

TAXA OF VASCULAR PLANTS ENDEMIC TO THE PANNONICUM FLORISTIC REGION

N. RIEZING

H-2851 Környe, Koltói A. u. 6, Hungary; E-mail: nriezing@gmail.com

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Following the work of Tatár (1939), no new revised and detailed list was made of endemic plants of the Pannonicum phytogeographical region, which takes into account the latest research results. A survey of vascular plants endemic and subendemic to the Pannonicum is presented here based on a critical revision of published and sometimes unpublished data on contemporary taxonomic and chorological knowledge. For this, it was necessary to review the delineation of Pannonicum and the problem of drawing the boundaries. I would also like to draw the attention to the Pannonian flora islands outside the Carpathians, which descend along the sandy alluvium of the Danube. The research covers 11 countries: Austria, Croatia, the Czech Republic, Hungary, Romania, Serbia, Slovakia, Slovenia and a small part of Bosnia and Herzegovina, Ukraine and Bulgaria (flora islands). The final evaluation of endemic status was made for 225 taxa of vascular plants, including 143 taxa confirmed as endemic or subendemic to the Pannonicum, 5 narrowly distributed taxa shared endemic of the Pannonicum and western part of the Carpathicum and 77 taxa are not endemic according to current taxonomic and phytogeographical knowledge (the list does not include hybrids). The final list of endemic and subendemic taxa includes 42 species, 29 subspecies and 73 apomictic species (including 47 taxa of *Sorbus* and 23 taxa of *Taraxacum*). Tatár mentions 55 taxa (without apomicts) of which only 29 (53%) are still considered endemic today. In terms of habitat preferences for (sub)endemic taxa most plants (excluding apomictic taxa) occur in rocky or sandy habitats.

Key words: Austria, Czech Republic, delineation of Pannonicum, Hungary, Pannonian endemic flora, revision, Romania, Serbia, Slovakia

INTRODUCTION

The most characteristic taxa in an area, country or biogeographical region are endemic species. Because of their importance to biodiversity and also of particular importance in studies of floristic and vegetation history of different areas they have attracted the attention of biologists as well as conservationists. Endemic plants may be an effective indicator for identifying and assessing regions with high biodiversity value. The growing attention on endemism and endemic species can be visualised based on the rising number of scientific publications. They can also be promoted well in the media: because they do not live elsewhere they often become “national” species. Plant endemics represent an important element of biodiversity, thus having a decisive role in studies for conservation planning. Countries have a particular respon-

sibility to protect those species that are restricted to their boundaries. Today endemism and endemic species are part of national and international laws and conventions; internet sites and many documentary films use these terms for characterising globally rare and threatened animals and plants (Hobohm 2014). Numerous lists have already been made of endemic plant species in a country, geographical region (Essl *et al.* 2009, Hurdu *et al.* 2012, Kaplan 2012, Kliment 1999, Kliment *et al.* 2016, Mráz *et al.* 2016, Nikolić *et al.* 2020, Novikov and Hurdu 2015, Petrova 2006, Piękoś-Mirkowa and Mirek 2003, etc.) or endemic species of a region within a country (Lubarda *et al.* 2014).

The Pannonian biogeographical region is an accepted biogeographical region in Europe and a separate unit in biogeographical maps (e.g. European Union: Anon. 2021). This biogeographical region is accepted in both zoology (Varga 2018) and botany. In botany, vegetational (Fekete *et al.* 2016) and floristic delineation (e.g.: Soó 1947) are also known. In the present paper, we take the floristic delineation (Soó 1947) as a basis. The name of this floristic region is Pannonicum.

Despite its importance and uniqueness, we lack an up-to-date list of endemic plant species. The last detailed article was written more than 80 years ago (Tatár 1939). The ongoing research in taxonomy and plant distribution resulted in a deeper knowledge of numerous taxa, which is reflected in changes in their endemic status. Following expert taxonomic reevaluations, some of the species and subspecies were included in other taxa with a broader (and so non-endemic) distribution area. Another group of taxa that were previously considered to be endemic were later excluded from the list of endemics due to new chorological data (and vice versa). Since 1939 many new species have been described that are thought to be endemic. The main aim of this paper was to review the older results (e.g. Tatár 1939) from this area, complete the collection of data for the whole Pannonicum and revise the information on taxonomy and distribution of endemic taxa in the light of recently published knowledge.

Delineation of Pannonicum

The speciality and unique character of the flora of the Great Hungarian Plain was already recognised by Kerner (1863). According to him, these grasslands are related to the steppes of the east (South Russia) and this is their “western island”. He also recognised that the steppe flora in the west along the Danube extends beyond Vienna to Wachau and the Moravian Basin. He had already used the term “Pannonian flora”, but still considered it the territory of the Pontic area (Kerner 1886). Borbás noticed the flora connection and similarity between the Hungarian Mountains and the Great Plain, and in his interpretation these together make up the Hungarian flora region (Borbás 1896,

1900). By the turn of the century, the first flora maps were completed (Borbás 1900, Kerner and Wettstein 1888). However, there was no agreement regarding the classification of the South Transdanubian flora. Kerner (1886) classified this as the Pannonian, while Borbás (1900) classified it as the Illyrian flora. At the beginning of the 20th century, many famous Hungarian botanists worked on the preparation of the flora classification in the Carpathian Basin (e.g. Borbás 1905, Jávorka 1924–1925, Rapaics 1910, Simonkai 1910, Soó 1933a, Tuzson 1915), and researched the unique characters of the Pannonian flora and presented the differences from the Pontic flora (Borbás 1905, Rapaics 1918, Tuzson 1913, 1915). Rapaics (1910) roughly draws the boundaries of Pannonicum. The map of Jávorka's book (1924–1925) essentially outlines the phytogeographical division of the Carpathian Basin accepted today. Soó (1933b) synthesised the knowledge of that time and drew the boundaries of smaller phytogeographical units within the territory of historical Hungary. In his later work, he also outlines the boundaries of the Pannonian flora beyond the Carpathian Basin (Soó 1947) and draws up a comprehensive and detailed demarcation of the Pannonicum (floristic region), which (except for the north-western part) has remained essentially or only slightly changed.

In the second half of the 20th century, researchers examined the borders of the Pannonian flora and its smaller units only within the borders of their own country (e.g. Soó 1961). The western, northwestern, and northern parts of the Pannonicum's border are the best researched and accepted. In the present dissertation, the works of Futák (1984), Király (2001), Michalko *et al.* (1986), Niklfeld (1964), Pócs (1981), Simon (2005), Skalický (1988), Vojtkó (2016), Willner (2013) are considered as guidelines for the delimitation in this section.

However, there are also two areas here where the flora boundary is not clear: Zemplén Mts in the northeast and the "Thermenlinie" in the west. In the case of the Zemplén Mts, it has long been a question of how far the Carpatium extends into the Pannonicum. According to most authors, it extends deep into the south but Michalko *et al.* (1986) draw the line further north. Recent and more detailed research also supports this (Vojtkó in litt.). (The two types of delimitation are shown by a dashed line on the map). The "Thermenlinie" is the area between the Vienna Basin and the Eastern Alps (south of Vienna). This very eastern margin of the Alps is strongly influenced by the Pannonian climate and phytogeographically it is a transitional area between the Alpicum and Pannonicum floristic regions with strong Pannonian influence (Willner 2013). Recent studies suggest that this Thermenlinie is part of the Pannonian region even though it belongs geologically to the Alps. However, it is a difficult question how many kilometres the Pannonian region penetrates into the Alps (Willner in litt.).

The southwestern border from the southern part of Burgenland (south of the rivers Pinka and Lafnitz) through Slovenia and Croatia to Bosnia and Serbia remains also questionable (Fekete *et al.* 2016, Marinček 1995, Niklfeld 1993, Willner 2013, Wraber 1969). In Slovenia, Wraber (1969) considered the eastern part of the country, east of the Maribor–Krško (Sava) and Kostanjevica (Krka) lines, to be a “sub-Pannonian” area, but mentioned that the most significant Pannonian influence in vegetation is only up to the Mura River. From here, to the west and south, the alpine influence is becoming more and more prevalent. Zupančič *et al.* (1987) classify areas south of the Slovenska Bistrica–Drava line as Illyricum floristic region.

The northern border of the Illyricum is mostly drawn at the foothills surrounding the Dinaric Mountains (Fukarek 1979, Meusel *et al.* 1965) or along the Sava river (from Zagreb) (Marinček 1995). South Slavic botanists consider the area between the Sava and the Drava river, and even to Lake Balaton to be transitional (“prepannonic region”) and classify it as Pannonicum, but mention that the Illyrian flora islands are still present here extrazonally (Marinček 1995). Fekete *et al.* (2016) (Hungarian botanists) do not accept this view, as they do not see what kind of floristic or vegetation arguments support such an extension of the boundary from the Pannonian side. The area between the Drava and the Sava is believed to be uncharacteristic and transitional, difficult or impossible to classify into any phytogeographical region. The areas north of the Drava river are named in Hungarian literature as “Praeillyricum” and are mostly classified as part of the Pannonicum (e.g. Pócs 1981).

The phytogeographical division of the area between the Sava and Lake Balaton is therefore not uniform, but the authors agree that it is a transitional region between Pannonicum and Illyricum. The delimitation of the Pannonicum was also based on the work of Soó (1947) in this section, but referring to the transitional area, the “boundary” on the map is indicated by a dashed line. The drawing of the eastern and southeastern borders with minor modifications (by the author) also follows the work of Soó (1947). (Fig. 1).

Pannonicum is surrounded by the Carpaticum (north and east), Moesiaticum (southeast), Illyricum (south), Alpicum (west) and Hercynicum (northwest) floristic regions.

Most of the area of the Pannonicum is located in Hungary, but the area is also located in Austria (part of Burgenland, the northeastern part of Lower Austria with the Hainburger Berge, which is geographically part of the Carpathians), the Czech Republic (southeastern Moravia, part of it belongs geographically to the Carpathians: Central and South Moravian Carpathians), the southern part of Slovakia, the western edge of Ukraine, the northwestern and western verge of Romania (Partium, Bánság), the northern part of Serbia, the northeastern edge of Bosnia, northeastern plains in Croatia and the northeastern edge of Slovenia.

Islands of the Pannonian flora

It is not part of the Pannonicum delineated here but there are some “Pannonian flora islands” along the lower part of the Danube outside the Carpathian Mountains. These are Pannonic sand steppes (Natura 2000 code: 6260), where endemic Pannonian species also occur (Vladimirov and Tsoneva 2006, ŠeffEROVÁ StanOVÁ *et al.* 2008).

The Pannonian sand steppe vegetation can still be found on the northern edge of the Iron Gate in the wide valley around Golumbac (this work

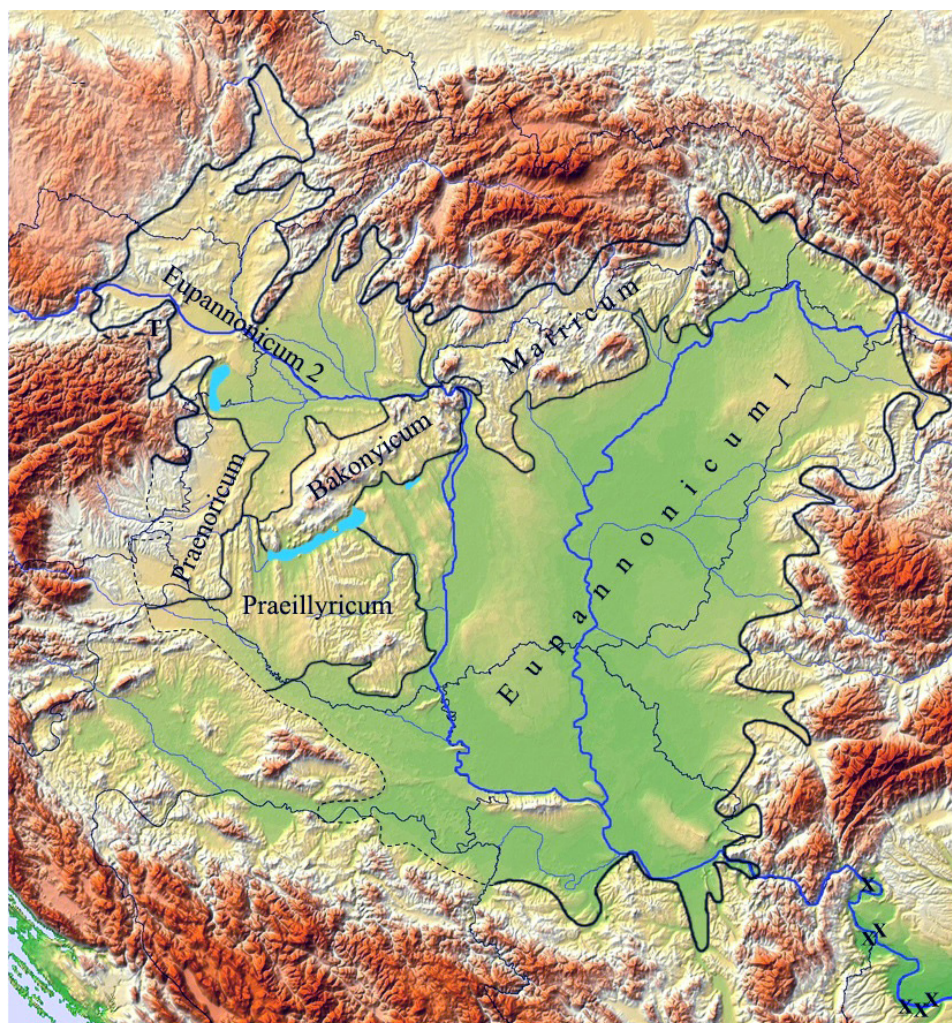


Fig. 1. Map showing the delineation of the Pannonicum and its subunits. T = Thermenlinie, X = Pannonian flora islands

classifies this area as part of Pannonicum). After crossing the Carpathians (this gorge called Iron Gate) the Danube arrives in a flat area where it has deposited sandy alluvium in a few places. On these sand dunes appeared sand steppe vegetation with many Pannonian elements for example around Kladovo and Prahovo-Radujevac in Serbia. In the middle of the 19th century the area of these sand steppes reached 800 hectares in both places (Pančić 1863), but this decreased significantly by the end of the century (Adamović 1904). Since then most of them have been cultivated or degraded and only very small fragments have survived. Some of the previously found Pannonian species have become extinct: *Colchicum arenarium*, *Iris arenaria*, *Sedum urvillei* subsp. *hillebrandtii*. Others can still be found: *Dianthus diutinus*, *D. pontederiae*, *Tragopogon floccosus*. A similar sand flora is found on the Romanian side of the Danube near Pisculet (occurrence of *Colchicum arenarium* and *Festuca vaginata*) and Gruia. Moreover, this Pannonian inland dunes type vegetation descends even to the northwestern edge of Bulgaria (Archar, Orsoya-Slivata) with Pannonian species, such as *Festuca vaginata* or *Tragopogon floccosus* (Vladimirov and Tsoneva 2006).

Division of Pannonicum

Pannonicum was divided into five parts by phytogeography (Molnár *et al.* 2018, Pócs 1981, Soó 1961, 1964a): Eupannonicum, Matricum, Bakonyicum, Praeillyricum, Praenorikum.

Eupannonicum: The plains from Southern Moravia (Czech Republic) in the northwest to Deliblato Sands (Serbia) in the southeast. This area makes up nearly 75% of the Pannonicum. The Transdanubian and the North Hungarian Mountains divide into two parts. Within this delimited area there are some foothills, hills (e.g. Hainburger Berge, Kaszonyi-hegy) and mountain (Fruška Gora). Most of the area belongs to the forest-steppe zone.

Matricum: This is a mountain range (more or less the geographical North Hungarian Mountains – Északi-középhegység) from the Börzsöny to the southern part of the Zemplén Mts. Limestone (Bükk, Gömör-Tornai karszt/Gemersko-Turniansky Kras) and eruptive bedrocks (e.g. andesite, basalt) make up a significant part of the mountains. The vegetation is characterised by two faces. The flora of the higher altitudes (800–900 m), the northern exposed slopes and the gorge valleys are mountainous (include some Carpathian elements), while the lower areas and the southern slopes are mostly dominated by thermophilous Pannonian vegetation.

Bakonyicum: The Transdanubian Mountains (Dunántúli-középhegység) from the Danube Bend to the Keszthelyi-hegység. The most typical bedrock

is dolomite and limestone here. The climate of this region has a strong sub-Mediterranean influence on the southern slopes.

Praeillyricum: This area has two mountains (Mecsek, Villányi-hegység) and collin regions (Somogy–Tolnai-dombvidék). It is an intermediate area between the Pannonicum and the Illyricum. The number of Illyrian elements is relatively high in the south but gradually disappears in the north.

Praenoricum: This is an intermediate zone between the Alpicum and the Pannonicum floristic regions.

Pannonian endemics in previous literature

The compilation of endemic species of an area or landscape within the Carpathian Basin was dealt with as early as the end of the 19th century (e.g. Borbás 1879, 1884, 1900, Grisebach 1872, Simonkai 1886). Some of the plants mentioned here are now considered synonyms, or non-endemic as they are more widespread. However, several of them are still considered endemic today: *Centaurea scabiosa* subsp. *sadleriana*, *Cirsium brachycephalum*, *Dianthus diutinus*, *D. pontederiae*, *Ferula sadleriana*, *Linum dolomiticum*, *L. hirsutum* subsp. *glabrescens*, *Seseli leucospermum*, *Noccaea (Thlaspi) jankae*, etc. The first comprehensive and detailed compilation and analysis of the endemic vascular plants of the Carpathian Basin (Carpaticum and Pannonicum) can be attributed to Soó (1933b).

The most detailed compilation of the endemism of the Pannonian flora to date is the result of the work of Tatár (1939) (student of R. Soó). The list is based on a detailed processing of the distribution area of about 55 taxa based on herbarium and literature data. The dissertation does not include such “critical” groups as *Sorbus*, *Rosa*, *Rubus*, *Hieracium*, *Tilia*, *Thymus*, *Mentha*. The article does not mention but did not process for example the genus *Taraxacum* or *Ranunculus auricomus* agg. group. The detailed processing of the distribution area of two other taxa considered to be endemic at that time (*Ononis semihircina*, *Centaureium uliginosum*) was carried out by U. Szabó (1939). Soó (1964a) also publishes lists, but only of areas within the borders of Hungary.

Since then, only a few flora databases have collected the Pannonian endemics (e.g. Horváth *et al.* 1995, Simon *et al.* 1992). These include species described since 1939 (e.g. *Scilla spetana*, *Vincetoxicum pannonicum*), some subspecies (not all), some hybrids and several other taxa that are not considered endemic today. Fekete *et al.* (2011, 2014) also report compilations of Pannonian endemics. In the latter, they listed 36 species and subspecies and one hybrid, and it is mentioned that there are another 11 endemic apomictic *Sorbus* species. Futák collected the Pannonian endemics that live in Slovakia (Futák 1972).

Regarding Pannonian endemics, it should be mentioned that the phytogeographical Pannonicum and the geographical Carpathians overlap. The North Hungarian Mountains (phytogeographic: Matricum) for example are part of both, but also the Hainburger Berge (Austria) and a part of the Central and South-Moravian Carpathians (the Czech Republic). Therefore, there may be Carpathian endemics (in a geographical sense) (Kliment *et al.* 2016) that can also be treated as Pannonian endemics (in a floristic sense).

METHODS

Delimitation of endemic and subendemic taxa and evaluation of endemism

Endemic taxa are those whose distribution is restricted to a particular geographic region or habitat (Bruchmann 2011, Hobohm 2014). The delimitation of the Pannonicum is not as clear as a national border or an island (see above). The boundary is not sharp on a fine scale. For example on the border of Pannonicum and Carpathicum, the southern warm slopes grow Pannonian vegetation while the northern exposed slopes and the gorge valleys have mountainous vegetation with many Carpathian elements and they are very close together. So these different flora patches often occur alternately in the area.

The delimitation of the phytogeographic units within the Pannonicum is not easy either. The Danube Bend area which is called Visegradense in the phytogeography is a transitional area between the Matricum (North Hungarian Mountains) and the Bakonyicum (Transdanubian Mountains). Endemic plants can be found here from both regions. There are some differences between the geographical and the phytogeographical regions as well. The sand steppe vegetation of the lowlands for example creeps up the foothills in several places. This is geographically a mountain region but phytogeographically vegetation of the lowlands.

Drawing sharp boundaries is therefore difficult, often impossible. In addition, there may be isolated occurrences in special habitats (e.g. on limestone hills or in sandy areas). In this paper, the geographical delimitation does not exclude endemic taxa restricted to a particular isolated occurrence of special habitats or habitat islands (e.g. to isolated outcrops of different types of bedrock, sand, etc.) (see Kliment *et al.* 2016).

As subendemic I considered taxa almost exclusively found only in a certain region, but with a limited occurrence also outside this region. *Achillea asplenifolia*, for example, is quite widespread in the Pannonicum, but can also be found in some places in the adjacent area. The distribution area of the *Chamaecytisus heuffelii* is limited to a few localities only. Most of the popula-

tion lives in Pannonicum, but a significant number also live in the neighbouring Iron Gate Gorge. But taxa with very limited occurrence outside a given region, e.g. taxa with a single population close to the main distribution area or taxa occurring in a transition zone between two adjacent phytochorions, were evaluated as endemic to the given region (see Kliment *et al.* 2016). For example endemic to the Pannonicum with a single occurrence outside but not “far” from the border (e.g. *Dianthus diutinus* is an occurrence in a “Pannonian flora island” near Kladovo). On the other hand, taxa with frequent occurrence in neighbouring regions or with only a single occurrence but far from the Pannonicum (e.g. *Rosa facsarii* is an occurrence in Albania) were not considered to be endemic or subendemic. The phytogeographical status of “Thermenlinie” is not completely clear. Because of its transitional status, taxa that occur only here are considered Pannonian subendemic.

In the evaluation of endemism, only the natural range is taken into account for plant occurrence data. The *Limonium gmelini* agg. for example spreads along the Austrian and Czech roads outside the Pannonicum due to road salting and international traffic (Hohla *et al.* 2015, Kocián *et al.* 2016). These data were not taken into account when determining the distribution area of the *Limonium*. Taxa under the subspecies rank were not evaluated as endemic. Hybrids were not evaluated as endemic but stabilised hybridogenous taxa (e.g. the apomictic taxa) were considered endemic.

Apomictic taxa (*Alchemilla*, *Hieracium*, *Pilosella*, *Rubus*, *Sorbus*, *Taraxacum*, *Ranunculus auricomus* agg.) form a separate group. With understanding of the apomictic origin and evolutionary stability of intermediate (hybridogenous) taxa, in 20th century the majority of researchers accepted such taxa at the level of species, but isolated from sexually reproducing species they are often referred to as “microspecies” (Hörandl 2008, Kirschner and Štěpánek 1998, Sennikov and Kurtto 2017). Their evolutionary history is mostly young (post-glacial) and such species are still evolving recently.

Among these apomictic taxa, the genus *Sorbus* is represented by most known Pannonian endemic species. In the current understanding, the apomictic species of *Sorbus* s. l. are allopolyploid (triploid or tetraploid) with typically restricted areas, sometimes confined to a single locality in which they had possibly originated. They are either single clones or lineages descending from single clones, thus having a very narrow genetic basis. The morphological variability of apomictic species is very limited and is mostly phenotypic (modification). The sexual species of *Sorbus* s. l. are variable in morphology and include a great diversity of genotypes. Similarly, interspecific hybrids that are diploid (allodiploid) and sexual are treated as a single taxon thus embracing all possible morphotypes of the same origin and at the same ploidy

level, as long as there is no evidence of their reproductive isolation (Sennikov and Kurtto 2017).

The status of the *Taraxacum* group is still little known. Within the Pannonicum, we have recent literature data only for the section *Palustris* (Kirschner and Štěpánek 1998). However, the exact identification of the majority of the populations living here is still unknown today.

Several endemic apomictic species have also been described from the *Ranunculus auricomus* group (Soó 1964b, 1965), but we had no relevant information about them since then, so their current status is unknown. These taxa are accepted as species by the databases "The Euro+Med PlantBase" and "Plants of the world online". These taxa are therefore presented in a separate list (Presumably endemic *Ranunculus* taxa, Appendix 4). Research on *Ranunculus auricomus* group in the Pannonicum has been limited to its western edge in recent decades (e.g. Hörandl and Gutermann 1995, 1998a, b, c, 1999). The species described and presumed endemic to this marginal area are also presented in this list.

Based on the size of the distribution area I distinguished four basic categories of endemic taxa in the Pannonicum: eurychoric endemics distributed rather evenly throughout the whole Pannonicum or in their major part; mesochoric endemics with distributions restricted more or less to the individual subunits (e.g.: Matricum or Bakonyicum); stenochoric endemics distributed only in a particular mountain or lowland range (e.g. Bükk or Nyírség) and microchoric endemics restricted to a (or sometimes two) particular small area (e.g.: the summit of the Szénások or the bog of Moosbrunn).

Taxa selection and their evaluation

This evaluation includes endemic and subendemic taxa reported from the Pannonicum in literature and database. Special attention was paid to taxonomic publications that contain up-to-date information on endemic taxa of vascular plants. Among some taxonomically difficult taxa (e.g. *Alchemilla*, *Chamaecytisus*, *Festuca*, *Rubus*, *Sorbus*), I listed only those with existing relevant information in recent taxonomic literature or those commented on by competent experts. The list does not include taxonomically difficult groups for which it has no or insufficient relevant information: *Taraxacum* (except sect. *Palustris*), most of the *Hieracium* and *Rubus* taxa or *Ranunculus auricomus* agg. group (latter presented in a separate list). Distribution data came from literature (see Appendix), internet databases (Database of the Czech Flora and Vegetation: <https://pladias.cz/en>, Vascular plants of Hungary online database: <http://floraatlasz.uni-sopron.hu/index.php?lang=en>, Flora Croacia Database <https://hirc.botanic.hr/fcd/Search.aspx>, Red Data Book of the Republic of Bul-

garia Digital edition: <http://e-ecodb.bas.bg/rdb/en/>), herbarium (Hungarian Natural History Museum, Budapest) and from personal communication. For the evaluation of endemism and classification of endemic taxa, comprehensive taxonomic and chorological studies as well as national floras were preferred. The publications, on which the evaluation of endemism was based, are listed in respective tables in the column "Reference" (Appendix 3).

Plant names mostly follow The Euro+Med PlantBase (<http://ww2.bgbm.org/EuroPlusMed/query.asp>), the remaining names are used according to the current taxonomic literature. The validity of plant names and their taxonomic status were checked also in supranational databases: The Plant List (<http://www.theplantlist.org>), Plants of the world online (<http://www.plantsoftheworldonline.org>), World Checklist of Selected Plant Families (<https://wccsp.science.kew.org>). I also considered authors' opinions published in current national floras and checklists.

Habitat preferences of (sub)endemic taxa

For further studies I examined the occurrence of endemic taxa in various habitat groups and habitats. I distinguished the following basic habitat groups: (Sal) Saline vegetation; (Sand) Steppe, steppe forest on sand; (Loes) Steppe, steppe forest on loess; (Ro) Rock fissures, rock shelters, shallow rocky solis; (Wet) Wetland communities like bogs, marshlands, alluvial meadows; (Xe) Xerophile/dry grasslands (in general) and shrubs; (Me) Mesic hay meadows and pastures; (XeF) Xerophilic mountain forests (oak and oak scrub forests, rocky forests, etc.); (MeF) Mesophilic forest communities (oak-hornbeam and beech forests, riverine forests, etc.).

Habitat preferences of (sub)endemic taxa were evaluated according to the ecological and phytosociological literature (e.g. Soó 1966, 1968, 1970, 1973, 1980), comprehensive studies of selected genera and species, or the knowledge of competent experts. Habitats less characteristic/ordinary of a given taxon are enclosed in parentheses "(" in the table (Appendix 3).

RESULTS

Research on many taxa is ongoing and the results of which may change the lists below. There are some little-known taxa in Pannonicum that may turn out to be endemic. *Ornithogalum* × *degenianum* has a hybrid origin but probably not a primary hybrid. The *Myosotis* taxon found in the southeastern part of the Great Plain is classified recently as *M. sicula*, but it differs from the plants found in Italy (Király 2009). The *Petrosimonia triandra* found in Hortobágy seems to be morphologically different from Eastern European plants

(Molnár A. and Jakab G. in litt). In other cases, research is already underway but there are no definitive results yet (e.g. *Odontarrhena tortuosa* subsp. *tortuosa* – Španiel S. in litt.). In addition, new taxa are expected to be described (e.g. genus *Sorbus*, *Rubus*, *Taraxacum*).

After the revision of endemic status the taxa of vascular plants studied were divided into the following categories: (a) non-endemic taxa (taxa with wider distribution or included in other taxa with wider distribution outside the Pannonicum) (Appendix 1); (b) shared endemic taxa of the Pannonicum and western part of the Carpathicum (Appendix 2); (c) taxa endemic or sub-endemic in the Pannonicum or its subunits (Appendix 3), (d) presumably endemic or subendemic *Ranunculus* taxa (Appendix 4).

Non-endemic taxa

77 taxa were evaluated as endemic to Pannonicum in the literature but are not endemic according to current taxonomic and phytogeographical knowledge (Appendix 1). Most of them belong to synonyms of other taxa with a wider distribution. Many of them have wider non-endemic distribution: *Artemisia santonicum* subsp. *patens*, *Aster tripolium* subsp. *pannonicus*, *Bromus pannonicus*, *Carduus collinus*, *Centaureum littorale* subsp. *uliginosum*, *Cirsium furiens*, *Dactylorhiza fuchsii* subsp. *sooana*, *Dianthus giganteiformis*, *Elatine hungarica*, *Galium austriacum*, *Knautia arvensis* subsp. *pannonica*, *Minuartia frutescens*, *Pilosella budensis*, *P. megatricha*, *Plantago schwarzenbergiana*, *Polygonum graminifolium*, *Primula auricula* subsp. *hungarica*, *Puccinellia distans* subsp. *limosa*, *Rhinanthus borbasii* subsp. *borbasii*, *Rorippa sylvestris* subsp. *kernerii*, *Rosa facsarii*, *R. zalana*, *Scilla bifolia* subsp. *buekkensis*, *Seseli osseum*. In recent times *Tilia*, *Thymus* and *Mentha* genera have since been processed in detail, resulting in a significant reduction in the number of species (e.g. *Thymus*: Mártonfi 1997). None of them is currently considered endemic.

The *Kitaibela vitifolia* has only a few data in the Pannonicum (Tatár 1939), and its main area of distribution is in the Balkans (Tunçkol *et al.* 2020). This list provisionally includes taxa with unclear taxonomic status. For example, *Achillea horanszkyi* is probably a primary hybrid, but further research is needed (Dobolyi 1997). The taxonomy of *Onosma arenaria* is not yet clearly resolved but it appears to have wider non-endemic distribution.

Shared endemic taxa of the Pannonicum and western part of the Carpathicum

Some taxa have a narrow range, but can be found in parts of both the western part of the Carpathicum and the Pannonicum. These are not endemic separately in either of the two above-mentioned phytogeographical regions,

but they are worth mentioning due to their narrow distribution area. These five taxa show the Appendix 2.

Erysimum wittmannii subsp. *pallidiflorum* was considered Pannonian endemic (Soó 1968) but according to recent literature, it also occurs in the Carpathicum (eastern part of Slovakia) (Michalková 2002). *Ophrys fuciflora* subsp. *holubyana* was considered Western Carpathians endemic but it also occurs in the Transdanubian Mountains (Molnár V. and Csábi 2021). *Dianthus plumarius* is called “*lumnitzeri*” in the literature but according to the latest research (Barina *et al.* 2020), this is the correct name for a taxon that occurs from Hainburg to Malé Karpaty and Inovec Mts. Further research of taxa previously classified as *Dianthus plumarius* agg. is required. For more detailed information see Appendix 2.

Endemic or subendemic taxa in Pannonicum

Based on current taxonomic literature, databases and consulting with local experts we identified 143 (73 of them apomicts) taxa endemic or subendemic to the Pannonicum (Appendix 3). Only 29 of the taxa mentioned by Tatár (1939) are still considered endemic today. Based on the list, 42 of the vascular plants are species, 29 subspecies (both subspecies of *Dianthus serotinus* are endemic) and another 73 are apomictic taxa. Most of the latter belong to the genus *Sorbus* (47 taxa) and *Taraxacum* (23 taxa). (This is the first compilation to include these in detail.) These taxa are analysed separately.

None of the Pannonian endemics are endemic at the genus or a higher taxonomic level. The Rosaceae has the most (sub)endemic taxa: 51 (but 49 of them apomictic), followed by Asteraceae (35 taxa but 24 of them apomictic) (Table 1). Orchidaceae have relatively few species in the Pannonicum but there is a relatively high rate of endemism among them. All of them belong to the genus *Epipactis*. Large families without endemics are the Cyperaceae and Lamiaceae. At the genus level, the highest number of endemic taxa is found in *Sorbus*, *Taraxacum*, *Dianthus* and *Epipactis*.

Occurrence of 70 endemic and subendemic taxa (apomictic taxa were omitted from this analysis) grouped according to the size of their distribution area as follows: eurychoric 19 (27%), mesochoric: 27 (39%), stenochoric: 16 (23%), microchoric: 8 (11%).

Eurychoric species in some cases occur in a wide range of habitats throughout the Pannonicum such as xerophil grasslands (*Centaurea scabiosa* subsp. *sadleriana*, *Dianthus pontederiae*, *Melampyrum barbatum* subsp. *barbatum*) or different types of forests (*Epipactis tallosii*). Other species occur in two types of habitats: sand steppes in the lowlands and foothills, and rocky grasslands in the hills (*Gypsophila fastigiata* subsp. *arenaria*, *Iris arenaria*). In other cases,

Table 1

Taxonomic composition of the endemic flora of Pannonicum at the family level. The table shows the number of endemic taxa (ET) per family (showing the number of apomictic taxa in parenthesis)

Family	ET
Rosaceae	51 (49)
Asteraceae	35 (24)
Poaceae	10
Caryophyllaceae	8
Brassicaceae	6
Fabaceae	6
Orchidaceae	6
Ranunculaceae	3
Apiaceae (Umbelliferae)	2
Crassulaceae	2
Linaceae	2
Scrophulariaceae	2
Asclepiadaceae	1
Boraginaceae	1
Chenopodiaceae	1
Colchicaceae	1
Dipsacaceae	1
Hyacinthaceae	1
Iridaceae	1
Paeoniaceae	1
Plumbaginaceae	1
Rubiaceae	1

noricum: 0 (1) and Thermenlinie 2(1).

The Eupannonicum has most of its own (sub)endemic taxa. Some occur in both lowlands (Great and Little Plain): *Centaurea tauscheri*, *Cirsium brachycephalum*, *Dianthus serotinus* subsp. *serotinus* (there are also occurrences in the foothills), *Galatella cana*, *Suaeda pannonica* and *Artemisia pancicii*. (The latter has an interesting distribution area as it lives on two opposite edges of the Eupannonicum.) However, most of them live only in the Great Plain. Within this,

some taxa are associated with only one habitat type, but they are widespread in it (e.g. *Festuca vaginata* on sands). Most of the endemic taxa are mesochoric. Their distribution range is typically (a part of the) the lowlands (e.g. *Suaeda pannonica*, *Festuca wagneri*, *Limonium gmelini* subsp. *hungaricum*) or mountain ranges: Transdanubian (exactly: Bakonyicum phytogeographical unit) (*Seseli leucospermum*) or North Hungarian (*Poa pannonica* subsp. *scabra*) (with limited occurrence in the Visegrád Mts). In some cases, a certain part of Pannonicum (*Lotus borbasii* in the northeast, *Paeonia officinalis* subsp. *banatica* in the south). Stenochoric species occur only in a special area of the lowland (e.g. *Crataegus nigra*, *Melampyrum nemorosum* subsp. *debreceniense*, *Pulsatilla flavescens*), collin region (*Chamaecytisus supinus* subsp. *pannonicus*), or a single mountain region (*Draba lasiocarpa* subsp. *klasterskyi*). The most exciting are the microchoric taxa. They occur mainly in rocky grasslands (*Festuca vojtkoi*, *Knautia kitaibelii* subsp. *tomentella*, *Linum dolomiticum*), sometimes in rocky forests (*Hesperis matronalis* subsp. *vrabelyiana*) but even in sandy steppes (*Centaurea jankeana*) or bogs (*Cochlearia macrorrhiza*).

In terms of phytogeographical units, the number of their own (or shared with another unit) endemics are as follows (apomictic taxa were omitted from this analysis): Eupannonicum 22 (27), Matricum 8 (13), Bakonyicum 6 (13), Praeillyricum 2 (5), Prae-

Table 2
Number of (sub)endemics in phytogeographical units. * = without apomictic taxa

	Own (shared) endemic (n = 70)*	Pannon- ian (sub) endemic (n = 70)*	Endemic <i>Sorbus</i> taxa (n = 47)	Endemic <i>Taraxa- cum</i> taxa (n = 23)	All apomic- tic taxa (n = 73)	All (sub) endemic (n = 143)
Eupannonicum	22 (27)	47 (67%)	0	23	23	70 (49%)
Matricum	8 (13)	28 (40%)	8 (17%)	0	9	37 (26%)
Bakonyicum	6 (13)	34 (49%)	39 (83%)	2	43	77 (54%)
Praeillyricum	2 (5)	22 (31%)	0	8	8	30 (21%)
Praenoricum	0 (1)	6 (9%)	0	0	1	7 (5%)
Thermenlinie	2 (1)	7 (10%)	0	0	0	7 (5%)

most of the (sub)endemic taxa can be found in the Duna–Tisza köze region, especially in the part called Kiskunság. Own endemics and subendemics in this area (often shared with Deliblato Sands or surrounding areas): *Colchicum arenarium*, *Dianthus diutinus*, *Epipactis bugacensis* subsp. *bugacensis* (the only true endemic), *Festuca pseudovaginata*, *F. wagneri*, *Sedum urvillei* subsp. *hillebrandtii*, *Tragopogon floccosus*. The northeastern part of Eupannonicum (Nyírség, Bodroghöz) has two endemics of its own: *Melampyrum nemorosum* subsp. *debreceniense* (Nyírség) and *Pulsatilla flavescens* (Nyírség–Bodroghöz). The following areas also have a (sub)endemic species: Deliblato Sands (*Centaurea jankeana*), floodplains of the Danube (*Crataegus nigra*) and floodplains of the Tisza (*Armoracia macrocarpa*). The Little Plain has only two endemics of its own: *Cochlearia macrorrhiza* and *Puccinellia peisonis*. Shared endemics of Eupannonicum and Matricum: *Onosma pseudoarenaria* subsp. *tuberculata*, *Pulsatilla zimmermanni*. Shared endemics of Eupannonicum and Bakonyicum: *Gypsophila fastigiata* subsp. *arenaria*, *Iris arenaria*.

The Matricum has 8 (sub)endemic taxa of its own. Most of them (6 taxa) can be found in Bükk Mountains which also has two endemics of its own: *Hesperis matronalis* subsp. *vrabelyiana*, *Sesleria hungarica* (the latter has one locality in Gömör–Torna Karst, but it is rather common on the rocky slopes of the Bükk Mts). The second most endemic-rich area is the Gömör–Torna Karst which has one endemics of its own: *Draba lasiocarpa* subsp. *klasterskyi*. These two areas share another endemic taxon, the *Dianthus praecox* subsp. *pseudopraecox*. *Noccaea jankae* and *Poa pannonica* subsp. *scabra* are widely distributed across the Matricum, while *Festuca vojtkoi* have only a few localities. Shared endemics of Matricum and Bakonyicum: *Semperivium matricum* (occurring also in Muranska planina Mts) and *Ferula sadleriana* (the latter has one locality in the Apuseni Carpathians).

The Bakonyicum has 6 endemic taxa of its own. *Dianthus serotinus* subsp. *kitaibelianus* and *Seseli leucospermum* are quite common and occur throughout this range while *Centaurea scabiosa* subsp. *vertesensis* is found only in the central part and *Sesleria sadleriana* (occurring also in Hainburger Berge) lives only in the eastern part of the area. Two taxa have a very limited range only in the Budai-hegység or Pilis: *Linum dolomiticum*, *Knautia kitaibelii* subsp. *tomentella*. Shared endemics of Bakonyicum and Praeillyricum is *Vincetoxicum pannonicum*.

The Praeillyricum has only 2 endemic taxa of its own. *Chamaecytisus supinus* subsp. *pannonicus* occurs in the northeastern hilly part of the area, while *Epipactis mecsekensis* occurs in the eastern part of the Mecsek Mountains. The largest population of *Paeonia officinalis* subsp. *banatica* lives in the Kelet-Mecsek, but can also be found in some localities on the southeastern edge of the Eupannonicum. *Chamaecytisus heuffelii* occurs in the Mecsek (Praeillyricum) in Deliblat (Eupannonicum) and in the Iron Gate Gorge (Southern-Carpathians).

The Thermenlinie area has 2 endemic taxa of its own: *Centaurea scabiosa* subsp. *badensis*, *Dianthus plumarius* subsp. *neilreichii*. Shared endemics of Thermenlinie and Praenoricum is *Festuca stricta* subsp. *stricta*.

The number of Pannonian (sub)endemic taxa (apomictic taxa were omitted from this analysis) in different phytogeographical units is as follows: Eupannonicum 47 (67%), Bakonyicum 34 (49%), Matricum 28 (40%), Praeillyricum 22 (31%), Praenoricum 6 (9%) and Thermenlinie area 7 (10%).

Five endemic taxa occur in the area between the Drava and the Sava river, which can be considered a transitional area from a phytogeographical point of view. These are the following: *Achillea asplenifolia*, *Dianthus collinus* subsp. *collinus*, *D. pontederae*, *Epipactis nordeniorum*, *Melampyrum barbatum* subsp. *barbatum*. They are quite sporadic here.

Occurrence of 47 endemic *Sorbus* taxa grouped according to the size of their distribution area as follows: eurychoric 0, mesochoric: 6 (13%), stenochoric: 18 (38%), microchoric: 23 (49%). Only six *Sorbus* taxa have mesochoric distribution, five of which live in the North Hungarian Mountains and another one in the Transdanubian Mountains. Most of the taxa have microchoric distribution. Many species occur in a single mountain gorge, summit, or northern slope of the valley. Endemic *Sorbus* taxa occur only in the Transdanubian Mountains (Bakonyicum: 39 taxa) and in the North Hungarian Mountains (Matricum: 8 taxa). The most diverse areas are Vértes (16 taxa), Bakony (14 taxa) and Gömör-Torna Karst (8 taxa).

The exact distribution of endemic *Taraxacum* species is little known, especially in Hungary, Serbia and Romania. Most of the records of the species are based on (sometimes old) herbarium specimens. Most of the plants observed in the field were identified as *T. palustre* agg. (e.g. Bartha *et al.* 2021). Based on our current knowledge there are only two microchoric species among them

(*T. catenatum* and *T. limosicola*). Most of them are steno-, meso- or eurychoric. They typically occur in lowlands and valleys. The main distribution area of endemic *Taraxacum* species is the Eupannonicum. The records from Praeillyricum came from wetlands in the southern part of the Lake Balaton area.

The other three apomictic taxa are stenochoric (*Alchemilla hungarica*, *Hieracium kossuthianum*) or mesochoric (*Rubus balatonicus*). The latter two occur in the Bakonyicum (*Rubus balatonicus* lives in the western and central parts of this area while *Hieracium kossuthianum* occurs only on the eastern margin of the area) and the former in the Matricum.

Habitat preferences of (sub)endemic taxa

Most endemic (not apomictic) plants occur in rocky (27%) or sandy (20%) habitats (Fig. 2). Together with the taxa that occur in both habitats, a total of 53% of the plants studied live here. Most of them are on calcareous soil. Only two taxa occur in acidic soils in both sandy (*Melampyrum nemorosum* subsp. *debreceniense*, *Pulsatilla flavescens*) and rocky (*Festuca vojtkoi*, *Semprevivum matricum*) habitats, but the latter can also be found on calcareous soils. Another

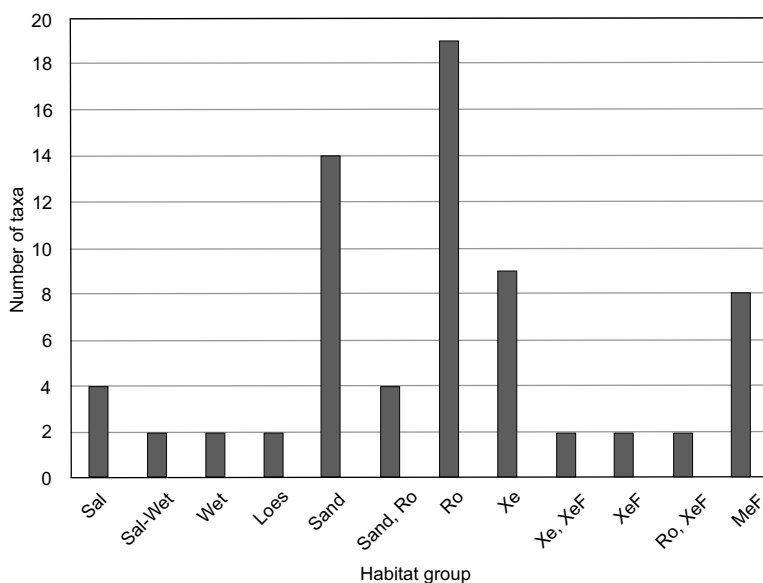


Fig 2. Habitat preferences of Pannonian (sub)endemic taxa (without apomictic taxa). Sal = saline vegetation; Sand = steppe, steppe forest on sand; Loes = steppe, steppe forest on loess; Ro = rocks, rocky grasslands; Wet = bogs, alluvial meadows and other wetland communities; Xe = xerophile/dry grasslands (in general) and shrubs; XeF = xerophilous mountain forests (oak and oak scrub forests, rocky forests, etc.); MeF = mesophilic forest communities (oak-hornbeam and beech forests, riverine forests, etc.)

9 taxa (13%) live in different types of xerophilic grasslands (in general) or shrubs and a further 2 (3%) mainly on rocks, but often also in rocky forests. Most of the (sub)endemic taxa (54 of them, 77%) live in dry habitats mentioned so far. There are only 2 species in wetlands, 4 in saline vegetation, and 2 in saline meadows. There is only one subspecies among them, so it seems that most endemics have developed in these habitats for a long time.

The extraordinary richness of rocks and rocky grasslands is not surprising, but the extraordinary richness of sandy habitats is interesting. Within the Pannonicum, there are significant differences in vegetation (and endemic species) on sandy soils. One of the main sandy area is situated in the southwestern part of Transdanubia (Belső-Somogy). Its climate is relatively humid (average annual rainfall 700–750 mm) (Bihari *et al.* 2018). The natural vegetation here is the forest (oak, oak-hornbeam, beech), and sand steppes are very rare and fragmented (Zólyomi 1989). This area has no endemic taxa of its own and only two of the endemic taxa of the Pannonian sand occur here (*Dianthus serotinus* subsp. *serotinus*, *Festuca vaginata*). Another important sandy area (this sand is acidophilus) is located in the northeastern part of the Pannonicum (Nyírség and some surrounding areas). The climate is drier here (average annual rainfall 550–650 mm) (Bihari *et al.* 2018). The main natural vegetation is steppe and forest-steppe (Zólyomi 1989). This area has two endemic taxa of its own (*Pulsatilla flavescens* and *Melampyrum nemorosum* subsp. *debrececiense*), and many other endemics can be found here (e.g. *Dianthus serotinus* subsp. *serotinus*, *Festuca vaginata*, *Iris arenaria*). The most important sand vegetation is found along the Danube, including its wider surroundings from southern Moravia to Deliblat. There are several sand areas here, which are more or less separated from each other. They are found in the hottest and driest areas of the Pannonicum. The average annual precipitation is 450–650 mm (Bihari *et al.* 2018, Milovanović *et al.* 2017, Tolasz *et al.* 2007). The main potential natural vegetation is steppe and forest-steppe (Chytrý 2012, Niklfeld 1973, Schratt-Ehrendorfer 2008, Zólyomi 1989). The most endemic-rich area is in the Duna–Tisza köze region, which is in the middle of the Pannonicum. This area, whose soil is mostly calcareous sand, has only one endemic taxon of its own (*Epipactis bugacensis* subsp. *bugacensis*), but it is the centre of the distribution area of many endemics. Similar but not so species-rich sand flora can be found in the Mezőföld (on the opposite side of the Danube), and in the eastern half of the Little Plain (on both sides of the Danube). Farther away, on the sand steppes of South Moravia (the northwestern part of Pannonicum), only a few endemics can be found. The Deliblat, located in the southeastern corner of the Pannonicum, is also rich in endemics. This area has one endemic taxon of its own (*Centaurea jankeana*). Some endemic species appear on the sand dunes of the lower part of the Danube, outside of Pannonicum, but not far from it.

These “Pannonian flora islands” have more Pannonian endemics than on the sands of South Moravia.

Only two endemic subspecies (*Chamaecytisus supinus* subsp. *pannonicus*, *Cirsium boujartii* subsp. *boujartii*) are restricted to the species-rich Pannonian loess steppes. Some authors (Fekete *et al.* 2014) also list the *Noccaea jankae* here, but this species often occurs in other habitats as well (Illyés and Bölöni 2007). In loess steppes, however, there are plenty of (sub-)Pontic-Pannonian elements. Of course, there are endemics in loess steppes as well, but these have fallen into the “xerophilous grasslands” category here.

Xerophilic mountain, sometimes grassy mosaic forests have only 4 (sub) endemic taxa (6%). Most of them were not widespread in Pannonicum. Some taxa occur only in the north (*Chamaecytisus virescens*), south (*Paeonia officinalis* subsp. *banatica*) or northeast (*Galium abaujense*). Mesophilic forest communities have 8 (sub)endemics (11%). Most of them are *Epipactis* species. Habitat grouping does not show, but some taxa (*Cirsium brachycephalum*, *Melampyrum barbatum* subsp. *barbatum*, *Noccaea jankae*) also occur in segetal weed communities.

Among apomictic taxa (not listed in the table) most of the endemic *Sorbus* species prefer xerophilic mountain forests (oak and oak scrub forests, rocky forests), but some also live in mesophilic forests. Endemic *Taraxacum* species live in wet (sometimes saline) meadows and other wetland communities. The other three species live in rocks or edges of the xerophilic mountain forests (*Hieracium kossuthianum*, *Rubus balatonicus*) or mountain mesic hay meadows and pastures (*Alchemilla hungarica*).

DISCUSSION

For the Pannonicum, our revised list of endemic and subendemic taxa contains 143 vascular plants (73 of them apomicts). Tatár (1939) mentions 55 taxa (without apomicts) of which only 29 (53%) are still considered endemic today. The other 26 taxa have either changed their taxonomic classification or have a wider (non-endemic) range of distribution in light of recent research. Subsequent publications (Horváth *et al.* 1995, Fekete *et al.* 2014, Simon *et al.* 1992) mention an additional 22 species that we do not consider endemic today. These compilations of endemic vascular plants do not list *Sorbus* taxa in detail. (Appendix 1 also includes species mentioned in other literature, e.g. Soó 1933, 1964a). Compared to previous lists, in this study a high number of (sub)endemic taxa is reported as endemic for the first time. This increase in the number of taxa is the result of current taxonomic and chorological research. The taxonomic status and/or distribution of many plants have been resolved in recent decades. (At the same time, many taxonomic questions remain unresolved and the exact distribution of some species is not known

even today, therefore further investigations are necessary.) In addition, the (Hungarian) lists of Pannonian endemics of recent decades are based on the borders of Hungary, so these lists do not include species that occur outside of Hungary (e.g. *Artemisia pancicii*, *Cochlearia macrorrhiza*, *Draba lasiocarpa* subsp. *klasterskyi*).

The proportion of stenochoric taxa (without apomicts) is more than one and a half times higher than in the Carpathians, but together with the apomictic genera, it is the same (see Kliment *et al.* 2016). The proportion of microchoric taxa in Pannonicum is about three and four times higher (with and without apomicts) than in the Carpathians.

Although inland endemic diversity centres are mainly found in the mountains, the area richest in endemic species (excluding apomictic taxa) in Pannonicum among the five phytogeographical units is a lowland region (Eupannonicum). This area has the most endemics of its own and the highest number of Pannonian (sub)endemic taxa. Within this area, most of the (sub)endemics can be found in the Duna–Tisza köze region, especially in the part called Kiskunság. It is located in the middle of the Pannonicum. Its natural vegetation is mainly sandy forest-steppe but the proportion of saline vegetation is also significant. This area is bordered by riparian forests to the east (Tisza river) and west (Duna river). The high number of endemic species can be explained by the Amazonas model according to Borhidi (2004). Based on this theory, it is probable that during the Holocene (more likely during the Pleistocene) warming and especially during the warm and rainy periods, the flow of the Danube may have been several times larger than now and its builder-destroyer work modify the vegetation of the Kiskunság similarly, what today the Amazonas does in the Amazonas Basin. As a result of this, not only a whole series of semi-desert and steppe endemics emerged and isolated, but the floodplain also created its own endemism. In a smaller volume but a similar process took place in the floodplain of the Tisza river, where endemic taxa were formed in a similar way on the sands of Nyírség.

Together with apomictic taxa, most endemics are found in the Transdanubian Mountains (Bakonyicum) (77 taxa, 54% of Pannonian (sub)endemics). This mostly calcareous (limestone and dolomite) bedrock mountain range is actually an island rising out of the lowlands, which connected in a narrow strip to the mostly silicate bedrock North Hungarian Mountains (Matricum) in the northeast and to the Praeillyricum in the southwest. Therefore, Carpathian flora elements from the north and Illyrian from the south may have appeared in the area. Partly as a result of this “flora meeting” a number of apomictic *Sorbus* taxa have evolved (through hybridisation of parent species of northern and southern origin) (Borhidi 2004). The geographically distant Budai-hegység (mountains) (East Bakonyicum) and the Villányi-hegység

(hills) (Southeast Praellyricum) may have had a closer floristic relationship in the past based on their shared endemic species (*Vincetoxicum pannonicum*). There may have been a similar connection between the Budai-hegység and the Hainburger Gebirge (hill) (Northeast Austria) (*Sesleria sadleriana*) or Transdanubian Mts and the Thermenlinie area (*Thalictrum minus* subsp. *majus*) in the past.

The third richest area in terms of Pannonian (sub)endemics is the North Hungarian Mountains (Matricum), which is separated from the Carpathians by river valleys for a longer part. Their endemic diversity centers are Bükk Mts and Gömör–Torna Karst. Bükk has the highest diversity. It is a relatively high (800–900 m) calcareous island surrounded by silicate mountains and lowlands. The Gömör–Torna Karst is connected to the calcareous mountains of the Carpathians.

The number of Pannonian (sub)endemics is still significant in the Praellyricum. Most of them are eurychoric which are more or less widespread in the Pannonicum. Some southern-distributed taxa are typical here that do not occur in the northern or central part of the Pannonicum (*Chamaecytisus heuffelii*, *Paeonia officinalis* subsp. *banatica*).

Praenoricum and the Thermenlinie are transitional areas with very few Pannonian (sub)endemics. Almost the same number of Pannonian taxa occur in the transitional region between the Drava and the Sava river. From this point of view, these areas are similar, but in terms of the vascular flora, the former two are transitioning to Alpicum and the latter to Illyricum.

In terms of habitat preferences for (sub)endemics, most plants (apomictic taxa were omitted from this analysis) occur in rocky or sandy habitats. The extraordinary richness of rocks and rocky grasslands is also reported by authors of studies on the surrounding Carpathians (Kliment *et al.* 2016), Alps (Essl *et al.* 2009) and the Dinaric Mountains (Nikolić *et al.* 2020), so this is not surprising in the Pannonicum either.

However, the extraordinary richness of sandy habitats is interesting. While in the Czech Republic only two endemics occurring in Bohemian sandy habitats (Kaplan 2012), in the Pannonicum it is one of the most endemic-rich areas. The sandy vegetation has a large extent here and appears under varied soil (e.g. calcareous and acidophilus) and climatic conditions. It is important to mention that the distribution of sandy soils (arenosols) in Europe is dispersed-disjunct. The sandy areas of Pannonicum are far from the others and/or there are geographical barriers (e.g. mountains) between them (Jones *et al.* 2005). Moreover, they are also separated within the Pannonicum. The flora of sandy habitats seems developed in isolation from those outside the Carpathian Basin, but sometimes also from each other (e.g. Kiskunság and Nyírség). However, the former connection with Eastern European steppes is

obvious due to morphologically similar sister species like *Dianthus diutinus* and *D. bessarabicus*, *D. platyodon*, or *Colchicum arenarium* and *C. fominii*, or *Iris arenaria* and *I. pineticola*, *I. humilis*, or *Onosma pseudoarenaria* subsp. *tuberculata* and subsp. *pseudoarenaria* (the latter in the Transylvanian Basin). The saline habitats of the Carpathian Basin probably developed in a similarly isolated way. However, they are less species-rich.

The species-rich Pannonian lowland loess steppes have only one endemic taxon of their own (the other endemic subspecies of loess live in the collin region of Tolna and Somogy). In loess steppes, however, there are plenty of (sub-)Pontic-Pannonian elements. Loess soils have a more or less continuous belt in a large part of Europe. The loess regions of the Pannonicum are connected to the large and continuous loess region of Eastern Europe (Lehmkuhl *et al.* 2021) (the Carpathian mountains become narrower towards the south-western edge). The Pannonian loess steppes do not seem to have separated enough from the Eastern Europeans to develop their own endemic species, or the taxa formed here have now spread to other types of dry grasslands (see endemics of xerotherm habitats). It is also conceivable that as only 3% of loess grasslands have survived due to human activity (Horváth *et al.* 2011, Kelemen 1997), endemic taxa have already become extinct.

Xerophilic mountain forests (oak and oak scrub forests, rocky forests) are very important for apomictic *Sorbus* taxa (they make up nearly a third of endemics) as well as wet meadows where (the known) endemic *Taraxacum* species live.

*

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Appendix 1

List of non-endemic taxa (previously considered endemic in the Pannonicum)

Taxon	Notes
<i>Acer acuminatilobum</i> J. Papp*	Taxonomic status uncertain
<i>Achillea horanszkyi</i> Ujhelyi	Primary hybrid of <i>Achillea nobilis</i> × <i>ochroleuca</i> ? (Dobolyi 1997)
<i>Achillea tuzsonii</i> Ujhelyi*	<i>Achillea crithmifolia</i> var. <i>tuzsonii</i> (Dobolyi in litt.)
<i>Allium ammophilum</i> Heuff.	Synonym of <i>Allium albidum</i> (Stearn 1980, Govaerts 1995) or <i>A. denudatum</i> F. Delaroché (theplantlist.org 2021) / <i>A. denudatum</i> Redouté (WCSP 2021). (wider non-endemic distribution)
<i>Artemisia santonicum</i> L. subsp. <i>patens</i> (Neilr.) K. M. Perss.	Wider non-endemic distribution. It occurs in Turkey for example (Kurşat <i>et al.</i> 2011)
<i>Aster tripolium</i> L. subsp. <i>pannonicus</i> (Jacq.) Soó = <i>Tripolium pannonicum</i> (Jacq.) Dobrocz. subsp. <i>pannonicum</i>	Wider non-endemic distribution (Greuter and Raab-Straube 2006)
<i>Bromus pannonicus</i> Kumm. et Sendtn. = <i>Bromopsis pannonica</i> (Kumm. et Sendtn.) Holub	Wider non-endemic distribution (Valdés and Scholz 2009)
<i>Campanula sibirica</i> L. subsp. <i>divergentiformis</i> (Jáv.) Domin*	Wider non-endemic distribution (e.g. Fedorov 1976)
<i>Carduus collinus</i> Waldst. et Kit.	Wider non-endemic distribution (Kliment <i>et al.</i> 2016)
<i>Centaurea indurata</i> Janka = <i>Centaurea phrygia</i> subsp. <i>indurata</i> (Janka) Stoj. et Acht.)	Wider non-endemic distribution (Greuter and Raab-Straube 2006)
<i>Centaureum uliginosum</i> (Waldst. et Kit.) Beck = <i>Centaureum littorale</i> (Turner) Gilmour subsp. <i>uliginosum</i> (Waldst. et Kit.) Rothm. ex Melderis)	Wider non-endemic distribution
<i>Cerastium arvense</i> L. subsp. <i>matrense</i> (Kit.) Jáv.	Synonym of <i>Cerastium arvense</i> subsp. <i>molle</i> (Vill.) Arcang. (Jalas 1993, theplantlist.org 2021) or <i>Cerastium arvense</i> (Marhold 2011a)
<i>Cirsium eriophorum</i> subsp. <i>degenii</i> (Petr.) Soó	Synonym of <i>Cirsium eriophorum</i> (L.) Scop.
<i>Cirsium furiens</i> Griseb. et Schenk	Wider non-endemic distribution (Oprea 2005)
<i>Cotoneaster matrensis</i> Domokos*	Synonym of <i>Cotoneaster laxiflorus</i> J. Jacq. ex Lindl. (Dickoré and Kasperek 2010)
<i>Cynoglossum hungaricum</i> Simonk.*	Wider non-endemic distribution
<i>Cytisus supinus</i> subsp. <i>pseudorocheii</i> (Simonk.)	Synonym of <i>Chamaecytisus</i> × <i>pseudorocheii</i> (Simonk.) Pifkó (Pifkó 2005)
<i>Dactylorhiza fuchsii</i> subsp. <i>sooana</i> (Borsos) Borsos	Wider non-endemic distribution (Kliment 1999, Kliment <i>et al.</i> 2016)
<i>Dianthus collinus</i> subsp. <i>glabriusculus</i> (Kit.) Thaisz	Wider non-endemic distribution (Jalas and Suominen 1986)
<i>Dianthus giganteiformis</i> Borbás	Wider non-endemic distribution (Jalas and Suominen 1986)
<i>Elatine hungarica</i> Moesz	Wider non-endemic distribution (Mosyakin and Fedoronchuk 1999, Didukh Ya. <i>et al.</i> 2010)

Taxon	Notes
<i>Epipactis atrorubens</i> subsp. <i>borbasii</i> Soó*	<i>Epipactis atrorubens</i> var. <i>borbasii</i> Soó (e.g. Voigt <i>et al.</i> 2011, Molnár and Csábi 2021)
<i>Epipactis lapidocampi</i> Klein et Laminger*	<i>Epipactis muelleri</i> var. <i>lapidocampi</i> (Kreutz 2007)
<i>Erysimum odoratum</i> Ehrh. subsp. <i>buekkense</i> (Boros) Soó*	<i>Erysimum odoratum</i> var. <i>buekkense</i>
<i>Festuca pannonica</i> * Wulfen	Questionable (Šmarda <i>et al.</i> 2007, 2009, Danihelka <i>et al.</i> 2009)
<i>Fraxinus angustifolia</i> Vahl subsp. <i>danubialis</i> Pouzar (= <i>F. a.</i> subsp. <i>pannonica</i> Soó et Simon)	Wider non-endemic distribution (Simon 1992, 2000, Raddi 2010, map: Bartha 2016)
<i>Galium austriacum</i> Jacq.	Wider non-endemic distribution (Marhold 2011b)
<i>Heracleum sphondylium</i> L. subsp. <i>chloranthum</i> (Borbás) H. Neumayer	Synonym of <i>H. sphondylium</i> subsp. <i>sibiricum</i> (L.) Simonk. (Hand 2011)
<i>Hieracium budense</i> Borbás = <i>Pilosella budensis</i> (Borbás) Soják	Wider non-endemic distribution (Bräutigam and Greuter 2007–2009)
<i>Hieracium chaetocymum</i> Deg. et Z.	Synonym of <i>Pilosella megatricha</i> (Borbás) Soják (Bräutigam and Greuter 2007–2009, CWG 2021)
<i>Hieracium megatrichum</i> Borbás = <i>Pilosella megatricha</i> (Borbás) Soják	Wider non-endemic distribution (Bräutigam and Greuter 2007–2009, CWG 2021)
<i>Hieracium sommerfeltii</i> subsp. <i>degenianum</i> Zahn*	Status and distribution unclear
<i>Iris aphylla</i> L. subsp. <i>hungarica</i> (Waldst. et Kit.) Hegi	Synonym of <i>Iris aphylla</i> L. (Wróblewska <i>et al.</i> 2010)
<i>Kitaibela vitifolia</i> Willd.	Wider non-endemic distribution (e.g. Tunçkol <i>et al.</i> 2020)
<i>Knautia arvensis</i> (L.) Coult subsp. <i>budensis</i> (Simonk.) Jáv.	Synonym of <i>Knautia arvensis</i> (L.) Coult subsp. <i>pannonica</i> (Heuff.) O. Schwarz (Király 2009)
<i>Knautia arvensis</i> (L.) Coult subsp. <i>pannonica</i> (Heuff.) O. Schwarz	Wider non-endemic distribution. (Domina 2017)
<i>Koeleria javorkae</i> Ujhelyi*	Probably synonymous, taxonomic research is needed.
<i>Koeleria majoriflora</i> (Borbás) Borbás ex Domin	Synonym of <i>Koeleria macrantha</i> (Ledeb.) Schult. (Valdés and Scholz 2009)
<i>Lathyrus pannonicus</i> (Jacq.) Garcke	Wider non-endemic distribution (Soó 1966, Ball 1968)
<i>Lepidium crassifolium</i> Waldst. et Kit.*	Synonym of <i>Lepidium cartilagineum</i> (J. C. Mayer) Thell.
<i>Melampyrum barbatum</i> Waldst. et Kit. ex Willd. subsp. <i>kitaibelii</i> (Soó) Soó	Synonym of <i>Melampyrum barbatum</i> subsp. <i>barbatum</i> Waldst. et Kit. ex Willd.
<i>Minuartia frutescens</i> (Kit.) Tuzson	Wider non-endemic distribution (Kliment <i>et al.</i> 2016)
<i>Molinia horanszkyi</i> Milk.*	Synonym of <i>Molinia caerulea</i> (L.) Moench
<i>Molinia hungarica</i> Milk.*	Synonym of <i>Molinia caerulea</i> (L.) Moench
<i>Molinia pocsii</i> Milk.*	Synonym of <i>Molinia arundinacea</i> Schrank

Taxon	Notes
<i>Molinia simonii</i> Milk.*	Synonym of <i>Molinia caerulea</i> (L.) Moench
<i>Molinia ujhelyii</i> Milk.*	Synonym of <i>Molinia arundinacea</i> Schrank
<i>Noccaea kovatsii</i> Heuff. subsp. <i>schudichii</i> (Soó) Soó*	Taxonomic status unresolved
<i>Ononis semihircina</i> Simonk. / <i>Ononis spinosiformis</i> Simonk.*	Taxonomic status uncertain. Probably a synonym
<i>Onosma arenaria</i> Waldst. et Kit.	Taxonomic research in progress (Kolarčík in litt.). Based on our current knowledge it has wider non-endemic distribution (Kolarčík <i>et al.</i> 2014, 2018)
<i>Onosma tornensis</i> Jáv.*	Synonym of <i>Onosma viridis</i> (Borbás) Jáv. (Mártonfi <i>et al.</i> 2014)
<i>Oxytropis pilosa</i> (L.) DC. subsp. <i>hungarica</i> (Borbás) Soó*	Synonym of <i>Oxytropis pilosa</i> (L.) DC.
<i>Plantago schwarzenbergiana</i> Schur	Wider non-endemic distribution (Oprea 2005)
<i>Polygonum graminifolium</i> Wierzb. ex Heuff.	Wider non-endemic distribution (Jalas and Suominen 1979)
<i>Polygonum kitaibelianum</i> Sadler	Synonym of <i>Polygonum bellardii</i> All. (e.g. Akeroyd 1993, Fischer <i>et al.</i> 2008, Király 2009)
<i>Potamogeton pectinatus</i> L. subsp. <i>balatonicus</i> (Gams) Soó*	Synonym of <i>Stuckenia pectinata</i> (L.) Börner (Kaplan 2008)
<i>Puccinellia limosa</i> (Schur) Holmb. = <i>Puccinellia distans</i> subsp. <i>limosa</i> (Schur) Soó et Jáv.	Wider non-endemic distribution (Hughes and Halliday 1980)
<i>Puccinellia pannonica</i> (Hack.) Holmb.	<i>Puccinellia distans</i> × <i>Puccinellia</i> (<i>Pseudosclerochloa</i>) <i>rupestris</i> = <i>P.</i> × <i>pannonica</i> (Hack.) Holmb. It was adventive (in Budapest), but it became extinct in Hungary
<i>Pyrus magyarica</i> Terpó*	Taxonomic status uncertain (Barina and Király 2014)
<i>Rhinanthus borbasii</i> (Dörf.) Soó subsp. <i>borbasii</i>	Status uncertain. Wider non-endemic distribution (e.g. Snowarski 2021)
<i>Rorippa sylvestris</i> (L.) Besser subsp. <i>kernerii</i> (Menyh.) Soó	Wider non-endemic distribution (Jalas and Suominen 1994)
<i>Rosa facsarii</i> Kerényi-Nagy	Wider non-endemic distribution (Kerényi-Nagy in litt.)
<i>Rosa pocsii</i> Kerényi-Nagy*	Taxonomic status uncertain. See Wissemann and Ritz 2007, Bakker <i>et al.</i> 2019
<i>Rosa sancti-andreae</i> Degen et Trautmann*	Synonym of <i>Rosa villosa</i> L.
<i>Rosa zagrabiensis</i> Vuk. et Heinr. Braun*	Synonym of <i>Rosa marginata</i> Wallr. (Kurtto 2009, theplantlist.org 2021)
<i>Rosa zalana</i> Wiesb.	Wider non-endemic distribution (Kurtto <i>et al.</i> 2004, Kerényi-Nagy 2012b)
<i>Scilla bifolia</i> subsp. <i>buekkensis</i> (Speta) Soó	Wider non-endemic distribution (Trávníček <i>et al.</i> 2009)

Taxon	Notes
<i>Scilla vindobonensis</i> subsp. <i>borhidiana</i> Kereszty	Synonym of <i>Scilla vindobonensis</i> (Govaerts <i>et al.</i> 2021)
<i>Sedum neglectum</i> Ten. subsp. <i>sopianae</i> Priszter	Taxonomic status uncertain. Probably synonym of <i>Sedum acre</i> L. (Sramkó 2009)
<i>Seseli osseum</i> Crantz (incl. <i>Seseli devenyense</i> Simonk.)	Wider non-endemic distribution (Oprea 2005, Štěpánková 2012, Wild <i>et al.</i> 2019)
<i>Sorbus budaiana</i> Kárpáti	It seems to be synonym of <i>Sorbus aria</i> (L.) Crantz (Sennikov and Kurtto 2017, Somlyay and Sulyok 2018). Caryosystematic studies are required
<i>Sorbus huljakii</i> Kárpáti	It seems to be synonym of <i>Sorbus aria</i> (L.) Crantz (Sennikov and Kurtto 2017, Somlyay and Sulyok 2018). Caryosystematic studies are required
<i>Sorbus javorkae</i> (Soó) Kárpáti	Synonym of <i>Sorbus danubialis</i> (Somlyay and Sennikov 2016)
<i>Sorbus sooi</i> (Soó) Kárpáti et Soó	Synonym of <i>Sorbus danubialis</i> (Somlyay and Sennikov 2016)
<i>Suaeda salinaria</i> (Schur) Simonk.	Synonym of <i>Suaeda salsa</i> (L.) Pall. (Govaerts <i>et al.</i> 2021)
<i>Thymus glabrescens</i> Willd. subsp. <i>degenianus</i> (Lyka) Soó	Synonym of <i>Thymus glabrescens</i> subsp. <i>glabrescens</i> (Mártonfi 1997)

Notes (*)

Acer acuminatilobum: This taxon was discovered and described by József Papp in the Mátra mountains (Hungary) as a leaf variety of *A. campestre* L (Papp 1954). Later he lifted this taxon up to species rank (Papp 1958). Hungarian botanists have discussed the status of this tree but there is no clear decision as to whether it is a species or a variety. It is mentioned as a species (Simon 1992, 2000, Bartha *et al.* 2011, Bartha and Kerényi-Nagy 2012), or taxonomic rank is questionable (Bartha 2009a, 2021). Other opinions suggest that it may be a hybrid of the *Acer campestre* L. and *A. monspessulanum* L.: *Acer × bornmuelleri* Borbás (Kerényi-Nagy 2019). Rivers *et al.* (2019) not listed.

Achillea tuzsonii: It is very similar to *A. crithmifolia*, but the leaf size is larger. Probably only a habitat modification.

Campanula sibirica subsp. *divergentiformis*: It has wider non-endemic distribution (e.g. Fedorov 1976, Conti *et al.* 2005, Oprea 2005). International databases treat it as a synonym of *C. sibirica* (Castroviejo *et al.* 2010, theplantlist).

Cotoneaster matrensis: Taxonomic status unclear. Treated as a varietas (Jávorka and Soó 1951), a subspecies (Hrabětová-Uhrová 1962), a species (Simon 1992), or a putative hybrid (Bartha 2009b). It is probably best to treat it as a synonym (e.g. Bölöni 2012, Macková *et al.* 2020). We follow here Dickoré and Kasperek (2010).

Cynoglossum hungaricum: Taxonomic status unclear. Extremely variable, particularly in indumentum, floral and fruit characters. Local variants have been given specific, subspecific or varietal rank (Kovanda 1972). Treat as a species (Kovanda 1972, Valdés 2011) with wider non-endemic distribution (SE and EC Europe) or a synonym of *C. montanum* L. (theplantlist.org 2021).

Epipactis atrorubens subsp. *borbasii* Soó: Probably a sandy habitat modification. The leaves are usually more ovate but not all individuals have this morphological difference in sandy habitats (Jávorka and Soó 1951, Voigt *et al.* 2011).

Epipactis lapidocampi: This orchid was described in 2004 from a *Pinus nigra* plantation near Wiener Neustadt (NE Austria) (Klein and Laminger 2004). It differs from the *E. muelleri* mainly in the properties of the vegetative parts, which is presumably due to a mutation that altered the growth processes. However, the flowers of the two taxa are very similar. Thus, and because only a small locality and very few individuals of *E. lapidocampi* are known it is presumably only a variant (Kreutz 2007).

Erysimum odoratum subsp. *buekkense*: Taxonomic status uncertain. It was considered a subspecies (Soó 1968, Farkas 1999) or a varietas (Jávorka and Soó 1951, Simon 1992, 2000). The newest Hungarian flora (Király 2009) not recognised as a taxon. The flowers of the “*buekkense*” are larger than those of type subspecies, but there are transitions (Soó 1968, Simon 1992, 2000). The difference is in the presence or absence of rosette when flowering is also uncertain.

Festuca pannonica: In recent floras, *F. pannonica* has been treated as a taxon of *F. pallens* group due to misinterpretation. The lectotype of the name *F. pannonica* corresponds to the *F. valesiaca* (Šmarda *et al.* 2007, 2009, Danihelka *et al.* 2009).

Hieracium sommerfeltii subsp. *degenianum*: It was described by Zahn (1926) and reported only from one locality in the Transdanubian Mountains (Szentendre: Berseg-hegy). Soó (1970) also reported from Leányfalu, but it is probably the same location (this is the nearest village). It is probably endemic, however, the current taxonomic and chorological knowledge is missing.

Koeleria javorkae: Although *Koeleria* has been subjected to several taxonomic revisions during the 20th century, many essential systematic questions remain unanswered. The main reason is the high morphological similarity of many taxa, especially in the *K. macrantha* aggregate accompanied by their large intraspecific phenotypic variability. Misunderstanding these facts and considering phenotypes as genotypes led some taxonomists to describe hundreds of intraspecific taxa, and thus provided the basis for many recent taxonomic problems (Pecinka *et al.* 2006). Many taxa are classified in the *K. macrantha* aggregate, but the taxonomic status of many is unresolved. Such is the case of *K. javorkae*, which shows clear morphological differences (Somlyay 2009), but further studies are needed. Occurs only in the Hungarian Great Plain: Duna–Tisza köze, Nyírség (Bartha *et al.* 2021).

Lepidium crassifolium: Taxonomic status unclear. Probably a synonym of *L. cartilagineum* (J. C. Mayer) Thell. (theplantlist.org 2021) and has wider non-endemic distribution.

Molinia horanszkyi, *M. hungarica*, *M. pocsii*, *M. simonii*, *M. ujhelyii*: They form a polyploid line and their taxonomic value is questionable (Király 2009). They are currently considered synonymous with *Molinia arundinacea* and *M. caerulea* (theplantlist.org 2021).

Noccaea kovatsii subsp. *schudichii*: Its taxonomic status is unresolved. It was first classified as a varietas or subspecies of *N. jankae* (Jávorka and Soó 1951). Later, Soó considered it a microspecies whose closest relative is the *N. kovatsii* (Soó 1968). Recent Hungarian literature mentions it as a subspecies of the latter (Simon 1992, 2000, Vidéki 1999, Barina and Király 2009). Jalas *et al.* (1996) classified it as *N. kovatsii* with the remark that “further biosystematic study is needed”. It differs from the type subspecies that fruits are deeply pinched at the apex, the wings are protruding, so the incision is so big that the pistil is sometimes shorter than the wings (Soó 1968, Simon 1992, 2000, Vidéki 1999). Known from only two localities in the Zemplén Mts (Füzéri-várhegy (hill), Kemence-patak valley). Based on field observations (Füzéri-várhegy) and comparative herbarium studies, only a part of the population shows the described (e.g. Soó 1968) morphological differences, and a significant part of the examined individuals seems to be very similar as the nominate subspecies. Further studies are needed.

Ononis semihircina / *O. spinosiformis*: Taxonomic status uncertain. In the early 20th century the two were considered separate species (*O. semihircina* as a synonym of *O. spinoso-hircina* Feicht.) (Jávorka 1924–1925). Later *O. spinosiformis* treat as a varietas (Jávorka and Soó 1951) or subspecies of *O. semihircina* (Soó 1966). Because *O. spinosiformis* was previously described (1877 vs. 1879), Soó changed the taxonomic rank of the two (Soó 1970). According to Săvulescu (1957) these two taxa are synonymous with *O. pseudohircina*, but according to Soó the latter is actually a hybrid and clearly separated from the other two (Soó 1966). The most recent Hungarian floras (Simon 1992, 2000, Király 2009) follow Soó (1970) and treat *O. spinosiformis* as a species and *O. semihircina* as a subspecies of the former with the remark that the separation of these taxa is uncertain (Király 2009). Recent Romanian floras (Ciocârlan 2000, 2009, Oprea 2005) treat *O. spinosiformis* as a subspecies of *O. arvensis* (= *O. hircina*). According to international databases these are synonym of *Ononis spinosa* subsp. *hircina* (Jacq.) Gams. (theplantlist, EuroPlusMed) or *O. arvensis* (WCVP). Their exact distribution is unknown. A taxon called “semihircina” was considered endemic in the Pannonicum (U. Szabó 1941, Soó 1966).

Onosma tornensis: This species has been considered as one of the rarest stenoendemic of the Pannonicum with a restricted occurrence in a small area in the eastern part of the Gömör–Torna Karst (at the Hungarian–Slovak border). Recent molecular study (Kolarčík *et al.* 2010) confirmed significant DNA similarity of *O. tornensis* populations from Slovakia with *O. viridis* populations from the Banat part of the Southern Carpathians and taxonomic identity of both species. Regarding this fact, Mártonfi *et al.* (2014) reports *O. tornensis* as synonym of *O. viridis*.

Oxytropis pilosa subsp. *hungarica*: It was originally a varietas (Jávorka 1924–1925, Jávorka and Soó 1951) and raised subspecies level by Soó (1966). The most recent Hungarian flora (Király 2009) does not mention.

Potamogeton pectinatus subsp. *balatonicus*: First described as a variety of *P. helveticus* from a Hungarian lowland lake (Balaton), as well as later collected specimens designated with this name, do not deviate from the usual variation of *S. pectinata* (Kaplan 2008).

Pyrus magyarica: Its taxonomic status is unclear. The confusions originate from the invalidity of the description and the lack of type material. No vouchers or living specimens that correspond to the protologue can be found and herbarium specimens assigned as *P. magyarica* mostly refer to *P. pyraster* (Barina and Király 2014). The leaf morphological characters given in the protologue of *P. magyarica* (used for distinguishing the taxon) (Terpó 1960) are also observable on *P. pyraster* (Barina and Király 2014). On the basis of the identification key by Terpó (1960), *P. magyarica* differs from *P. pyraster* in the calyx: it is either deciduous (*magyarica*) or persistent (*pyraster*). In his more recent studies Terpó (1992) characterised *P. magyarica* by the same morphological features. Unfortunately, only two herbarium sheets bear ripe fruits, but these specimens do not have cordate and sharply serrate leaves, their petioles are remarkably longer (–6 cm) while the peduncles shorter (1.5 cm) than given in the protologue of *P. magyarica* (Barina and Király 2014). In the vicinity of one of the sites marked in the description (Pilis–Visegrád Mts: Pomáz and examined nearby sites), only individuals with a mixed fruit morphology character could be found (Riezing ined.).

Rosa pocsii: Recently described taxon (Kerényi-Nagy 2012a). Distribution: in the northern and northeastern part (sometimes on the edge) of the Pannonicum (Kerényi-Nagy *et al.* 2014, Kerényi-Nagy and Penksza 2015). It is very similar to *R. micrantha*. The only difference is in the leaflet (glandular or eglandular above Kerényi-Nagy 2012a). Taxonomic status uncertain. See Wissemann and Ritz (2007), Bakker *et al.* (2019). Further studies are needed.

Rosa sancti-andreae: Synonym of *R. ciliatopetala* Besser (Kerényi-Nagy 2011) and it has wider non-endemic distribution range. The latter is probably synonym of *R. villosa* L. (see Kurtto 2009, Govaerts *et al.* 2021, theplantlist.org 2021).

Rosa zagrabiensis: According to Kerényi-Nagy (2012b) it is probably a microspecies of *R. rubiginosa*. Further studies are needed.

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- World Checklist of Selected Plant Families (WCSP): <https://wcsp.science.kew.org>

Appendix 2

Shared endemic taxa of the Pannonicum and western part of the Carpathicum

Taxon	Occurrence	References
<i>Dianthus plumarius</i> L.*	Au, Sk, Cz	Barina <i>et al.</i> 2020
<i>Epipactis futakii</i> Mered'a et Potůček*	Cz, Hu, Sk	Mered'a and Potůček 1998, Vlčko <i>et al.</i> 2003, Molnár and Csábi 2021
<i>Epipactis pseudopurpurata</i> Mered'a*	Cz, Hu, Sk	Vlčko <i>et al.</i> 2003, Csábi and Halász 2016, AHO-Bayern e.V. 2021
<i>Erysimum wittmannii</i> Zaw. subsp. <i>pallidiflorum</i> (Jáv.) Jáv.*	Hu, Sk	Soó 1968, Michalková 2002, Türke <i>et al.</i> 2020
<i>Ophrys fuciflora</i> (E. W. Schmidt) Moench subsp. <i>holubyana</i> (Andras.) Jáv.*	Cz, Hu, Sk	Andrasovszky 1917, Gulyás <i>et al.</i> 2005, Óvári and Molnár 2011

Notes (*)

Dianthus plumarius: Syn.: *D. lumnitzeri* Wiesb., *Dianthus plumarius* L. subsp. *lumnitzeri* (Wiesb.) Domin, *Dianthus praecox* subsp. *lumnitzeri* (Wiesb.) Kmeťová. According to the latest literature, this is the correct name for a taxon that occurs from Hainburg to Malé Karpaty and Inovec Mts. (Barina *et al.* 2020). South Moravian plants certainly belong to this taxon. Determining its exact distribution area requires further research. Hungarian records are probably erroneous. *D. p.* subsp. *neilreichii*, *D. p.* subsp. *blandus* and *D. p.* subsp. *hoppei* treated here as different taxa.

Epipactis futakii: Exact distribution area is still unknown. It occurs in the southern and western parts of the Slovakian Carpathicum (and in the neighbouring Czech Republic) and in the northern part of the Pannonicum (Vlčko *et al.* 2003, Wild *et al.* 2019, Molnár and Csábi 2021, AHO-Bayern e.V. 2021).

Epipactis pseudopurpurata: This orchid was discovered and described in 1996 (Mered'a 1996) and exact distribution is still unknown. It occurs in the western parts of the Slovakian Carpathicum (and in the neighbouring Czech Republic) and in the northern part of the Pannonicum (Transdanubian Mts and western edge of the North Hungarian Mts) (Vlčko *et al.* 2003, Wild *et al.* 2019, Molnár and Csábi 2021, AHO-Bayern e.V. 2021).

Erysimum wittmannii subsp. *pallidiflorum*: Some authors treat it as a species: *Erysimum pallidiflorum* Jáv. (Baksay 1956, Soó 1968, Michalková 2002). Soó (1968) considered it is a Pannonian endemic, but according to recent literature it also occurs in the eastern part of the Slovakian Carpathicum (Michalková 2002).

Ophrys fuciflora subsp. *holubyana*: (Syn.: *Ophrys holoserica* subsp. *holubyana* (Andras.) Dostál, *Ophrys holubyana* Andras.). *Ophrys holubyana* was found and described by the Hungarian botanist Andrasovszky (Andrasovszky 1917). This taxon has been interpreted as a hybrid derivative of *O. fuciflora* and *O. oestriifera* expressing floral morphological features intermediate between its presumed progenitors. This is very widely accepted in the orchid literature (e.g. Buttler 1986, Delforge 2001, 2006, Vlčko *et al.* 2003, Gulyás *et al.* 2005, Óvári and Molnár 2011), probably on the basis of the morphological and chorological features of the species involved. Hungarian plants are not recent hybrids as Kliment *et al.* (2016) said (Molnár V. in litt.). The distribution areas of the three taxa are separated (Molnár and Csábi 2021). *O. holubyana* occurs in the northwestern part of the Carpatho-Pannonian region and is considered to be endemic. This taxon is mentioned at different taxonomic levels and classifications (see synonyms). We follow Óvári and Molnár (2011).

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Appendix 3

Endemic or subendemic taxa in Pannonicum. Apomictic taxa are marked with a grey background. Plants whose taxonomic status is unclear are marked in light gray. Distribution menas phylogeographical.

Abbreviations: Au = Austria, Bu = Bulgaria, Cr = Croatia, Cz = Czech Republic, Hu = Hungary, Ro = Romania, Sk = Slovakia, Slo = Slovenia, Srb = Serbia, Ua = Ukraine; Eu = Eupannonicum (Eu1 = Great Plain, Eu2 = Little Plain and its surroundings), Ba = Bakonyicum, Ma = Matricum, Pi = Praeil-lyricum, Pn = Praenorikum, Th = Thermenlinie;

Sal = saline vegetation, Sand = steppe, steppe forest on sand, Loes = steppe, steppe forest on loess, Ro = rocks, rocky grasslands, Wet = bogs, alluvial meadows and other wetland communities, Xe = xerophilous/dry grasslands (in general) and schrubs, Me = mesic hay meadows and pastures, Xef = xerophilous mountain forests (oak and oak scrub forests, rocky forests, etc.). Mef = mesophilous forest communities (oak-hornbeam and beech forests, riverine forests, etc.). Sporadic/less typical occurrences in parentheses “()”. * = notes

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Achillea asplenifolia</i> Vent.*	Au, Cz, Hu, Sk, Ro, Srb, Cr, Slo, Bu	subendemic	Eu, Pi, (Ba, Ma)	Sal-Wet	Danihelka 2003, Saukel <i>et al.</i> 2009
<i>Alchemilla hungarica</i> Soó*	Hu	endemic	Ma: Bükk, Zemplén	Me	Soó 1966, Farkas 1997, 1999, 2009
<i>Armoracia macrocarpa</i> (Waldst. et Kit.) Kit. ex Baumg.*	Hu, Sk, Ro, Srb, Cr†?	endemic	Eu1, (Ma)	Wet	Tatár 1939, Vargáné 1999, Dihoru and Négrea 2009, Stevanović <i>et al.</i> 2011
<i>Artemisia panicicii</i> Danihelka et Marhold	Au, Cz, Srb	endemic	Eu	Xe	Danihelka and Marhold 2003, Kitner <i>et al.</i> 2012
<i>Astragalus vesicarius</i> L. subsp. <i>albidus</i> (Waldst. et Kit.) Braun-Blanq.*	Hu, Sk	subendemic	Ba, Ma, Pi	Ro	Tatár 1939, Soó 1966, Csapody 1982, Chrtková 1988a, Király 2009
<i>Centaurea jankeana</i> Simonk.*	Srb, (Ro?)	endemic	Eu1: Deliblato Sands	Sand	Tatár 1939, Hilpold <i>et al.</i> 2014, CWG 2021
<i>Centaurea scabiosa</i> L. subsp. <i>badensis</i> Trattinnick*	Au	subendemic	Th	Ro	Dreyer 1998, Fischer <i>et al.</i> 2008
<i>Centaurea scabiosa</i> L. subsp. <i>sadleriana</i> (Janka) Asch. et Graebn.	Au, Hu, Sk, Ro, Srb	endemic	Eu, Ba, Ma, Pi	Xe	Soó 1970, Greuter and Raab-Straube 2006†, Király 2009, CWG 2021
<i>Centaurea scabiosa</i> L. subsp. <i>vertesensis</i> (Boros) Soó*	Hu	endemic	Ba	Ro	Boros 1940, Jávorka and Soó 1951

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Centaurea tauscheri</i> A. Kern.*	Hu, Ro, Srb?	endemic	Eu	Sand	Dostál 1976, Soó 1980, Simon 2000, Greuter and Raab-Straube 2006 ⁺ , Hilpold <i>et al.</i> 2014, CWG 2021
<i>Chamaecytisus heuffelii</i> (Wierzb.) Rothm.*	Hu, Ro, Srb	subendemic	Eu, Pi	Ro, Sand	Pifkó 2010
<i>Chamaecytisus supinus</i> (L.) Link subsp. <i>aggregatus</i> (Schur) Pifkó*	Hu, Sk, Ro?	endemic	Eu, Ba, Ma, Pi	Xe, XeF	Pifkó 2005, 2014, 2015, Pifkó and Shevera 2011
<i>Chamaecytisus supinus</i> (L.) Link subsp. <i>pannonicus</i> (Simonkai) Pifkó*	Hu	endemic	Pi	Loes	Pifkó 2005, 2009b, 2015
<i>Chamaecytisus virescens</i> (Kováts ex Neilr.) Dostál*	Au, Cz, Hu, Sk	endemic	Eu, Ba, Ma	Xe, XeF	Pifkó 2004, 2014
<i>Cirsium boujarii</i> (Piller et Mitterp.) Sch. Bip. subsp. <i>boujarii</i> *	Hu, Ro, Srb+	sub?-endemic	Eu, Ba Pi	Loes	Csiký <i>et al.</i> 2005
<i>Cirsium brachycephalum</i> Jur.	Au, Cz, Hu, Sk, Ro, Srb	endemic	Eu (Ba, Pi)	Sal-Wet	Tatár 1939, Soó 1970, Farkas and Aradi 2014
<i>Cochlearia macrorrhiza</i> (Schur) Pobed.*	Au ("+"?)	endemic	Eu2: Moosbrunn	Wet	Fischer <i>et al.</i> 2008, Mrkvicka <i>et al.</i> 2015
<i>Colchicum arenarium</i> Waldst. et Kit.*	Hu, Sk, Srb, Ro	endemic	Eu	Sand	Tatár 1939, Soó 1973, Gnatjuk <i>et al.</i> 2018, Oganezova 2019
<i>Crataegus nigra</i> Waldst. et Kit.*	Hu, Srb, Hr, Ro, Sk+	endemic	Eu1	MeF	Tatár 1939, Bartha and Kerényi-Nagy 2010, 2012, Kerényi-Nagy 2015
<i>Dianthus collinus</i> Waldst. et Kit. subsp. <i>collinus</i> *	Au, Hu, Sk, Ro, Cr, Slo, Ua	subendemic	Eu, Ba, Ma, Pi	Xe	Soó 1970
<i>Dianthus diutinus</i> Kit.*	Hu, Srb	endemic	Eu1	Sand	Tatár 1939, Vidéki and Máté 2005, 2011, Mile <i>et al.</i> 2014
<i>Dianthus plumarius</i> L. subsp. <i>neil-reichii</i> Hayek*	Au	subendemic	Th: Mödling	Ro	Fischer <i>et al.</i> 2008

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Dianthus pontederæ</i> A. Kern.*	Au, Cz, Hu, Sk, Ro, Srb, Cr	subendemic	Eu, Ba, Ma, Pi, Pn	Xe	Tatár 1939, Soó 1970, Simon 1992, 2001, Király 2009
<i>Dianthus praecox</i> Schult. subsp. <i>pseudopraecox</i> (Novák) Dostál*	Hu, Sk	endemic	Ma: Bükk, Gömör-Torna Karst	Ro	Kmetová 2012
<i>Dianthus serotinus</i> Waldst. et Kit. subsp. <i>kitaibelianus</i> Zapal.*	Hu	endemic	Ba	Ro	Tatár 1939, Baksay 1970, Soó 1970, Somogyi <i>et al.</i> 2013, Barina <i>et al.</i> 2020
<i>Dianthus serotinus</i> Waldst. et Kit. subsp. <i>serotinus</i> *	Au, Hu, Sk, Ro, Srb, Cr	endemic	Eu, (Ba)	Sand	Tatár 1939, Soó 1970, Somogyi <i>et al.</i> 2013, Barina <i>et al.</i> 2020
<i>Draba lasiocarpa</i> Rochel subsp. <i>klasterskyi</i> (Chrtek) Chrtek	Sk	endemic	Ma: Gömör-Torna Karst	Ro	Chrtek 1978, Peniašteková and Kliment 2002, Virók <i>et al.</i> 2016
<i>Epipactis bugacensis</i> Robatsch subsp. <i>bugacensis</i> *	Hu	endemic	Eu1: Duna-Tisza köze	Sand	Wucherpfenning 2007, Vidéki and Molnár 2011
<i>Epipactis mecsekensis</i> Molnár et Robatsch	Hu	endemic	Pi: Kelet-Mecsek	MeF	Molnár 2011, AHO-Bayern e.V. 2021
<i>Epipactis moravica</i> Batoušek*	Cz, Hu, Sk	sub-endemic	Eu, Ba, Pi	MeF	Óvári and Molnár 2011, AHO-Bayern e.V. 2021
<i>Epipactis nordeniorum</i> Robatsch*	Au, Hu, Slo, Cr, Ro, Sk?	sub-endemic	Eu, Ba, Ma, Pi, Pn	MeF	Wucherpfenning 2007, Molnár and Óvári 2011, AHO-Bayern e.V. 2021
<i>Epipactis tallosii</i> A. Molnár et Robatsch*	Cz, Hu, Sk, Ua, Ro, Srb, Cr	(sub)endemic	Eu, Ba, Ma, Pi, (Pn)	MeF	Süveges <i>et al.</i> 2019
<i>Epipactis zoethii</i> Robatsch*	Au, Cz, Hu, Sk	(sub)endemic	Eu2, Ba, Ma, Pi, Pn, Th	MeF, (XeF)	Robatsch 1993, Vlčko <i>et al.</i> 2003, Mészáros <i>et al.</i> 2011, AHO-Bayern e.V. 2021
<i>Ferula sadleriana</i> Ledeb.*	Hu, Sk, Ro	subendemic	Ba, Ma (+ Apuseni Carpathians)	Ro, XeF	Tatár 1939, Lendvay and Kalapos 2009, 2014, Kalapos and Nagy 2014
<i>Festuca pseudooaquinata</i> Penksza*	Hu, Ro	endemic	Eu1	Sand	Penksza 2003, Šmarda 2006

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Festuca stricta</i> Host subsp. <i>carunentina</i> (R. Tracey) Pils*	Au	endemic	Eu2	Ro	Tracey 1977, Pils 1984, Englmaier 2008, Foggi and Müller 2009
<i>Festuca stricta</i> subsp. <i>stricta</i> Host*	Au	subendemic	Th, Pn	Ro	Pils 1984, Englmaier 2008
<i>Festuca vaginata</i> Waldst. et Kit. ex Willd*	Hu, Sk, Ro, Cr, Srb, Bu, Au?	subendemic	Eu, Ba, Ma, Pi	Sand	Šmarda <i>et al.</i> 2007
<i>Festuca vojtkoi</i> Penksza*	Hu	endemic	Ma	Ro	Penksza 2005
<i>Festuca wagneri</i> (Degen, Thaisz et Flatt) Degen, Thaisz et Flatt in Degen*	Hu, Sk, Srb	endemic	Eu1	Sand	Tatár 1939, Soó 1973, Penksza and Engloner 2000, Šmarda 2008
<i>Galatella cana</i> (Waldst. et Kit.) Nees*	Au, Hu, Sk, Ro, Srb, Cz†	sub?-endemic	Eu, (Ba)	Sal	Tatár 1939, Roskov <i>et al.</i> 2018
<i>Galium abaujense</i> Borbás*	Hu, Sk, Ro	subendemic	Ma, (Eu1)	XeF, (MeF)	Kliment 1999, Fekete <i>et al.</i> 2014, Negrean <i>et al.</i> 2015, Bartha <i>et al.</i> 2021
<i>Gypsophila fastigiata</i> L. subsp. <i>arenaria</i> (Waldst. et Kit.) Domín*	Au(?), Cz, Hu, Sk, Srb	endemic	Eu, Ba	Sand, Ro	Tatár 1939, Soó 1970, Simon 2000
<i>Hesperis matronalis</i> L. subsp. <i>vrabelyiana</i> (Schur) Soó	Hu	endemic	Ma: Bükk	MeF, (XeF, Xc)	Tatár 1939, Soó 1968, Ball 1993, Less 1999, Barina 2009, Kliment <i>et al.</i> 2016
<i>Hieracium kossuthianum</i> Soó*	Hu	endemic	Ba: Budai-hg., Pilis, (Visegrádi-hg.?)	Ro, XeF	Soó 1970, Király 2009
<i>Iris arenaria</i> Waldst. et Kit.*	Au, Cz, Hu, Sk, Ro, Srb	endemic	Eu, Ba	Sand, Ro	Soó 1973, Zhygalova and Olshanskyy 2016, Barker and Govaerts 2021
<i>Knaulia kitaibelii</i> (Schult.) subsp. <i>tomentella</i> (Szabó) Baksay*	Hu	endemic	Ba: Budai-hg., Pilis	Ro, (Me)	Baksay 1956, Böhm and Facsar 2000
<i>Linonium gmelinii</i> (Willd.) Kuntze subsp. <i>hungaricum</i> (Klokov) Soó *	Hu, Sk, Ro, Srb	subendemic	Eu1	Sal	Soó 1970, Simon 1992, 2000, Piškó 2009d, Michalková 2016

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Lotus borbasii</i> Újhelyi*	Au, Cz, Hu, Sk	endemic	Eu, Ba, Ma, Th	Xe	Chrtková 1988b, Fischer <i>et al.</i> 2008, Király 2009
<i>Melampyrum barbatum</i> subsp. <i>barbatum</i> Waldst. et Kit. ex Willd.	Au, (Czt?), Hu, Sk, Ro, Srb, Cr	(sub)endemic	Eu, Ba, Ma, Pi, Pn, Th	Xe	Tatár 1939, Soó 1968, Soó and Webb 1972, Király 2009
<i>Melampyrum nemorosum</i> L. subsp. <i>debrecenense</i> (Rapaits) Soó*	Hu, Ro	endemic	Eu1: Nyírség	Sand, (MeF)	Tatár 1939, Soó 1968, Soó and Webb 1972, Simon 2000, Oprea 2005, Ciocarian 2009
<i>Nocca janikae</i> (A. Kern.) F. K. Mey.*	Hu, Sk	endemic	Ma, (Ba,) Eu	Xe, (Loes)	Tatár 1939, Hodalová and Mártonfi 2002, Schmotzer and Takács 2014, Lisztes <i>et al.</i> 2016, Laczkó <i>et al.</i> 2018
<i>Odontarrhena tortuosa</i> (Waldst. et Kit. ex Willd.) C. A. Mey. subsp. <i>heterophylla</i> (Nyar.) Španiel <i>et al.</i> *	Hu, Sk	endemic	Ma: Gömör–Torna Karst, Vihorlat Mts	Ro	Španiel <i>et al.</i> 2015, 2018
<i>Otosma pseudoarenaria</i> Schur subsp. <i>tuberculata</i> (Kit.) Rauschert*	Hu, Sk, Srb	endemic	Eu, Ma	Sand, Ro	Kolarčík <i>et al.</i> 2014, 2018
<i>Paeonia officinalis</i> L. subsp. <i>banatica</i> (Rochel) Soó*	Hu, Ro, Srb, Cr+	endemic	Eu, Pi	XeF, (Sand, MeF)	Tatár 1939, Soó 1960, 1966, Kevey <i>et al.</i> 2005, Hong 2010, Bilz 2011
<i>Poa pannonica</i> A. Kern subsp. <i>scabra</i> (Kit.) Soó*	Hu, Sk, Uat, Ro?	subendemic	Ma, Ba (Visegrádi-hg.)	Ro, XeF	Tatár 1939, Soó 1973, Kliment 1999, Fekete <i>et al.</i> 2011, 2014
<i>Puccinellia peisonis</i> (Beck) Jáv.*	Au, Hu	endemic	Eu2: Fertő-tó/Neusiedler See	Sal	Englmaier 1982
<i>Pulsatilla flavescens</i> (Hazsl.) Borb.*	Hu, Sk, Ro	endemic	Eu1: Nyírség, Bodrogköz	Sand	Tatár 1939, Somlyay 2000, Lesku 2006, 2014
<i>Pulsatilla zimmermanni</i> Soó*	Hu, Sk	endemic	Ma, Eu1	Xe	Soó 1965, 1966, Mártonfi 2004, Takács <i>et al.</i> 2018
<i>Rosa kmetiana</i> Borbás*	Hu, Ro, Sk+?	endemic	Ba, Ma, Eu	Xe	Facsar and Király 2009, Kerényi-Nagy 2010, 2012a–b
<i>Rubus balatonicus</i> Borbás	Hu, (Au)	endemic	Ba, (Pn)	XeF	Király <i>et al.</i> 2013

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Scilla bifolia</i> L. subsp. <i>spetana</i> (Kereszty) Trávníček	Au, Cz, Hu, Sk, Cr	endemic	Eu, Ba, Pi	MeF, (XeF)	Trávníček <i>et al.</i> 2009
<i>Sedum urvilletii</i> DC. subsp. <i>hillebrandtii</i> (Fenzl) D. A. Webb*	Hu, Srb, Ro?	endemic	Eu1	Sand	Tatár 1939, Egglí 2005, Sramkó 2009
<i>Semperivium matricum</i> Letz*	Hu, Sk	endemic	Ba, Ma	Ro	Letz 2009
<i>Seseli leucospermum</i> Waldst. et Kit.*	Hu	endemic	Ba	Ro	Tatár 1939, Farkas and Bauer 2014
<i>Sesleria hungarica</i> Ujhelyi*	Hu, Sk	endemic	Ma	Ro	Soó 1973, Somlyay 2009, Mered'a <i>et al.</i> 2019
<i>Sesleria sadleriana</i> Janka*	Au, Hu	endemic	Ba, (Eu2)	Ro	Tatár 1939, Mered'a <i>et al.</i> 2019, Hodálóvá <i>et al.</i> 2020
<i>Sorbus acutiserrata</i> Cs. Németh	Hu	endemic	Ba: Vértes (Gánt)	XeF	Németh 2009a
<i>Sorbus adamii</i> Kárpáti	Hu	endemic	Ba: Vértes	XeF	Németh 2006, 2009b
<i>Sorbus andreanszkyana</i> Kárpáti	Hu	endemic	Ba: Keszthelyi-hg.	XeF	Kárpáti 1960, Németh 2009b
<i>Sorbus bakonyensis</i> (Jávorka) Kárpáti*	Hu	endemic	Ba: Bakony (Márkó)	XeF	Somlyay and Sennikov 2014
<i>Sorbus balatonica</i> Kárpáti	Hu	endemic	Ba: Bakony, Keszthelyi-hg.	XeF	Németh 2013
<i>Sorbus barabitsii</i> Németh	Hu	endemic	Ba: Bakony (Bánd)	XeF	Németh 2012, 2013
<i>Sorbus barthae</i> Kárpáti	Hu	endemic	Ba: Bakony (Várpalota)	MeF, XeF	Németh 2013
<i>Sorbus bodajkensis</i> Barabits	Hu	endemic	Ba: Bakony (Bodajk)	XeF	Barabits 2007, Németh 2013
<i>Sorbus borosiana</i> Kárpáti	Hu	endemic	Ba: Vértes (Gánt)	MeF, XeF	Németh 2006, 2009b

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Sorbus bueckensis</i> (Soó) Soó*	Hu, Sk	endemic	Ma: Bükk, Gömör-Torna Karst	XeF	Kárpáti 1960, Németh 2009b, Virók <i>et al.</i> 2016, Sennikov <i>et al.</i> 2017
<i>Sorbus concavifolia</i> Cs. Németh	Hu	endemic	Ba: Keszthelyi-hg. (Vállus)	XeF	Németh <i>et al.</i> 2016
<i>Sorbus decipiensiformis</i> Kárpáti*	Hu (?)	endemic	Ba: Keszthelyi-hg. (?)	XeF	Kárpáti 1960, Németh 2009b, Németh <i>et al.</i> 2016
<i>Sorbus degenii</i> Jávorika	Hu	endemic	Ba: Vértes, (Bakony)	XeF	Németh 2006, 2009b, 2013
<i>Sorbus dracofolia</i> Cs. Németh	Hu	endemic	Ba: Vértes (Gánt)	XeF	Németh 2009a
<i>Sorbus eugen-kelleri</i> Kárpáti	Hu	endemic	Ba: Vértes, (Bakony)	XeF	Németh 2006, 2009b, 2013
<i>Sorbus gayariana</i> Kárpáti	Hu	endemic	Ba: Bakony, Keszthelyi-hg.	MeF, XeF	Németh 2013
<i>Sorbus greceensis</i> Boros et Kárpáti	Hu	endemic	Ba: Gerecse (Szártiliget)	XeF	Németh 2009b
<i>Sorbus hazslinszkyana</i> (Soó) Má-jovský*	Hu, Sk	endemic	Ma: Gömör-Torna karst, (Bükk)	XeF	Kárpáti 1960, Németh 2009b, Virók <i>et al.</i> 2016, Mikoláš <i>et al.</i> 2017
<i>Sorbus jaoorkana</i> Somlyay, Sennikov et Vojtkó*	Hu, Sk	(sub)endemic	Ma: Gömör-Torna karst, (Slovak Paradise)	XeF	Somlyay <i>et al.</i> 2017
<i>Sorbus karpáti</i> Boros	Hu	endemic	Ba: Vértes (Csákberény, Gánt)	XeF	Németh 2006, 2009b

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Sorbus keszthelyensis</i> Somlyay et Semnikov	Hu	endemic	Ba: Keszthelyi-hg., Balaton-felvidék	XeF	Somlyay <i>et al.</i> 2016b
<i>Sorbus latissima</i> Kárpáti*	Hu (?)	endemic	Ba: Keszthelyi-hg. (?)	XeF	Kárpáti 1960, Németh 2009b
<i>Sorbus pannonica</i> Kárpáti	Hu	endemic	Ba: Bakony, Balaton-felvidék, Vértes	XeF	Németh 2009b, Somlyay and Sennikov 2015
<i>Sorbus pelsőensis</i> Cs. Németh	Hu	endemic	Ba: Balaton-felvidék	XeF	Németh 2015a
<i>Sorbus polgariana</i> Cs. Németh	Hu	endemic	Ba: Bakony (Iisztimér)	XeF	Németh 2012, 2013
<i>Sorbus pseudobakonyensis</i> Kárpáti	Hu	endemic	Ba: Vértes	XeF	Németh 2006, 2009b
<i>Sorbus pseudolatifolia</i> Boros	Hu	endemic	Ba: Vértes, (Gerecse)	XeF	Németh 2006, 2009b
<i>Sorbus pseudosemiincisa</i> Boros*	Hu (?)	endemic	Ba: Vértes (Csákberény)	XeF	Németh 2009a, 2015b
<i>Sorbus pseudovertesensis</i> Boros	Hu	endemic	Ba: Vértes	XeF	Németh 2006, 2009b
<i>Sorbus pyricarpa</i> Cs. Németh*	Hu	endemic	Ba: Vértes (Csákberény)	XeF	Németh 2015b
<i>Sorbus redliana</i> Kárpáti	Hu	endemic	Ba: Bakony	XeF	Németh 2013
<i>Sorbus rhombiformis</i> Barabits et Cs. Németh	Hu	endemic	Ba: Keszthelyi-hg. (Vállus)	XeF	Németh <i>et al.</i> 2016
<i>Sorbus semiincisa</i> Borbás	Hu	endemic	Ba	XeF	Kárpáti 1960, Kézdy 1999
<i>Sorbus simonkaiana</i> Kárpáti	Hu	endemic	Ba: Vértes	XeF	Németh 2006, 2009b
<i>Sorbus subdamibialis</i> (Soó) Kárpáti	Hu, Sk	endemic	Ma: Gömör-Torna Karst	XeF	Somlyay <i>et al.</i> 2016a

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Sorbus thaiszii</i> (Soó) Kárpáti*	Hu, Sk	endemic	Ma: Bükk, Gömör-Torna Karst	XeF	Kárpáti 1960, Németh 2009b, Virók <i>et al.</i> 2016, Mikolász <i>et al.</i> 2017
<i>Sorbus tobani</i> Cs. Németh	Hu	endemic	Ba: Bakony (Hajmáskér)	XeF	Németh 2007, 2013
<i>Sorbus tuzsoniana</i> Kárpáti	Sk	endemic	Ma: Gömör-Torna Karst	XeF	Kárpáti 1960, Virók <i>et al.</i> 2016
<i>Sorbus udvardyana</i> Somlyay et Sennikov	Hu	endemic	Ba	XeF	Somlyay and Sennikov 2014
<i>Sorbus ujhelyii</i> Somlyay et Sennikov	Hu	endemic	Ba: Budai-hg.	XeF	Somlyay <i>et al.</i> 2016b
<i>Sorbus ulmifolia</i> Kárpáti	Hu	endemic	Ba: Vértes	XeF	Németh 2009b, 2010, Somlyay and Sennikov 2015
<i>Sorbus vajdae</i> Boros*	Hu, Sk	endemic	Ma: Bükk, Gömör-Torna Karst, Zemplén	XeF	Kárpáti 1960, Németh 2009b, 2010, Virók <i>et al.</i> 2016, Beech and Rivers 2017a
<i>Sorbus valleribusensis</i> Cs. Németh	Hu	endemic	Ba: Vértes (Csákberény)	XeF	Németh 2009a
<i>Sorbus vallusensis</i> Cs. Németh	Hu	endemic	Ba: Keszthelyi-hg. (Vállus)	XeF	Németh <i>et al.</i> 2016
<i>Sorbus vertesensis</i> Boros	Hu	endemic	Ba: Vértes (Csákberény, Csókakő)	XeF	Németh 2006, 2009b
<i>Sorbus veszpremenensis</i> Barabits	Hu	endemic	Ba: Bakony	XeF	Barabits 2007, Németh 2013
<i>Sorbus zolyonii</i> (Soó) Kárpáti*	Hu, Sk?	endemic	Ma: Bükk, Mátra, Gömör-Torna Karst	XeF	Kárpáti 1960, Németh 2009b, Virók <i>et al.</i> 2016, Beech and Rivers 2017b
<i>Suaeda pannonica</i> (Beck) Graebn.*	Au, Hu, Srb	endemic	Eu	Sal	Tatár 1939, Mile and Walter 2003

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Taraxacum ambrosium</i> Kirschner et Štěpánek	Czt?, Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum bibulum</i> Kirschner et Štěpánek	Au, Hu, Sk, Po	(sub)endemic	Eu2	Wet	Kirschner and Štěpánek 1998, Marciniuk <i>et al.</i> 2019
<i>Taraxacum bufonium</i> Kirschner et Štěpánek	Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum catenatum</i> Kirschner et Štěpánek	Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum cognatum</i> Kirschner et Štěpánek	Au, Cz, Hu, Sk, Ua (intr.: Ca, USA)	subendemic	Eu, Ba	Wet, Xe	Kirschner and Štěpánek 1998, Wild 2019
<i>Taraxacum domabile</i> Kirschner et Štěpánek	Au, Hu, Sk, Ua	endemic	Eu, Pi	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum farroris</i> Kirschner et Štěpánek	Cz, Sk	subendemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum fluviatile</i> Kirschner et Štěpánek	Hu, Sk, Ua	endemic	Eu1	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum humidicola</i> Kirschner et Štěpánek	Hu, Sk	endemic	Eu1, Pi	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum inundatum</i> Kirschner et Štěpánek	Cz, Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum irroratum</i> Kirschner et Štěpánek	Au, Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum limosicola</i> Kirschner et Štěpánek	Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum limosum</i> Soest	Au, Cz, Hu, Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum litigiosum</i> Kirschner et Štěpánek	Cz, Sk	subendemic	Eu2	Wet	Kirschner and Štěpánek 1998, Wild 2019
<i>Taraxacum portentosum</i> Kirschner et Štěpánek	Czt?, Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998

Taxa	Occurrence	Status	Distribution	Habitat	Reference
<i>Taraxacum pitor</i> Kirschner et Štěpánek	Hu, Sk	endemic	Eu, Pi	Wet, Sal	Kirschner and Štěpánek 1998
<i>Taraxacum pseudobalticum</i> Soest	Au, Cz, Sk	endemic	Eu2	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum pseudopaucilobum</i> Kirschner et Štěpánek	Hu, Sk	endemic	Eu, Pi	Wet, Sal	Kirschner and Štěpánek 1998
<i>Taraxacum pulchellum</i> Kirschner et Štěpánek	Hu, Sk	endemic	Eu2, Pi	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum ranarium</i> Kirschner et Štěpánek	Hu, Sk	endemic	Eu2, Pi	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum telmatophilum</i> Kirschner et Štěpánek	Au, Hu, Sk, Po	sub-endemic	Eu, Ba, Pi	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum uliginosum</i> Kirschner et Štěpánek	Au, Hu, Sk	endemic	Eu, Pi	Wet	Kirschner and Štěpánek 1998
<i>Taraxacum uvidum</i> Kirschner et Štěpánek	Au, Cz, Hu, Sk	endemic	Eu	Wet, Sal	Kirschner and Štěpánek 1998
<i>Thalictrum minus</i> subsp. <i>majus</i> (Crantz) Hook.*	Au, Hu, Sk, Slo	subendemic	Ba, (Pi), Th	Ro, (XeF)	Tatár 1939, Hand 2001
<i>Tragopogon floccosus</i> Waldst. et Kit.*	Hu, Srb, Ro, Bu	sub(?)endemic	Eu1	Sand	Soó 1970, Simon 1992, 2000
<i>Vincetoxicum pannonicum</i> (Borhidi) Holub*	Hu	endemic	Ba, Pi	Ro, (XeF)	

Notes (*)

Achillea asplenifolia: Typical species of the Pannonian lowlands, has been so far documented from Southeast Czechia, South Slovakia, East Austria, Hungary, Northeast Slovenia, North Croatia, North Serbia, Romania and in one locality in Bulgaria (Sofia) (Jogan 2001, Danihelka 2003, Nikolić 2005, Fisher *et al.* 2008, Saukel *et al.* 2009, Bartha *et al.* 2021).

Alchemilla hungarica Soó (Syn.: *Alchemilla plicata* Buser subsp. *hungarica* Soó, *Alchemilla monticola* Opiz var. *hungarica* Soó). In most of the literature it is synonymous with *A. monticola* or sometimes a subspecies of *A. plicata*. According to Farkas (1997, 1999, 2009) this taxon differs from both.

Armoracia macrocarpa: Some of its previous records are questionable or incorrect, only data supported by the herbarium specimen can be taken into account. This species has been in a decrease in the number of known localities in the last century. It has only one or two populations per country in Slovakia, Serbia, and Romania (Dihoru and Negrean 2009, Stevanović *et al.* 2011). It is extinct from many localities in Hungary and today it occurs mostly in the floodplains of the Tisza River (Bartha *et al.* 2021).

Astragalus vesicarius subsp. *albidus*: Taxonomic status is unclear. The subsp. *albidus* is not sufficiently separated from the type subspecies according to some author (e.g. Fischer *et al.* 2008). It is accepted in recent floras in Hungary (e.g. Simon 1992, 2000, Király 2009), Slovakia (Chrtková 1988a) and Romania (Ciocârlan 2009). Further studies are needed. Outside the Pannonicum it also occurs in Transylvania (Romania). Most of the localities are in the Transdanubian Mountains (Bartha *et al.* 2021).

Centaurea jankeana: This plant was described by Lajos Simonkai (Simkovics) in 1877 near Gerebenc ("Grebenáč", today: Grebenac) as *Centaurea jankeana* (Simonkai 1877). It is often referred to as *C. jankaeana* (Wagner 1910, 1914, Jávorka 1924–1925, Tatár 1939, etc.) or *C. jankana* (Greuter and Raab-Straube 2006+) in later literature. It is a member of the *Centaurea arenaria* group. It has an old record in Romania (Moldavia: Bârlad), but recent works (e.g. Ciocârlan 2000, 2009) do not mention. Probably erroneous. Based on our current knowledge it is found only in Deliblato Sands (Deliblatska peščara) especially in its southern parts (Wagner 1910, Tatár 1939), where it is quite common, but becomes rare in the north (Riezinger ined.). Literature has treated it as a species (Jávorka 1924–1925), varietas (Wagner 1910, 1914, Tatár 1939) or form (Josifović 1975), but recent literatures treat it again as a species (Hilpold *et al.* 2014, CWG 2021). Perhaps it is better to treat it as a subspecies of *C. arenaria*.

Centaurea scabiosa subsp. *badensis*: A typical plant of the "Thermenlinie". It lives on warm tops and slopes along the eastern margin of the Alps ("Thermenlinie") south of Vienna (Dreyer 1998, Fischer *et al.* 2008).

Centaurea scabiosa L. subsp. *vertesensis*: This plant was described as a species by Ádám Boros (Boros 1940). Jávorka-Soó (1951) mentioned it as a subspecies of *C. scabiosa* but according to Baksay (1956) it is a Pannonian endemic species and has a relict character. The closest relative is the *C. tematinensis* according to Boros (1954). Later Soó considered it as a varietas of *C. scabiosa* subsp. *tematinensis* (Soó-Kárpáti 1968, Soó 1970). Recent Hungarian floraworks follow this (Simon 1992, 2000). According to Soó, *vertesensis* is an intermediate taxon between the *tematinensis* and *sadleriana* (Soó 1970) because the leaves morphology similar than *tematinensis* while the bract appendages resemble *sadleriana*. However, the morphology of the leaves within the *Centaurea* group is the result of adaptation to edaphic conditions and therefore this similarity does not indicate relationship (Dreyer 1998, Hilpold *et al.* 2014). The morphology of the bract appendages is more suitable for this, but for the most part, geography is a better predictor for relationships within the *Centaurea* group (Hilpold *et al.* 2014). Within the *C. scabiosa* group, the area of *vertesensis* is surrounded by *sadleriana*. Due to the morphology of the bract appendages and the geographical position of the area, the *sadleriana* is presumably the closest relative to *vertesensis*. Leaf morphological differences between the two taxa are also shown by *vertesensis* under better soil conditions, so it is not just an edaphic morph. Based on the above mentioned, it is best treated as a subspecies: *C. scabiosa* subsp. *vertesensis*. (A more detailed discussion is being prepared by the author.) Distribution: southern part of the Vértes, southeastern margin of the Bakony, northeastern edge of the Balaton-felvidék (Boros 1940, Redl 1942, Barina and Németh 2009, Bauer 2009, 2010).

Centaurea tauscheri: Member of the taxonomically problematic and difficult to identify *Centaurea arenaria* group. Literatures treated as a hybrid (Jávorka 1924–1925), varietas (Josifović 1975), subspecies (Soó 1980, Simon 1992, 2000) or species (Dostál 1976, Ciocârlan 2000, 2009, Greuter and Raab-Straube 2006+, Hilpold *et al.* 2014, Roskov *et al.* 2018, CWG 2021). Recent works mentions it as a species, but maybe it is better to treat it as a subspecies of *C. arenaria*. The records and exact distribu-

tion (mostly based on Soó 1980, Simon 2000, Ciocarlan 2009) need confirmation. It occurs in Hungary (Kisalföld – only in the eastern part, Duna–Tisza köze, Nyírség and old records from Tengelic Sands – Wagner 1910) and Romania (Arad County). Its current occurrence in Serbia is poorly known. Old records are known from Vojvodina (Subotica Sands, Deliblato Sands and a few other localities) (Wagner 1910, Sturc 1997).

Chamaecytisus heuffelii (Syn.: *Cytisus austriacus* L. subsp. *heuffelii* (Wierzb.) Asch. et Graebn., *Cytisus supinus* L. var. *heuffelii* (Wierzb.) Briq.). Most of the literature records are erroneous. Mostly confused with the *Ch. banaticus*. Only three localities are known: Pécs (Hu), Deliblato Sands (Srb), Iron Gate Gorge (Srb, Ro) (Pifkó 2010).

Chamaecytisus supinus subsp. *aggregatus* (Syn.: *Cytisus capitatus* Scop. subsp. *aggregatus* (Schur) Jáv.). It occurs in Hungary (mainly in Transdanubia and mosaic-like pattern in the North Hungarian Mountains) and in southern Slovakia (Pifkó 2005, 2014, Pifkó and Shevera 2011). Other records need to be reviewed (Pifkó D. in litt.). It has very old record from Romania (Pifkó 2007, 2009c).

Chamaecytisus supinus subsp. *pannonicus*: Distribution: eastern part of Tolna and Somogy counties (southeastern part of Transdanubia in Hungary). Records in Zala county are probably erroneous (Pifkó 2005, 2009b). Habitat: loess steppes and their fragments.

Chamaecytisus virescens: This species has alien records outside the Pannonicum in the Czech Republic (R. Řepka in Kaplan *et al.* 2019).

Cirsium boujartii subsp. *boujartii*: Taxonomic status has long been misinterpreted. The subsp. *boujartii* is supposed to be a Pannonian endemic (Csiky *et al.* 2005) or subendemic, which is still known only from Hungary and South Romania. It is extinct in Serbia (Butorac 1999). Most of the Romanian data needs confirmation.

Cochlearia macrorrhiza: This endemic species is only known from lowland fens in a small area in the Vienna Basin. At least since the 1980s this species is highly endangered and on the verge of extinction. During winter 2009/2010 the last known specimen in-situ perished. Luckily, the plants were cultivated from seed collected from the site in 2001 and 2002. Reestablishment is in progress (Mrkvicka *et al.* 2015, Mrkvicka in litt.).

Colchicum arenarium: According to Persson (2007), *C. fominii* is a synonym of *C. arenarium*. Eastern European botanists don't accept this and treat them as a separate species (Gnatiuk 2008, Gnatiuk *et al.* 2018, Oganezova 2019). These two taxa are discussed in detail and the differences are shown: morphology of leaf and flower, ecology. The two species are also geographically separated. *C. arenarium* lives in the central Pannonian lowlands (Tatár 1939, Soó 1973, Sturc 1997, Melečková and Hajdú 2012, Bartha *et al.* 2021, Ranko Perić in litt.) and two small patches in western Oltenia (Dihoru and Negrean 2009). *C. fominii* lives from eastern Romania to the Odessa region of Ukraine (Gnatiuk *et al.* 2018).

Crataegus nigra: Endemic to the middle section of the Danube floodplain. It has become extinct from many of its former known localities. Many of its previous records are incorrect, presumably referring to the *C. pentagyna*. Recent distribution: from Csepel Island (Budapest) to the Iron Gate Gorge (Bartha and Kerényi 2012).

Dianthus collinus subsp. *collinus*: Many data are erroneous because it is often confused with other taxa. Most often with *D. collinus* subsp. *glabriusculus* (sometimes considered a different species – e.g. Fedoronchuk and Didukh 2002). The exact distribution is therefore not entirely clear. It occurs in Hungary (from the eastern part of Transdanubian Mountains through the North Hungarian Mountains and the surrounding areas) (Bartha *et al.* 2021), southern Slovakia (Kmeťová 2012), Lower Austria (Fischer *et al.* 2008) along the border of Slovakia, Romania (few localities in the Pannonicum; Ciocarlan 2009), Ukraine (one locality in the Carpathians; Fedoronchuk and Didukh 2002), Croatia (Papuk; Nikolić 2005+) and Slovenia (Jogan 2001). No records in Serbia (Ranko Perić in litt.). Subendemic.

Dianthus diutinus: It is a "flagship" plant of the sand steppes of Duna–Tisza köze (Hu). It has disappeared from most of its former localities in Hungary (only 8 out of 38 remain) (Vidéki and Máté 2011). In Serbia it was found in six localities in the sandy steppes in north Vojvodina and along the Danube in northeastern Serbia. It is now extinct from five localities, while only one subpopulation survives in the Kladovska Sands in northeast Serbia (Király and Stevanović 2011). The population in Hungary is currently stable due to protection activities (Gál 2011).

Dianthus plumarius subsp. *neilreichii*: Only one locality is known (near Vienna: Mödling). As a typical "Thermelinie" species, it is referred to herein as subendemic.

Dianthus pontederæ: Transient forms can be observed with the *D. carthusianorum* and the *D. giganteiformis*, where the ranges of these species are in contact. This zone is relatively narrow in the west, but quite wide in the south and east. It is difficult to distinguish individuals showing transient morphological characters. Records from peripheral areas should be revised, especially in the southern and eastern part of the distribution area. The Romanian records outside the Carpathians need to be confirmed, presumably erroneous.

Dianthus praecox subsp. *pseudopraecox*: Taxonomic status is uncertain. Treated here as a subspecies of *D. praecox* (Kmeřová 2012). It is a rare taxon, occurring only in the Gömör–Torna Karst (Slovenský kras, Aggteleki-karszt), and sporadically also in the Bükk Mts (Kmeřová 2012, Bartha *et al.* 2021).

Dianthus serotinus subsp. *kitaibelianus* (Syn.: *D. plumarius* L. subsp. *regis-stephani* (Rapaics) Baksay, *D. serotinus* Waldst. et Kit. subsp. *regis-stephani* (Rapaics) Baksay). Nomenclature reference: Barina *et al.* (2020). This taxon occurs in rocky habitats along the Transdanubian Mountains. For a distribution map see Farkas *et al.* (2014).

Dianthus serotinus subsp. *serotinus*: Many old records (e.g. Poland, Romania and Ukraine outside Pannonicum) are erroneous. Transylvanian data needs to be confirmed. This taxon lives on sandy lowlands and sometimes on sandy foothills (Soó 1970, Király 2009).

Epipactis bugacensis subsp. *bugacensis*: This orchid was described in the sandy region of Central Hungary, near the village of Bugac (Robatsch 1990). For a while, this species was considered endemic the Duna–Tisza köze (Central Hungary). Later, the plants initially identified as *E. rhodanensis* (France, Switzerland, Germany, and Austria) were also classified in this species as a separate subspecies: *E. bugacensis* subsp. *rhodanensis* (Gévaudan et Robatsch) Wucherpffenig (Wucherpffenig 2003). However, the type subspecies is confined to endemic (Vidéki and Molnár 2011).

Epipactis moravica: This species was described from southeastern Moravia in the Czech Republic (Batoušek 2004). According to the latest knowledge, its main distribution area is in Pannonicum and only a few data are known from the neighbouring Western Carpathians. It occurs in the Czech Republic (SE Moravia) (Wild *et al.* 2019), Hungary (Transdanubia) (Molnár V. and Csábi 2021) and western Slovakia (there are only a few records) (Daniel Dítě in litt.).

Epipactis nordeniorum: This orchid was described in 1991 (Austria: SE Styria) (Robatsch 1991). It occurs on the SE edge of Austria (Griebl 2013), Slovenia (Hertel 2015), N Croatia (Nikolić 2005–), Hungary (Molnár V. and Csábi 2021), and recently discovered in W Romania (Cornia *et al.* 2018). Records for Slovakia need to be confirmed (Martin Kolník in litt.).

Epipactis tallosii: This orchid was discovered and described in 1997, based on a single Hungarian population at the SW foot of the Bakony Mts, near the village of Nyírad. According to the latest knowledge, it occurs in the Czech Republic (Moravia) (Wild *et al.* 2019), in southwestern Slovakia (Vlčko *et al.* 2003, Daniel Dítě in litt.), in Hungary (almost the whole country) (Molnár V. and Csábi 2021) and in adjacent part of Croatia, Serbia, Romania and Ukraine (Cornia *et al.* 2018, Süveges *et al.* 2019). It grows in various types of forests: gallery forests (poplar gallery forests and riparian mixed forests of oak, elm and ash), birch bogs, furthermore in oak and oak-hornbeam forests both in the lowlands and in more hilly regions, as well as in poplar plantations. Additionally, a population of *E. tallosii*, originally described as a subspecies, was found in N Italy (*E. tallosii* subsp. *zaupolensis* Barbaro et Kreutz). In 2010, the latter taxon was treated as a separate species, named *E. zaupolensis* (Barbaro et Kreutz) Bongiorno, De Vivo et Fori. Nonetheless, according to Batoušek and Kežlínek this taxon as well as *E. autumnalis* D. Doro are conspecifics with *E. tallosii* (Süveges *et al.* 2019).

Epipactis voethii: This *Epipactis* was described in 1993 (Austria: Bisamberg) (Robatsch 1993). In Austria it occurs only in the vicinity of Vienna and near the Hungarian border in Rechnitz (Günsen Gebirge) (Griebl 2013, Falkner 2016). It is found sporadically in the Czech Republic (Moravia) (Wild *et al.* 2019), Slovakia (Vlčko *et al.* 2003, Daniel Dítě in litt.) and NE Slovenia (Dolinar 2010). Its main distribution area is in Hungary, especially in Transdanubia, but it also occurs in the North Hungarian Mountains too (Molnár V. and Csábi 2021).

Ferula sadleriana Ledeb.: According to the current data, *Ferula sadleriana* occurs recently in seven natural localities (and there is a planted one in Pilis Mts. – Somlyay 2007): two of them located in the Transdanubian Mountains (60% of the population), four in the North Hungarian Mountains (11%) and one in the Apuseni Carpathians (29%) outside the Pannonicum (Lendvay and Kalapos 2009, 2014).

Festuca pseudovaginata: Recently described taxon (Penksza 2003). Known only a few sites in sandy habitats of Central Hungary (Penksza *et al.* 2020) and one locality in Romania (Stănişlau) (Šmarda 2006) but the latter is questionable according to Penksza (2019).

Festuca stricta subsp. *caruuntina*: It was described in 1977 as a species (Tracey 1977) and was accepted by Flora Europaea (Markgraf-Dannenberg 1980). Recent literature also mostly mentions it as a species (Clayton *et al.* 2006, Šmarda 2008, theplantlist 2021), but Englmaier (2008) notes that its taxonomic status is uncertain. Foggi and Müller (2009) treat it as a subspecies. We follow the opinion of Pils (1984), who says that transient specimens often occur and that the taxon is not so differentiated by morphology that it is classified into a separate species. It is endemic in the Hainburg hills (North-eastern Austria).

Festuca stricta subsp. *stricta*: This taxon was mistreated for a long time. The name *F. stricta* has been used for plants with similar morphology due to similar (extremely xerotherm) habitat conditions, which developed independently (polyphyletic) of each other (Pils 1984). Therefore, plants designated as “*F. stricta*” in various parts of Central Europe are now classified as a separate species or subspecies (Pils 1984, Clayton *et al.* 2006, Englmaier 2008). Distribution: Northeastern Austria (Thermenlinie, Leitha hills) (Pils 1984, Englmaier 2008).

Festuca vaginata: Older literature indicates this taxon from many areas of Central and Eastern Europe (e.g. Soó 1973). Pawlus (1985) recorded several localities of *F. vaginata* in Poland and described a new variety, *F. vaginata* var. *aristata*. Recent studies have shown that this taxon is equivalent to *F. psammophila* (Šmarda *et al.* 2007). *Festuca dominii* (SE Poland, SE Moravia, SW Slovakia, NE Austria) was considered a subspecies of *F. vaginata*, but more recent studies have shown it is more likely a subspecies of *F. psammophila*. The plants are reported to occur along the Dnieper River in Ukraine and on coastal sands of the Black Sea in Romania and Bulgaria formerly treated at various ranks within *F. vaginata* and *F. pallens* were later assigned to *F. polesica* and *F. beckeri* (Dihoru 1987, Šmarda *et al.* 2007). The records of *F. vaginata* from rocky sites in Slovakia and Croatia seems to be doubtful. According to recent research, *F. vaginata* is a plant of the Pannonian sandy lowlands (Šmarda *et al.* 2007). It is found: Hungary, S and SE Slovakia, NE Croatia (Drava plain), Serbia (Subotica Sands, Deliblato Sands, Golubac), NW and SW Romania (few localities) and NE Bulgaria (one locality: Archar, near the Danube) (Sturc 1997, Nikolić 2005+, Šmarda *et al.* 2007, Peev and Vladimirov 2011, Bartha *et al.* 2021).

Festuca vojtkoi: Recently described taxon (Penksza 2005). Only a few localities are known in silicate rocks and rocky grasslands in the Bükk and Mátra Mts.

Festuca wagneri (Syn.: *Festuca sulcata* (Hack) Beck var. *wagneri* Degen, Thaisz, Flatt, *Festuca* × *wagneri* Degen, Thaisz, Flatt). It occurs on the sand steppes of the Duna–Tisza köze (Hu) (Bartha *et al.* 2021), Subotica(?) and Deliblato Sands (Srb) (Tatár 1939, Sturc 1997) and one locality in southeastern Slovakia (Šmarda 2008).

Galatella cana (Syn.: *Aster canus* Waldst. et Kit., *Aster punctatus* subsp. *canus* (Waldst. et Kit.) Soó, *Aster sedifolius* L. subsp. *canus* (Waldst. et Kit.) Merxm.). Czech data is very old: Měnin (South Moravia) 1825, it has since become extinct (Daníhelka 2008). The records in Bulgaria are unconfirmed (Assyov *et al.* 2012, Petrova and Vladimirov 2018). Recent data shows it has one locality in Slovakia (Eliáš *et al.* 2020) and two in Austria (Fischer *et al.* 2008). Most of the Romanian data needs confirmation. Most of the extant populations are found in Hungary (Bartha *et al.* 2021) and Serbia (Vojvodina) (Đakić *et al.* 2012).

Galium abaujense: Subsp. *polonicum* is currently treated as a separate species: *Galium polonicum* Blocki. The main distribution area of *Galium abaujense* is in the Matricum (Börzsöny, Mátra, Bükk, Úpponyi-hg., Cserehát, Zempléni-hg., Gömör–Torna Karst) but has one locality in the Eupannonicum (Kaszonyi-hegy) (Bartha *et al.* 2021), a few localities on the edge of the Pannonicum (Romania: Szilágy-ság) (Negrean *et al.* 2015) and in the Carpathicum (Zemplínské vrchy, Nízke Beskydy in Slovakia) (Klíment 1999).

Gypsophila fastigiata subsp. *arenaria* (Syn.: *Gypsophila arenaria* Waldst. et Kit.). Taxonomic status is unclear. It is usually treated as a subspecies (e.g. Soó 1970, Hejny and Slavík 1990, Simon 2000, Fisher *et al.* 2008, Eliáš and Dítě 2012), but sometimes considered to be a variant of *Gypsophila fastigiata* L. (Akeroyd 1993) or other times it is considered a separate species (e.g. Jávorka and Soó 1951, Soó and Kárpáti 1968, Király 2009). Treat here as a subspecies. Romanian records of *Gypsophila arenaria*

var. *leioclados* Borbás refer to the species *Gypsophila collina* Ser. It is probably extinct from Austria (H. Niklfeld in litt.).

Hieracium kossuthianum (Syn.: *Hieracium danubiale* Borbás non Pollich.). Poorly known taxon. The author studied this *Hieracium* on the basis of Borbás's detailed description (Borbás 1879), examination of herbarium specimens, field observations and in cultivation (research in progress). Until the last decade, we only had records of this species about more than half a century ago. Older Hungarian floraguides (Jávorka and Soó 1951, Soó and Kárpáti 1968, Simon 1992, 2000) are less suitable for identifying this taxon. The New Hungarian herbal (Király 2009) is more usable, but there are also some misinterpretations (e.g. the number of leaves on the stem). The "subsp. *pseudodanubiale*" (Soó 1970) in Szentendre (Visegrád Mts) probably belongs to another taxon. *H. kossuthianum* is a stable hybridogenous species. Its putative parents are *H. schmidtii* and *H. lachenalii* (Soó 1970). To the best of our recent knowledge, the exact distribution is: Budai-hg. and Pilis. The records from Mátra, Vértes and Balaton-felvidék are erroneous.

Iris arenaria: Taxonomic classification is unclear. It was a subspecies of *Iris humilis* until it was reclassified as a separate species (e.g.: Barker and Govaerts 2021), but many sources still state it is either a synonym (Alexeeva 2018) or subspecies of *Iris humilis*. Populations in Ukraine and southwestern part of Russia are isolated as a separate species: *Iris pineticola* (Zhygalova and Olshanskyi 2016). In this case, *Iris arenaria* occurs only in the Carpathian Basin. More than 95% of the population is located in Hungary and only smaller fragments are found in the surrounding countries (Soó 1973, Stevanović 1999, Fischer *et al.* 2008, Dihoru and Negrean 2009, Melečková and Hajdú 2012, Aradi and Bérces 2014, Wild *et al.* 2019).

Knautia kitaibelii subsp. *tomentella*: According to current data this taxon occurs recently only at three localities: two of them in the Budai-hg. (Piliscsaba, Pilisszentiván) and one in Pilis (Pilisszentkereszt) (Bóhm and Facsar 2000). It is a widely accepted taxon, but further studies of the whole species are needed (see Király and Király 2006).

Limonium gmelinii subsp. *hungaricum* (Syn.: *Limonium hungaricum* (Klokov)). Its taxonomic status is unclear. The genus *Limonium* is characterised by variable morphological characters, but it is impossible to define characters that contribute to clear distinction of taxa. *L. hungaricum* was described by Klokov (1957). Soó (1963) changed the taxonomic status to a subspecies. According to Soó (1970) the *L. gmelinii* subsp. *gmelinii* inhabits Siberia and Central Asia, *L. g.* subsp. *hypanicum* can be found in Ukraine and Romania and *L. g.* subsp. *hungaricum* is endemic in Pannonicum. Pignatti (1972) classified all into one species, but remarked that *L. hypanicum* and *L. hungaricum* "have been separated from the remaining populations of *L. gmelinii* (...) but their status requires further examination". Recent Hungarian and Slovakian Floras are treated as subspecies (Simon 1992, 2000, Pifkó 2009d, Michalková 2016), but international database (Domina 2011) and the latest literature (Koutroumpa *et al.* 2018) have raised the rank of the species. Here we "traditionally" refer to it as the subspecies of *L. gmelinii*. Recent molecular phylogeny studies suggest quite different relationships in this taxon. According to Koutroumpa *et al.* (2018), its closest relatives live mainly in the southern part of the Balkan peninsula and western Turkey, not in Eastern Europe. It is worth mentioning that subsp. *hypanicum* considered before the closest relative of subsp. *hungaricum* was reclassified by Moysienko (2008) and moved from *L. gmelinii* to as a subspecies of *L. tomentellum* (Boiss.) O. Kuntze (Eastern European species). Distribution: *Limonium* group are morphologically highly variable in appearance, and it is often difficult to find usable distinguishing marks among the taxa, thus their exact range is often unknown. To the best of our recent knowledge, the subsp. *hungaricum* is native in the central and eastern part of Pannonicum from southern Slovakia to Serbia and the western margin of Romania, but has one locality in the Transylvanian Basin (Ro). However, populations in southern Serbia and Macedonia (outside Pannonicum) morphologically differ from those in Vojvodina (Pannonicum) (Vestek *et al.* 2016), probably belonging to this taxon. It spreads by salting the roads in Hungary, but it has also appeared in Austria (Hohla *et al.* 2015) and in the Czech Republic (Kocián *et al.* 2016). Introduced in the Lake Fertő (Hu) (Király and Takács 2020).

Linum dolomiticum: It was discovered and described by Vince Borbás (Borbás 1897). Several similar-looking *Linum* species are known in the Balkans. The most morphologically similar to *Linum elegans* from Dalmatia to Greece. According to Ockendon and Walters (1968) *L. elegans* perhaps conspecific with *L. dolomiticum*, but according to Degen (1903) (who knew the flora of the Balkans well) "a

L. elegans-tól rövid, a toknál rövidebb, vagy avval egyenlő hosszúságú, de korántsem kétszer akkora csészesallangjai miatt biztosan megkülönböztethető." ("It is obviously distinguishable from *L. elegans* by its short sepals, which are shorter or equal to the length of the fruit and not twice as long."). In his dissertation on the *Linum flavum* group, Sándor Jávorka also treated as a different species (Jávorka 1910).

Linum hirsutum subsp. *glabrescens* (Syn.: *Linum nudifolium* Borbás, *Linum pannonicum* A. Kern.). This subspecies of *Linum hirsutum* adapted to dry sandy steppe habitats. Occurs in the Duna–Tisza köze Region, Deliblato Sands and sporadically on sandy foothills (Tatár 1939).

Lotus borbasii (Syn.: *Lotus corniculatus* subsp. *slovacus* Žertová, *Lotus degenii* Ujhelyi). This diploid taxon is endemic in the northwestern part of Pannonicum (Chrtková 1988b, Fischer *et al.* 2008, Király 2009, Bartha *et al.* 2021). Much of its data relate to the hairy form of *Lotus corniculatus*, so its exact distribution needs to be checked. Serbian data (Boža and Vasić 1986) is doubtful (Ranko Perić in litt.).

Melampyrum nemorosum L. subsp. *debreceniense* (Rapaics) Soó: Taxonomic status is unclear. Hungarian authors (with the exception of Király 2009 who does not mention it), the Flora Europaea and recent Romanian literature treat it as a subspecies (e.g. Jávorka and Soó 1951, Soó 1968, Soó and Kárpáti 1968, Soó and Webb 1972, Simon 1992, 2000, Oprea 2005, Ciocarlan 2000, 2009), but international databases treat it as a synonym (Euro+Med) or status "unresolved" (theplantlist). Sometimes the bracts of the subsp. *nemorosum* are also green or whitish similar to subsp. *debreceniense*, but the latter have narrow (narrowly lanceolate or linear) leaves and only slightly toothed and narrow bracts. Habitat: sandy oak forests and their margins. Distribution: Nyírség (Northeastern Pannonicum), roughly between Debrecen (Hu) and Carei (Ro).

Noccaea jankae (Syn.: *Thlaspi jankae* A. Kern., *Thlaspi pannonicum* Dvořáková). Based on molecular phylogenetic studies, *N. pannonica* is synonymous with *N. jankae* (Laczkó *et al.* 2018). Records of *N. jankae* from Romania (Dihoru and Negrean 2009, Sárbu *et al.* 2013, and others) probably refer to a Carpathian-Balkan species *Noccaea kovatsii* (Heuff.) F. K. Mey due to a misinterpretation of the name. (*T. jankae* Borbás non A. Kern. and *T. jankae* Velen. non A. Kern. also belong to synonyms of *N. kovatsii* (Ančev 2007, Kliment *et al.* 2016). It is endemic in the northern part of the Pannonicum. Its main distribution area is the North Hungarian Mountains and surrounding areas of the Hungarian Great Plain (Schmotzer and Takács 2014).

Odontarrhena tortuosa subsp. *heterophylla* (Syn.: *Alyssum tortuosum* Waldst. et Kit. ex Willd. subsp. *heterophyllum* Nyár.). It is difficult to distinguish. Many of its old records are presumably incorrect, therefore the exact distribution is unknown (Barina and Király 2009, Stanislav Španiel in litt.). Confirmed records are currently known of the Gömör–Torna Karst and the foot of the Vihorlat Mts (Španiel *et al.* 2018).

Onosma pseudoarenaria Schur subsp. *tuberculata*: The Austrian population (Dürnstein) treats it as a different subspecies: *Onosma pseudoarenaria* subsp. *austriaca* (Beck) Dostál (Kolarčík *et al.* 2018). Old data needs to be revised.

Paeonia officinalis subsp. *banatica*: Some authors treat it as a species (Sang *et al.* 1997, Kevey *et al.* 2005, Lendvai 2006). Occurrence in Italy (Trieste Karst) (Passalacqua and Bernardo 2004) is doubtful (Bilz 2011). In Serbia, it is extinct in the Fruška Gora hills (it has a very old record that has never been confirmed), and there is only a small population in the Deliblato Sands (Stevanović 1999, Bilz 2011). It is found at three sites in Romania (Oprea 2005, Dihoru and Negrean 2009), but almost 90% of extant populations are found in Hungary (Kelet-Mecsek) (Kevey *et al.* 2005).

Poa pannonica subsp. *scabra*: Some authors treat it as a species (Penksza 2009). The main distribution area is in the Pannonicum (Tatár 1939, Soó 1973) but it occurs in the adjacent Carpathians in Slovakia (Slovenské stredohore, Zvolenská kotlina, Spišské kotliny, Stredné Pohornádie) (Kliment 1999). Ukrainian data (Vynohradiv, at the edge of the Pannonicum) are very old (1935) and it was not reported any more (Kliment *et al.* 2016). Recent Romanian data from the Iron Gate Gorge (between Vărciorova and Gura Văii – Oprea 2005) needs confirmation, old Romanian records are erroneous.

Puccinellia peisonis: It is a widely accepted species, but separation is problematic from *P. distans* (this includes *P. limosa*, which is sometimes treated as a synonym) (Király and Takács 2020).

Pulsatilla flavescens (Hazsl.) Borb. (Syn.: *Pulsatilla hungarica* Soó, *Pulsatilla pratensis* (L.) Mill. subsp. *flavescens* (Hazsl.) Holub., *Pulsatilla pratensis* (L.) Mill. subsp. *hungarica* Soó).

Pulsatilla zimmermanni: It was considered an intermediate taxon between *P. (pratensis* subsp.) *nigricans* and *P. montana* (Rummelspacher 1965), but recent morphological studies do not confirm this (Takács *et al.* 2018). Distribution: Bükk Mts, Putnoki-dombság, Cserehát (?), Zemplén Mts and Bodroghöz/Medzibodrožie (Mártonfiová 2004, Malatinszky 2007, Bartha *et al.* 2021).

Rosa kmetiana: It was described from Banská Štiavnica (Selmechánya) (Sk) (Borbás 1881). There has been no record since then. It is a poorly known taxon, presumably of hybrid origin. This is also supported by molecular genetic studies. Its putative parent species are the *R. marginata* and the *R. gallica* (Deák 2010). It is currently known only from the Pannonicum: Pilis–Visegrád Mts, Börzsöny Mts, Gömör–Torna Karst in Hungary and one locality in Romania (Cehăluț /Magyarcsaholy) (Kerényi-Nagy 2012b, Virók *et al.* 2016).

Sedum urvillei subsp. *hillebrandtii* (Syn.: *Sedum sartorianum* Boiss. subsp. *hillebrandtii* (Fenzl) D. A. Webb, *Sedum hillebrandtii* Fenzl, *Sedum asperifolium* Borbás). Taxonomic status is unclear. Plants classified as *Sedum urvillei* have very variable appearance (they were originally described as different species), but represent an almost continuous series of forms. Of all described segregates, the geographically isolated *S. hillebrandtii* seems to be most distinct. Most of the taxa live on rocky slopes and stony meadows, it is the only one that lives on sand (Eggl 2005). Romanian data needs to be confirmed. There are many misidentified or unverified data outside Eupannonicum.

Sempervivum matricum: Its main distribution area is in the Pannonicum and has only two known localities in the Praecarpaticum (Letz 2009).

Seseli leucospermum: Preglacial relict of the Transdanubian Mts (Soó 1966).

Sesleria hungarica: It was considered endemic to the Bükk Mts and nearby Uppony Hills (Soó 1973, Vojtkó 2001, Somlyay 2009, Kliment *et al.* 2016), although some Slovak populations were also assigned to this taxon (as *S. heufleriana* subsp. *hungarica* (Ujhelyi): Deyl 1980, Dostál 1989). Recent data indicate that the species is most likely an autopolyploid derivative of *S. heufleriana* with similar morphology and ecology (Mered'a *et al.* 2019). Some authors do not recognise these two ploidy levels (cytotypes) as separate taxa and merge *S. hungarica* into *S. heufleriana*. Others recognise them either as subspecies (e.g. Deyl 1980, Soó 1980, Dostál 1989, Kliment *et al.* 2016) or species (e.g. Soó 1973; Kliment 1999; Somlyay 2009, Budzákóvá *et al.* 2014). Mered'a *et al.* (2019) consider the two taxa (cytotypes) as separate species for the following reasons: (1) *S. hungarica* (octoploid) seems to be reproductively isolated from *S. heufleriana* (tetraploid) because no hexaploid individuals of hybrid origin have been reported yet, even in areas where these two cytotypes come into contact; (2) the putative autopolyploidisation (thus the origin of *S. hungarica*) could not be a recent event, because octoploids underwent a serious downsizing of the monoploid genome size. In this study the authors found that octoploid plants from Slavec (Slovakia) (Gömör–Torna Karst), formerly identified as *S. heufleriana*, actually represent *S. hungarica*, which is the first reliable record of this species from Slovakia (Mered'a *et al.* 2019). This species is therefore endemic to the Matricum.

Sesleria sadleriana (Syn. *S. budensis* (Borbás) Asch. et Graebn.). For a long time, it was considered endemic to Hungary (Jávorka 1924–1925, Tatár 1939). Later, its putative distribution area was extended to adjacent Austria, Italy, Slovakia and the former Yugoslavia (Ujhelyi 1959, Soó 1973, Lysák *et al.* 1997). Subsequently, however, all records from SE Austria, Slovenia and NE Italy have been interpreted as misidentifications (Fischer *et al.* 2008, Di Pietro 2017) and the occurrence of *S. sadleriana* in Slovakia is still controversial (Mered'a *et al.* 2019). None of the studied populations from Slovenia or Croatia could be assigned to *S. sadleriana* or the hybrid *S. kalnikensis* × *S. sadleriana* (Hodálová *et al.* 2020). According to the new studies *S. sadleriana* occurs only in the Pannonicum: in the Pilis and Budai-hegység (Mts) (Hungary) and the Hainburger Berge hills (NE Austria) (Mered'a *et al.* 2019).

Sorbus: In this work we follow the classical systematisation of genus *Sorbus*. More recently, other divisions have been presented in the literature (Sennikov and Kurtto 2017), but due to our limited knowledge and lack of detailed (e.g. genetic) research, grouping is often based on assumptions. Moreover, the new systematisation changed the names of several taxa, making them difficult to interpret. Other authors (Christenhusz *et al.* 2018) classify all *Sorbus* species in the genus *Pyrus*. In the nomenclature we follow Rivers *et al.* (2019).

Sorbus bakonyensis: According to Somlyay and Sennikov (2014) *S. majeri* is a synonym name for *S. bakonyensis*, while the species formerly treated *S. bakonyensis* has been described as *S. udvardyana*.

The distribution area of the *S. bakonyensis* is restricted to the vicinity of Márkó village in the eastern Bakony Mts.

Sorbus buekkensis: Further research is needed to confirm the taxonomic status and exact distribution range.

Sorbus decipientiformis: In the Keszthely Mts (locus classicus), there are several undescribed morphotypes of subgenus *Tormaria* consisting of a single individual, some of which are similar to *S. decipientiformis*, but cannot be identified with it. According to our recent knowledge apart from the type specimens deposited in BP neither further herbarium materials nor living representatives of the species are known (Németh Cs. pers. comm.).

Sorbus hazslinszkyana: Mikoláš *et al.* (2017) reported only from Slovakia, but there are few records on the Hungarian side of the Gömör–Torna Karst (Virók *et al.* 2016) and one locality in the Bükk Mts (Somlyay and Sulyok 2018).

Sorbus javorkana Somlyay, Sennikov *et* Vojtkó: This and *Sorbus javorkae* (Soó) Kárpáti are different taxa!

Sorbus latissima: Sennikov and Kurtto (2017) synonymised it with the rather similar *S. andreanszkyana* (without any morphological or molecular investigations), but the type specimens of *S. latissima* show some morphological differences (Németh Cs. pers. comm.). It is exclusively represented by the type herbarium specimens, recent occurrences are not known (Németh *et al.* 2016). Rivers *et al.* (2018) accepted as a separate species.

Sorbus udvardyana: The taxon previously treated as *S. bakonyensis* (Somlyay and Sennikov 2014). It occurs mainly in the western part of the Balaton Uplands and the southwestern part of the Bakony Mts, as well as in the eastern part of the Keszthely Mts.

Sorbus pseudosemiincisa: Apart from the type specimens all the remaining herbarium specimens deposited in BP and BPU and formerly identified as *S. pseudosemiincisa* proved to belong to other taxa (Németh 2015b). According to our recent knowledge it was known from a single locality where it was not found despite intensive search (Németh 2015b, Riezing N. ined.).

Sorbus pyricarpa: This species was described by Németh (2015b). Despite the obvious morphological differences, Sennikov and Kurtto (2017) synonymised it with *S. pseudosemiincisa*, but later Rivers *et al.* (2019) accepted it as a separate species.

Sorbus thaiszii: Mikoláš *et al.* (2017) reported it only from Slovakia, but there are some records on the Hungarian side of the Gömör–Torna Karst (Virók *et al.* 2016) and it was reported from the Bükk Mts as well (Vojtkó 2001). Further research is needed to reveal its real distribution area.

Sorbus vajdae: There is only very few verified information available on its full distribution. So far, it has reliably only been reported from the Zemplén Mts (but not only from the locus classicus site as Beech and Rivers (2017a) says – Mészáros G. in litt.). Other reports of *S. vajdae* from the Bükk Mts and the Gömör–Torna Karst (Németh 2009, Virók *et al.* 2016) need further verification.

Sorbus zolyomii: Poorly known taxon reported from the Bükk, Zemplén and Mátra Mts and the Gömör–Torna Karst (Kárpáti 1960), as well as even the northeastern part of the Transdanubian Mountains (Kurtto *et al.* 2018). All records including those of the Slovakian part of the Gömör–Torna Karst (Slovak Karst) and the Muran Plateau (Májovský 1992) require confirmation.

Suaeda pannonica: This taxon was misidentified for a long time (Mile and Walter 2003). Old data for *S. pannonica* (without herbarium background) cannot be identified because *S. pannonica* and *S. prostrata* have been mixed by both authors and monographs. Confirmed occurrences are known only from Austria (Seewinkel) (Fischer *et al.* 2008), Hungary (Bartha *et al.* 2021) and Serbia (Dítě *et al.* 2015).

Thalictrum minus subsp. *majus* (Syn.: *T. pseudominus* (Borbás) Jáv., *T. minus* subsp. *pseudominus* (Borbás) Soó). Its taxonomic status was unresolved for a long time. It used to be considered a species (Jávorka 1924–25, Jávorka and Soó 1951, Király 2009) or a subspecies (e.g. Tatár 1939, Soó 1966, 1966b, Osvačilová 1982, Simon 1992, 2000). The taxonomic status of “*pseudominus*” and “*majus*” was uncertain, ones lumped other times split them (Soó 1966, 1966b). This work follows Hand (2001). Area: mainly in the dolomit lowhills around the Little Plain. The northeastern edge of the Alps (Thermenlinie) (Austria) (Fischer *et al.* 2008), Transdanubian Mountains (Hungary) (Bartha *et al.* 2021), on the southern slope of some mountains in western and central Slovakia (Osvačilová 1982) and one locality in Slovenia (Hand 2001).

Tragopogon floccosus: Exact distribution range and taxonomy needs to be revised. The populations of eastern Romania and Ukraine (formerly a subspecies) are isolated as separate species: *Tragopogon borysthenicus* Artemczuk (Greuter and Raab-Straube 2006, Roskov *et al.* 2018, theplantlist 2021). Previous data from the Baltics refer to another species: *Tragopogon heterospermus* Schweigg (Greuter and Raab-Straube 2006, Roskov *et al.* 2018, theplantlist 2021). The plants mentioned under this name from Ukraine belong to other taxa (Mosyakin and Fedoronchuk 1999), but it occurs in Bessarabia according to Ionita (2012). Most of its data in Romania needs to be confirmed. According to current data, *T. floccosus* occurs in Hungary (mainly in the Duna–Tisza köze region) (Bartha *et al.* 2021), Serbia (Josifović 1975, Sturc 1997), and Romania (review required) (Oprea 2005, Ciocârlan 2009). It was recently discovered on the northwestern edge of Bulgaria near the Danube in Pannonian inland dunes type vegetation (Vladimirov and Tsoneva 2006).

Vincetoxicum pannonicum: Phylogenetic research showed that *V. pannonicum* is an allopolyploid hybrid species, and its parent taxa are *V. fuscatum* (Balkan species) and *V. adriaticum* (Adriatic species) (Horváth *et al.* 2020). Known only from a few localities in the southern part of the Budai-hegység (Mts) and on the eastern edge of the Villányi-hegység (Mts) (Bérces *et al.* 2020).

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Appendix 4
Presumably endemic or subendemic *Ranunculus* taxa

Taxa	Occurrence	Distribution (phytogeographical)	Reference
<i>Ranunculus balatonensis</i> Soó	Hu	Ba	Soó 1965
<i>Ranunculus bekesensis</i> Soó	Hu	Eu1	Soó 1964, 1965
<i>Ranunculus beregensis</i> Soó	Hu, Sk	Eu1	Soó 1964, 1965, Marhold and Hindák 1998
<i>Ranunculus bernatskyanus</i> Soó	Srb	Eu	Soó 1965
<i>Ranunculus borbasianus</i> Soó	Hu, Ro?	Eu1, Ba, Pn	Soó 1964, 1965
<i>Ranunculus budaianus</i> Soó	Hu, Sk, Ro?	Eu, Ma	Soó 1964, 1965, Marhold and Hindák 1998
<i>Ranunculus budensis</i> Soó	Hu, Sk, Ua	Ba, Ma	Soó 1964, 1965, Mosyakin and Fedoronchuk 1999
<i>Ranunculus buekensis</i> Soó	Hu	Ma	Soó 1964, 1965
<i>Ranunculus carpinetorum</i> Hörandl et Gutermann	Au	Pn	Fischer 2008
<i>Ranunculus elegantifrons</i> Hörandl et Gutermann	Au	Eu2	Fischer 2008
<i>Ranunculus gayeri</i> Soó	Au, Hu, Sk	Eu	Soó 1964, 1965, Marhold and Hindák 1998, Fischer 2008
<i>Ranunculus heuffelii</i> Soó	Ro	Eu1	Soó 1964, 1965
<i>Ranunculus hortobagyanus</i> Soó	Hu	Eu	Soó 1965
<i>Ranunculus jaczorkae</i> Soó	Hu, Ro?	Ba	Soó 1964, 1965
<i>Ranunculus karpátianus</i> Soó	Hu	Ba	Soó 1964, 1965
<i>Ranunculus kitaibelii</i> Soó	Hu, Sk, Ua?, Ro?	Eu, Ba	Soó 1964, 1965, Marhold and Hindák 1998
<i>Ranunculus laticrenatus</i> Hörandl et Gutermann	Au, Cz	Eu2	Fischer 2008, Wild <i>et al.</i> 2019
<i>Ranunculus megalocaulis</i> Hörandl et Gutermann	Au	Eu2	Fischer 2008
<i>Ranunculus mendosus</i> Hörandl et Gutermann	Au	Eu2	Fischer 2008
<i>Ranunculus panmonicus</i> Soó	Au, Cz, Hu, Sk, Ua, Ro?	Eu, Ba, Ma, Pn	Soó 1964, 1965, Marhold and Hindák 1998, Fischer 2008

Taxa	Occurrence	Distribution (phytogeographical)	Reference
<i>Ranunculus pentadactylus</i> Hörandl et Gutermann	Au	Eu2	Fischer 2008
<i>Ranunculus pilisiensis</i> Soó	Au, Hu, Sk, Ua	Eu, Ba	Soó 1965, Marhold and Hindák 1998, Fischer 2008
<i>Ranunculus pseudoacris</i> Tzvelev	Hu, Sk	Eu, Ba, Pn	Soó 1964, 1965
<i>Ranunculus pseudoincisifolius</i> Soó	Hu, Sk	Ma, Ba	Soó 1964, 1965, Marhold and Hindák 1998
<i>Ranunculus stauibii</i> Soó	Au, Hu	Ma, Ba, Eu2	Soó 1964, 1965, Fischer 2008
<i>Ranunculus subpannonicus</i> Soó	Hu, Sk	Ma, Ba	Soó 1964, 1965, Marhold and Hindák 1998
<i>Ranunculus transibiscensis</i> Soó	Hu	Eu1	Soó 1964, 1965
<i>Ranunculus trautmannii</i> Soó	Hu	Ba: Vác	Soó 1964, 1965
<i>Ranunculus vindobonensis</i> Hörandl et Gutermann	Au	Th	Fischer 2008

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