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 Podilsky 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 Podilsky 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%.
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 Kornaš (1968), modified by Protopopova (1991). The following categories were used: colonophytes (epoecophytes 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), evoecophytes (naturalized in human-made and disturbed habitats) and agriophytes (naturalized in natural and seminatural habitats). 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
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 subhydrophytes) 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 epecophytes (187 spp.), followed by ephemero-phytes (55), colonophytes (48), ergasiophytes (27) and agriophytes (18) (Fig. 4). The stable component of this group (epecophytes, agriophytes, and colonophytes) is represented by 252 species and the unstable one (ergasiophytes and ephemero-phytes) by 82 species.

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

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

**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, XMs – xeromesophytes, MXr – mesoxerophytes, Xr – xerophytes
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 *Phalacroloma annuum*, have been recorded in different types of habitats, such as: anthropogenic ecotypes – ass. *Chelidonio-Acerion negundi* L. et A. Jsh. 1989 (*Robinitea*) 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 (*Saliceta purpurea*), and natural – *Salvio nemorosae-Elytrigietum intermediae* Tyschenko 1996 and *Trifolia-Melampyretum nemorosii* Passary 1967 (*Trifolio-Geranietea*). Moreover, *Phalacroloma annuum* has been noted also in anthropogenic ecotypes – in ass. *Impatiens parviflorae-Robinietum* Sofron 1962 (*Robiniettea*) and *Lamio-Cornietum maculatae* Oberd. 1957 (*Artemisietea vulgaris*), seminatural – *Myosotido palustris-Salicetum albae* Shevcyk et V. Solomakha 1996 (*Saliceta purpu-

![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](image)

**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 – epoecophytes, Ephem – ephemeroophytes, Col – colonophytes, Ergaz – ergaziophytes, Agr – agriophytes

| Species                  | Type of habitat                      | Anthropogenic | Semi-natural                          | Natural                        |
|-------------------------|--------------------------------------|---------------|---------------------------------------|--------------------------------|
| *Acorus calamus*         | C – river                            | Sp – river    | bank river habitats                   |                               |
| *Elodea canadensis*      | C – river                            | Sp – forest   |                                       |                               |
| *Juncus tenuis*          | C – various type: incl. ruderal, parks, forest, bank river habitats, limestone carrier | Sp – degradation meadow-steppe, | R – meadow steppe |                             |
| *Acer negundo*           | Sp – ruderal places, waste, road, ruderal places | Sp – degradation meadow-steppe, | R – meadow steppe |                             |
| *Bidens frondosa*        | C – ruderal places, man-made forest   | C – ruderal places, | Sp – meadow, steppe, forest edge, Sp – meadow, steppe |                             |
| *Cnuyca canadensis*      | C – ruderal places, waste, parks, flowerbeds, | C – ruderal places, | Sp – meadow, steppe, forest edge, Sp – meadow, steppe |                             |
| *Phalacroloma annuum*    | C – ruderal places, waste, parks, flowerbeds, | C – ruderal places, | Sp – meadow, steppe, forest edge, Sp – meadow, steppe |                             |
| *Impatiens parviflora*   | C – ruderal places, parks             | Sp – forest   |                                       |                               |
| *Salix fragilis*         | C – bank artificial rates             | Sp – bank river habitats |                                       |                               |
| *Brotia alba*            | R – parks, man-made forest            | C – bank river habitats, shrubby |                                       |                               |
| *Echinocystis lobata*    | Sp – ruderal places                   | R – ruderalised forest glades |                                       |                               |
| *Thladiana dubia*        | R – ruderal places                    | R – meadow-steppe |                                       |                               |
| *Lathyrus sativus*       | Sp – ruderal places                   | Sp – meadow-steppe |                                       |                               |
| *Trifolium hybridum*     | C – ruderal places, ruderal places    | Sp – ruderal places, | Sp – meadow-steppe, steppe, R – meadow-steppe | R – meadow-steppe |
| *Vicia angustifolia*     | C – ruderal places, ruderal places    | Sp – ruderal places, | Sp – meadow-steppe, steppe, R – meadow-steppe | R – meadow-steppe |
| *Vicia villosa*          | C – ruderal places, ruderal places    | Sp – ruderal places, | Sp – meadow-steppe, steppe, R – meadow-steppe | R – meadow-steppe |
| *Oenothera biennis*      | C – ruderal places, ruderal places    | Sp – ruderal places, | Sp – meadow-steppe, steppe, R – meadow-steppe | R – meadow-steppe |

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

![Table 1. Participation of agriophytes in the various types of habitats of the Podilsky Tovtry National Nature Park](image)
reae) and *Eringio plani-Bromopsietum inermis* Shevcky et V. Solomakha 1996 (*Molinio-Arrhenatheretum*), and natural ones: *Trifolium-Melampyretum nemorosii* Passarye 1967 (*Trifolio-Geranieta*) and *Trifolietum montani* Mirk. et al. 1983 (*Molinio-Arrhenatheretum*).

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. monspessulanus*, *Jurinea calcaria*, *Pulsatilla nigricans*, *Poa versicolor* and *Stipa pennata* have been destroyed (Didukh & Korotchenko 2003). The *Phalacrolooma annuum* very intensively colonizes neglected agricultural land and roadways, 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 2003), *Adonis vernalis*, etc.

Migration of alien plants along roads and rivers results in formation of such plant communities as: *Impatiens glandulifera-Convolvuletum sepium* (Moor 1958) Hilbig 1972, *Polygonetum cuspidati* (Moor 1958) Th. Müller et Görs 1969 ex Görs 1974, *Sicyo-Echino-cystietum lobatae* Fijalkowski 1978 ex Brzeg et M. Wojterska 2001, *Aegopodio-Reynoutrietum sachalinensis* Brzeg in Brzeg et M. Wojterska 2001, *Impatietietum parviflorae* Brzeg 1989 ex Borysiak 1994, *Stachyo sylvatica-Impatietietum noli-tangere* Pass. 1967 ex Hilbig 1972, *Geranio phaeti-Urticetum dioicae* Hadač et al. 1969, *Galio-Urticetum* Pass. 1967 em. Kopecky 1969 and *Urtico-Sambucetetum* 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.

**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

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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**         |   |   |   |   |
| Picea abies (L.) H. Karst. | Kn | Eur | Ephem | Ms |
| Pinus nigra J. F. Arnold | Kn | MedIT | Ephem | XMs |
| Pinus pallasiana D. Don | Kn | Med | Ephem | XMs |
| Pinus sylvestris L. | Kn | anth | Ephem | XMs |
| **Araeae**           |   |   |   |   |
| Acorus calamus L. | Ar | As | Agr | Ms |
| **Hemerocoididaeae** |   |   |   |   |
| Hemerocallis lilooaphodella L. | Kn | EAs | Ergaz | Ms |
| **Hydrocharitaceae** |   |   |   |   |
| Elodea canadensis Michx. | Kn | NA | Agr | Ms |
| **Juncaceae**        |   |   |   |   |
| Juncus tenuis Willd. | Kn | NA | Agr | Ms |
| **Liliaceae**        |   |   |   |   |
| Gagea pratensis (Pers.) Dumort. | Ar | Med | Epo | Ms |
| Gagea villosa (M. Bieb.) Duby | Ar | Med | Epo | Ms |
| **Hyacinthaceae**    |   |   |   |   |
| Ornithogalum umbellatum L. | Kn | CEur | Col | Ms |
| **Amaryllidaceae**   |   |   |   |   |
| Narcissus poeticus L. | Kn | SEur | Ephem | Ms |
| **Poaceae**          |   |   |   |   |
| Anisantha tectorum (L.) Nevski | Ar | MedIT | Epo | XMs |
| Apera spica-venti (L) P. Beav. | Ar | un | Epo | XMs |
| Avena cultiformis (Malzev) Malzev | Ar | IT | Epo | Ms |
| Avena fatua L. | Ar | MedIT | Epo | XMs |
| Avena sativa L. | Kn | SEur | Epo | XMs |
| Bromus arvensis L. | Ar | Med | Epo | XMs |
| Bromus cornutatus Schrad. | Kn | CEur | Epo | XMs |
| Bromus secalinus L. | Ar | EM | Epo | Ms |
| Bromus squarrosus L. | Kn | MedIT | Epo | XMs |
| Digitaria ischaemum (Schr). Muehl. | Ar | CEur | Epo | XMs |
| Digitaria sanguinalis (L.) Scop. | Ar | S-EAs | Epo | Mxr |
| Echinochloa crusgalli (L.) P. Beauv. | Ar | As | Epo | Ms |
| Eragrostis minor Host | Kn | SEur | Epo | XMs |
| Hordeum bulbosumL. | Kn | Med | Ephem | Mxr |
| Hordeum marinum L. | Ar | MedIT | Col | Mxr |
| Lolium remotum Schrenk | Ar | anth | Epo | Ms |
| Panicum capillare L. | Kn | NA | Ephem | Mxr |
| Phalaris canariensis L. | Kn | Med | Ephem | XMs |
| Scirchoila dura (L) P. Beauv. | Ar | MedIT | Epo | XMs |
| Secale cereale L. | Ar | AsMin | Col | XMs |
| Setaria glauca (L) P. Beauv. | Ar | IMal | Epo | Ms |
| Setaria verticillata (L) P. Beauv | Ar | IMal & Sud | Epo | XMs |
| Setaria viridis (L) P. Beauv. | Ar | MedIT | Epo | XMs |
| Tragus racemosus (L) All. | Kn | Med | Epo | Mxr |
| Triticum aestivum L. | Kn | As | Col | XMs |
| Zea mays L. | Kn | C & SA | Ephem | XMs |
| **Aceraceae**        |   |   |   |   |
| Acer negundo L. | Kn | NA | Agr | Ms |
| **Amaranthaceae**    |   |   |   |   |
| Amaranthus albus L. | Kn | NA | Epo | XMs |
| Amaranthus blitoides S. Watson | Kn | NA | Epo | Mxr |
| Amaranthus blitum L. | Kn | SEur | Epo | Mxr |
| Amaranthus caudatus L. | Kn | SA | Ergaz | XMs |
| Amaranthus hybridus L. | Kn | un | Ephem | XMs |
| Amaranthus paniculatus L. | Kn | CA | Ergaz | XMs |
| Amaranthus povelli S. Watson | Kn | NA | Epo | XMs |
| Amaranthus retroflexus L. | Kn | NA | Epo | XMs |
| **Anacardiaceae**    |   |   |   |   |
| Rhus typhina L. | Kn | NA | Col | XMs |
| **Apiaceae**         |   |   |   |   |
| Aethusa cynapium L. | Ar | CEur | Epo | Mxr |
| Anetum graveolens L. | Kn | MedIT | Ephem | Ms |
| Bifora radians M. Bieb. | Ar | Med | Epo | Mxr |
| Bupleurum rotundifolium L. | Ar | MedIT | Epo | XMs |
| Caulis platycarplos L. | Ar | MedIT | Epo | XMs |
| Conium maculatum L. | Ar | MedIT | Epo | XMs |
| Family                  | Species                        | Distribution      | Lifeform   | Period   |
|------------------------|--------------------------------|-------------------|------------|----------|
| Coriandrum sativum L.  | Kn Med Ephem XMs               |                   |            |          |
| Heracleum mantegazzianum Sommier & Levier | Kn CAs Ephem Ms            |                   |            |          |
| Pastinaca sativa L.    | Kn MedIT Col Ms                |                   |            |          |
| Torilis arvensis (Huds.) Link | Kn Med Epo XMs        |                   |            |          |
| Asclepiadaceae         | Asclepis syriaca L.           | Kn NAm Epo XMs    |            |          |
| Asteraceae             | Ambrosia artemisifolia L.      | Kn NAm Epo XMs    |            |          |
|                        | Anthemis arvensis L.           | Ar Med Epo XMs    |            |          |
|                        | Anthemis cotula L.             | Ar Med Epo XMs    |            |          |
|                        | Artemisia abrotanum L.         | Kn MedEAs Col XMs |            |          |
|                        | Artemisia absinthium L.        | Ar IT Epo Ms      |            |          |
|                        | Artemisia annua L.             | Kn SAs Epo XMs    |            |          |
|                        | Aster nova-angueae L.          | Kn NAm Col Ms     |            |          |
|                        | Aster novi-belgii L.           | Kn NAm Col Ms     |            |          |
|                        | Aster salignus Willd           | Kn NAm Ephem XMs  |            |          |
|                        | Bidens frondosa L.             | Kn NAM Agr Ms     |            |          |
|                        | Calendula officinalis L.       | Kn Med Ergaz Ms   |            |          |
|                        | Carduus acanthoides L.         | Ar Med Epo XMs    |            |          |
|                        | Carduus nutans L.              | Ar Med Epo MXr    |            |          |
|                        | Centaurea cyanus M. Bieb.      | Kn Crim & Ca Col Xr |          |          |
|                        | Centaurea difusa Lam.          | Kn Medl Epo Xr    |            |          |
|                        | Centaurea iberica Trev.& Spreng. | Kn SEur & SWA Epo MXr |      |          |
|                        | Cichorium intybus L.           | Ar MedIT Epo XMs  |            |          |
|                        | Conyza canadensis (L.) Cronq.  | Kn NAm Agr Ms     |            |          |
|                        | Cosmos bipinnatus Cav.         | Kn CAm Ergaz XMs  |            |          |
|                        | Crepis roheadifolia Bieb.      | Kn PanPont Epo XMs |          |          |
|                        | Galinsoga parviflora Cav.      | Kn SAm Epo Ms     |            |          |
|                        | Galinsoga articifolia (Kunth) Benth. | Kn C or SAm Col Ms |          |          |
|                        | Helianthus annuus L.           | Kn NAm Ergaz XMs  |            |          |
|                        | Helianthus tuberosus L.        | Kn NAm Col Ms     |            |          |
|                        | Heliopsis scabra Dunal         | Kn NAM Epo XMs    |            |          |
|                        | Iva xanthifolia Nutt.          | Kn NAM Epo XMs    |            |          |
|                        | Lactuca serriola L.            | Ar MedIT Epo XMs  |            |          |
|                        | Lepidotheca suveolens (Prush) Nutt. | Kn NAM Epo Ms     |            |          |
|                        | Matricaria recutita L.         | Ar EEur Epo XMs   |            |          |
|                        | Onopordum acanthium L.         | Ar Med Epo MXr    |            |          |
|                        | Phalacroloma annuum (L.) Dumort. | Kn NAM Agr Ms   |            |          |
|                        | Phalacroloma septentriionale (Fernald & Wiegand) Tzvelev | Kn NAM Epo Ms |            |          |
|                        | Pyrethrum parthenium(L.) Smith | Kn EEur Col MXr   |            |          |
|                        | Rudbeckia laciniata L.         | Kn NAM Ergaz XMs  |            |          |
|                        | Senecio viscosus L.            | Kn CEur Epo XMs   |            |          |
|                        | Senecio vulgaris L.            | Ar As Epo XMs     |            |          |
|                        | Silphyum perforatum L.         | Kn NAM Col XMs    |            |          |
|                        | Solidago canadensis L.         | Kn NAM Epo Ms     |            |          |
|                        | Sonchus arvensis L.            | Ar Med Epo Ms     |            |          |
|                        | Sonchus asper (L.) Hill.       | Ar Med Epo Ms     |            |          |
|                        | Sonchus oleraceus L.           | Ar Med Epo Ms     |            |          |
|                        | Tripleurospermum inodorum (L.) Sch. Bip. | Ar As Epo Ms |            |          |
|                        | Xanthium albium (Widder) H. Schulz | Kn CEur Epo XMs |            |          |
|                        | Xanthium spinosum L.           | Kn SAm Ephem XMs  |            |          |
|                        | Xanthium strumarium L.         | Ar IT Epo XMs     |            |          |
| Balsaminaceae           | Impatiens glandulifera Royle.   | Kn S-EAs Epo Hg   |            |          |
|                        | Impatiens parviflora DC.       | Kn CAs Agr Ms     |            |          |
| Boraginaceae            | Anchusa officinalis L.         | Ar Med Epo MXr    |            |          |
|                        | Argusia sibirica (L.) Dandy    | Kn As Ephem XMs   |            |          |
|                        | Borago officinalis L.          | Kn Med Ergaz XMs  |            |          |
|                        | Buglossoides arvensis (L.) I. M. Johnst. | Ar MedIT Epo XMs |            |          |
|                        | Cynoglossum officinale L.      | Ar Med Epo XMs    |            |          |
|                        | Lappula patula (Lehm.) Menyh.  | Kn As Epo MXr     |            |          |
|                        | Lappula squarrosa (Retz.) Dumort. | Ar MedIT Epo XMs |            |          |
|                        | Lycopsis arvensis L.           | Ar Med Epo XMs    |            |          |
|                        | Myosotis arvensis (L.) Hill    | Ar MedIT Epo Ms   |            |          |
|                        | Nomea lutea (Desr.) DC         | Kn un Col Xr      |            |          |
| Brassicaceae            | Arabidopsis thaliana (L.) Heynh. | Kn MedIT Epo XMs |            |          |
|                        | Armoracia rusticana P. Gaertn., B. Mey. & ScKenb. | Kn IT Col Ms |            |          |
| Species                                              | Ar | CA | Epo | MXr |
|------------------------------------------------------|----|----|-----|-----|
| Brassica campestris L.                               |    |    |     |     |
| Brassica juncea (L.) Czern.                          | Kn | S-EAs | Col |     |
| Brassica nigra (L.) W.D.J. Koch                      | Kn | Med | Ephem | Ms |
| Capsella bursa-pastoris (L.) Desv.                   |    |    |     |     |
| Camelina microcarpa Andrz.                           | Ar | Med | Epo | XMs |
| Camelina sativa (L.) Crantz                          |    |    |     |     |
| Camelina syvolestis Wallr.                           | Kn | un | Epo | MXr |
| Cardaria draba (L.) Desv.                            | Kn | SEur & As | Epo | XMs |
| Dipotassium muraus (L.) DC.                           | Kn | SEur | Epo | XMs |
| Descurania sophia (L.) Webb & Prantl                 |    |    |     |     |
| Erucia vesicaria (L.) Cav.                           | Kn | Med | Epo | MXr |
| Eruca vesicaria (L.) Cav.                            |    |    |     |     |
| Erysimum cheiranthoides L.                           | Ar | un | Epo | XMs |
| Erysimum repandum L.                                 | Ar | IT | Epo | MXr |
| Euclidium syriacum (L.) R.Br.                        | Kn | As | Epo | MXr |
| Hesperis matronalis L.                               | Kn | Med | Ergaz | Ms |
| Hesperis pycnotricha Borbas et Degen                 | Kn | As | Ergaz | Ms |
| Isatis tinctoria L.                                  | Kn | IT | Epo | MXr |
| Lepidium campestre (L.) R. Br.                       | Ar | Med | Epo | XMs |
| Lepidium densiflorum Schrad.                         | Kn | NA | Epo | XMs |
| Lepidium perfoliatum L.                              | Kn | Med | As | XMs |
| Lepidium ruderale L.                                 | Ar | IT | Epo | XMs |
| Lunaria annua L.                                     | Kn | SEur | Ephem | Ms |
| Matthiola annua (L) Sweet                            | Kn | SEur | Ergaz | XMs |
| Neslia paniculata (L) Desv.                          | Ar | anh | Epo | XMs |
| Raphanus raphanistrum L.                             | Ar | Med | Epo | XMs |
| Raphanus sativus L.                                  | Kn | Med | Ergaz | XMs |
| Raucumar perenne (L.) All.                           | Ar | Med | Epo | XMs |
| Sinapis alba L.                                      | Ar | Med | Epo | XMs |
| Sinapis arvensis L.                                  | Ar | Med-Ad Eur | Epo | XMs |
| Sisymbrium aliusissimum L.                           | Kn | SEur & As | Epo | Ms |
| Sisymbrium loeseli L.                                | Kn | Med | As | Epo | MXr |
| Sisymbrium officinale (L) Scop.                      | Ar | Med | Epo | XMs |
| Thlaspi alliaceum L.                                 | Kn | SEur | Ephem | Ms |
| Thlaspi arvense L.                                   | Ar | IT | Epo | Ms |
| Thlaspi perfoliatum L.                               | Kn | Med | Epo | XMs |

**Caesalpiniaeceae**

- Gleditsia triacanthos L.
- Gymnochloa dioica (L.) K. Koch

**Cannabaceae**

- Cannabis sativa L.

**Capparidaeae**

- Lonicera caprifolium L.
- Lonicera tatarica L.

**Caryophyllaceae**

- Agrostemma githago L.
- Dianthus barbatus L.
- Petrorhagia saxifraga (L.) Link
- Saponaria officinalis L.
- Scirenthus annua L.
- Spergula arvensis (L.) Clairv.
- Vaccaria hispanica (Mill.) Rauschert

**Celastraceae**

- Euonymus latifolia (L.) Mill.

**Chenopodiaceae**

- Atriplex hortensis L.
- Atriplex prostrata Boucher & DC
- Atriplex sagittata Borkh.
- Atriplex tatarica L.
- Chenopodium bonus-henricus L.
- Chenopodium botrys L.
- Chenopodium ficifolium Smith
- Chenopodium hybridum L.
- Chenopodium opulifolium Schrad. & Koch. et Ziz.
- Chenopodium polyspermum L.
- Chenopodium rubrum L.
- Chenopodium suecicum J. Murr
- Kochia densiflora (Moq.) Aell.
- Kochia scoparia (L.) Schrad.
| Family                  | Genus                          | Kn | Taxonomic group  | Subgroup |
|------------------------|--------------------------------|----|-----------------|----------|
| Convolvulaceae         | Ipomea purpurea (L.) Roth      | Kn | SAs             | Ergaz    |
| Crassulaceae           | Pediatus spurius (M. Bieb.)    | Kn | Ca              | Ephem    |
|                        | Sedum album L.                 | Kn | un              | Col      |
| Cucurbitaceae          | Brioia alba L.                 | Kn | MediT           | Agr      |
|                        | Brioia dioica Jacq.            | Kn | MediT           | Col      |
|                        | Citrullus lanatus (Thunb.) Matsum. & Nakai | Kn | Afric          | Ergaz    |
|                        | Cucurbita maxima Duch.         | Kn |                |          |
|                        | Echinocystis lobata (Michx.) Torr. & A. | Kn | NAmd          | Agr      |
|                        | Thalidathia dubia Bunge        | Kn | NAmd          | Agr      |
| Cuscusatceae           | Cuscuta campestris Yunck       | Kn | NAmd          | Epo      |
|                        | Cuscuta cesatiana Bertol.      | Kn | IT             | Epo      |
|                        | Cuscuta tinei Insenga          | Kn | NAmd          | Epo      |
| Elaeagnaceae           | Elaeagnus angustifolia L.      | Kn | Med             | Epo      |
| Euphorbiaceae          | Euphorbia exigua L.            | Ar | Med             | Epo      |
|                        | Euphorbia falcata L.           | Ar | MedIT           | Epo      |
|                        | Euphorbia helioscopia L.       | Ar | Med             | Col      |
|                        | Euphorbia peplus L.            | Ar | Med             | Epo      |
|                        | Euphorbia platyphylos L.       | Ar | Med             | Epo      |
|                        | Euphorbia salicifolia Host.    | Ar |                | XMs      |
| Fabaceae               | Amorpha fruticosa L.           | Kn | NAmd           | Epo      |
|                        | Bituminaria ninitinoussa (L.) Stirton | Kn | Med            | Col      |
|                        | Caragana arborescens Lam.      | Kn | un             | Epo      |
|                        | Colutea arborescens L.         | Kn | Med             | Ergaz    |
|                        | Lathyrus sativus L.            | Kn | Med             | Agr      |
|                        | Lathyrus tuberosus L.          | Ar | IT             | Epo      |
|                        | Lupinus polyphyllus Lindl.     | Kn | NAmd           | Col      |
|                        | Medicago sativa L.             | Kn | As             | Epo      |
|                        | Onobrychis vicifolia Scop.     | Kn | SEur           | Ephem    |
|                        | Robinia hispida L.             | Kn | NAmd           | Ergaz    |
|                        | Robinia pseudocacia L.         | Kn | NAmd           | Epo      |
|                        | Robinia viscousa Vent.         | Kn | NAmd           | Col      |
|                        | Trifolium hybridum L.          | Kn | Med             | Agr      |
|                        | Trifolium incarnatum L.        | Kn | Med             | Ephem    |
|                        | Trifolium sativum (Schreb.) Crome | Kn | Eur           | Col      |
|                        | Trigonella caerulea (L.) Ser.  | Kn | Med             | Col      |
|                        | Vicia angustifolia Reichard    | Kn | MediT           | Agr      |
|                        | Vicia hirsuta (L.) S. F. Grey  | Ar | WMed           | Epo      |
|                        | Vicia tetrasperma (L.) Schreb. | Ar | Med             | Epo      |
|                        | Vicia villosa Roth             | Ar | Med             | Agr      |
| Fagaceae               | Quercus rubra L.               | Kn | NAmd           | Ephem    |
| Fumariaceae            | Fumaria parviflora Lam         | Kn | Med             | Col      |
|                        | Fumaria schleicheri Soy.-Willem.| Ar | IT           | Epo      |
|                        | Fumaria vaillantii Loisel.      | Ar | MediT           | Ephem    |
| Geraniaceae            | Geranium columbinum L.         | Kn | MediT           | Epo      |
|                        | Geranium dissectum L.          | Ar | Med             | Epo      |
|                        | Geranium molle L.              | Kn | Med             | Epo      |
|                        | Geranium pusillum L.           | Ar | IT             | Epo      |
|                        | Geranium sibiricum L.          | Kn | As             | Epo      |
| Hippocastanaceae       | Aesculus hippocastanum L.      | Kn | SEur           | Ergaz    |
| Hydrophyllaceae        | Placelia tanacetifolia Benth.   | Kn | NAmd           | Ergaz    |
| Juglandaece            | Juglans regia L.               | Kn | As             | Ergaz    |
| Lamiaeae               | Ballota nigra L.               | Ar | MediT           | Epo      |
|                        | Draccocephalum thymifolium L.  | Kn | un             | Ephem    |
|                        | Lallemantia canescens (L.) Fisch. | Kn | Med           | Col      |
|                        | Lallemantia iberica (M. Bieb.) Fisch. & C. A. May | Kn | MedAsMin | Col |
|                        | Lamium album L.                | Ar | IT             | Epo      |

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| Family          | Genus                          | Subgenus | Speciation | Distribution | Life Form | Type |
|-----------------|--------------------------------|----------|------------|--------------|-----------|------|
| Lamium amplexicaule L. | Ar | MedIT | Epo | XMs |
| Lamium purpureum L. | Ar | Med | Epo | XMs |
| Leonurus cardiaca L. | Ar | MedIT | Epo | XMs |
| Marrubium vulgare L. | Ar | MedIT | Epo | MXr |
| Melissa officinalis L. | Kn | Med / As / Min | Col | XMs |
| Mentha spicata L. | Kn | Med | Col | MShd |
| Mentha pulegium L. | Kn | Med | Col | MShd |
| Nepeta cataria L. | Ar | EM | Epo | XMs |
| Salvia sclarea L. | Kn | C / E | Col | MXr |
| Stachus annua (L.) L. | Ar | Med | Epo | XMs |
| **Linaceae**          |                |          |            |              |           |      |
| Linum usitatissimum L. | Kn | Atl & CEur | Ephem | XMs |
| **Malvaceae**          |                |          |            |              |           |      |
| Abutilon theophrastiil Medik. | Kn | WAs | Epo | XMs |
| Althaea officinalis L. | Ar | IT | Epo | XMs |
| Hibiscus trionum L. | Ar | Med | Epo | XMs |
| Malva crispa L. | Kn | E As | Col | Ms |
| Malva neglecta Wallr. | Ar | IT | Epo | XMs |
| Malva pusilla Smith | Ar | Resistant Ar | Epo | XMs |
| Malva sylvestris L. | Ar | Med | Epo | XMs |
| **Moraceae**          |                |          |            |              |           |      |
| Morus alba L. | Kn | E As | Ergaz | Ms |
| **Oleaceae**          |                |          |            |              |           |      |
| Fraxinus pennsylvanica Marshall | Kn | NAm | Col | XMs |
| Ligustrum vulgare L. | Kn | un | Col | XMs |
| Syringa vulgaris L. | Kn | EM | Col | MXr |
| **Onagraceae**          |                |          |            |              |           |      |
| Oenothera biennis L. | Kn | NAm | Agr | XMs |
| Oenothera depressa E. Greene | Kn | NAm | Ephem | XMs |
| Oenothera hoelscheri Rener ex Rostanski | Kn | CEur | Ephem | XMs |
| Oenothera rubricaulis Klebahn | Kn | NAm | Epo | XMs |
| **Orobanchaceae**       |                |          |            |              |           |      |
| Phelipanche brassicae (Novopokr.) Sojak | Kn | un | Epo | XMs |
| **Oxalidaceae**          |                |          |            |              |           |      |
| Xanthoxalis corniculata (L.) Small. | Kn | Pantrop | Ergaz | XMs |
| Xanthoxalis stricta (L.) Small. | Kn | NAm | Epo | Ms |
| **Papaveraceae**         |                |          |            |              |           |      |
| Glauca crocus L. (L.) J. Rudolph | Kn | Med | Ephem | XMs |
| Papaver argemone L. | Ar | MedIT | Epo | MXr |
| Papaver dubium L. | Ar | MedIT | Epo | XMs |
| Papaver rhoas L. | Ar | MedIT | Epo | XMs |
| Papaver somniferum L. | Kn | Med | Ergaz | XMs |
| **Phytolaccaceae**        |                |          |            |              |           |      |
| Phytolacca americana L. | Kn | NAm | Ephem | XMs |
| **Plumbaginaceae**        |                |          |            |              |           |      |
| Limonium bungei (Claus) Gamajun | Kn | Pont | Ephem | Xr |
| **Polygonaceae**          |                |          |            |              |           |      |
| Phlox paniculata L. | Kn | NAm | Ephem | XMs |
| **Resedaceae**           |                |          |            |              |           |      |
| Reseda lutea L. | Ar | Med | Epo | XMs |
| Family         | Species                                      | Time of Immigration | Geographical Origin | Degree of Naturalization | Ecological Forms |
|---------------|----------------------------------------------|---------------------|---------------------|--------------------------|-----------------|
| Rosaceae      | Aphanes arvensis L.                         | Ar                  | EM Epo              | XMs                      |                 |
|               | Armeniaca vulgaris Lam.                     | Kn                  | CAs Ergaz           | XMs                      |                 |
|               | Cerasus vulgaris Mill.                      | Kn                  | AsMin Ergaz         | XMs                      |                 |
|               | Crataegus coccinea L.                      | Kn                  | NAm Ephem           | XMs                      |                 |
|               | Duchesnea indica (Andrews) Focke            | Kn                  | EAs Col             | XMs                      |                 |
|               | Malus domestica Borkh.                     | Kn                  | anth Ergaz          | XMs                      |                 |
|               | Physocarpus opulifolius (L.) Maxim.        | Kn                  | NAm Ephem MXr       | XMs                      |                 |
|               | Potentilla orientalis Juz.                 | Kn                  | AsMin Col XMs       |                          |                 |
|               | Prunus cerasifera Ehrh.                    | Kn                  | Ca Col              | Ms                       |                 |
|               | Prunus domestica L.                         | Kn                  | I & As Min Epo XMs  |                          |                 |
|               | Prunus insititia L.                        | Kn                  | anth Col            | Ms                       |                 |
|               | Pyrus communis L.                          | Kn                  | As Ergaz            | Ms                       |                 |
|               | Rosa rugosa Thunb.                         | Kn                  | EAs Col             | XMs                      |                 |
|               | Spiraea media F. Schmidt                  | Kn                  | C & SAs Col         | Ms                       |                 |
|               | Sorbaria sorbifolia (L.) A. Braun         | Kn                  | S-WAs Col XMs       |                          |                 |
| Rubiaceae     | Galium spurium L.                          | Ar                  | anth Epo            | XMs                      |                 |
| Rutaceae      | Ptelea trifoliata L.                       | Kn                  | NAM Ephem XMs       |                          |                 |
| Salicaceae    | Salix fragilis L.                          | Ar                  | AsMin Agr Ms        |                          |                 |
| Scrophulariaceae | Digitalis lanata Ehrh.                | Kn                  | CEur Epo Ms         |                          |                 |
|               | Rhinanthus apetrum (Friers) Osternf.       | Ar                  | anh Epo             | Ms                       |                 |
|               | Veronica arvensis L.                       | Ar                  | MedIT Epo XMs       |                          |                 |
|               | Veronica persica Foir.                    | Kn                  | S-WAs Epo XMs       |                          |                 |
|               | Veronica polita Fries                     | Ar                  | MedIT Epo XMs       |                          |                 |
| Simaroubaceae | Ailanthus altissima (Mill.) Swingle       | Kn                  | S-WAs Col XMs       |                          |                 |
| Solanaceae    | Datura stramonium L.                       | Kn                  | S-EAs Epo XMs       |                          |                 |
|               | Hyoscyamus niger L.                        | Kn                  | MedIT Epo XMs       |                          |                 |
|               | Lycium barbatum L.                         | Ar                  | EAs Epo XMs         |                          |                 |
|               | Lycopersicon esculentum Mill.              | Kn                  | SAm Ephem XMs       |                          |                 |
|               | Nycandra physalodes (L.) P. Gaertn.        | Kn                  | SAm Ephem XMs       |                          |                 |
|               | Physalis ixocarpa Brot. & Hornem.          | Kn                  | CAM Ephem Ms        |                          |                 |
|               | Solanum nigrum L.                          | Ar                  | SEur Epo XMs        |                          |                 |
|               | Solanum tuberosum L.                       | Kn                  | SAm Ephem XMs       |                          |                 |
| Ulmaceae      | Ulmus pumila L.                            | Kn                  | EAs Epo XMs         |                          |                 |
| Urticaceae    | Urtica urens L.                            | Ar                  | Med Epo XMs         |                          |                 |
| Valerianaceae | Valerianella dentata (L.) Polich           | Ar                  | Med Epo XMs         |                          |                 |
|               | Valerianella locusta (L.) Laterr           | Ar                  | MedIT Epo XMs       |                          |                 |
|               | Valerianella ramosa Bast.                  | Ar                  | Med Epo XMs         |                          |                 |
| Verbenaceae   | Verbena officinalis L.                     | Ar                  | MedIT Epo XMs       |                          |                 |
| Violaeeae     | Viola arvensis Murray                      | Ar                  | Med Epo Ms          |                          |                 |
| Vitaceae      | Parthenocissus quinquefolia (L.) Planch.   | Kn                  | NAm Epo XMs         |                          |                 |
| Zygophyllaceae| Tribulus terrestris 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, Med – Mediterranean-Asian, MedIT – Mediterranean-Irano-Turanian, Med & SEur – Mediterranean & South European, MedAsMin – Mediterranean Asian Minor, Med-Atl Eur – Mediterranean-Atlantic European, MedEAs – Mediterranean-Eastern Asian, MedEET – 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 – agriphytes, Col – colonophytes, Eph – epheryphytes, Epho – ephoecophytes, Ergaz – ergaziophytes; 4 – Ecological forms in relation to water requirements, Hd – hydrophytes, Hg – hygrophytes, Ms – mesophytes, MsHd – subhydrophytes, XMs – xeromesophytes, MXr – mesoxerophytes, Xr – xerophytes.