

Alien plants of the Podilski Tovtry National Nature Park (Ukraine)

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Abstract: The results of a study on alien plants of the Podilsky Tovtry National Nature Park are presented. The alien fraction of the Park's flora comprises 335 species of vascular plants. Its taxonomic structure, ecological and life forms and species primary geographical origin are analyzed.

Key words: alien plants, Podilsky Tovtry National Nature Park, Ukraine

1. Introduction

By the end of the 20th century, invasions of alien plants were widely recognized as one of the major threats to biodiversity on the global scale. At present, in Ukraine, alien species are found in almost all types of semi-natural and natural plant communities and ecosystems and the process of their expansion and naturalization progresses rapidly (Protopopova 1991; Protopopova *et al.* 2002).

The plant cover of different areas belonging to the natural-preservation fund of Ukraine is prone to the invasion of alien plant species. The spread of some highly invasive taxa is a serious threat to the Ukrainian most valuable and unique flora and vegetation, like e.g. the Podilski Tovtry National Nature Park.

Since long time, the flora and vegetation of the Podilski Tovtry National Nature Park has been subject to studies by various researchers, such as: Besser (1822), Andrzejowski (1823), Belke (1859), Rogovich (1868), Schmalhausen (1886), Paczosky (1910), Krutskevych (1937, 1961), Makowiecki (1939), Kuznetsova (1953), Moroz (1978), Kukovytsa (1973), Zaverukha (1985), Lyubinska *et al.* (1999), Kovtun (2002) and Kagalo *et al.* (2003, 2004). However, the alien fraction of the flora has not been investigated so far.

The aim of the present study was to analyze the alien plants of the Podilski Tovtry National Nature Park.

2. Study area

The Podilski Tovtry National Nature Park (PTNNP) is situated in the Khmelnytsky Region, including Kamyanets-Podilsky, Gorodok, and Chemeryvtsi Districts (Fig. 1). The area of the Park is 261 316 ha. The Park was founded in 1996 with the purpose of conservation, restoration and rational use of natural landscapes of Podillya and its unique historical-cultural complexes. These landscapes and complexes have aesthetic, scientific, recreational, medicinal and environmental protection value. The territory of the PTNNP is the core area of the Ukrainian National and European ECONET. It comprises the Dniester river corridor and two wetland areas of international importance: the Lower Smotrych River and Bakotska bay. The Park represents unique nature of the Ukrainian Pre-Dniester region - the southwest border of the Central Europe. It is distinguished by the presence of many rare, relict and endemic plant and animal species which are included in the Red List of IUCN (2010a), European Red List (2010b) and Bern Convention (1979).

The following functional zones can be distinguished on the territory of the Park: nature reserve zone, zone of controlled and stationary recreation and economical zone. Today, natural vegetation occupies no more than 17% of the Park's area, while agricultural landscape – 56.6 % and urban landscape – 15.1%.



Fig. 1. Location of the Podilski Tovtry National Nature Park in Ukraine

3. Material and methods

Our investigations were based on the original materials obtained during field studies in the different regions of the PTNNP in 1996–2008, as well as on herbarium materials and literature data. They involved an analysis of the Park's alien flora taxonomic structure (according to the Tolmachev classification 1974), ecological forms (after Didukh 2000) and life forms (after Raunkiaer 1934), species geographic origin, time of immigration, degree of naturalization and distribution and frequency of occurrence (common, rare, sporadic) (Procudin et al. 1987).

The herbarium collections of the PTNNP, Kamyanets-Podilsky Botanical Garden, Ivan Ogiyenko Kamyanets-Podilsky National University, M. G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine (KW) and Institute of Ecology of Carpathians, NAS of Ukraine (LWKS) were used in the study.

The terminology and classification of alien species is after Kornaś (1968), modified by Protopopova (1991). The following categories were used: colonophytes (epocophytes limited to one or several stable populations in the area, with little or no trend toward further expansion), ephemerophytes (non-naturalized, occasional immigrants, casuals or waifs), epocophytes (naturalized in human-made and disturbed habitats) and agriophytes (naturalized in natural and seminatural habi-

tats). Phytosociological relevés were made according to the Braun-Blanquet method (1964), modified by Solomakha (2008). The nomenclature of vascular plants follows the Checklist of vascular plants of Ukraine (Mosyakin & Fedoronchuk 1999).

4. Results and discussion

The flora of the PTNNP is represented by 1543 species of vascular plants (Lyubinska *et al.* 1999). According to our data, the total list of the alien fraction of the Park's flora comprises 335 species of vascular plants from 226 genera and 68 families (Appendix) or 21.7% of the total number of vascular species. As compared with other reserves and parks of Ukraine, it is characterized by higher number of alien taxa. This results from a large share of agricultural fields in the Park's territory in the past and numerous settlements and recreation grounds at present.

Depending on the time of immigration of alien species to the Park, they can be divided into archaeophytes (125 spp.) and kenophytes (210).

The 10 leading families of the Park's alien flora (according to Tolmachev classification) are: Asteraceae (46 spp.), Brassicaceae (38), Poaceae (26), Fabaceae (20), Lamiaceae (19), Rosaceae (15), Chenopodiaceae (14), Boraginaceae, Apiaceae (10), Solanaceae (8), Scrophulariaceae (7); other families comprise from one

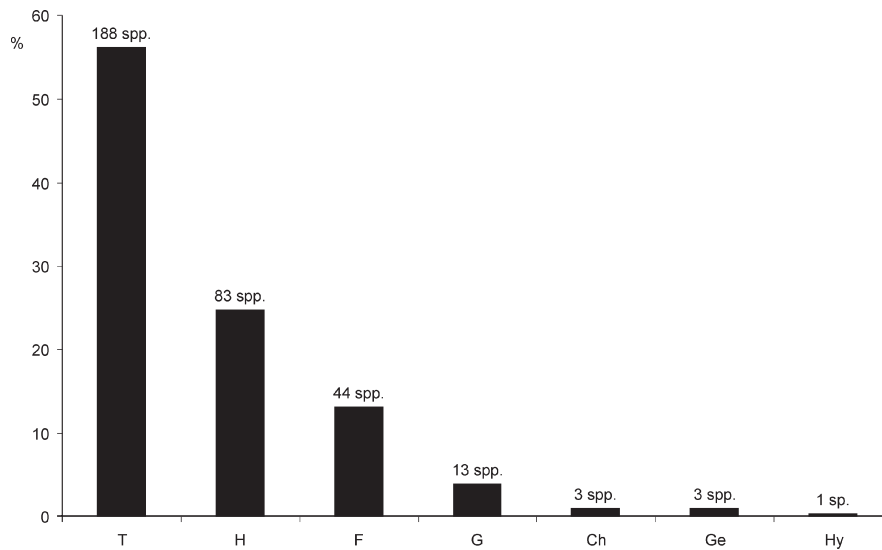


Fig. 2. Participation of different life forms in the alien flora of the Podilsky Tovtry National Nature Park
 Explanations: T – terophytes, H – hemicytrophites, F – phanerophytes, G – geophytes, Ch – chamaephytes, Ge – geophytes, Hy – hydrophytes

to five species (Appendix). The spectrum of these families is very similar to the spectrum of alien fraction of the whole Ukrainian flora (Protopopova 1991). Among leading genera are: *Amaranthus* and *Chenopodium* (8 species each), *Euphorbia* (6), *Papaver*, *Centaurea*, *Bromus* and *Geranium* (4 each); other genera consist of one to three species.

The dominant life form (according to the Raunkiaer’s classification) are terophytes which are represented by 188 species. The spectrum of life forms represented in the alien flora of the Park is similar to other regional alien floras and the whole Ukrainian flora (Fig. 2).

It was established that among ecological forms prevail submesophytes (xeromesophytes) (198 spp.), followed by mesophytes (84) and subxerophytes (mesoxerophytes) (40). Other groups (hydrophytes and subhy-

drophytes) include from one to four species (Fig. 3).

In the mode of species origin predominate Mediterranean taxa (77 spp.), followed by North American (50), Asian (49), Mediterranean-Iran-Turanian (43) and European (34); other regions are poorly represented (Appendix).

In terms of the degree of species naturalisation prevail epocophytes (187 spp.), followed by ephemero-phytes (55), colonophytes (48), ergasiophytes (27) and agriophytes (18) (Fig. 4). The stable component of this group (epocophytes, agriophytes, and colonophytes) is represented by 252 species and the unstable one (ergasiophytes and ephemetrophytes) by 82 species.

The most important group in the Park’s flora are agriophytes. Among them prevail terophytes, meso-phytes and species of North American origin. They occupy different types of anthropogenic, semi-natural

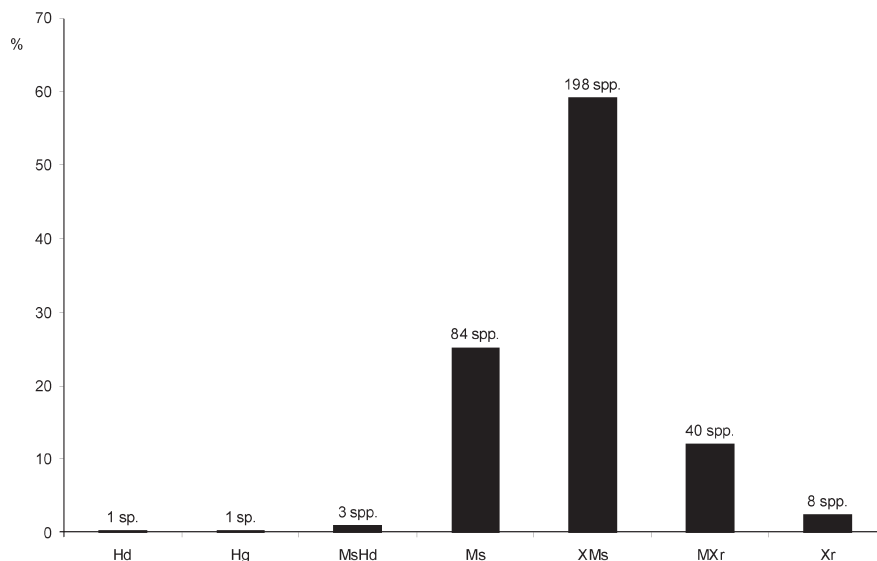


Fig. 3. Participation of different ecological forms in the alien fraction of the Podilsky Tovtry National Nature Park
 Explanations: Hd – hydrophytes, Hg – hygrophytes, MsHd – subhydrophytes, Ms – mesophytes, XM – xeromesophytes, MXr – mesoxerophytes, Xr – xerophytes

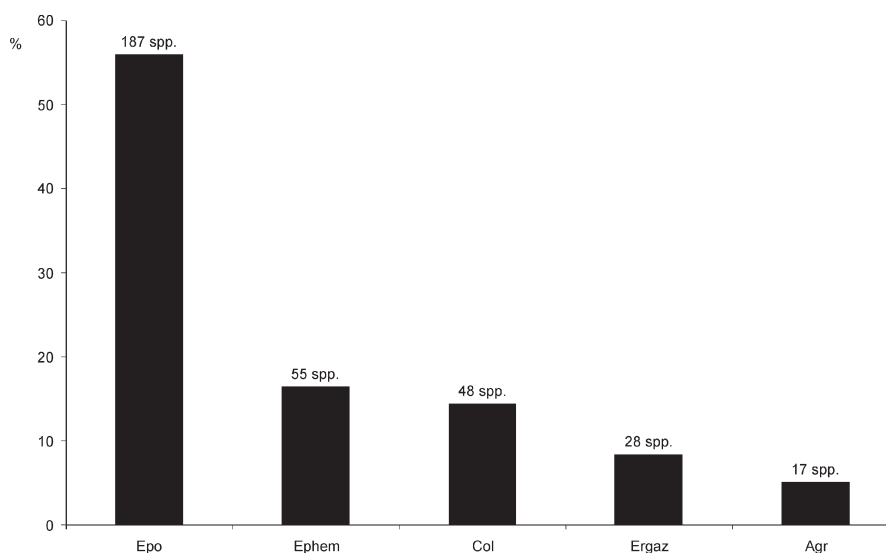


Fig. 4. Participation of the different sub-fractions of non-native plants according to the degree of their naturalization in the alien flora of the Podilsky Tovtry National Nature Park

Explanations: Epo – epocophytes, Ephem – ephemeroxytes, Col – colonophytes, Ergaz – ergazyphytes, Agr – agriophytes

and natural habitats (Table 1), but majority of them grow in meadow-steppe ecotypes.

At present, the process of anthropogenic changes of flora and vegetation in natural habitats progresses rapidly. Many alien species are not only a stable component of these habitats, but also form communities in which they dominate. Particularly, a great influence on the structure of plant communities exert invasive species. Some invasive plants in the Park's territory, e.g. *Acer negundo* and *Phalacrologa annuum*, have been recorded in different types of habitats, such as: anthropogenic ecotypes – ass. *Chelidonio-Acerion negundi* L. et A. Jsh. 1989 (*Robinetea*) and *Urtico-Aegopodietum*

(R. Tx. 1963) Oberd. 1964 (*Galio-Urticetea*), semi-natural – *Poo nemoralis-Salicetum albae* Shevcyk et V. Solomakha 1996 and *Myosotido palustris-Salicetum albae* Shevcyk et V. Solomakha 1996 (*Salicetea purpureae*), and natural – *Salvia nemorosae-Elytrigietum intermediae* Tyschenko 1996 and *Trifolia-Melampyretum nemorosi* Passarye 1967 (*Trifolio-Geranietea*). Moreover, *Phalacrologa annuum* has been noted also in anthropogenic ecotypes – in ass. *Impatiens parviflorae-Robinetum* Sofron 1962 (*Robinetea*) and *Lamio-Cornietum maculatae* Oberd. 1957 (*Artemisieteae vulgaris*), semminatural – *Myosotido palustris-Salicetum albae* Shevcyk et V. Solomakha 1996 (*Salicetea purpu-*

Table 1. Participation of agriophytes in the various types of habitats of the Podilsky Tovtry National Nature Park

Species	Type of habitat		
	Anthropogenic	Semi-natural	Natural
<i>Acorus calamus</i>	.	Sp – bank river habitats	.
<i>Elodea canadensis</i>	C – river	C – river	.
<i>Juncus tenuis</i>	.	Sp – forest road	.
<i>Acer negundo</i>	Sp – various type: incl. ruderal, parks, forest, bank river habitats, limestone carrier	Sp – degradation meadow-steppe, limestone slope	R – meadow steppe
<i>Bidens frondosa</i>	Sp – waste, road, ruderal places	Sp – bank river habitats	.
<i>Conyza canadensis</i>	C – ruderal places, man-made forest	C – degradation steppe, meadow	Sp – steppe, meadow
<i>Phalacrologa annuum</i>	C – ruderal places, waste, parks, flowerbeds, derelict fields	C – meadow, steppe, forest edge	Sp – meadow, steppe
<i>Impatiens parviflora</i>	C – ruderal places, parks	Sp – forest	.
<i>Salix fragilis</i>	C – bank artificial rates	Sp – bank river habitats	.
<i>Brionia alba</i>	R – parks, man-made forest	R – ruderalised forest glades	.
<i>Echinocystis lobata</i>	Sp – ruderal places	C – bank river habitats, shrubby	.
<i>Thladiantha dubia</i>	R – ruderal places	R – meadow-steppe	.
<i>Lathyrus sativus</i>	Sp – ruderal places	.	.
<i>Trifolium hybridum</i>	.	Sp – degradation meadow-steppe	.
<i>Vicia angustifolia</i>	.	Sp – degradation meadow-steppe	R – meadow-steppe
<i>Vicia villosa</i>	R – derelict	Sp – meadow-steppe, steppe	R – meadow
<i>Oenothera biennis</i>	C – limestone slope, ruderal places, derelict fields, flowers-bed	Sp – limestone	.

Explanations: C – common, R – rare, Sp – sporadic

reae) and *Eringio plani-Bromopsietum inermis* Shevchyk et V. Solomakha 1996 (*Molinio-Arrhenatheretea*), and natural ones: *Trifolia-Melampyretum nemorosi* Passarye 1967 (*Trifolio-Geranietea*) and *Trifolietum montani* Mirk. et al. 1983 (*Molinio-Arrhenatheretea*).

Some alien plants pose threat to the Park's native plant communities. They comprise, e.g. *Ailanthus altissima* L. – the species primarily found in seminatural habitats but also in natural ones. This tree produces abundant root sprouts that can develop into extensive thickets and displace native vegetation. The limestone communities with *Allium flavescens*, *A. montanum*, *A. podolicum*, *Aurinia saxatilis*, *Astragalus albidus*, *A. monepessulanus*, *Jurinea calcarea*, *Pulsatilla nigricans*, *Poa versicolor* and *Stipa pennata* have been destroyed (Didukh & Korotchenko 2003). The *Phalacrologium annuum* very intensively colonizes neglected agricultural land and roadsides, but it is observed also in limestone communities, meadows, steppe and at forest edges. During 1970-1990, foresters planted *Pinus sylvestris* in the steppe and limestone areas. This species has a high level of seed production and gives rise to numerous progeny now. It changes life conditions for native plants, e.g. for populations of *Pulsatilla grandis*, *P. nigricans* (Lyubinska 2009), *Adonis vernalis*, etc.

The territory of PTNNP consists of 3 administrative districts: Kamyaneets Podilsky, Chemirivtzi and Gorodok, characterized in the Table 2. Numerous automobile and railway roads, industrial and agricultural activities as well as the Dnister river and its seven tributaries contribute to the spread of alien plants in this region.

Migration of alien plants along roads and rivers results in formation of such plant communities as: *Impatiens glanduliferae-Convulvuletum sepium* (Moor

in the Dnister reservoir promote formation of *Xanthio albini-Chenopodietum rubri* Lohmeyer et Walther in Lohm. 1950 associations along the Park's rivers of. The syntaxa of *Agropyretea repentis* Oberd., Th.Mill. et Gurs in Oberd. et al. 1967, *Artemisietea vulgaris* Lohm., Prsg. et R. Tx. in R. Tx 1950, *Chenopodietea* Br.-Bl. 1951 em. Lohm., J. et R. Tx. 1961 ex Matusz. 1962 make evident the ongoing changes to vegetation and the process of its synanthropisation (Solomakha 2008; Lyubinska 2008).

5. Conclusions

The natural ecosystems of the Podilski Tovtry National Nature Park are almost completely lost due to significant anthropogenic transformation. The main factors limiting restoration of native plant communities are cattle pasturing and, clearing of forests, steppe and meadow lands.

For the effective preservation of the whole biodiversity of plant cover, including rare species and components of unique plant communities, it is necessary to ensure urgent protection of habitats (biocenoses). The management plan for the Park includes such activities as: regulation of a hydrological regime, restoration of native biotopes, reintroduction of locally extinct plant species and establishment of a monitoring system. Monitoring of the Park's unique vegetation and flora was introduced for the first time in 2002 and involves controlling the condition of rare plants and plant communities by the Park's scientists. The monitoring data from the Park have been an important tool for the evaluation of forest management practices.

The high proportion of archaeophytes in the alien flora of the Podilski Tovtry National Nature Park re-

Table 2. Characteristics of the administrative regions of the Podilski Tovtry National Nature Park

Administrative district	Area in %	Inhabitants in %	% of alien species*
Kamyaneets Podilsky	58.8	76.8	100.0
Chemirivtzi	35.6	21.4	86.1
Gorodok	5.6	1.8	59.3

Explanation: * – the total number of the Park's alien vascular plant species = 335

1958) Hilbig 1972, *Polygonetum cuspidati* (Moor 1958) Th. Müller et Görs 1969 ex Görs 1974, *Sicyo-Echinocystietum lobatae* Fijałkowski 1978 ex Brzeg et M. Wojterska 2001, *Aegopodio-Reynoutrietum sachalinensis* Brzeg in Brzeg et M. Wojterska 2001, *Impatiens parviflorae* Brzeg 1989 ex Borysiak 1994, *Stachyo sylvaticae-Impatiens noli-tangere* Pass. 1967 ex Hilbig 1972, *Geranio phaei-Urticetum dioicae* Hadač et al. 1969, *Galio-Urticetea* Pass. 1967 em. Kopecky 1969 and *Urtico-Sambucetea* Doing 1962 em. Pass. 1968 in forests. Furthermore, fluctuations in water level

reflects the intense anthropogenic changes of plant cover in the past, while the high number of kenophytes proves that man-made environmental change proceeds rapidly at present. The presence of a large and permanent group of alien species in the Park indicates their stable status in the area.

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Appendix. Checklist of the alien fraction of flora of the Podilski Tovtry National Nature Park

Families and species	1	2	3	4
Pinaceae				
<i>Picea abies</i> (L.) H. Karst.	Kn	Eur	Ephem	Ms
<i>Pinus nigra</i> J. F. Arnold	Kn	MedIT	Ephem	XMs
<i>Pinus pallasiana</i> D. Don	Kn	Med	Ephem	XMs
<i>Pinus sylvestris</i> L.	Kn	anth	Ephem	XMs
Araceae				
<i>Acorus calamus</i> L.	Ar	As	Agr	Ms
Hemerocallidaceae				
<i>Hemerocallis lilioasphodelus</i> L.	Kn	EAs	Ergaz	Ms
Hydrocharitaceae				
<i>Elodea canadensis</i> Michx.	Kn	NAm	Agr	Hd
Juncaceae				
<i>Juncus tenuis</i> Willd.	Kn	NAm	Agr	Ms
Liliaceae				
<i>Gagea pratensis</i> (Pers.) Dumort.	Ar	Med	Epo	Ms
<i>Gagea villosa</i> (M. Bieb.) Duby	Ar	Med	Epo	Ms
Hyacinthaceae				
<i>Ornithogalum umbellatum</i> L.	Kn	CEur	Col	Ms
Amaryllidaceae				
<i>Narcissus poëticus</i> L.	Kn	SEur	Ephem	Ms
Poaceae				
<i>Anisantha tectorum</i> (L.) Nevski	Ar	MedET	Epo	XMs
<i>Apera spica-venti</i> (L.) P. Beav.	Ar	un	Epo	XMs
<i>Avena culatiformis</i> (Malzev) Malzev	Ar	IT	Epo	Ms
<i>Avena fatua</i> L.	Ar	MedIT	Ephem	Ms
<i>Avena sativa</i> L.	Kn	SEur	Epo	XMs
<i>Bromus arvensis</i> L.	Ar	Med	Epo	XMs
<i>Bromus commutatus</i> Schrad.	Kn	CEur	Epo	XMs
<i>Bromus secalinus</i> L.	Ar	EM	Epo	Ms
<i>Bromus squarrosus</i> L.	Kn	MedIT	Epo	XMs
<i>Digitaria ischaemum</i> (Schreb.) Muehl.	Ar	CEur	Epo	XMs
<i>Digitaria sanguinalis</i> (L.) Scop.	Ar	S-EAs	Epo	MXr
<i>Echinochloa crusgalli</i> (L.) P. Beauv.	Ar	As	Epo	Ms
<i>Eragrostis minor</i> Host	Kn	SEur	Epo	XMs
<i>Hordeum bulbosum</i> L.	Kn	Med	Ephem	MXr
<i>Hordeum murinum</i> L.	Ar	MedIT	Col	MXr
<i>Lolium remotum</i> Schrenk	Ar	anth	Epo	Ms
<i>Panicum capillare</i> L.	Kn	NAm	Ephem	MXr
<i>Phalaris canariensis</i> L.	Kn	Med	Ephem	XMs
<i>Sclerochloa dura</i> (L.) P. Beauv.	Ar	MedIT	Epo	XMs
<i>Secale cereale</i> L.	Ar	AsMin	Col	XMs
<i>Setaria glauca</i> (L.) P. Beauv.	Ar	IMal	Epo	Ms
<i>Setaria verticillata</i> (L.) P. Beauv.	Ar	IMal & Sud	Epo	XMs
<i>Setaria viridis</i> (L.) P. Beauv.	Ar	MedIT	Epo	XMs
<i>Tragus racemosus</i> (L.) All.	Kn	Med	Epo	MXr
<i>Triticum aestivum</i> L.	Kn	As	Col	XMs
<i>Zea mays</i> L.	Kn	C & SAm	Ephem	XMs
Aceraceae				
<i>Acer negundo</i> L.	Kn	NAm	Agr	Ms
Amaranthaceae				
<i>Amaranthus albus</i> L.	Kn	NAm	Epo	XMs
<i>Amaranthus blitoides</i> S. Watson	Kn	NAm	Epo	MXr
<i>Amaranthus blitum</i> L.	Kn	SEur	Epo	MXr
<i>Amaranthus caudatus</i> L.	Kn	SAm	Ergaz	XMs
<i>Amaranthus hybridus</i> L.	Kn	un	Ephem	XMs
<i>Amaranthus paniculatus</i> L.	Kn	CAM	Ergaz	XMs
<i>Amaranthus powellii</i> S. Watson	Kn	NAm	Epo	XMs
<i>Amaranthus retroflexus</i> L.	Kn	NAm	Epo	XMs
Anacardiaceae				
<i>Rhus typhina</i> L.	Kn	NAm	Col	XMs
Apiaceae				
<i>Aethusa cynapium</i> L.	Ar	CEur	Epo	MXr
<i>Anetum graveolens</i> L.	Kn	MedIT	Ephem	Ms
<i>Bifora radians</i> M. Bieb.	Ar	Med	Epo	MXr
<i>Bupleurum rotundifolium</i> L.	Ar	MedIT	Epo	XMs
<i>Caucalis platycarpus</i> L.	Ar	MedIT	Epo	XMs
<i>Conium maculatum</i> L.	Ar	MedIT	Epo	XMs

<i>Coriandrum sativum</i> L.	Kn	Med	Ephem	XMs
<i>Heracleum mantegazzianum</i> Sommier & Levier	Kn	CAs	Ephem	Ms
<i>Pastinaca sativa</i> L.	Kn	MedIT	Col	Ms
<i>Torilis arvensis</i> (Huds.) Link	Kn	Med	Epo	XMs
Asclepiadaceae				
<i>Asclepias syriaca</i> L.	Kn	NAm	Epo	XMs
Asteraceae				
<i>Ambrosia artemisiifolia</i> L.	Kn	NAm	Epo	XMs
<i>Anthemis arvensis</i> L.	Ar	Med	Epo	XMs
<i>Anthemis cotula</i> L.	Ar	Med	Epo	XMs
<i>Artemisia abrotanum</i> L.	Kn	MedEAs	Col	XMs
<i>Artemisia absinthium</i> L.	Ar	IT	Epo	Ms
<i>Artemisia annua</i> L.	Kn	SAs	Epo	XMs
<i>Aster nova-angliae</i> L.	Kn	NAm	Col	Ms
<i>Aster novi-belgii</i> L.	Kn	NAm	Col	Ms
<i>Aster salignus</i> Willd	Kn	NAm	Ephem	XMs
<i>Bidens frondosa</i> L.	Kn	NAm	Agr	Ms
<i>Calendula officinalis</i> L.	Kn	Med	Ergaz	Ms
<i>Carduus acantoides</i> L.	Ar	Med	Epo	XMs
<i>Carduus nutans</i> L.	Ar	Med	Epo	MXr
<i>Centaurea cyanus</i> L.	Ar	Med & SEur	Epo	XMs
<i>Centaurea declinata</i> M. Bieb.	Kn	Crim & Ca	Col	Xr
<i>Centaurea diffusa</i> Lam.	Kn	MedI	Epo	Xr
<i>Centaurea iberica</i> Trev. & Spreng.	Kn	SEur & SWA	Ephem	MXr
<i>Cichorium intybus</i> L.	Ar	MedIT	Epo	XMs
<i>Conyza canadensis</i> (L.) Cronq.	Kn	NAm	Agr	Ms
<i>Cosmos bipinnatus</i> Cav.	Kn	CAm	Ergaz	XMs
<i>Crepis rheadifolia</i> Bieb.	Kn	PanPont	Epo	XMs
<i>Galinsoga parviflora</i> Cav.	Kn	SAM	Epo	Ms
<i>Galinsoga urticifolia</i> (Kunth) Benth.	Kn	C or SAM	Col	Ms
<i>Helianthus annuus</i> L.	Kn	NAm	Ergaz	XMs
<i>Helianthus tuberosus</i> L.	Kn	NAm	Col	Ms
<i>Heliopsis scabra</i> Dunal	Kn	NAm	Epo	XMs
<i>Iva xanthiifolia</i> Nutt.	Kn	NAm	Epo	XMs
<i>Lactuca serriola</i> L.	Ar	MedIT	Epo	XMs
<i>Lepidotheca suveolens</i> (Pursh) Nutt.	Kn	NAm	Epo	Ms
<i>Matricaria recutita</i> L.	Ar	EEur	Epo	XMs
<i>Onopordum acanthium</i> L.	Ar	Med	Epo	MXr
<i>Phalacroloma annuum</i> (L.) Dumort.	Kn	NAm	Agr	Ms
<i>Phalacroloma septentrionale</i> (Fernald & Wiegand) Tzvelev	Kn	NAm	Epo	Ms
<i>Pyrethrum parthenium</i> (L.) Smith	Kn	EEur	Col	MXr
<i>Rudbeckia laciniata</i> L.	Kn	NAm	Ergaz	XMs
<i>Senecio viscosus</i> L.	Kn	CEur	Epo	XMs
<i>Senecio vulgaris</i> L.	Ar	As	Epo	XMs
<i>Silphium perfoliatum</i> L.	Kn	NAm	Col	XMs
<i>Solidago canadensis</i> L.	Kn	NAm	Epo	Ms
<i>Sonchus arvensis</i> L.	Ar	Med	Epo	Ms
<i>Sonchus asper</i> (L.) Hill.	Ar	Med	Epo	Ms
<i>Sonchus oleraceus</i> L.	Ar	Med	Epo	Ms
<i>Tripleurospermum inodorum</i> (L.) Sch. Bip.	Ar	As	Epo	Ms
<i>Xanthium albinum</i> (Widder) H. Scholz	Kn	CEur	Epo	XMs
<i>Xanthium spinosum</i> L.	Kn	SAM	Ephem	XMs
<i>Xanthium strumarium</i> L.	Ar	IT	Epo	XMs
Balsaminaceae				
<i>Impatiens glandulifera</i> Royle.	Kn	S-EAs	Epo	Hg
<i>Impatiens parviflora</i> DC.	Kn	CAs	Agr	Ms
Boraginaceae				
<i>Anchusa officinalis</i> L.	Ar	Med	Epo	MXr
<i>Argusia sibirica</i> (L.) Dandy	Kn	As	Ephem	XMs
<i>Borago officinalis</i> L.	Kn	Med	Ergaz	XMs
<i>Buglossoides arvensis</i> (L.) I. M. Johnst.	Ar	MedIT	Epo	XMs
<i>Cynoglossum officinale</i> L.	Ar	Med	Epo	XMs
<i>Lappula patula</i> (Lehm.) Menyh.	Kn	As	Epo	MXr
<i>Lappula squarrosa</i> (Retz.) Dumort.	Ar	MedIT	Epo	XMs
<i>Lycopsis arvensis</i> L.	Ar	Med	Epo	XMs
<i>Myosotis arvensis</i> (L.) Hill	Ar	MedIT	Epo	Ms
<i>Nonea lutea</i> (Desr.) DC	Kn	un	Col	Xr
Brassicaceae				
<i>Arabidopsis thaliana</i> (L.) Heynh.	Kn	MedIT	Epo	XMs
<i>Armoracia rusticana</i> P. Gaertn., B. Mey. & ScKenb.	Kn	IT	Col	Ms

<i>Brassica campestris</i> L.	Ar	CAs	Epo	MXr
<i>Brassica juncea</i> (L.) Czern.	Kn	S-EAs	Col	XMs
<i>Brassica nigra</i> (L.) W.D.J. Koch	Kn	Med	Ephem	Ms
<i>Bunias orientalis</i> L.	Kn	EM	Epo	XMs
<i>Camelina microcarpa</i> Andr.	Ar	MedET	Epo	XMs
<i>Camelina sativa</i> (L.) Crantz	Ar	anth	Epo	XMs
<i>Camelina sylvestris</i> Wallr.	Kn	un	Epo	MXr
<i>Capsella bursa-pastoris</i> (L.) Medik.	Ar	un	Epo	XMs
<i>Cardaria draba</i> (L.) Desv.	Kn	SEur & As	Epo	XMs
<i>Diplotaxis muralis</i> (L.) DC.	Kn	SEur	Epo	XMs
<i>Descurania sophia</i> (L.) Webb & Prantl	Ar	IT	Epo	XMs
<i>Eruca vesicaria</i> (L.) Cav.	Kn	MedAsMin	Epo	MXr
<i>Erysimum cheiranthoides</i> L.	Ar	un	Epo	XMs
<i>Erysimum repandum</i> L.	Ar	IT	Epo	MXr
<i>Euclidium syriacum</i> (L.) R.Br.	Kn	AsMin	Epo	MXr
<i>Hesperis matronalis</i> L.	Kn	Med	Ergaz	Ms
<i>Hesperis pycnotricha</i> Borbas et Degen	Kn	As	Ergaz	Ms
<i>Isatis tinctoria</i> L.	Kn	IT	Epo	MXr
<i>Lepidium campestre</i> (L.) R. Br.	Ar	Med	Epo	XMs
<i>Lepidium densiflorum</i> Schrad.	Kn	NAm	Epo	XMs
<i>Lepidium perfoliatum</i> L.	Kn	MedIT	Epo	XMs
<i>Lepidium ruderales</i> L.	Ar	IT	Epo	XMs
<i>Lunaria annua</i> L.	Kn	SEur	Ephem	Ms
<i>Mattihola annua</i> (L) Sweet	Kn	SEur	Ergaz	XMs
<i>Neslia paniculata</i> (L.) Desv.	Ar	anth	Epo	XMs
<i>Raphanus raphanistrum</i> L.	Ar	Med	Epo	XMs
<i>Raphanus sativus</i> L.	Kn	Med	Ergaz	XMs
<i>Rapistrum perenne</i> (L.) All.	Kn	Med	Epo	XMs
<i>Sinapis alba</i> L.	Ar	MedIT	Epo	Ms
<i>Sinapis arvensis</i> L.	Ar	Med-Atl Eur	Epo	XMs
<i>Sisymbrium altissimum</i> L.	Kn	SEur & As	Epo	Ms
<i>Sisymbrium loeselii</i> L.	Kn	Med & As	Epo	MXr
<i>Sisymbrium officinale</i> (L.) Scop.	Ar	Med	Epo	XMs
<i>Thlaspi alliaceum</i> L.	Kn	SEur	Ephem	Ms
<i>Thlaspi arvense</i> L.	Ar	IT	Epo	Ms
<i>Thlaspi perfoliatum</i> L.	Kn	Med	Epo	XMs
Caesalpinaceae				
<i>Gleditsia triacanthos</i> L.	Kn	NAm	Ephem	XMs
<i>Gymnocladus dioica</i> (L.) K. Koch	Kn	NAm	Ephem	XMs
Cannabaceae				
<i>Cannabis sativa</i> L.	Kn	SAs	Epo	XMs
Caprifoliaceae				
<i>Lonicera caprifolium</i> L.	Kn	Med	Ephem	MXr
<i>Lonicera tatarica</i> L.	Kn	Sib	Ephem	MXr
Caryophyllaceae				
<i>Agrostemma githago</i> L.	Ar	anth	Ephem	XMs
<i>Dianthus barbatus</i> L.	Kn	CEur	Ephem	Ms
<i>Petrorhagia saxifraga</i> (L.) Link	Kn	Med	Col	Xr
<i>Saponaria officinalis</i> L.	Kn	Med	Epo	Ms
<i>Scleranthus annuus</i> L.	Ar	Med	Epo	Xr
<i>Spergula arvensis</i> (L.) Clairv.	Ar	Med	Epo	XMs
<i>Vaccaria hispanica</i> (Mill.) Rauschert	Ar	SWAs	Epo	XMs
Celastraceae				
<i>Euonymus latifolia</i> (L.) Mill.	Kn	EurMed	Ephem	XMs
Chenopodiaceae				
<i>Atriplex hortensis</i> L.	Kn	As	Epo	Ms
<i>Atriplex prostrata</i> Boucher & DC	Ar	MedIT	Epo	Ms
<i>Atriplex sagittata</i> Borkh.	Ar	IT	Epo	MXr
<i>Atriplex tatarica</i> L.	Kn	MedIT	Epo	XMs
<i>Chenopodium bonus-henricus</i> L.	Ar	CEur	Epo	Ms
<i>Chenopodium botrys</i> L.	Kn	MedIT	Epo	Ms
<i>Chenopodium ficifolium</i> Smith	Ar	Med	Epo	Ms
<i>Chenopodium hybridum</i> L.	Ar	Med	Epo	XMs
<i>Chenopodium opulifolium</i> Schrad. & Koch. et Ziz.	Ar	Med	Epo	XMs
<i>Chenopodium polyspermum</i> L.	Ar	un	Epo	XMs
<i>Chenopodium rubrum</i> L.	Kn	CEur	Epo	Ms
<i>Chenopodium suecicum</i> J. Murr	Kn	As	Epo	Ms
<i>Kochia densiflora</i> (Moq.) Aell.	Kn	MedIT	Epo	MXr
<i>Kochia scoparia</i> (L.) Schrad.	Kn	IT	Epo	MXr

Convolvulaceae

Ipomea purpurea (L.) Roth Kn SAs Ergaz XMs

Crassulaceae

Phedimus spurium (M. Bieb.) Hart Kn Ca Ephem XMs

Sedum album L. Kn un Col XMs

Cucurbitaceae

Brionia alba L. Kn MedIT Agr XMs

Brionia dioica Jacq. Kn MedIT Col XMs

Citrullus lanatus (Thunb.) Matsum. & Nakai Kn Afric Ergaz Ms

Cucurbita maxima Duch. Kn Ergaz Ms

Echinocystis lobata (Michx.) Torr. & A. Kn NAm Agr Ms

Thladiantha dubia Bunge Kn NAm Agr Ms

Cuscutaceae

Cuscuta campestris Yunck Kn NAm Epo Ms

Cuscuta cesatiana Bertol. Kn IT Epo Ms

Cuscuta tinei Insenga Kn NAm Epo XMs

Elaeagnaceae

Elaeagnus angustifolia L. Kn Med Epo MXr

Euphorbiaceae

Euphorbia exigua L. Ar Med Epo XMs

Euphorbia falcata L. Ar MedIT Epo XMs

Euphorbia helioscopia L. Ar Med Col XMs

Euphorbia peplus L. Ar Med Epo Ms

Euphorbia plathyphylos L. Ar Med Epo Ms

Euphorbia salicifolia Host. Ar CEur Epo XMs

Fabaceae

Amorpha fruticosa L. Kn NAm Epo Ms

Bituminaria nituminosua (L.) Stirton Kn Med Col XMs

Caragana arborescens Lam. Kn un Epo MXr

Colutea arborescens L. Kn Med Ergaz XMs

Lathyrus sativus L. Kn Med Agr XMs

Lathyrus tuberosus L. Ar IT Epo XMs

Lupinus polyphyllus Lindl. Kn NAm Col XMs

Medicago sativa L. Kn As Epo XMs

Onobrychis vicifolia Scop. Kn SEur Ephem XMs

Robinia hispida L. Kn NAm Ergaz XMs

Robinia pseudoacacia L. Kn NAm Epo XMs

Robinia viscosa Vent. Kn NAm Col XMs

Trifolium hybridum L. Kn Med Agr Ms

Trifolium incarnatum L. Kn Med Ephem XMs

Trifolium sativum (Schreb.) Crome Kn Eur Col Ms

Trigonella caerulea (L.) Ser. Kn Med Col XMs

Vicia angustifolia Reichard Kn MedIT Agr XMs

Vicia hirsuta (L.) S. F. Grey Ar WMed Epo XMs

Vicia tetrasperma (L.) Schreb. Ar Med Epo XMs

Vicia villosa Roth Ar Med Agr XMs

Fagaceae

Quercus rubra L. Kn NAm Ephem XMs

Fumariaceae

Fumaria parviflora Lam Kn Med Col MXr

Fumaria schleicheri Soy.-Willem. Ar IT Epo XMs

Fumaria vaillantii Loisel. Ar MedIT Ephem MXr

Geraniaceae

Geranium columbinum L. Kn MedIT Epo XMs

Geranium dissectum L. Ar Med Epo XMs

Geranium molle L. Kn Med Epo XMs

Geranium pusillum L. Ar IT Epo XMs

Geranium sibiricum L. Kn As Epo XMs

Hippocastanaceae

Aesculus hippocastanum L. Kn SEur Ergaz XMs

Hydrophyllaceae

Phacelia tanacetifolia Benth. Kn NAm Ergaz XMs

Juglandaceae

Juglans regia L. Kn As Ergaz XMs

Lamiaceae

Ballota nigra L. Ar MedIT Epo XMs

Dracocephalum thymifolium L. Kn un Ephem XMs

Lallemantia canescens (L.) Fisch. Kn Med Col MXr

Lallemantia iberica (M. Bieb.) Fisch. & C. A. May Kn MedAsMin Col Xr

Lamium album L. Ar IT Epo Ms

<i>Lamium amplexicaule</i> L.	Ar	MedIT	Epo	XMs
<i>Lamium purpureum</i> L.	Ar	Med	Epo	XMs
<i>Leonurus cardiaca</i> L.	Ar	MedIT	Epo	XMs
<i>Marrubium vulgare</i> L.	Ar	MedIT	Epo	MXr
<i>Mellisa officinalis</i> L.	Kn	MedAsMin	Col	XMs
<i>Mentha gentilis</i> L.	Kn	anth	Col	MsHd
<i>Mentha pulegium</i> L.	Kn	Med	Col	MsHd
<i>Mentha spicata</i> L.	Kn	Med	Col	MsHd
<i>Nepeta cataria</i> L.	Ar	EM	Epo	XMs
<i>Salvia sclarea</i> L.	Kn	CEur	Col	MXr
<i>Stachus annua</i> (L.) L.	Ar	Med	Epo	XMs
Linaceae				
<i>Linum usitatissimum</i> L.	Kn	Atl & CEur	Ephem	XMs
Malvaceae				
<i>Abutilon theophrastii</i> Medik.	Kn	WAs	Epo	XMs
<i>Althaea officinalis</i> L.	Ar	IT	Epo	XMs
<i>Hibiscus trionum</i> L.	Ar	Med	Epo	XMs
<i>Malva crispa</i> L.	Kn	E As	Col	Ms
<i>Malva neglecta</i> Wallr.	Ar	IT	Epo	XMs
<i>Malva pusilla</i> Smith	Ar	Resistant Ar	Epo	XMs
<i>Malva sylvestris</i> L.	Ar	Med	Epo	XMs
Moraceae				
<i>Morus alba</i> L.	Kn	E As	Ergaz	Ms
Oleaceae				
<i>Fraxinus pennsylvanica</i> Marshall	Kn	NAm	Col	XMs
<i>Ligustrum vulgare</i> L.	Kn	un	Col	XMs
<i>Syringa vulgaris</i> L.	Kn	EM	Col	MXr
Onagraceae				
<i>Oenothera biennis</i> L.	Kn	NAm	Agr	XMs
<i>Oenothera depressa</i> E. Greene	Kn	NAm	Ephem	XMs
<i>Oenothera hoelscheri</i> Rener ex Rostanski	Kn	CEur	Ephem	XMs
<i>Oenothera rubricaulis</i> Klebahn	Kn	NAm	Epo	XMs
Orobanchaceae				
<i>Phelipanche brassicae</i> (Novopokr.) Soják	Kn	un	Epo	XMs
Oxalidaceae				
<i>Xanthoxalis corniculata</i> (L.) Small.	Kn	Pantrop	Ergaz	XMs
<i>Xanthoxalis stricta</i> (L.) Small	Kn	NAm	Epo	Ms
Papaveraceae				
<i>Glaucium corniculatum</i> (L.) J. Rudolph	Kn	Med	Ephem	XMs
<i>Papaver argemone</i> L.	Ar	MedIT	Epo	MXr
<i>Papaver dubium</i> L.	Ar	MedIT	Epo	XMs
<i>Papaver rhoeas</i> L.	Ar	MedIT	Epo	XMs
<i>Papaver somniferum</i> L.	Kn	Med	Ergaz	XMs
Phytolaccaceae				
<i>Phytolacca americana</i> L.	Kn	NAm	Ephem	XMs
Plumbaginaceae				
<i>Limonium bungei</i> (Claus) Gamajun	Kn	Pont	Ephem	Xr
Polemoniaceae				
<i>Phlox paniculata</i> L.	Kn	NAm	Ephem	XMs
Polygonaceae				
<i>Fagopyrum esculentum</i> Moench	Kn	CAs	Ephem	XMs
<i>Fallopia convolvulus</i> (L.) A. Löve	Ar	As	Epo	XMs
<i>Persicaria orientalis</i> (L.) Spach	Kn	CAs	Col	XMs
<i>Reynoutria japonica</i> Hoult.	Kn	EAs	Epo	Ms
<i>Reynoutria sachalinensis</i> (F. Schmidt & Maxim.) Nakai	Kn	EAs	Ephem	Ms
Portulacaceae				
<i>Portulaca oleracea</i> L.	Ar	IT	Epo	XMs
Primulaceae				
<i>Anagallis arvensis</i> L.	Ar	MedIT	Epo	XMs
<i>Anagallis foemina</i> Mill.	Ar	Med	Ephem	XMs
Ranunculaceae				
<i>Adonis aestivalis</i> L.	Ar	MedIT	Epo	XMs
<i>Aquilegia vulgaris</i> L.	Kn	Eur	Ergaz	Ms
<i>Clematis vitalba</i> L.	Kn	Med	Ephem	MXr
<i>Consolida regalis</i> S. F. Gray	Ar	MedIT	Epo	MXr
<i>Delphinium cuneatum</i> Steven & DC	Kn	Eur	Ephem	Ms
<i>Nigella arvensis</i> L.	Ar	SEurAsMin	Epo	MXr
Resedaceae				
<i>Reseda lutea</i>	Ar	Med	Epo	XMs

Rosaceae				
<i>Aphanes arvensis</i> L.	Ar	EM	Epo	XMs
<i>Armeniaca vulgaris</i> Lam.	Kn	CAs	Ergaz	XMs
<i>Cerasus vulgaris</i> Mill.	Kn	AsMin	Ergaz	XMs
<i>Crataegus coccinea</i> L.	Kn	NAm	Ephem	XMs
<i>Duchesnea indica</i> (Andrews) Focke	Kn	EAs	Col	XMs
<i>Malus domestica</i> Borkh.	Kn	anth	Ergaz	XMs
<i>Physocarpus opulifolius</i> (L.) Maxim.	Kn	NAm	Ephem	MXr
<i>Potentilla orientalis</i> Juz.	Kn	AsMin	Col	XMs
<i>Prunus cerasifera</i> Ehrh.	Kn	Ca	Col	Ms
<i>Prunus domestica</i> L.	Kn	I & As Min	Epo	XMs
<i>Prunus insititia</i> L.	Kn	anth	Col	Ms
<i>Pyrus communis</i> L.	Kn	As	Ergaz	Ms
<i>Rosa rugosa</i> Thunb.	Kn	EAs	Col	XMs
<i>Spiraea media</i> F. Schmidt	Kn	C & SAs	Col	Ms
<i>Sorbaria sorbifolia</i> (L.) A. Braun	Kn	S-WAs	Col	XMs
Rubiaceae				
<i>Galium spurium</i> L.	Ar	anth	Epo	XMs
Rutaceae				
<i>Ptelea trifoliata</i> L.	Kn	NAm	Ephem	XMs
Salicaceae				
<i>Salix fragilis</i> L.	Ar	AsMin	Agr	Ms
Scrophulariaceae				
<i>Digitalis lanata</i> Ehrh.	Kn	CEur	Ephem	XMs
<i>Rhinanthus apterus</i> (Friers) Osternf.	Ar	anth	Epo	Ms
<i>Veronica arvensis</i> L.	Ar	MedIT	Epo	XMs
<i>Veronica persica</i> Poir.	Kn	S-WAs	Epo	XMs
<i>Veronica polita</i> Fries	Ar	MedIT	Epo	XMs
Simaroubaceae				
<i>Ailanthus altissima</i> (Mill.) Swingle	Kn	S-WAs	Col	XMs
Solanaceae				
<i>Datura stramonium</i> L.	Kn	S-EAs	Epo	XMs
<i>Hyoscyamus niger</i> L.	Kn	MedIT	Epo	XMs
<i>Lycium barbatum</i> L.	Ar	EAs	Epo	XMs
<i>Lycopersicon esculentum</i> Mill.	Kn	SAM	Ephem	XMs
<i>Nycandra physalodes</i> (L.) P. Gaertn.	Kn	SAM	Ephem	XMs
<i>Physalis ixocarpa</i> Brot. & Hornem.	Kn	CAM	Ephem	Ms
<i>Solanum nigrum</i> L.	Ar	SEur	Epo	Ms
<i>Solanum tuberosum</i> L.	Kn	SAM	Ephem	XMs
Ulmaceae				
<i>Ulmus pumila</i> L.	Kn	EAs	Epo	XMs
Urticaceae				
<i>Urtica urens</i> L.	Ar	Med	Epo	XMs
Valerianaceae				
<i>Valerianella dentata</i> (L.) Polich	Ar	Med	Epo	XMs
<i>Valerianella locusta</i> (L.) Laterr	Ar	MedIT	Epo	XMs
<i>Valerianella rimosa</i> Bast.	Ar	Med	Epo	XMs
Verbenaceae				
<i>Verbena officinalis</i> L.	Ar	MedIT	Epo	XMs
Violaceae				
<i>Viola arvensis</i> Murray	Ar	Med	Epo	Ms
Vitaceae				
<i>Parthenocissus quinquefolia</i> (L.) Planch.	Kn	NAm	Epo	XMs
Zygophyllaceae				
<i>Tribulus terrestris</i> L.	Kn	Med	Ephem	MXr

Explanations: 1 – Time of immigration, Ar – archaeophytes, Kn – kenophytes; 2 – Geographical origin, Afric – African, anth – anthropogenic, As – Asian, AsMin – Asia Minor, Atl & CEur – Atlantic and Central European, C & SAs – Central & South Asian, C or SAM – Central or South American, C & SAM – Central & South American, Ca – Caucasian, CAM – Central American, CAs – Central Asian, CEur – Central European, Crim & Ca – Crimea & Caucasian, EAs – Eastern Asian, EEur – East European, EM – Eastern Mediterranean, Eur – European, EurMed – European Mediterranean, I & As Min – Iranian & Asian Minor, IMal – Indo-Malayan, IMal & Sud – Indo-Malayan and Sudanian, IT – Irano-Turanian, Med – Mediterranean, Med & As – Mediterranean & Asian, MedI – Mediterranean-Iranian, MedIT – Mediterranean-Irano-Turanian, Med & SEur – Mediterranean & South European, MedAsMin – Mediterranean Asian Minor, Med-Atl Eur – Mediterranean-Atlantic European, MedEAs – Mediterranean-Eastern Asian, MedET – Mediterranean Eastern Turanian, NAm – North American, PanPont – Pannonian-Pontic, Pantrop – pantropic, Pont – pontic, SAM – South American, SAs – South Asian, S-EAs – South-East Asian, SEur – South European, SEur & As – South European & Asian; 3 – Degree of naturalization, Agr – agriophytes, Col – colonophytes, Ephem – ephemerophytes, Epo – epocophytes, Ergaz – ergaziophytes; 4 – Ecological forms in relation to water requirements, Hd – hydrophytes, Hg – hygrophytes, Ms – mesophytes, MsHd – subhydrophytes, XMs – xeromesophytes, MXr – mesoxerophytes, Xr – xerophytes