, Crete and the steppe zones in Ukraine and European Russia, and is rare in Iceland, northernmost Scandinavia and the north-eastern part of European Russia; from Europe it extends to western and central Siberia. It has been introduced into North America (Meusel et al. 1965, Friedrich 1979, Jalas & Suominen 1986). In the Czech Republic *L. flos-cuculi* grows mainly in damp to wet meadows, ditches, springs, along wet forest tracks, in fens, pastures and open-canopy alder carrs, usually on deep soils rich in humus and nutrients. It is widespread from the lowlands up to the mountains almost throughout this country but is rare in dry, agricultural landscapes in north-western Bohemia and southern Moravia.

Ophrys apifera (Fig. 52)

Ophrys apifera is distributed in the Mediterranean part of Europe, extending northwards to the British Isles and southern Sweden and eastwards to Crimea; it is also found in northern Africa and south-western Asia eastwards to northern Iran (Meusel et al. 1965, Kühn et al. 2019). The species appears to have expanded its range during the past decades, at least in central Europe, as it has recently been discovered for the first time in Poland (Osiadacz & Kręciała 2014, Wójcicka-Rosińska et al. 2020) and Denmark

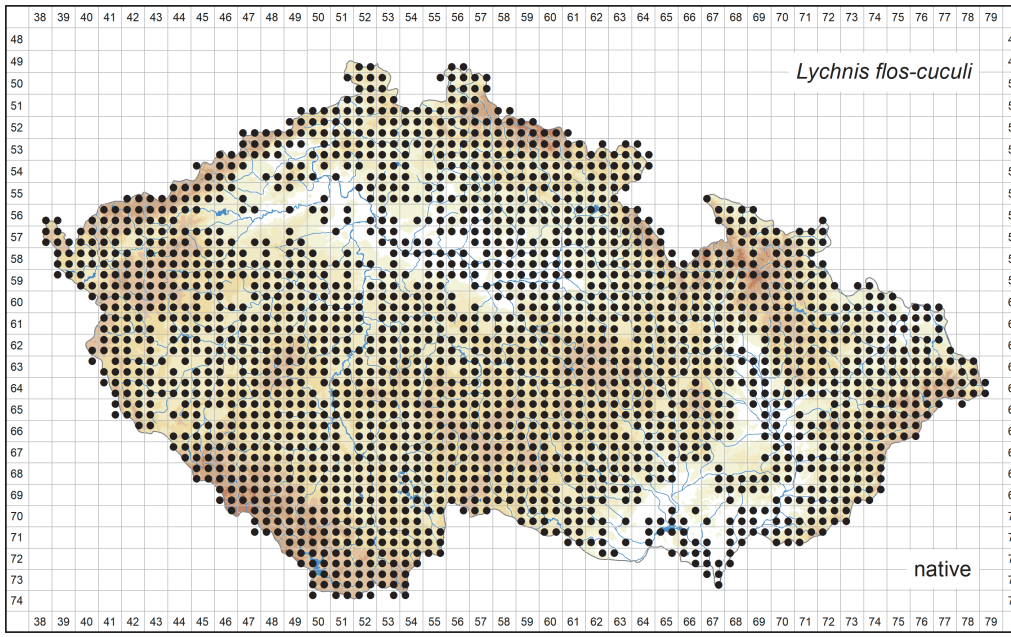

Fig. 51. Distribution of *Lychnis flos-cuculi* in the Czech Republic (2138 occupied quadrants). Prepared by Zdeněk Kaplan & Jiří Danihelka.

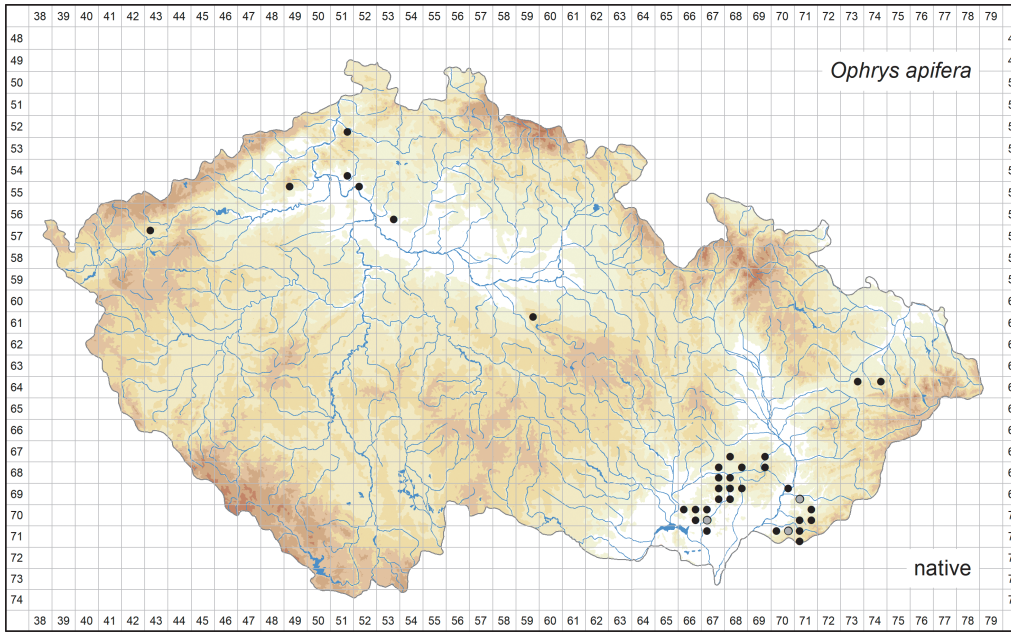

Fig. 52. Distribution of *Ophrys apifera* in the Czech Republic: ● at least one record in 2000–2021 (33 quadrants), ● pre 2000 records only (3 quadrants). Prepared by Zdeněk Kaplan.

(Mattiasson 2015), and new populations were found in Germany (Zimmermann 2011) and western Ukraine (Danylyk & Borsukevych 2011). In addition, it started to colonize secondary habitats in urban locations in western Europe (Heinrich & Dietrich 2008). However, some of these occurrences are intentional or accidental introductions rather than spontaneous establishment due to wind dispersal of seeds (Wójcicka-Rosińska et al. 2020). In the Czech Republic *O. apifera* was for the first time recorded in 1980 (Garaj & Růžička 1981). It grows mainly in sparse short grasslands, rarely also in forest fringes, sparse shrub vegetation, open-canopy beech forest and abandoned quarries, and a temporary occurrence was once observed in a lawn in a village. The soils are mostly deep, rich in mineral nutrients and humus. During the past four decades *O. apifera* has spread and has been recorded at about 38 sites in southern Moravia and at about 7 sites in eastern Moravia. In 2006 it was for the first time also found in Bohemia, namely in the České středohoří Mts. To date, it has been recorded at 7 sites in Bohemia, all situated in its northern half. In spite of the recent increase in the number of records, most of the populations are small, and the species is classified as critically threatened (Grulich 2012).

Ophrys holoserica subsp. *holubyana* (Fig. 53)

Ophrys holoserica is a taxonomically complex group distributed mainly in parts of western, central and southern Europe, westwards to south-eastern England and western France, eastwards to Slovakia, and southwards to Sardinia and Sicily, with isolated outposts eastwards as far as Romania, Turkey, Syria, Lebanon and Israel; it also occurs in north-eastern Libya (Meusel et al. 1965, Baumann & Künkele 1982, Kühn et al. 2019). It is subdivided into several subspecies, of which only subsp. *holoserica* is widespread, while the other subspecies have small ranges. The populations that occur in the south-eastern Czech Republic, western Slovakia and western Hungary are classified as subsp. *holubyana* (Procházka 2002, 2010, Vlčko et al. 2003, Delforge 2006). In the Czech Republic this taxon grows in meadows and grasslands but was also recorded around meadow springs and on stream banks. It prefers humid, calcareous soils rich in nutrients and humus. In this country *O. holoserica* subsp. *holubyana* is confined to the Bílé Karpaty Mts, where it has been recorded at about 77 sites (Procházka et al. 1999). Most of these occurrences have vanished, and the extant populations are mostly small and are threatened by abandonment of meadows and pastures and by eutrophication followed by succession. The taxon is therefore classified as critically threatened (Grulich 2012).

Ophrys insectifera (Fig. 54)

Ophrys insectifera has a highly disjunct European range. The largest part of its range is in western, central and southern Europe westwards to the British Isles and northern Spain and eastwards to western Ukraine and central Greece, with outposts northwards up to central Norway and eastwards to the north-western part of European Russia and Romania (Meusel et al. 1965, Baumann & Künkele 1982, Hultén & Fries 1986, Kühn et al. 2019). In the Czech Republic *O. insectifera* grows in dry grasslands, pastures, forest-steppes, open-canopy pine forests and forest edges, on rather dry, basic soils developed mainly over marlstone and limestone bedrock. Most of its sites in this country are in northern Bohemia, particularly in the marlstone areas between the České středohoří Mts in the north and Prague in the south. Isolated occurrences are on marlstone hills east of the town

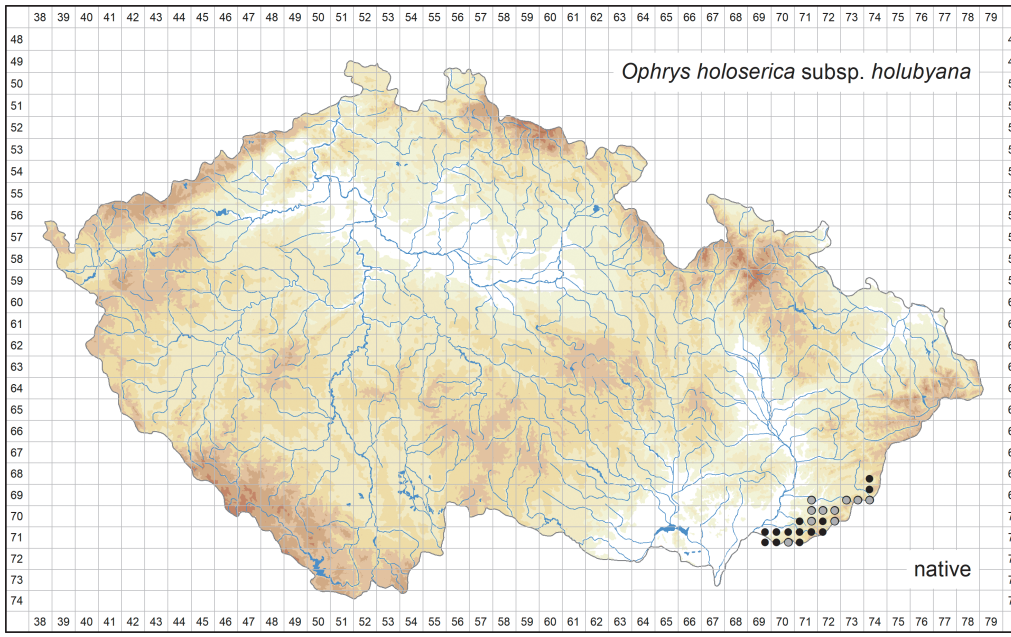

Fig. 53. Distribution of *Ophrys holoserica* subsp. *holubyana* in the Czech Republic: ● at least one record in 2000–2021 (13 quadrants), ● pre 2000 records only (10 quadrants). Prepared by Zdeněk Kaplan.

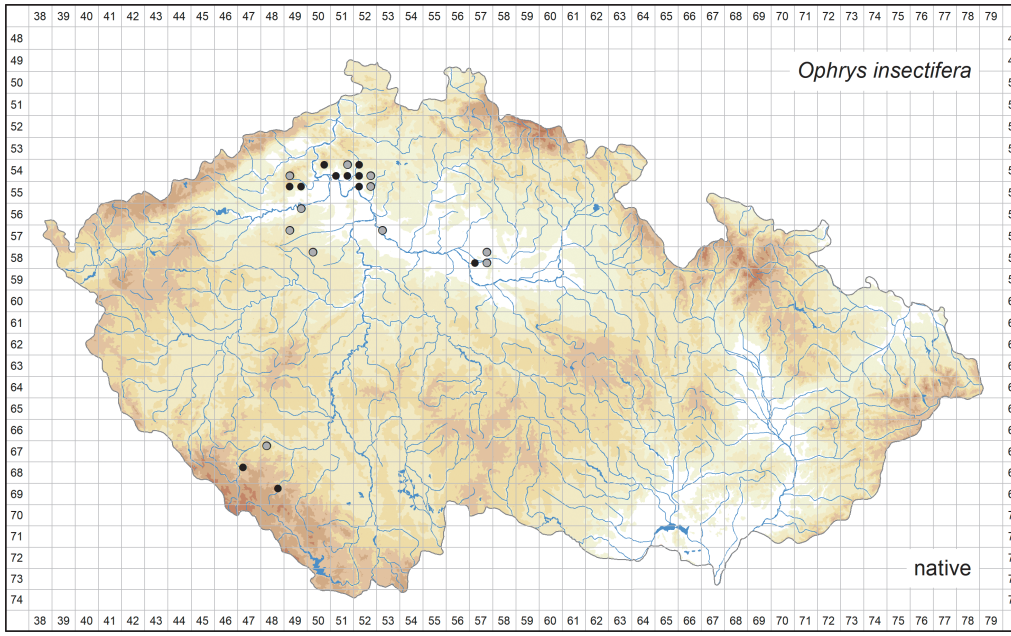

Fig. 54. Distribution of *Ophrys insectifera* in the Czech Republic: ● at least one record in 2000–2021 (11 quadrants), ● pre 2000 records only (11 quadrants). Prepared by Zdeněk Kaplan.

of Poděbrady in central Bohemia and limestone outcrops in south-western Bohemia. Its populations are threatened by abandonment of pastures and meadows, conversion of open-canopy forests to spruce plantations and general eutrophication of the landscape that suppresses symbiotic fungi. The species is therefore classified as critically threatened (Grulich 2012).

Ornithopus compressus (Fig. 55)

Ornithopus compressus is native to the Atlantic coastal areas from Morocco to western France, extending eastwards through the Mediterranean area as far as western Anatolia, and also occurs in the Canary Islands, the eastern coast of the Black Sea, Syria and Israel (Meusel et al. 1965). It has been locally grown as a pasture plant in western Spain; in the mid-20th century it was introduced into cultivation in western Australia and since then it has been cultivated there on sandy soils as a pasture and forage plant (Hanelt 2001). In the Czech Republic *O. compressus* was found accidentally introduced at three ruderal sites at a railway in the city of Prague in 1929–1937. It is classified as a casual neophyte (Pyšek et al. 2012).

Ornithopus perpusillus (Fig. 56)

Ornithopus perpusillus is native to the Atlantic and Sub-Atlantic regions of Europe from northern Portugal and northern Spain in the south to the British Isles and southern Sweden in the north, extending eastwards to Lithuania, Poland, southern Germany, Corsica and adjacent central Italy; it also occurs in the Azores and the Canary Islands. Occurrences in more eastern regions of the European continent are secondary (Meusel et al. 1965, Hultén & Fries 1986, Vilkonis & Svirskis 2006). In the Czech Republic the populations in northern Bohemia appear to represent a projection of the frequent and widespread occurrences of this species in the adjacent parts of Germany and Poland, where it is considered native (Hadinec et al. 2008). Occurrences in other parts of this country are considered secondary. *Ornithopus perpusillus* grows on margins and verges of sandy roads, in abandoned sand pits and other open sandy places, rarely also as a weed in clover fields, on drained sandy bottoms of fishponds, at railway stations and ruderal sites in towns. It is a competitively weak annual plant that is found in places in an initial stage of succession and in disturbed sites but vanishes soon with succession of stronger competitors. *Ornithopus perpusillus* has been recorded at about two dozen sites in this country but only six populations were found extant during the past decade. It is therefore classified as critically threatened (Grulich 2012).

Ornithopus sativus (Fig. 57)

Ornithopus sativus is native to south-western Europe from Portugal and northern Spain to southern and western France. It has been cultivated and used as a forage crop and for green manuring in western and central Europe, western parts of eastern Europe, western Australia and the south-eastern USA (Hanelt 2001). In the Czech Republic *O. sativus* has been in cultivation since the late 19th century, particularly on rather dry, sandy soils. It has been occasionally escaping along roads, on dams and emerged bottoms of fishponds, and on railway embankments. Some occurrences originated as accidental introductions

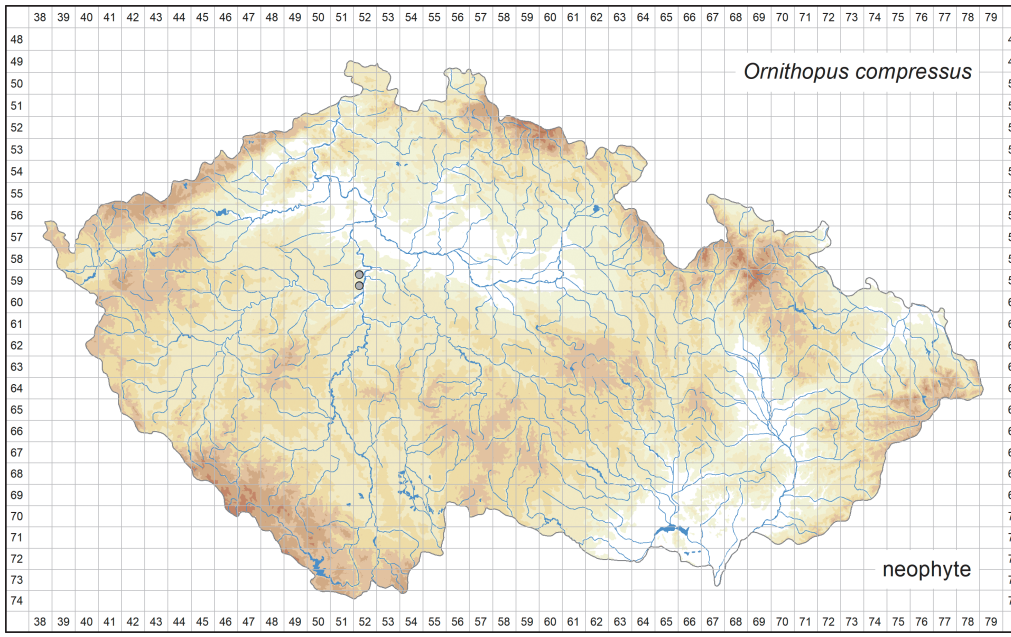

Fig. 55. Distribution of *Ornithopus compressus* in the Czech Republic: ● pre 2000 records only (2 quadrants). Prepared by Zdeněk Kaplan.

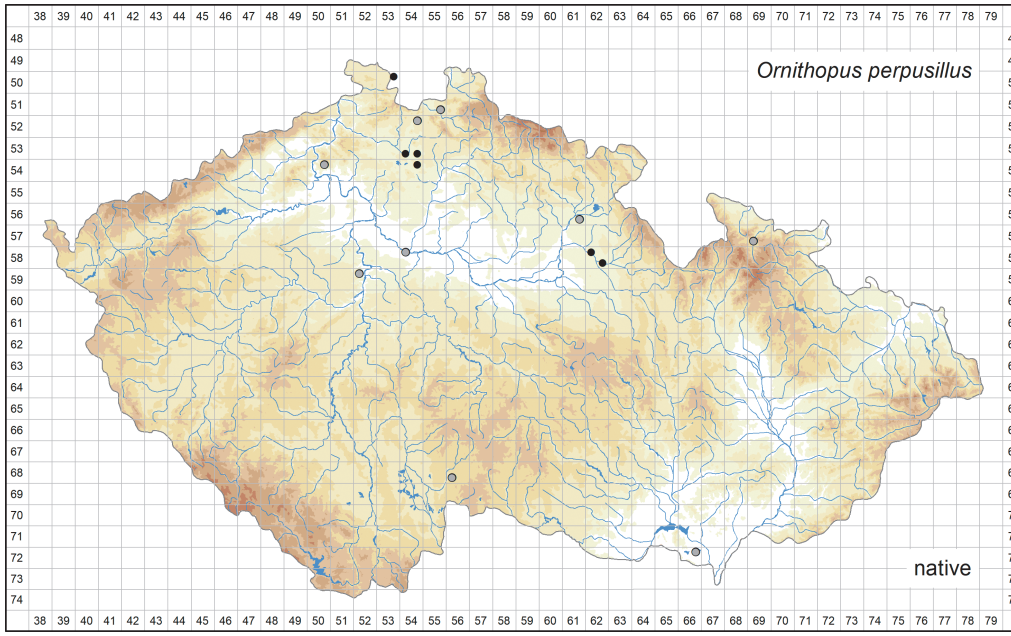

Fig. 56. Distribution of *Ornithopus perpusillus* in the Czech Republic: ● at least one record in 2000–2021 (6 quadrants), ● pre 2000 records only (9 quadrants). Prepared by Zdeněk Kaplan.

with seeds of *Onobrychis viciifolia* and *Lupinus angustifolius*. The earliest record of escaped plants in this country dates back to 1885 when *O. sativus* was collected in a stubble field at the village of Lutonina in eastern Moravia. Later this species disappeared from cultivation and consequently spontaneous occurrences vanished by the mid-20th century. The only record since 2000 is from a former hunter's field, where forage seed mixture had apparently previously been sown (Grulich 2011). *Ornithopus sativus* is classified as a casual neophyte (Pyšek et al. 2012).

Pseudofumaria alba (Fig. 58)

The native range of *Pseudofumaria alba* extends from the southern Alps through the countries of the former Yugoslavia up to Albania and Greece, where it grows in rock crevices, on stony slopes and shady screes. Three subspecies are recognized, of which only subsp. *alba* is cultivated and has become naturalized elsewhere (Lidén 1993, 2011). It has been recorded as escaped in several European countries from the British Isles and France in the west to southern Sweden and Slovakia in the east; it has also become naturalized in south-eastern Australia and New Zealand (Lidén 2011, Harden 2017). In the Czech Republic *P. alba* is occasionally cultivated and is rarely found escaped in joints of walls; however, it is sometimes able to persist at sites for a long time. It is a myrmecochorous species with similar ecology to the much more common *P. lutea* (see below), but it is probably less tolerant to frost. It was first collected as escaped in 1978 in the town of Veselí nad Lužnicí in southern Bohemia, but was not correctly recognized until recently (Kolbek et al. 2007). To date, *P. alba* has been found at about twenty localities in this country. It is considered a naturalized neophyte (Pyšek et al. 2012).

Pseudofumaria lutea (Fig. 59)

Pseudofumaria lutea native range comprises to southern Europe, from the southern foothills of the south-western Alps in Switzerland and Italy in the west to Serbia and North Macedonia in the east. It is naturalized through much of the rest of Europe, particularly in temperate regions including France, central Europe and southern Scandinavia. It is only rarely recorded from the Mediterranean area and eastern Europe (Lidén 1993, 2011). In the native range it grows in rock crevices, on stony slopes and screes, usually on limestone. In the Czech Republic *P. lutea* is commonly cultivated and naturalized in the crevices of old mortar and concrete-jointed walls, pavements, staircases and other masonry, in joints along pavements at the foot of building walls, sometimes also on piles of rubble. It is a light-demanding species, but also requires a humid substrate. Unlike the other central European plants growing in similar habitats, *P. lutea* is able to colonize joints bonded by concrete, as its long roots are able to penetrate into the very narrow crevices formed by weathering (Láníková 2009). Its seeds are spread efficiently by ants. The species is a short-lived perennial, but its populations are often able to persist for decades. In the Czech Republic the earliest occurrence of *P. lutea* dates back to 1881, when it was collected in the town of Litomyšl in eastern Bohemia; however, it is not clear if these plants were escaped or cultivated. The first reliable record of escaped plants was made in 1887 in the town of Dobřichovice in central Bohemia. To date, this species is scattered across the country, mainly at lower and middle elevations, reaching its elevational maximum at 805 m in the village of Hojná Voda in southernmost Bohemia. The vast majority of localities are

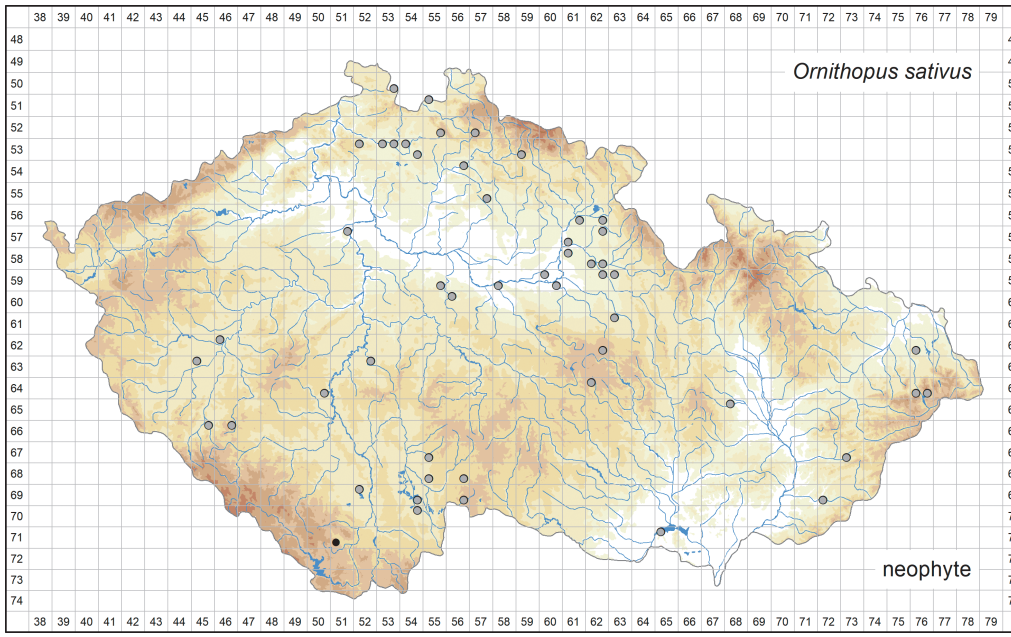

Fig. 57. Distribution of *Ornithopus sativus* in the Czech Republic: ● at least one record in 2000–2021 (1 quadrant), ● pre 2000 records only (50 quadrants). Prepared by Zdeněk Kaplan.

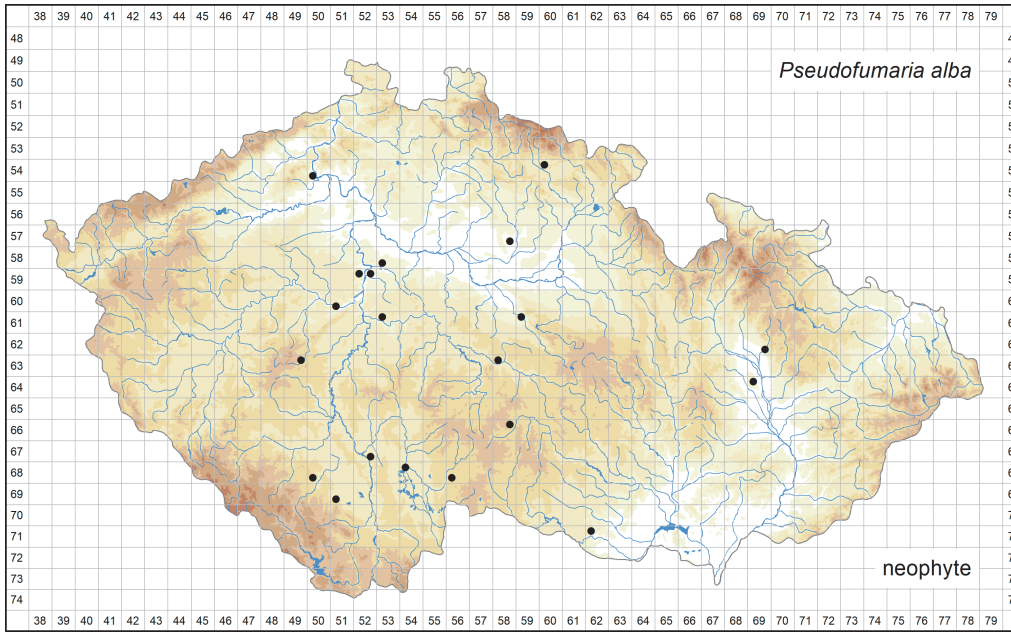

Fig. 58. Distribution of *Pseudofumaria alba* in the Czech Republic (20 occupied quadrants). Prepared by Jan Prančl.

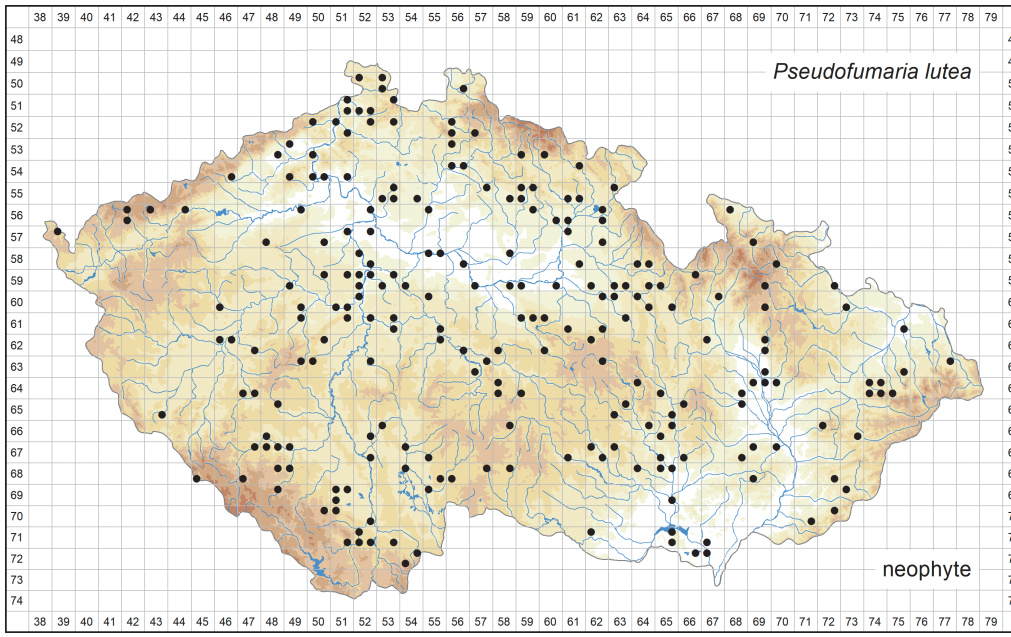

Fig. 59. Distribution of *Pseudofumaria lutea* in the Czech Republic (230 occupied quadrants). Prepared by Jan Prančl.

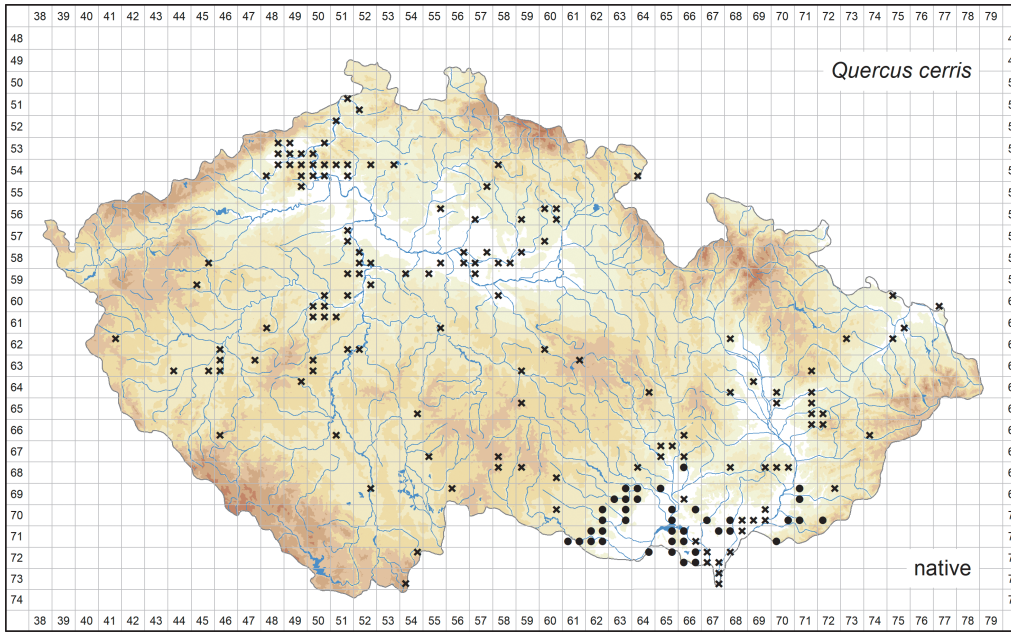

Fig. 60. Distribution of *Quercus cerris* in the Czech Republic: ● native (39 quadrants), × alien (138 quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

situated in settlements. *Pseudofumaria lutea* is considered a naturalized neophyte (Pyšek et al. 2012). The distribution map includes only clear cases of escapes.

Quercus cerris (Fig. 60)

Quercus cerris is native to southern and south-eastern Europe, particularly to the Apennine Peninsula, Sicily and the Balkan Peninsula, and to Asia, where it extends through Anatolia to Syria and Lebanon. In Europe its northern boundary passes through Austria, southern Moravia and Slovakia (Jalas & Suominen 1976, Magic 2006). *Quercus cerris* has been cultivated for a long time outside its native range. Some occurrences previously considered primary, are now being questioned, such as those in the Upper Rhine and Rhône river basins (Jäger 2017) and in the Iberian Peninsula (do Amaral Franco 1990). In the Czech Republic it may be native to southern Moravia, while the occurrences elsewhere in this country are considered secondary. Its assumed natural populations in southern Moravia occur in thermophilous oak forests or in forest steppes. *Quercus cerris* occurs on both acidic and base-rich soils. It tolerates dry and shallow soils. It is often planted in game reserves for acorn production, and rarely is planted in forests (especially in Moravia) and parks as an ornamental species. Its native populations are classified as endangered (Grulich 2012).

Quercus frainetto (Fig. 61)

Quercus frainetto is native to the Balkan Peninsula, the adjacent part of Anatolia and in rather isolated locations in the Apennine Peninsula. The northern boundary of its range is unclear. According to some authors, its distribution extends to Romania, Hungary and Slovakia (Janković 1970, Magic 2006), while other authors consider its occurrences in Hungary and Slovakia as secondary (Király 2009, Caudullo et al. 2017). *Quercus frainetto* is unlikely to be indigenous to the Czech Republic. Most of the records relate to individuals in parks and gardens, but there are a handful of records from sites outside settlements. Reliable records exist from four such sites, one in Bohemia and three in Moravia. Two of them are approximately a hundred years old and the occurrences have not been subsequently confirmed. The other two occurrences, from thermophilous oak forests on acidic permeable soils, are recent. There are only a few individuals at each location and there is no natural regeneration (Novák & Roleček 2013). Even though these sites have been frequently visited by botanists for a long time, there were no records of *Q. frainetto* before the second half of the 20th century. Old floras (e.g. Čelakovský 1871, Formánek 1887) do not mention this species in this country, which also indicates its alien rather than native status in the Czech Republic.

Quercus petraea agg. (Figs 62–64)

Quercus petraea agg. is a variable species complex. Despite the fact that many taxonomists have studied it, the taxonomy of this group has not yet been satisfactorily resolved. Until recently, three species had been distinguished within the aggregate in the Czech Republic: *Quercus petraea*, *Q. dalechampii* and *Q. polycarpa* (Koblížek 1990, 2002). However, this concept has been abandoned because of difficulties delimitating and identifying these taxa (Štech 2019). In addition, there are nomenclatural problems with the

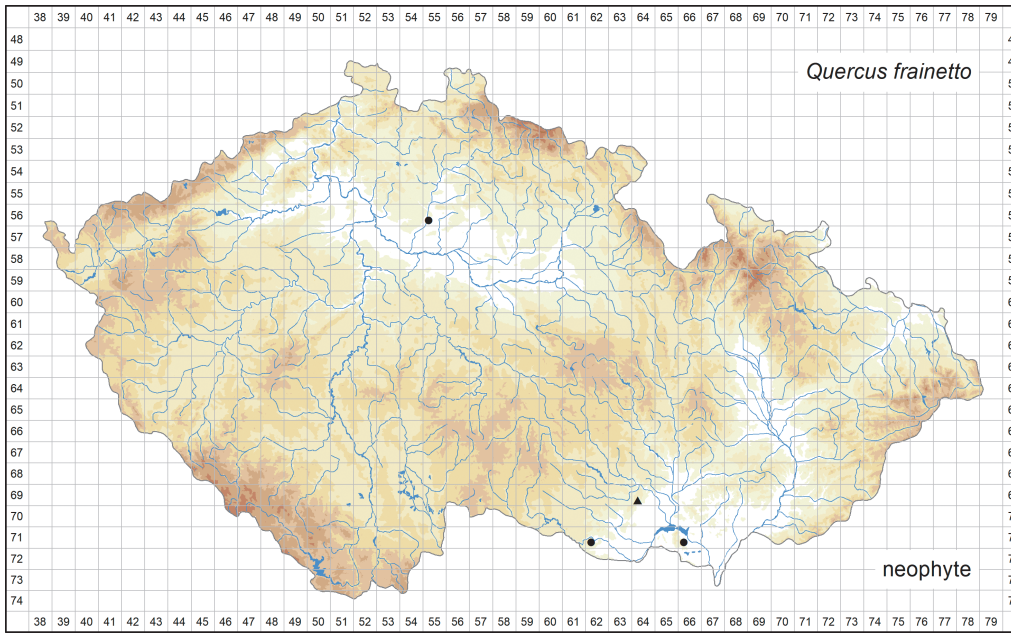

Fig. 61. Distribution of *Quercus frainetto* in the Czech Republic: ● occurrence documented by herbarium specimens (3 quadrants), ▲ occurrence based on other records (1 quadrant). Prepared by Boleslav Jelínek & Luboš Úradníček.

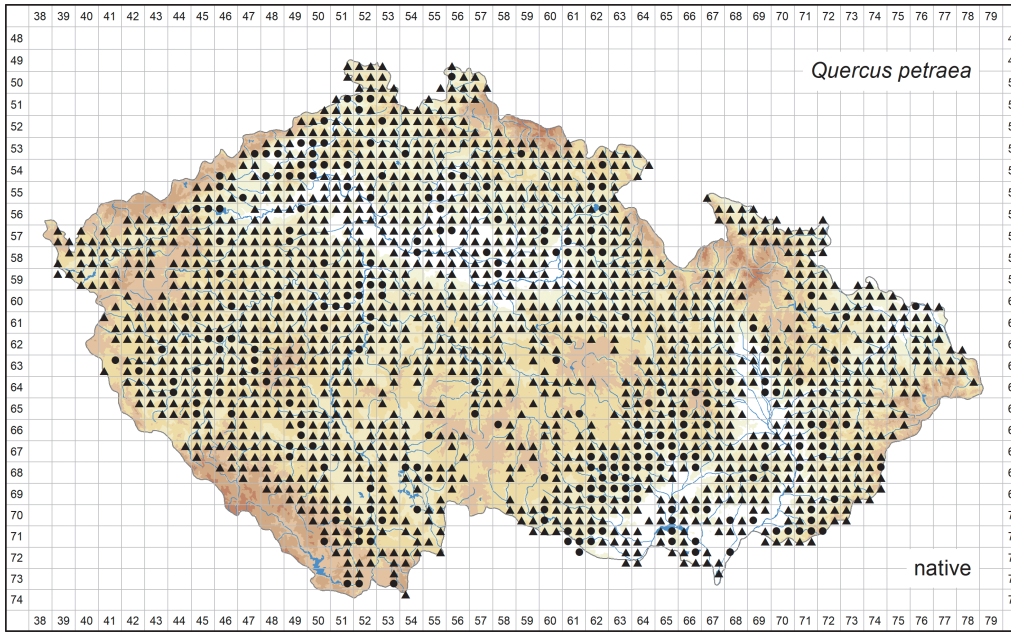

Fig. 62. Distribution of *Quercus petraea* in the Czech Republic: ● occurrence documented by herbarium specimens (237 quadrants), ▲ occurrence based on other records (1611 quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

names *Q. dalechampii* and *Q. polycarpa*. As Di Pietro et al. (2012) pointed out, the name *Q. dalechampii* is based on a specimen close to *Q. pubescens*. For this reason, Kučera (2018) proposed a new name, *Q. banatus*. Several recent studies that include *Q. dalechampii* (Viscosi et al. 2011, Fortini et al. 2015, Di Pietro et al. 2020a, 2021) actually focus on *Q. pubescens* agg. Similarly, Euro+Med (2010) and WFO (2021) consider *Q. polycarpa* synonymous with *Q. petraea* subsp. *iberica*, Camus (1939) and Menitsky (1968) with *Q. pubescens*, whereas WCSP (2021) treats it as *Q. petraea* subsp. *polycarpa*. There have been several studies on delimitation and differentiation of taxa within *Q. petraea* agg. but they came to different conclusions. Proietti et al. (2021) failed to differentiate between *Q. dalechampii* and *Q. petraea* s. str. from northern Italy using any of the employed morphological methods. Neither Jedináková-Schmidtová et al. (2004) were able to separate Slovak taxa within *Q. petraea* agg; however, the authors themselves drew attention to the fact that the characters of acorns, which are important for distinguishing the taxa, were not included in the analysis. In contrast, the morphometric analysis carried out by Borovics (1999) on samples from Hungary distinguished all three taxa within this aggregate. Kanalas et al. (2009) report a similar result. The identification of exact variation patterns of morphological characters requires rigorous study based on genetically identified material from a broad geographical scale. In the absence of such data we provisionally adopt the traditional concept of three species here. The distribution map of *Q. petraea* is based on herbarium, literature and database records. The maps of *Q. banatus* (= *Q. dalechampii* auct.) and *Q. polycarpa* are based only on herbarium specimens that correspond to descriptions provided by Koblížek (1990) and Magic (2006). Transient forms were not considered.

Quercus petraea s. str. is distributed in western, central and south-eastern Europe, northwards to the British Isles and southern Scandinavia, eastwards to western Ukraine and eastern Bulgaria, and southwards to the north-eastern Iberian Peninsula, Sicily and the Balkan Peninsula. Isolated occurrences are in Crimea and the Caucasus Mts (Hultén & Fries 1986, do Amaral Franco 1990, Dimopoulos et al. 2020). In the Czech Republic *Q. petraea* is one of the main trees of thermophilous and acidophilous oak forests. It grows mainly on acidic fresh to dry soils. It occurs throughout this country from the lowlands to middle elevations (Fig. 62). In the lowlands, it is absent from periodically flooded sites. It is less common in or even locally absent from the Českomoravská vrchovina highlands. It rarely ascends rocky peaks up to elevations of about 800 m (Koblížek 1990). However, its current distribution is strongly affected by plantations.

Quercus banatus occurs mainly in southern and south-eastern Europe, particularly in the Balkan Peninsula. Towards the north, its range extends through Hungary to Slovakia, eastern Austria and the Czech Republic, and towards the south-east, to Anatolia and the Caucasus Mts (Magic 2006, Kučera 2019). In the Czech Republic it is documented by herbarium specimens mainly from warm areas of southern Moravia, from central Bohemia and the České středohoří Mts in northern Bohemia (Fig. 63). Its distribution in the Czech Republic is similar to that of *Q. pubescens*. Isolated occurrences in other parts of the Czech Republic are most likely secondary. *Quercus banatus* has similar ecological requirements as *Q. petraea* s. str. but prefers more nutrient-rich soils and is more tolerant to drought. *Quercus banatus* (as *Q. dalechampii* auct.) is classified as of lower risk – data deficient (Grulich 2012).

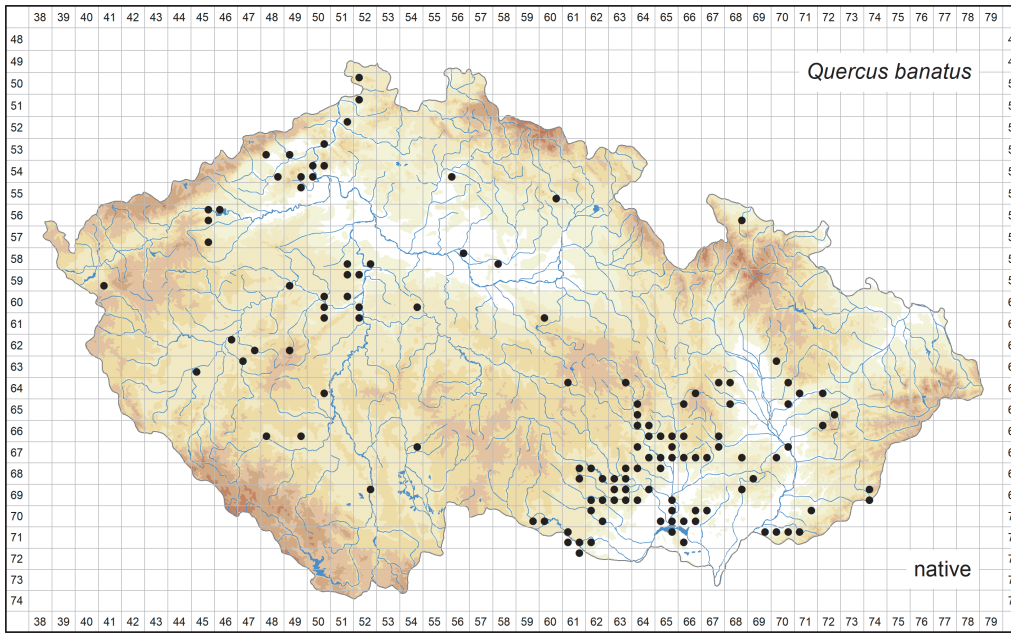

Fig. 63. Distribution of *Quercus banatus* in the Czech Republic (125 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

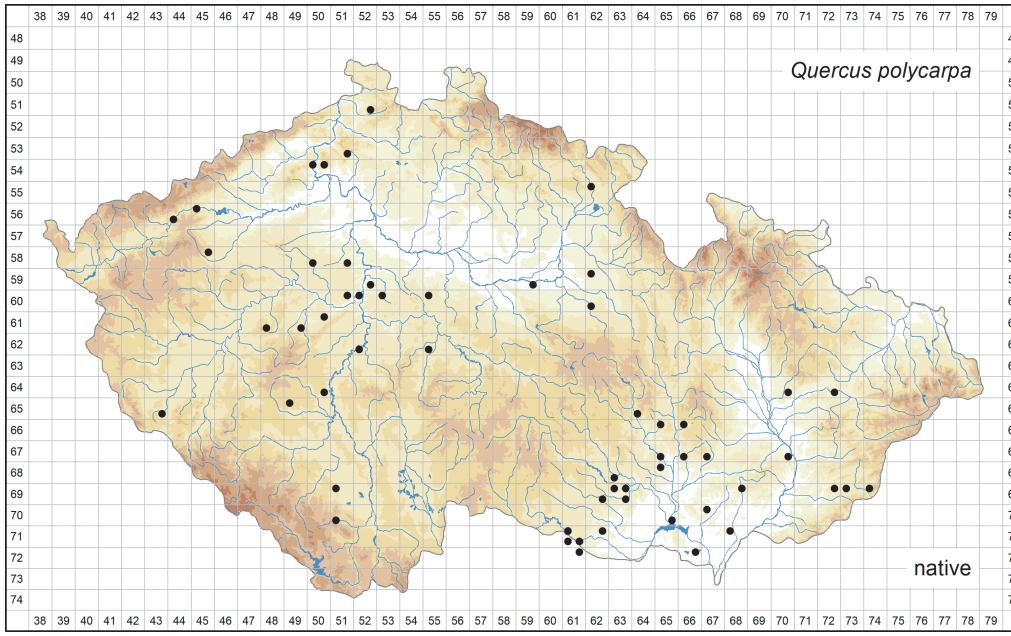

Fig. 64. Distribution of *Quercus polycarpa* in the Czech Republic (56 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

Quercus polycarpa is distributed mainly in the Balkan Peninsula, Anatolia, the Caucasus and northern Iran. The northern limit runs from Romania through Hungary, Slovakia and the Czech Republic to Austria (Hedge & Yaltırık 1982, Magic 2006, Euro+Med 2010, Dimopoulos et al. 2020). In the Czech Republic it is documented by herbarium specimens mainly from warm hilly areas of central Bohemia and southern Moravia (Fig. 64), where it occurs in thermophilous oak forests. Its distribution is similar to that of *Q. banatus* and *Q. pubescens*. The habitat requirements are similar to those of *Q. petraea* s. str. However, *Q. polycarpa* is more thermophilous and tolerates drier soils. Secondary occurences are known also from other parts of this country. *Quercus polycarpa* is classified as of lower risk – data deficient (Grulich 2012).

Quercus pubescens agg. (Figs 65–66)

A number of taxa have been distinguished within *Quercus pubescens* agg. throughout its range (Schwarz 1937, Camus 1939, Brullo et al. 1999), although opinions on their taxonomic value have varied. In the Czech Republic, *Q. pubescens* s. str. and *Q. virgiliana* have been distinguished (Koblížek 1990). Different studies have reached contradictory conclusions regarding whether there truly is any distinction between them. Jedináková-Schmidtová et al. (2004), Franjić et al. (2006) and Jerše & Batič (2007), were not able to distinguish between *Q. virgiliana* and *Q. pubescens* using mainly morphometric analyses. In contrast, Kanalas et al. (2009), Fortini et al. (2009) and Viscosi et al. (2011) documented differences justifying the recognition of *Q. virgiliana* as a species. However, Di Pietro et al. (2016, 2020a, b, 2021), using molecular methods, concluded that *Q. pubescens* is morphologically a very variable taxon, with the division of it into multiple species or intraspecific taxa unfounded. No detailed taxonomic study of these taxa has been conducted in the Czech Republic. Koblížek (1990) considered both *Q. pubescens* and *Q. virgiliana* to be native. In contrast, Štech (2019) doubths that the Czech individuals identified as *Q. virgiliana* are taxonomically identical with those from southern Italy and suggests that these may represent hybrids between *Q. pubescens* and *Q. petraea* or *Q. robur*. In the absence of solid evidence, here we provisionally adopt the delimitation of *Q. virgiliana* as circumscribed by Koblížek (1990). The map of *Q. vigiliana* is based solely on herbarium specimens.

Quercus pubescens is widespread in southern Europe, Anatolia and the Caucasus Mts. The northern boundary of its range runs from France through southern Germany, the Czech Republic, Slovakia, Romania and Moldova to the Black Sea and Crimea, while the southern boundary passes from the Iberian Peninsula through Sardinia and Sicily to Peloponnese (Meusel et al. 1965, Jalas & Suominen 1976). In the Czech Republic *Q. pubescens* grows in thermophilous oak forests on warm rocky and stony slopes, on shallow and dry soils mainly above basic bedrock. It is most frequent in warm hilly areas of southern Moravia northwards to the Moravský kras karst area, with isolated occurrences around the city of Olomouc. In Bohemia it is mainly found in the Český kras karst area and the České středohoří Mts, while isolated occurrences exist around the towns of Kadaň and Louny, and between the towns of Mladá Boleslav and Chlumec nad Cidlinou (Fig. 65). It is classified as vulnerable (Grulich 2012).

Quercus virgiliana is widespread in southern and south-eastern Europe, southwards to Sardinia, Sicily and the Balkan Peninsula, from where it extends to northern Anatolia; the northern limit distribution limit is unclear, depending on the taxonomic concept, possibly

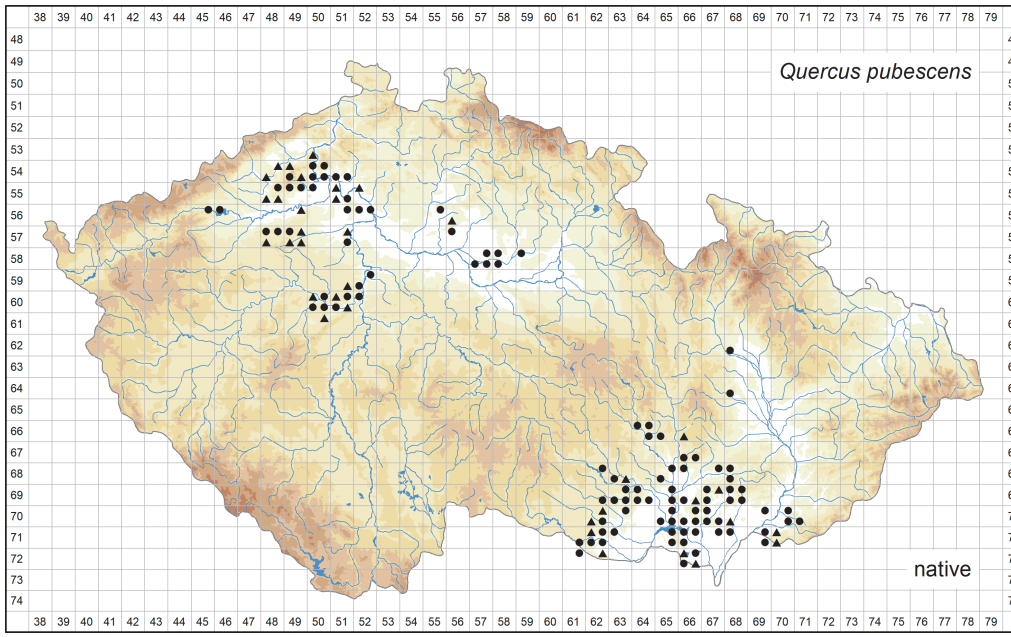

Fig. 65. Distribution of *Quercus pubescens* in the Czech Republic: ● occurrence documented by herbarium specimens (101 quadrants), ▲ occurrence based on other records (35 quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

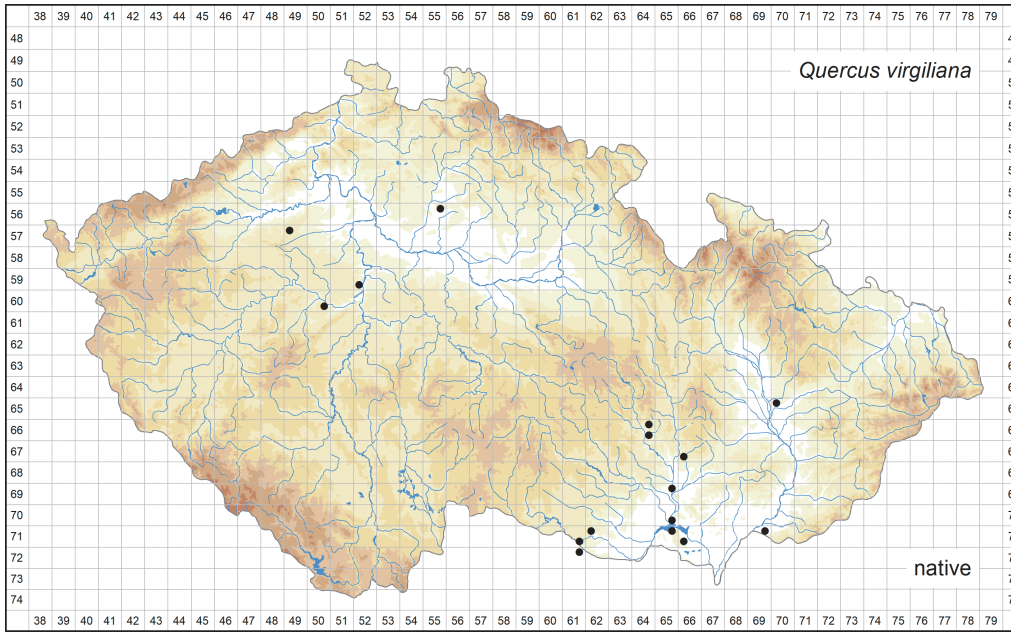

Fig. 66. Distribution of *Quercus virgiliana* in the Czech Republic (16 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

extending northwards to Hungary, Slovakia and southern Moravia (Ganchev & Bondev 1966, Hedge & Yaltırık 1982, Koblížek 1990, Magic 2006). In the Czech Republic it grows in thermophilous oak forests on basic substrates, usually on shallow dry soils. In Moravia most of the records of *Q. virgiliana* come from south-west and south of the city of Brno. For Bohemia there are only a handful of records from its central part (Fig. 66). *Quercus virgiliana* is classified as of lower risk – data deficient (Grulich 2012).

Quercus robur (Fig. 67)

Quercus robur is distributed across most of Europe, extending northwards to the British Isles, to 63°N in coastal Norway and to 61°N in southern Finland, while the southern distribution limit runs through the Iberian, Apennine and Balkan Peninsulas, and along the middle Volga river basin in Russia (Malev 1936, Hultén & Fries 1986, do Amaral Franco 1990). It has been introduced into North America (Nixon 1997), Australia and New Zealand (ALA 2018). In the Czech Republic *Q. robur* grows mainly in alluvial forests and in thermophilous oak forests, less frequently in acidophilous oak forests. It prefers deep, humid to wet, sometimes periodically flooded, nutrient-rich soils. Native occurrences are mainly found in large river basins such as those of the Morava, Dyje and Labe rivers and in the adjacent hilly landscapes in warm areas. At middle elevations it is less frequent, occurring mainly as an admixture in forests on rather poor and wet soils. Sporadic occurrences on southern slopes are found up to elevations of about 800 m (Koblížek 1990). *Quercus robur* has long been grown not only for the timber industry but also as an ornamental species. In the past it was often planted on pond dams and along watercourses. At present it is found almost throughout the Czech Republic but is locally absent from areas within the highest parts of the mountains along this country's border as well as in northwestern Moravia and the Českomoravská vrchovina highlands.

Quercus rubra (Fig. 68)

Quercus rubra is native to the eastern part of the USA and the adjacent part of south-eastern Canada (Little 1971). It has been introduced into Europe, southern Asia, New Zealand and South America (Dyderski et al. 2020). Introduction to the Czech Republic dates back to 1794 (Pejchal et al. 2021). It was first planted in parks for ornamental purposes and later also in forests where it has become naturalized and begun to spread. At present *Q. rubra* is scattered from the lowlands to middle elevations, rarely higher. It grows in various habitats ranging from floodplain forests on wet nutrient-rich soils to acidophilous forests on poor dry soils developed on sandstones. It is classified as an invasive neophyte (Pyšek et al. 2012).

Salix appendiculata (Fig. 69)

Salix appendiculata occurs mainly in the Alps and their foothills, from where its natural range extends to the Jura Mts, Schwarzwald Mts, Bayerischer Wald hills and Šumava Mts (Chmelař & Meusel 1976, Chmelař & Koblížek 1990). There are isolated localities in the Apennine and Balkan Peninsulas (Jalas & Suominen 1976, Skvortsov 1999, Kailis & Eleftheriadou 2013). In the Czech Republic *S. appendiculata* grows on screes of siliceous rocks in glacial cirques and on waterlogged soils along mountain streams. Its occurrence

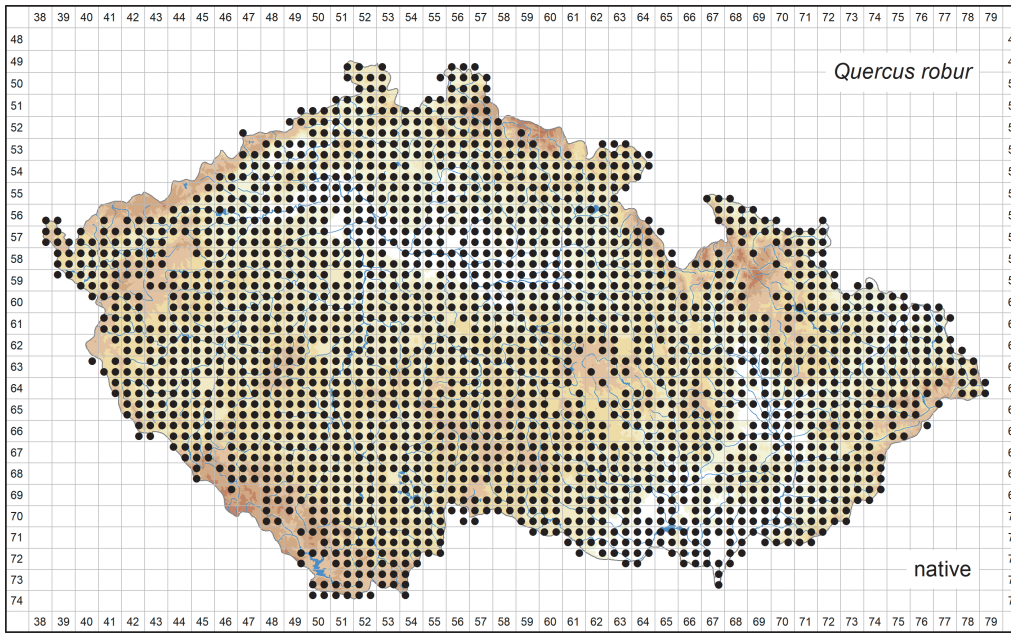

Fig. 67. Distribution of *Quercus robur* in the Czech Republic (2238 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

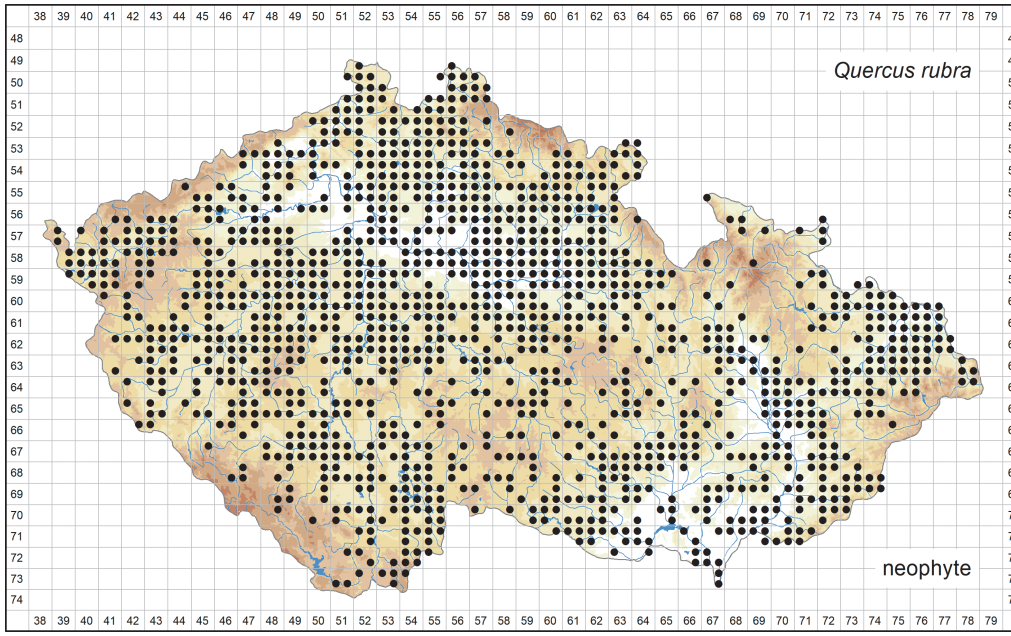

Fig. 68. Distribution of *Quercus rubra* in the Czech Republic (1327 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

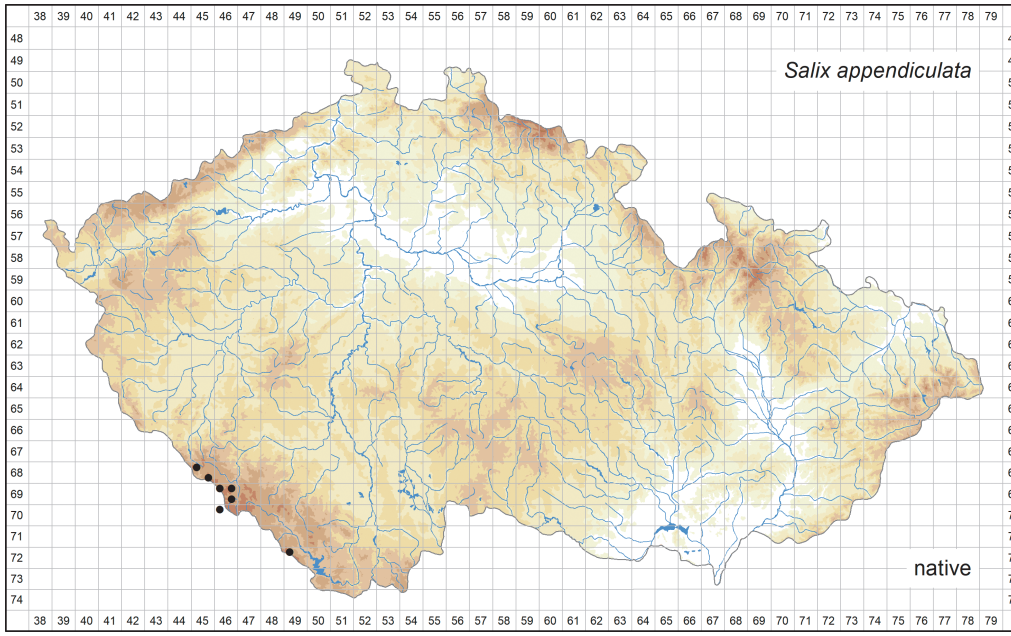

Fig. 69. Distribution of *Salix appendiculata* in the Czech Republic (7 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

has been documented by herbarium specimens from the Šumava Mts, particularly from the surroundings of the Černé jezero, Laka, Prášilské jezero and Plešné jezero lakes and from a few other sites. Recently its presence has only been confirmed at the Černé jezero and Plešné jezero lakes (Ekrt & Koutecký 2013). At other places in the Šumava Mts hybrids with *S. caprea* have been identified. Records of *S. appendiculata* from the Novohradské hory Mts and the Českomoravská vrchovina highlands (Chmelař 1963) are not documented by herbarium specimens and are doubtful. This species is classified as critically threatened (Grulich 2012).

Salix bicolor (Fig. 70)

Salix bicolor belongs to the *S. phylicifolia* group. In the traditional, narrow sense accepted here, *S. bicolor* is divided into two subspecies. The typical subspecies is distributed in the mountains of central Europe, i.e. in the Krkonoše Mts, Harz Mts and Vosges Mts (Chmelař & Meusel 1976), while subsp. *basaltica* occurs in the mountains of southwestern Europe, i.e. in the Massif Central and the Pyrenees. The view that populations of *S. phylicifolia* in the Alps and the Carpathians also belong to *S. bicolor* (Belyaeva 2004) is not generally accepted. In the Czech Republic *S. bicolor* occurs in subalpine deciduous scrub, subalpine tall-forb communities and rarely along mountain brooks. It is very rare in this country, and its relict occurrence is confined to a single site in the Úpská jáma glacial cirque in the Krkonoše Mts. All early records apparently are from a single site referred to as Sněhový žlab. Some years ago, two populations were artificially established at other

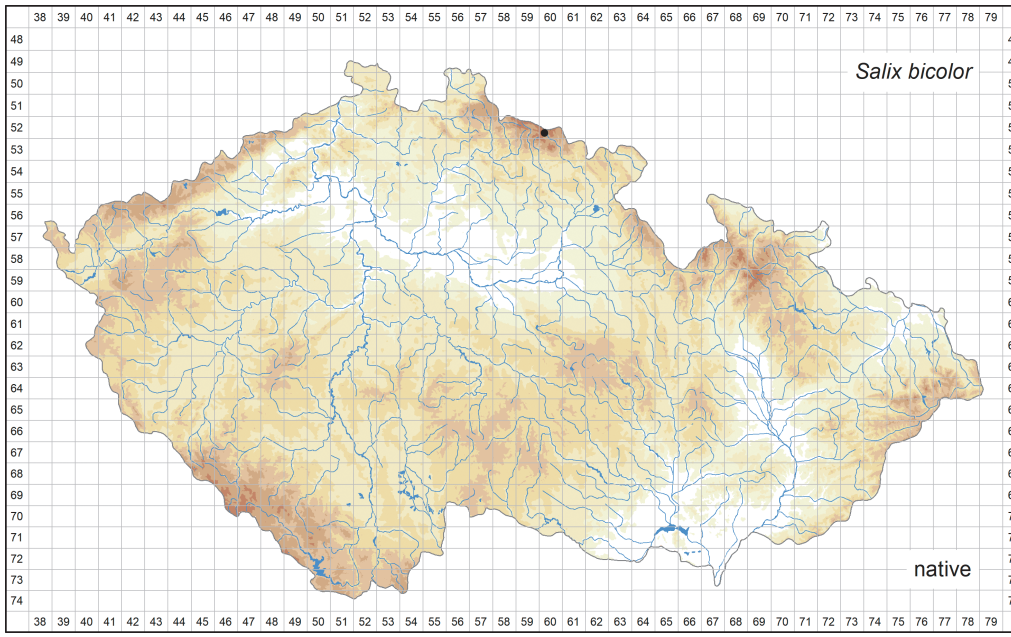

Fig. 70. Distribution of *Salix bicolor* in the Czech Republic (1 occupied quadrant). Prepared by Radim J. Vašut, Michal Hroneš & Veronika Nývltová.

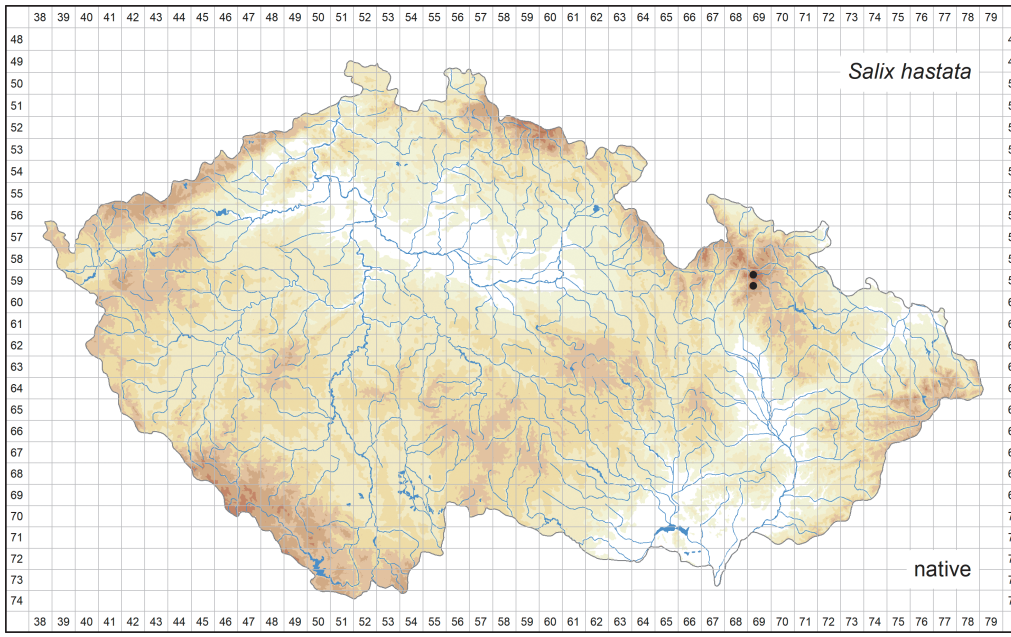

Fig. 71. Distribution of *Salix hastata* in the Czech Republic (2 occupied quadrants). Prepared by Radim J. Vašut, Blanka Trnková & Michal Hroneš.

sites in the Úpská jáma cirque, using genetically identical clones from the original site (Zahradníková 2007). Records from the Wielki Staw glacial cirque on the Polish side of the Krkonoše Mts are erroneous. The population at the Úpská jáma site is genetically uniform and represents a single clone, as shown by its isozyme pattern (Chrtek Jr. et al. 2007) and microsatellites (Vašut et al. unpubl.). All plants are female. A hybrid of this species with *S. silesiaca* was recorded at this site, based on morphological characters, but it is extremely rare, and molecular evidence is still lacking. The only population of *S. bicolor* in this country has the strongest possible protection. This species is classified as critically threatened due to its rarity (Grulich 2012).

Salix hastata (Fig. 71)

Salix hastata has a wide distribution spanning northern Eurasia and north-western North America and extending to southern Siberia. Isolated occurrences exist in the mountains of Europe and Asia, including the Caucasus and mountains in Central Asia as well as Sakhalin. In Europe it mainly occurs in southern Scandinavia, with isolated occurrences in the mountains of central Europe, where it is frequent in the Alps, infrequent in the Carpathians and rare in the Sudetes (Meusel et al. 1965, Chmelař & Meusel 1976, Elven & Karlsson 2000, Argus 2010). In the Czech Republic *S. hastata* grows mainly along subalpine soft-water springs and mires and in subalpine tall-forb vegetation. It is recently known from two localities in the Hrubý Jeseník Mts, with one large population in the Velká kotlina glacial cirque and the other, rather small population in springs below the Petrovy kameny cliffs. An ephemeral occurrence was documented at a ruderal site near the touristic chalet of Ovčárna. The former occurrence in the Malá kotlina glacial cirque has not been confirmed recently. A record from a ravine on Mt Šerák is dubious: neither *S. hastata* nor its hybrid with *S. silesiaca* has been found there recently, and no suitable habitats are present there. *Salix hastata* is classified as critically threatened due to its rarity (Grulich 2012).

Salix hastata is morphologically variable and is sometimes divided into three subspecies (e.g. Elven & Karlsson 2000). Though the populations from the Czech Republic are assigned to subsp. *vegeta*, their taxonomic position remains unclear. The leaf shape of *S. hastata* from the Velká kotlina site varies between the shapes typical of subsp. *hastata* and subsp. *vegeta*, although the population is genetically uniform and is well separated from the populations in the Belianske Tatry Mts and the Nízke Tatry Mts in the Carpathians (Vašut et al., unpubl.). Czech plants of *S. hastata* somewhat resemble *S. aurita* in their leaf characters (prominent stipules and lamina often rugose above), but introgression of *S. aurita* was excluded using molecular techniques (by DArTseq whole-genome genotyping using large number of SNPs; Vašut et al. unpubl.).

Salix hastata hybridizes with other sympatric diploid species in the Alps and northern Europe. Genetic analyses of populations in the Sudetes and eastern Carpathians (Vašut et al. unpublished data) indicate that this species hybridizes rarely there. The only documented hybrid is *S.* ×*chlorophana* (*S. hastata* × *S. silesiaca*), described from the Hrubý Jeseník Mts (Andersson 1867). The existence of the triple hybrid *S. aurita* × *S. hastata* × *S. silesiaca*, reported by Andersson (1867) under the invalid name *S.* ×*goeppertii*, was refuted by molecular methods (Vašut et al. unpubl.). All specimens interpreted as such based on their morphological characters turned out to be various morphs of *S.* ×*subaurita* (*S. aurita* × *S. silesiaca*).

Salix herbacea (Fig. 72)

Salix herbacea has a wide amphi-atlantic distribution in northern Europe and north-eastern North America (including Greenland), extending to western Siberia and the mountains of Europe. In central and southern Europe it is frequent in the Alps, Carpathians, Pyrenees and mountains of the Balkan Peninsula. Isolated occurrences are known from the Apennines, Central Massif and Sudetes (Meusel et al. 1965, Chmelař & Meusel 1976, Jalas & Suominen 1976, Argus 2010). Present distribution of this species in major parts of Europe reflects the extent of glaciation during the LGM (Alsos et al. 2009). In the Czech Republic *S. herbacea* grows on wind-exposed cliffs and rarely in subalpine grasslands and snow beds. It is very rare in this country, and only four very small native populations have been known. In the Krkonoše Mts it grows in the Malá kotelní jáma glacial cirque and on the screes and cliffs on the eastern slopes of Mt Studniční hora. In the Hrubý Jeseník Mts it grows on the Petrovy kameny cliffs and Tabulové kameny cliffs. The population in the Velká kotelní jáma glacial cirque in the Krkonoše Mts was established artificially and is derived from the population on Mt Studniční hora. The occurrence in the Velká kotlina glacial cirque in the Hrubý Jeseník Mts, documented in 1924–1971, was not recently confirmed.

Analyses of the genetic structure of Czech populations has revealed very limited variation. The populations in the Malá kotelní jáma glacial cirque (Krkonoše) and the Petrovy kameny cliffs (Hrubý Jeseník) each consist of a single genotype (clone). The population at the Tabulové kameny site (Hrubý Jeseník) consists of two (or three) genotypes. Only the population from Mt Studniční hora (Krkonoše) is genetically variable. However, in all Czech populations only female plants are known, and apparently all populations now reproduce only clonally.

Hybrids of *S. herbacea* with several species were described from northern Europe (Elven & Karlsson 2000), but no such hybrid is known from the Czech Republic. We repeatedly saw capsules in the purely female population at the Tabulové skály site, indicating possible pollination by the *S. silesiaca* pollen, but we have never observed full ripening of such fruits.

Although all Czech populations of *S. herbacea* are extremely small, they are not under risk of immediate extinction. The strongest threat comes from climate change and possible shifts in environmental conditions (Alsos et al. 2009). In the past some populations were damaged by stone quarrying (Tabulové kameny site) or by botanists excessively collecting for herbaria (Petrovy kameny site). The species is classified as critically threatened due to its rarity and decline (Grulich 2012).

Salix lapponum (Figs 73–74)

Salix lapponum is continuously distributed in northern Europe and western Siberia; isolated outposts occur in the Massif Central, the Sudetes, eastern and southern Carpathians and in the Vitosha and Rila Mts in the Balkan Peninsula (Meusel et al. 1965, Chmelař & Meusel 1976). In the Czech Republic *S. lapponum* mostly grows in subalpine deciduous scrub, less frequently in subalpine grasslands. It has been recorded at 30 localities in the Krkonoše and Hrubý Jeseník Mts (Fig. 74). Of these occurrences, 11 have been preserved in the Krkonoše Mts and a single one in the Hrubý Jeseník Mts (Hroneš et al. 2011, 2014). In the Krkonoše Mts the occurrences on the Czech side are grouped in two areas:

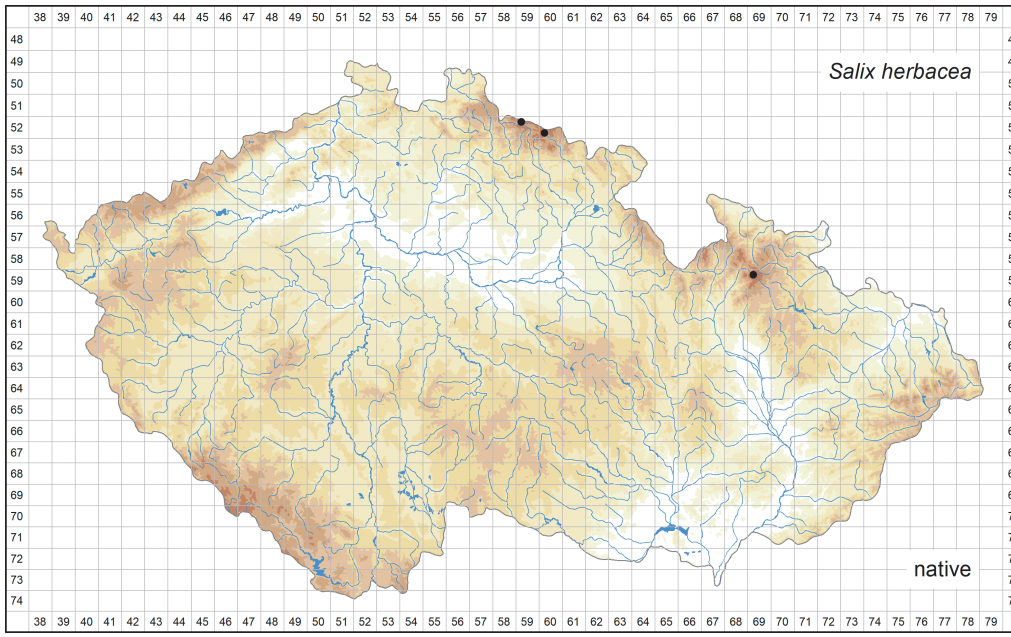

Fig. 72. Distribution of *Salix herbacea* in the Czech Republic (3 occupied quadrants). Prepared by Radim J. Vašut, Jan Lukavský & Michal Hroneš.

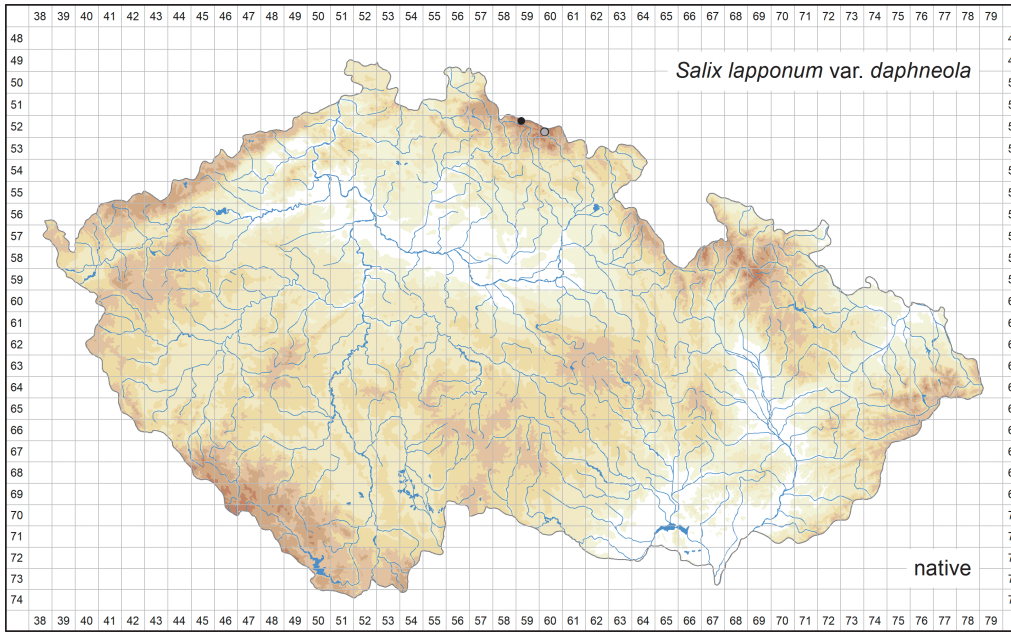

Fig. 73. Distribution of *Salix lapponum* var. *daphneola* in the Czech Republic: ● at least one record in 2000–2021 (1 quadrant), ● pre 2000 records only (1 quadrant). Prepared by Michal Hroneš & Radim J. Vašut.

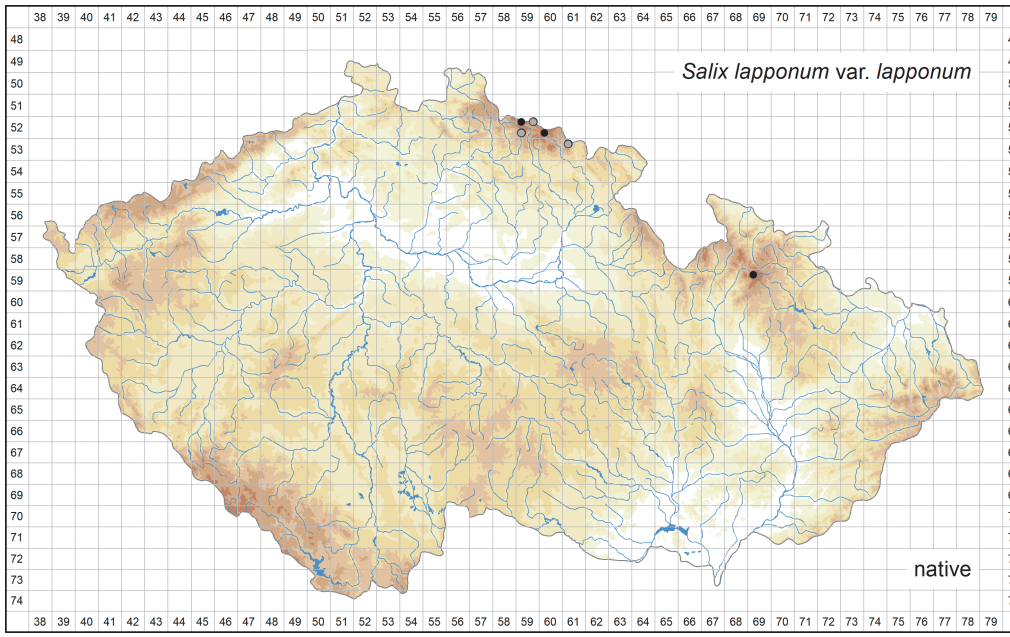

Fig. 74. Distribution of *Salix lapponum* var. *lapponum* in the Czech Republic: ● at least one record in 2000–2021 (3 quadrants), ◍ pre 2000 records only (3 quadrants). Prepared by Michal Hroneš & Radim J. Vašut.

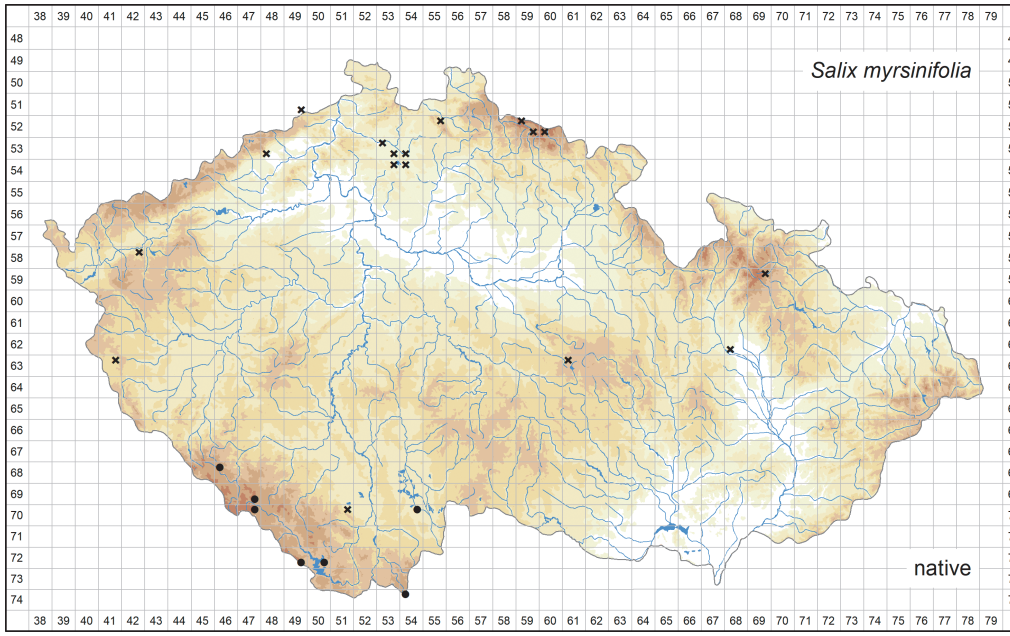

Fig. 75. Distribution of *Salix myrsinifolia* in the Czech Republic: ● native (7 quadrants), × alien (17 quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

Mt Studniční hora on the eastern part of the ridge and the Pančavská louka and Labská louka meadows north of Mt Kotel on the western part of the ridge. *Salix lapponum* was extensively planted at original as well new sites (using native plant material) in the Krkonoše Mts; therefore, it is difficult to distinguish between native and artificially established populations. The native populations in the Krkonoše Mts are genetically variable, but they have a female-biased sex ratio, with females on average twice as frequent as males (Hroneš et al. 2019). In the Hrubý Jeseník Mts, only a single large bush of *S. lapponum* survives near the Tabulové kameny cliff. It is divided into several smaller parts, but all ramets belong to a single genetic clone (M. Sochor et al. unpubl.) that is female. In some populations of *S. lapponum* in the Krkonoše Mts, glabrous individuals are present, usually referred to as *S. lapponum* var. *daphneola*. They are rare and occur among plants with normal indumenta. Genetic analyses (Vašut et al. unpublished data) did not indicate introgression of any other species suggesting that they constitute infraspecific variation limited to a small geographic area. These individuals were originally known from a single site, Pančavská louka, and only recently were found also at other sites north of Mt Kotel (Hroneš et al. 2011). In addition, there are two old records from other parts of the Krkonoše Mts (Fig. 73). *Salix lapponum* var. *lapponum* is classified as endangered due to its rarity, while *S. lapponum* var. *daphneola* is considered as critically threatened, also due to its rarity (Grulich 2012).

Salix myrsinifolia (Fig. 75)

Salix myrsinifolia is distributed in northern Europe and the adjacent part of Siberia. The southern boundary passes through the northern part of the British Isles, Denmark, north-eastern Poland, southern Belarus and the middle Volga river basin to the southern end of the Ural Mts. There are isolated occurrences in the Alps and their foothills (Chmelař & Meusel 1976, Jalas & Suominen 1976). Records of this species' naturalization in south-eastern Canada need confirmation (Argus 2010). In the Czech Republic *S. myrsinifolia* grows in wet to peat meadows and wet open-canopy forests. Native populations are probably found in south-western and southern Bohemia, namely in the Český les hills, Šumava Mts, Novohradské hory Mts and the Třeboňská pánev basin. However, this species has been planted as a nectar source for honeybees; therefore, the occurrences near settlements in these areas as well as in other parts of this country are most likely secondary, i.e. planted individuals. Seven indigenous populations (six in the Šumava Mts and one in the Novohradské hory Mts) of *S. myrsinifolia* have been confirmed during the past 10 years. *Salix myrsinifolia* is classified as critically threatened (Grulich 2012).

Salix myrtilloides (Fig. 76)

Salix myrtilloides is continuously distributed in the boreal zone of Eurasia, extending to north and north-eastern Europe (Meusel et al. 1965, Chmelař & Meusel 1976). In central Europe it is very rare, occurring in Switzerland, southern Bavaria, the Czech Republic and Slovakia, and its populations are usually small (Chmelař 1966, Oberli 1981, Jirásek 1995, Migra & Mičieta 1996, Brandová & Vašut 2016). In the Czech Republic *S. myrtilloides* grows in acidic moss-rich fens, fen meadows and transitional mires. Over the years, twelve populations have been recorded in this country, one each in the Jizerské hory Mts, Orlické hory Mts and the Železné hory hills, and the others in western and southern

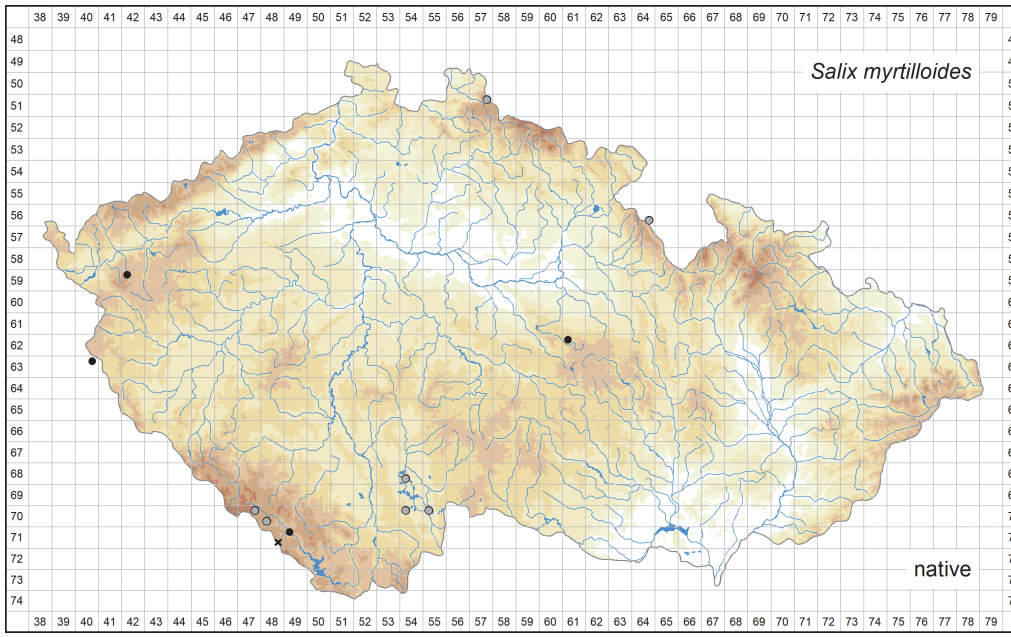

Fig. 76. Distribution of *Salix myrtilloides* in the Czech Republic: ● at least one record in 2000–2021 (4 quadrants), ● pre 2000 records only (7 quadrants), × deliberate introductions in the countryside only (1 quadrant). Prepared by Radim J. Vašut, Blanka Trnková, Boleslav Jelínek & Luboš Úradníček.

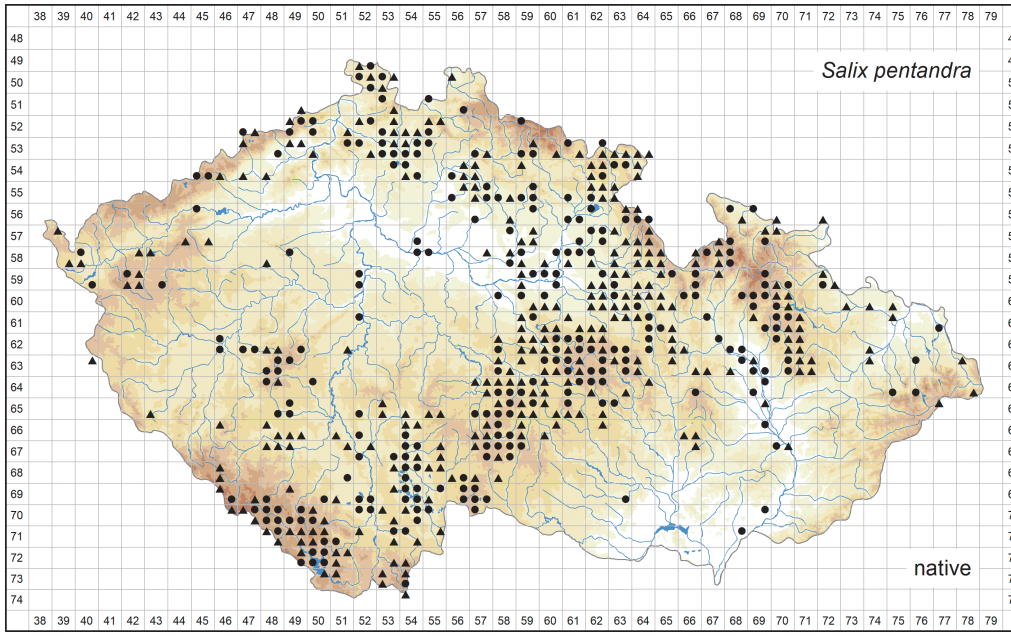

Fig. 77. Distribution of *Salix pentandra* in the Czech Republic: ● occurrence documented by herbarium specimens (257 quadrants), ▲ occurrence based on other records (305 quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

Bohemia (Brandová & Vašut 2016). Although it was considered as missing in the second half of the 20th century, small populations were later found at four of these sites (Koblížek 1989, Jirásek 1995, Mudra 2003, Koutecký et al. 2014). The species is classified as critically threatened because of its rarity and decline (Grulich 2012).

Even though the diploid *Salix myrtilloides* easily hybridizes with other diploid species (Elven & Karlsson 2000, Vašut et al. unpubl.), only two hybrids are known from the Czech Republic. *Salix* ×*onusta* (*S. aurita* × *S. myrtilloides*) was repeatedly collected but its identity has not been confirmed by genetic analyses yet. The identification of *Salix* ×*finmarchica* (*S. myrtilloides* × *S. repens*) from the Upolínová louka pod Křížky National Nature Reserve in western Bohemia was supported by molecular methods. The map is based on herbarium specimens and selected literature records; records by Chmelař (1966) of *S.* ×*onusta*, implicating former occurrence of *S. myrtilloides* (Brandová & Vašut 2016), are not included in the map.

Salix pentandra (Fig. 77)

The continuous range of *S. pentandra* extends from central Europe to western Siberia, reaching northern Scandinavia and the northern part of European Russia in the north, and the Alps, Carpathians, middle Dniester river basin and northern edge of the Caspian Depression in the south. There are isolated occurrences in the British Isles, Apennine Peninsula and Dinaric Alps (Hultén & Fries 1986, Skvortsov 1999). Blanco (2006) questioned its indigenous status in the Pyrenees. It has been introduced into North America (Argus 2010). In the Czech Republic *S. pentandra* grows in wet to peaty meadows, alder carrs and along streams, mainly on acidic soils. It is most frequent in the Šumava Mts, the Českomoravská vrchovina highlands, most of eastern Bohemia and in parts of northern Bohemia; in Moravia it grows less frequently and is mainly found in the upper Morava river basin around the town of Litovel and in the Nízký Jeseník Mts. It is classified as of lower risk – near threatened (Grulich 2012).

Salix repens agg. (Figs 78–81)

The *Salix repens* complex includes two closely related species, *S. repens* and *S. rosmarinifolia*, which often grow together not only in the Czech Republic but also in other places where their ranges overlap. Because they cross easily, hybrid swarms consisting of various morphs are formed. Individuals combining leaves similar to those of one parent and inflorescences of the other are not rare. Transient morphs are often referred to as *S.* ×*incubacea*. Both leaves and inflorescences are needed for exact identification, which, however, are not available in most herbarium specimens. Therefore, four maps were produced. The distribution maps of *S. repens*, *S. rosmarinifolia* and *S.* ×*incubacea* are based solely on examined herbarium specimens. The map of the entire complex (Fig. 78) includes all available literature, database and herbarium records.

Salix repens s. str. is distributed in western, northern and central Europe, southwards to the northern Iberian Peninsula, southern France, Switzerland, southern Germany and the Czech Republic, eastwards to western Poland and the coastal areas of the Baltic countries and Finland (Hultén & Fries 1986, Skvortsov 1999). In the Czech Republic it grows in wet and peaty meadows and at edges of fishponds on sandy to clayey or peaty soils. In this country *S. repens* s. str. is the rarer of the two species. It is found mainly in northern

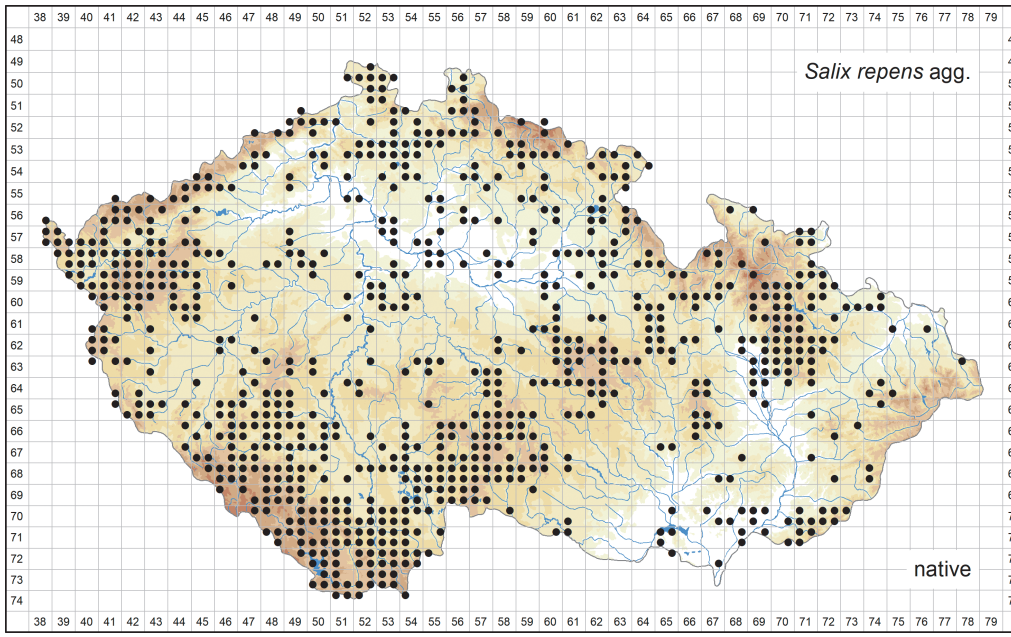

Fig. 78. Distribution of *Salix repens* agg. in the Czech Republic (816 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

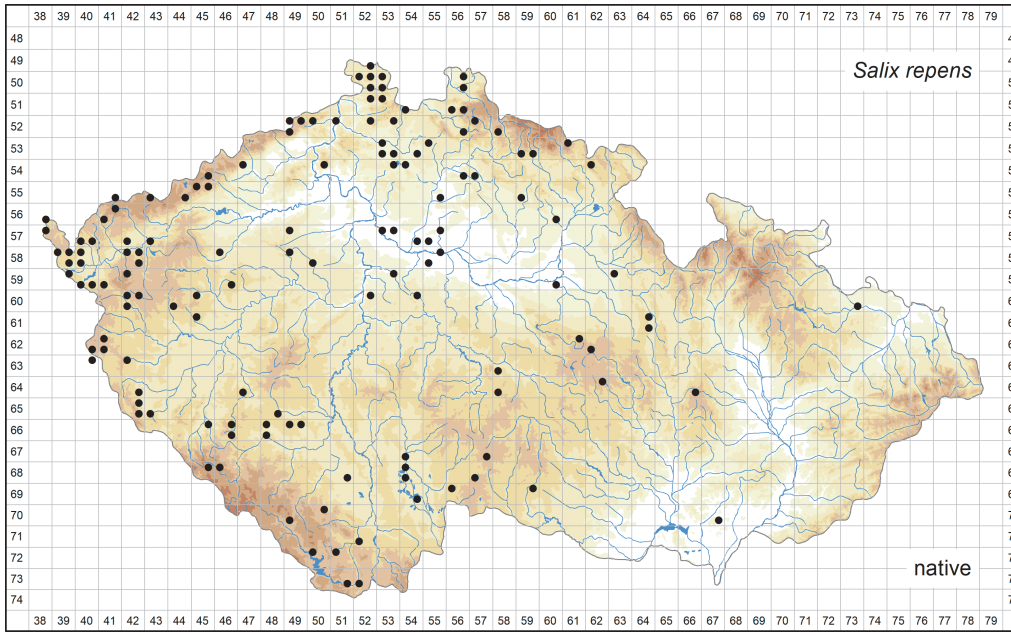

Fig. 79. Distribution of *Salix repens* in the Czech Republic (137 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

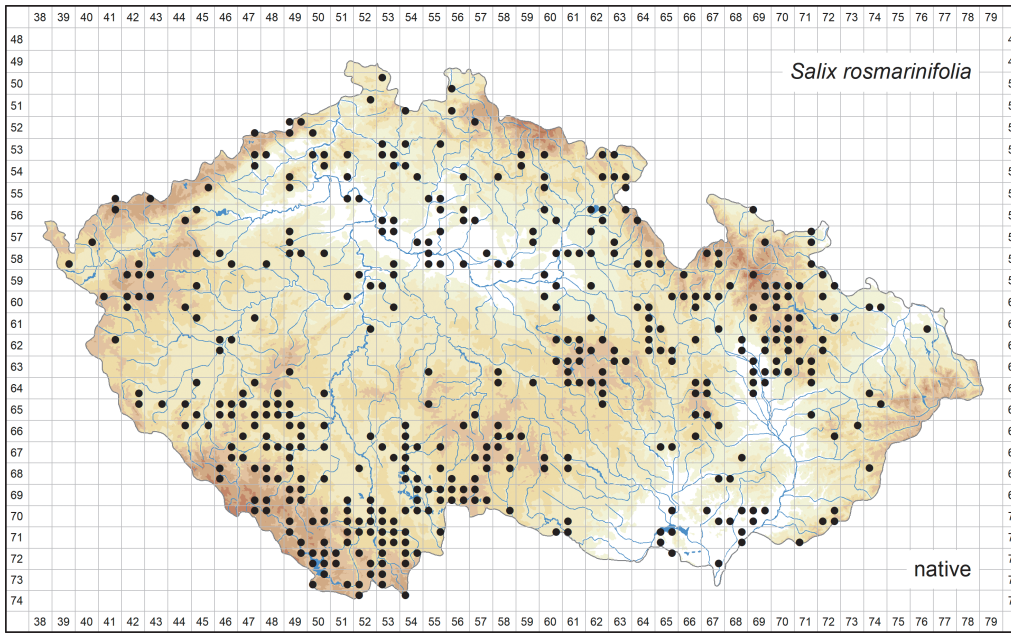

Fig. 80. Distribution of *Salix rosmarinifolia* in the Czech Republic (429 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

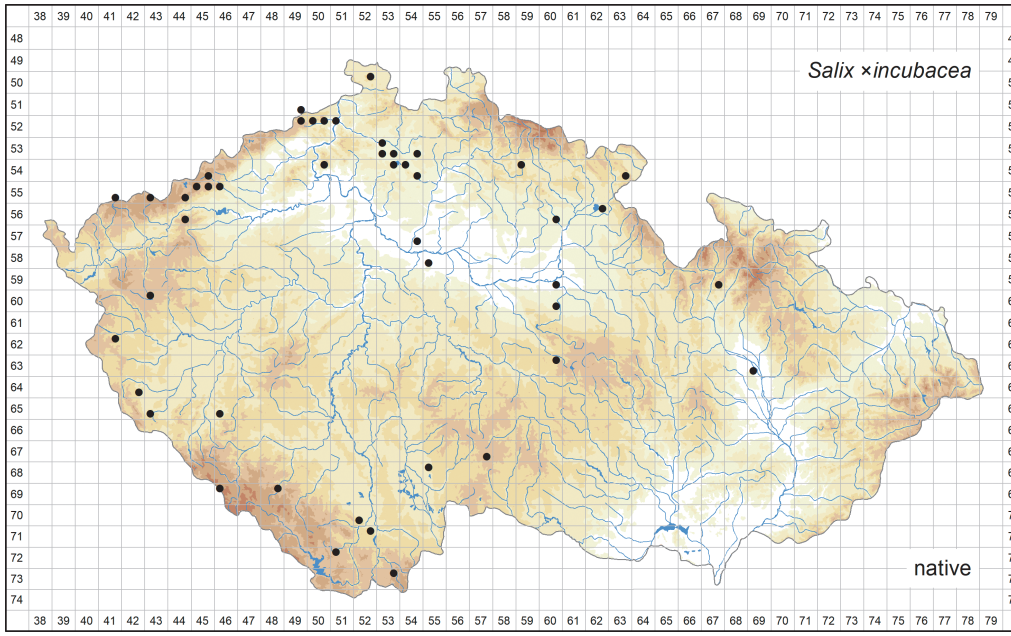

Fig. 81. Distribution of *Salix ×incubacea* in the Czech Republic (46 occupied quadrants). Prepared by Boleslav Jelínek & Luboš Úradníček.

and western Bohemia, particularly in the mountains along this country's border and around the town of Doksy (Fig. 79). Sporadic occurrences have been recorded in other parts of the country, although some records may actually represent the unrecognized *S.* ×*incubacea*. It is classified as endangered (Grulich 2012).

Salix rosmarinifolia is distributed from central Europe in the west to eastern Siberia and Mongolia in the east. In Europe it extends northwards to Denmark, central Finland and the northern part of European Russia, westwards to Germany and the Alps, and southwards to Austria, Hungary, the Carpathians, southern Ukraine and the Caspian Depression (Jalas & Suominen 1976, Skvortsov 1999). In central Europe, namely in southern Germany, the Czech Republic and Poland, there is a wide zone of co-occurrence of both species where hybrids (*S.* ×*incubacea*) are common and many transient morphotypes are formed. In the Czech Republic *S. rosmarinifolia* grows in fens, peat meadows and birch bog forests. It is most frequent in southern Bohemia, particularly in the Šumava and Novohradské hory Mts, their foothills and adjacent fishpond basins. It is also scattered in the northern half of Bohemia, in the Žďárské vrchy hills and in northern Moravia (Fig. 80). It is classified as vulnerable (Grulich 2012).

Salix ×*incubacea* has been recorded in the Czech Republic in the areas of co-occurrence of the parental species, namely in Bohemia along this country's border and around the town of Doksy (Fig. 81).

Salix silesiaca (Fig. 82)

Salix silesiaca occurs in the mountains of eastern central Europe. It is native to the Sudetes, Carpathians and western Dinaric Alps (Chmelař & Meusel 1976). In the Czech Republic it mainly grows in subalpine acidophilous scrub, subalpine tall-forb vegetation, and subalpine and montane springs. It often grows along mountain brooks and can occasionally be found downstream at lower elevations. Less frequently it occurs in spruce forests, rarely in forest belts and forest clearings. *Salix silesiaca* is still relatively common in the Sudetes, especially in the Krkonoše and Hrubý Jeseník Mts, with numerous populations and more or less continuous distribution in their subalpine zones. In the Orlické hory Mts and the Moravskoslezské Beskydy Mts this species is affected by hybridization (especially with *S. aurita*) and occurs in small populations, sometimes consisting of a few individuals, or often even as a single plant per site. At some places hybrids (mainly *S.* ×*subaurita*) are even more frequent than *S. silesiaca*. Therefore, specimens from the lower montane and submontane zones require genetic investigation in order to distinguish "pure" *S. silesiaca* from individuals influenced by introgressive hybridization, mainly with *S. aurita* and less frequently with *S. caprea*. Based on this, the plants from Mt Ještěd and the Žďárské vrchy hills require genetic examination to determine whether those resembling *S. silesiaca* represent rare occurrences of this species or in fact are hybrids. Records from montane and submontane areas of the Nízký Jeseník hills are not included in the map because field observations confirmed only the presence of hybrids. *Salix silesiaca* easily hybridizes with many other willow species: in central Europe hybrids with all sympatric species except *S. myrtilloides* were described. In the Czech Republic genetically confirmed hybrids include those with *S. aurita*, *S. caprea*, *S. hastata* and *S. lapponum*. *Salix silesiaca* is classified as of lower risk – near threatened (Grulich 2012).

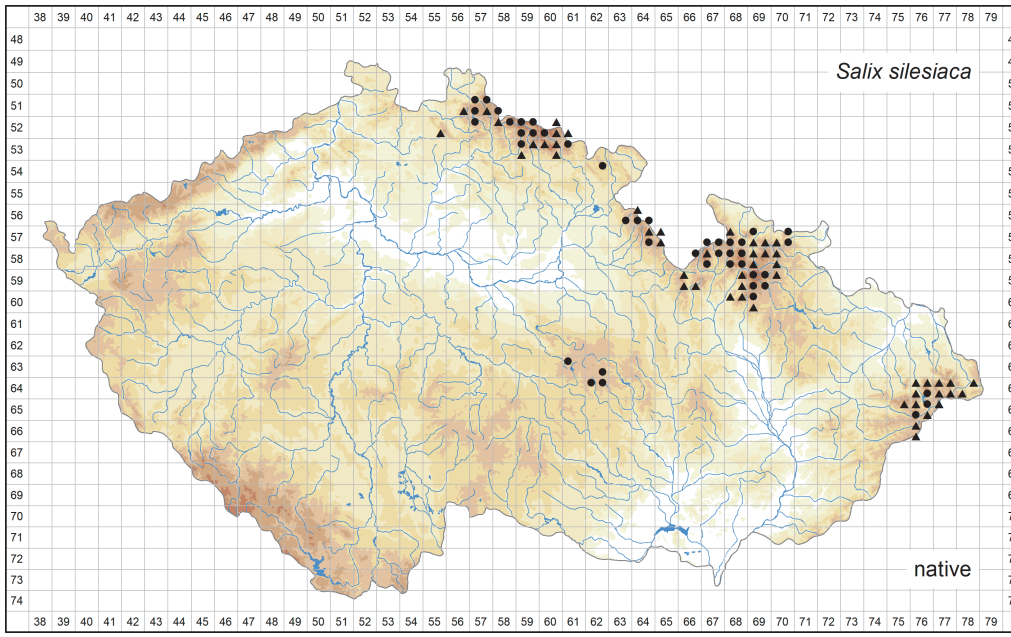

Fig. 82. Distribution of *Salix silesiaca* in the Czech Republic: ● occurrence documented by herbarium specimens (44 quadrants), ▲ occurrence based on other records (50 quadrants). Prepared by Radim J. Vašut & Michal Hroneš.

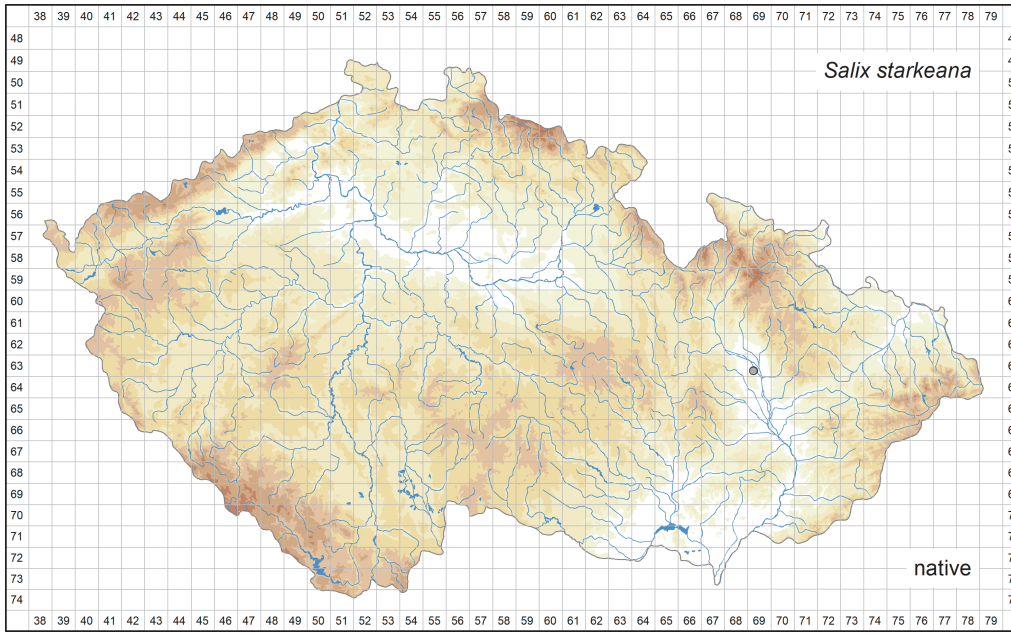

Fig. 83. Distribution of *Salix starkeana* in the Czech Republic: ● pre 2000 records only (1 quadrant). Prepared by Radim J. Vašut & Jan Lukavský.

Salix starkeana (Fig. 83)

Salix starkeana in its broad circumscription (including subsp. *cinerascens*) occurs in the boreal zones in Europe and Asia; in its narrow sense (subsp. *starkeana*) it is confined to Scandinavia and north-eastern Europe (Chmelař & Meusel 1976, Jalas & Suominen 1976). Most European localities are in southern Scandinavia. In central Europe *S. starkeana* is extremely rare or now mostly extirpated. The only known herbarium specimen of this species from the Czech Republic was collected in 1956 at the village of Řepčín (now northern outskirts of the city of Olomouc) but at the time it was unrecognized. Its true taxonomic identity was recognized almost four decades later (Deyl & Koblížek 1994). The site near Řepčín was once a mosaic of wetland habitats, but they were gradually destroyed by drainage and land development. Although we do not know exactly where the specimen was collected in 1956, we assume that the relict small population of *S. starkeana* was destroyed during the channelization of the Mlýnský potok stream soon afterwards. Repeated searches in the area since 1994 did not reveal any plant of this species. *Salix starkeana* is therefore classified as nationally extinct (Grulich 2012).

Sium latifolium (Fig. 84)

Sium latifolium is a Euro-Siberian species distributed mostly in the temperate zone, occurring from Spain in the west to the Lake Baikal area in the east. In Europe this species is absent from the northernmost regions and it only rarely occurs in the Mediterranean area (Meusel et al. 1978, Hultén & Fries 1986). It has also been introduced into Chile (Ugarte et al. 2011). In the Czech Republic *S. latifolium* occurs on the banks and in the littoral zone of alluvial pools, oxbows, fishponds, ditches and slowly flowing rivers and streams, and in wet depressions in intermittently flooded meadows. It can grow in willow and alder carrs, but cannot cope with deep shade. It prefers nutrient-rich, basic to slightly basic muddy substrates. This species is well adapted to periodic fluctuations in water level, capable of forming submerged, finely dissected leaves in spring and early summer. However, it is sensitive to disturbances and cannot survive regular mowing or intensive grazing. In this country *S. latifolium* grows almost exclusively in lowland floodplains, especially in the basins of the Labe (Bohemia), Morava and Dyje (Moravia) rivers. It has declined markedly during recent decades due to habitat destruction and succession, drainage, reclamation of alluvial meadows and changes in water level management. It is classified as endangered (Grulich 2012).

Vaccaria hispanica (Fig. 85)

Vaccaria hispanica is probably native to the Mediterranean area but it has been introduced in Europe northwards to central Norway, northern Sweden, central Finland and northern Russia, and also into Asia, southern Africa, Australia, New Zealand and North America (Hultén & Fries 1986, Jalas & Suominen 1986, Kurtto 2001b). In the Czech Republic *V. hispanica* used to be a weed on arable land, mainly in cereal fields, less frequently in flax, alfalfa, vetch and clover fields, mostly on base-rich soils. It was locally common in warm, dry lowlands and adjacent hilly landscapes in north-western and central Bohemia and southern Moravia, and scattered to rare at middle elevations in most of this country. However, the occurrences in moderately warm areas and at middle elevations

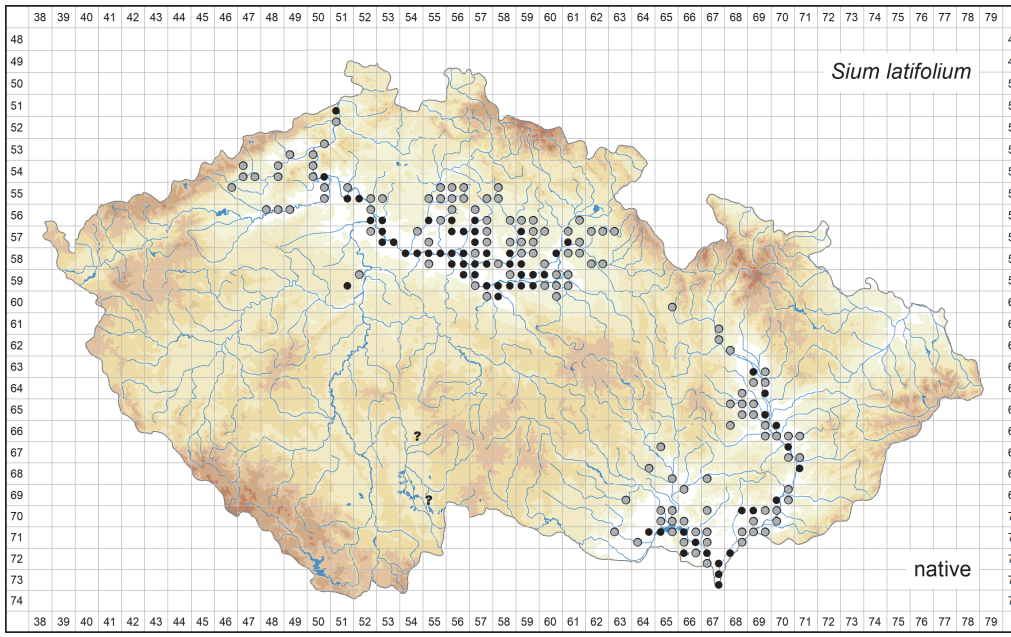

Fig. 84. Distribution of *Sium latifolium* in the Czech Republic: ● at least one record in 2000–2021 (46 quadrants), ● pre 2000 records only (126 quadrants). Prepared by Jan Prančl.

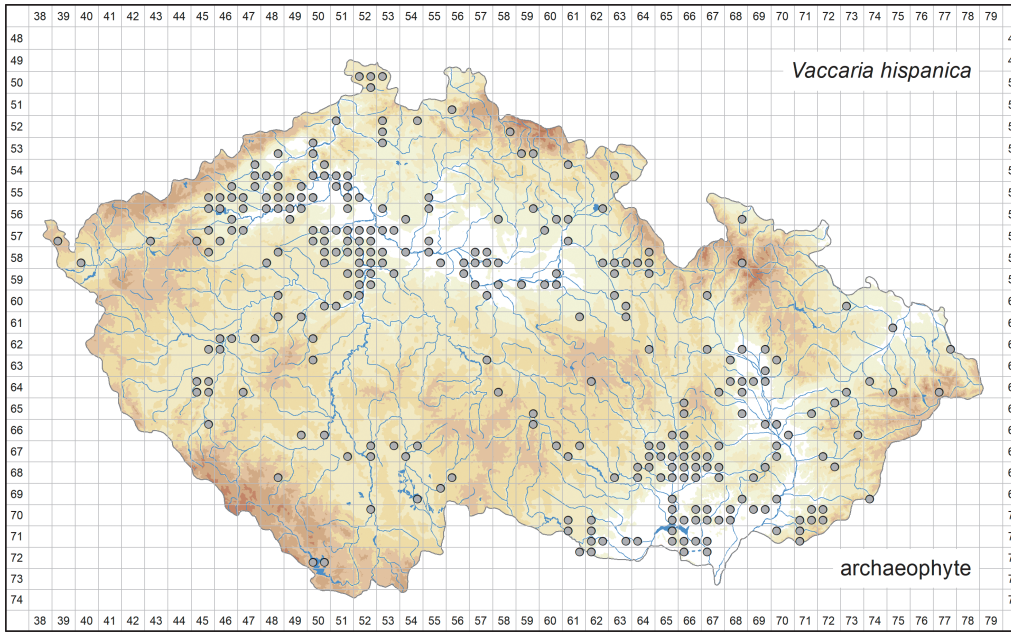

Fig. 85. Distribution of *Vaccaria hispanica* in the Czech Republic: ● pre 2000 records only (283 quadrants). Prepared by Zdeněk Kaplan & Jiří Danihelka.

were often transient, dependent on repeated introductions with imported seed. The occurrences in crop fields generally ceased by the mid-20th century due to changes in agricultural practices. The last record from an arable field in the area with more or less stable occurrence of *V. hispanica* dates back to 1977 when this species was collected near the town of Velké Pavlovice in southern Moravia. All later records are sporadic and mostly came from ruderal habitats such as transit sheds, railway stations, railway embankments and road verges. These occurrences mostly consisted of single plants. The last spontaneous occurrence in this country was recorded in 1982 when a single plant of *V. hispanica* was collected at a field edge near the village of Zářící in central Moravia; however, this may have been accidentally introduced with crop seeds. Two populations found recently at edges of settlements resulted from intentional sowing and these were not included in the map. In the Czech flora *V. hispanica* is now considered a casual archaeophyte (Pyšek et al. 2012) and classified as missing (Grulich 2012).

Supplementary materials

Data S1–S85. – Records used for producing maps

Supplementary materials are available at www.preslia.cz

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Rozšíření cévnatých rostlin v České republice. Část 11

Jedenáctá část ze série prací věnovaných rozšíření cévnatých rostlin v České republice obsahuje síťové mapy a komentáře k 85 taxonům rodů *Agrostemma*, *Berula*, *Bromus*, *Carex*, *Corydalis*, *Echinocystis*, *Festuca*, *Himantoglossum*, *Lychnis*, *Ophrys*, *Ornithopus*, *Pseudofumaria*, *Quercus*, *Salix*, *Sium* a *Vaccaria*. Základem jsou údaje získané excerpcí herbářů a literatury, terénní zápisy a databázové údaje, které prověřili taxonomičtí experti. Většina studovaných rostlin je zařazena do červeného seznamu ohrožených druhů. Mezi kriticky ohroženými taxony jsou zejména horské rostliny, psamofyty, polní plevele a orchideje. Koukol, *Agrostemma githago*, v minulosti úporný plevel obilných polí rozšířený téměř po celém našem území, z orné půdy téměř vymizel a vzácné novější nálezy pocházejí nejčastěji z různých typů ruderálních stanovišť, anebo se jedná přímo o záměrné výsevy. *Festuca albensis* je endemit tří malých písčitých oblastí v Německu a severních Čechách, odkud byl tento druh popsán teprve nedávno. Je ohrožen zejména svou vzácností, schopností křížit se s ostatními kostřavami a zarůstáním stanovišť v důsledku eutrofizace. Zatímco populace mnohých orchidejí spíše ustupují, *Ophrys apifera* má ve své středoevropské části areálu tendenci k šíření na nová území i nové typy stanovišť. V České republice byl poprvé nalezen v roce 1980 na Moravě a v roce 2006 i v Čechách. Přestože celkový počet jeho lokalit přesáhl čtyři desítky, většina populací je malá a druh je stále považován za kriticky ohrožený. Dva taxony je třeba na našem území hodnotit jako vyhynulé. Jediná populace *Himantoglossum calcaratum* subsp. *rumelicum* zanikla na konci 50. let 19. století, zatímco jediný sběr druhu *Salix starkeana* pochází z roku 1956. Další druh, *Vaccaria hispanica*, je u nás nezvěstný již po více než tři desetiletí. Mnohé nepůvodní druhy jsou naopak na naše území zavlékány. V tomto příspěvku to platí zejména o zástupcích rodu *Bromus*. Dva zavlečené druhy se u nás chovají jako invazní. *Echinocystis lobata* se rozšířila podél řek a potoků v nižších polohách po téměř celém území České republiky. Severoamerický dub *Quercus rubra* byl vysazován nejen do parků, ale i do lesů, kde zdomácněl a nyní se invazně šíří. Celkový obraz rozšíření zpracovávaných taxonů v ČR poskytují mapy; konkrétní floristické údaje, které zachycují frekvenci výskytu v různých oblastech a v různých obdobích, případně dokumentují ústup, nebo naopak šíření některých druhů, jsou uloženy v databázi Pladias a dostupné v přílohách. Každou mapu doprovází komentář, který obsahuje nástin celkového areálu, výčet nejčastějších stanovišť a stručnou charakteristiku rozšíření v České republice, případně i doplňující informace k taxonomii, biologii, změnám v rozšíření a míře ohrožení.

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