

## Spreading of adventive plants on river banks of the Elbe River in the Czech Republic and the Danube River in Slovakia outside of harbours

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Abstract: In the years 1973-2004, an adventive flora (so called neophytes) and vegetation on open river at planar level outside of harbour bodies in Bohemia on the Elbe River between the towns Mělník and Hřensko, and in Slovakia, on the Danube River between the towns Bratislava-Devín and Štúrovo, as a part of flora and vegetation of river harbours monitoring were investigated. The banks of watercourses on open river (i.e. outside of harbours) are in direct contact with river current carrying away diaspores of plants not only from harbours but also from all ecotopes along river in river basins. In this process, floods play a significant role as well. With regard to transport of diaspores, the Elbe River harbours, in comparison with the Danube River harbours (Bratislava, Komárno), are influenced more significantly by watercourse that is associated with a lower height of harbour embankments and walls above the level of watercourse. Spreading of plants on open river banks is influenced, apart from human activities, also by the erosion-accumulation process that has a selective impact during ecesis of introduced species. Flora of river banks is therefore less rich than flora of actual harbours. In total, there were found on the banks of both watercourses 54 (=100%) adventive plant species (not including archeophytes). The highest number of them belonged to therophytes (68%) and hemicryptophytes (22%). Of 54 neophytes

on the banks of the Elbe and Danube Rivers, 50% belong to invasive species. On the Danube River, they were occasionally registered also in the vegetation of the ass. *Bidenti-Polygonetum hydropiperis*, *Odontito-Ambrosietum artemisiifoliae* and *Rumici crispi-Agrostietum stoloniferae*. Of newly spreading invasive species, *Xanthium saccharatum* and *Amaranthus blitum* subsp. *emarginatus* var. *pseudogracilis* were registered on the Danube River in Slovakia. The difference in presence of alien expansive weeds is significant on both watercourses outside of harbours: 3 species on the Elbe River, 8 species on the Danube River, total 9 species that is not quite 1/3 of all these species known from the harbours. For their spreading, there are particularly favourable broad areas of the Podunajská nížina Lowland, on which fields many species of expansive weeds are naturalised that we cannot state for the planar Elbe River Lowland. To conclude, it can be noted that watercourses in cultivated landscape represent an important way of spreading of neophytes, especially of invasive species.

Keywords: Adventive plants, river banks outside of harbours, Elbe in the Czech Republic, Danube in Slovakia.

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## Introduction

In the years 1973-2004, an adventive flora (so called neophytes, not archeophytes) and vegetation on open river bank at planar level outside of harbour bodies, in Bohemia on the Elbe River in more localities between the towns Mělník and Hřensko (1973, 1987, 1990, 2003, 2004), and in Slovakia on the Danube River between the towns Bratislava-Devín and Stúrovo (1974, 1976, 1990, 2004) (Tab. 1) were investigated. We summarise results of this research in a brief contribution. We follow a repeated monitoring of flora and vegetation of river harbours on the Elbe-Vltava and Danube water route in Central Europe in the years 1968-2004.

## Materials and methods

During botanical excursions in the territory of Bohemia and Slovakia, a floristic-taxonomic and vegetation research was carried out in various periods of the year on open river on the banks of the Elbe and Danube Rivers (outside of river harbours). Botanical nomenclature follows KUBÁT et al. (2002), sometimes also WISSKIRCHEN & HAEUPLER (1998), vegetation analysis in conformity with MORAVEC (1994), characteristics of vegetation units in conformity with MORAVEC (1995) and JAROLÍMEK et al. (1997). The terms from classification of antropophytes, so called neophytes (= ephemerophytes, epocophytes, neoindigenophytes) are understood in harmony with HOLUB & JIRÁSEK (1967), invasive species are listed mostly on the basis of the works P. PYŠEK et al. (2002) and OPRAVIL (1980) and alien expansive weeds in conformity with JEHLÍK (1998).

## Results

While the harbour macro-localities represent very special ecotopes, located usually several or more meters above the level of river, then the banks on open river flow represent ecotopes that are for the whole year in contact with river current, carrying away diasporas of plants not only from harbours but from all ecotopes along river in river basin. In this process, floods play an important role as well.

In general, the Elbe River harbours were more significantly influenced during the process of carrying away diasporas by watercourse than the Danube River harbours. It is caused by a different level of harbour embankments and walls that is in Slovak localities (Bratislava, Komárno) much higher above the level of watercourse than it is the case in the Elbe-Vltava harbours (JEHLÍK 1985: 89). Synanthropic flora of harbour macro-localities is, to a significant extent, similar to the flora of dry and warm ecotopes of big railway stations while the flora and vegetation of river banks is by its composition closer to the flora of natural landscape, however, enriched locally by some "harbour species", spread spontaneously by watercourse. During floods, also some alien expansive weeds and other, often ephemerophyte adventive species, resp. their diasporas, coming to water also during transshipping of goods in harbours, are flooded from harbour localities to river bank localities. While in harbours, environment for development of synanthropic vegetation is disturbed mainly by human activities, on open river, resp. on its banks, it is disturbed also by natural erosion-accumulation process that has a selective impact on ecesis of introduced species. Also for this reason, flora of watercourses is poorer than synanthropic flora of actual harbours. On open river, the Elbe River is, in comparison with the Danube River, more adjusted by canals while the Danube River is characteristic by mostly natural banks.

In total, there were found on the banks of both watercourses 54 (=100%) adventive plant species (not including archeophytes) (Tab. 1), of which the highest number was for therophytes (68%), the second place was taken by hemicryptophytes (22%), and further sporadically by macrophanerophytes (4%), nanophanerophytes (2%), geophytes (2%) and hydrophytes (2%).

Of 54 neophytes on the banks of the Elbe and Danube Rivers, 27 (50%) belong to invasive species and 9 (17%) to alien expansive weeds. Among invasive species (mostly in conformity with the definition of P. PÝŠEK et al. (2002), we include the following plants:

*Acer negundo*, *Amaranthus blitum* subsp. *emarginatus* var. *pseudogracilis*, *A. powellii*, *A. retroflexus*, *Ambrosia artemisiifolia*, *Amorpha fruticosa*, *Angelica archangelica* subsp. *archangelica*, *Aster x salignus*, *Bidens frondosa*, *Conyza canadensis*, *Echinocystis lobata*, *Echinops sphaerocephalus*, *Erigeron annuus* subsp. *annuus*, *Galingsoga ciliata*, *G. parviflora*, *Helianthus tuberosus*, *Impatiens glandulifera*, *I. parviflora*, *Kochia scoparia* subsp. *scoparia*, *Matricaria discoidea*, *Oenothera biennis*, *Reynoutria japonica*, *Robinia pseudacacia*, *Rumex thyrsiflorus*, *Solidago canadensis*, *S. gigantea*, *Xanthium saccharatum*.

On both watercourses, there occur invasive species in a similar representation by number: 20 species on the Elbe River, 18 species on the Danube River.

On the natural banks of the Danube River, some invasive species penetrate also into the natural synanthropic communities. As an example, we can list 3 records of vegetation relevés from the deposits of the Danube River (the left bank):

1. Hamuliakovo, a gravel bank at the reservoir Hrušov of the water body Gabčíkovo, a flooded depression with wood detritus. Date: 27.7.2004 (the relevé area: 6m<sup>2</sup>; slope: 0°; cover E<sub>1</sub>: 75%; number of species: 17): *Persicaria hydropiper* 4.3, *Bidens frondosa* 2.2, *Ranunculus repens* 2.2, *Echinocystis lobata* 1.2, *Xanthium saccharatum* 1.2, *Ambrosia artemisiifolia* +, *Aster xsalignus* +, *Carex acuta* +.2, *Galium palustre* +.2, *Iris pseudacorus* +.2, *Persicaria lapathifolia* +, *Persicaria mitis* +.2, *Phalaris arundinacea* +, *Plantago lanceolata* +.2, *Tripleurospermum inodorum* +, *Lycopus europaeus* r, *Ranunculus sceleratus* r. – The vegetation belongs to the ass. *Bidenti-Polygonetum hydropiperis* LOHMEYER in R. Tx. 1950 from the alliance *Bidention tripartiti*. Invasive species: *Ambrosia artemisiifolia*, *Aster xsalignus*, *Bidens frondosa*, *Echinocystis lobata*, *Xanthium saccharatum*.

2. Komárno-Malá Iža, a sandy deposit of the Danube River between the towns Malý and Velký Harčáš, bellow the harbour, a greyish-yellow loose sand above a gravel-sand background. Date: 24.8.1990 (the relevé area: 24m<sup>2</sup>; exposure: SSW; slope: 5°; altitude: 108 m a.s.l.; cover E<sub>1</sub>: 50%; number of species: 28): *Ambrosia artemisiifolia* 3.2, *Trifolium bonannii* J. PRESL et C. PRESL 2.2-3, *Agropyron repens* 1.2, *Agrostis stolonifera* 1.3, *Carex hirta* 1.2, *Convolvulus arvensis* +, *Conyza canadensis* +, *Daucus carota* +, *Lolium perenne* +.2, *Plantago lanceolata* +.2, *Plantago major* agg. +.2, *Poa annua* +.2, *Polygonum arenastrum* +, *Persicaria lapathifolia* +, *Populus* cf. *nigra* juv. +, *Trifolium repens* +.2, *Tripleurospermum inodorum* +, *Verbena officinalis* +, *Xanthium* cf. *italicum* MORETTI +.2, *Atriplex tatarica* r.2, *Bidens frondosa* r, *Cichorium intybus* subsp. *intybus* r.2, *Cirsium arvense* r, *Potentilla anserina* r. *Rorippa sylvestris* r, *Rumex crispus* r, *Rumex maritimus* r.2, *Tanacetum vulgare* r.2. – The vegetation belongs probably to the ass. *Odontito-Ambrosietum artemisiifoliae* JAROLÍMEK et al. 1997 from the alliance *Dauco-Melilotion*. Invasive species: *Ambrosia artemisiifolia*, *Bidens frondosa*, *Conyza canadensis*.

3. Iža, a gravel-sand deposit of the Danube River, 2 m from water level, bellow the town, not far from the harbour Komárno. Date: 28.7.2004 (the relevé area: 8m<sup>2</sup>; exposure: south; slope: 5°; cover E<sub>1</sub>: 95%; number of species: 15): *Agrostis stolonifera* 3.3, *Mentha pulegium* 3.2-3, *Trifolium repens* 3.3, *Plantago lanceolata* 2.2, *Plantago major* 2.2, *Rorippa sylvestris* 2.2, *Trifolium bonannii* J. PRESL et C. PRESL 2.2, *Aster xsalignus* 1.2, *Potentilla anserina* 1.2, *Carex hirta* +.2, *Cirsium arvense* +, *Rumex crispus* +, *Calystegia sepium* r, *Ranunculus repens* r.2, *Rumex conglomeratus* r. – The vegetation belongs to the ass. *Rumici crispi-Agrostietum stoloniferae* MOOR 1958 from the alliance *Agropyro-Rumicion crispi*. Invasive species: *Aster xsalignus*.

On the Slovak part of the Danube River, we can locally find a North-American species *Xanthium saccharatum* WALLR. that spreads invasively, in the similar way as some time ago *X. albinum* on the Elbe River that occurs more rarely also on the Danube River; in the eastern part perhaps also *X. italicum* MORETTI, known also from the neighbouring Hungary and Balkan Peninsula. Of other, newly spreading invasive species in Slovakia, there was found, in the year 2004, on the banks of the Danube River and its tributary Morava, an invasive taxa from tropes, *Amaranthus blitum* L. subsp. *emarginatus* (MOQ. ex ULINE W. L. BRAY) CARRETERO, MUÑOZ GARM. PEDROL var. *pseudogracilis* (THELL.) LAMBINON (JEHLÍK & ZALIBEROVÁ 2005). Both above mentioned invasive taxa were determined especially in conformity with WISSKIRCHEN (1995: 50-72) and ROTHMALER et al. (2002).

On both watercourses outside the harbours, there can be registered a prominent difference in quantitative presence of alien expansive weeds: 3 species on the Elbe River: *Amaranthus powellii*, *Erigeron annuus* subsp. *annuus*, *Setaria macrocarpa* – this species only temporarily at Děčín-Loubí; 8 species on the Danube River: *Amaranthus albus*, *A. powellii*, *Ambrosia artemisiifolia*, *Artemisia annua*, *Erigeron annuus* subsp. *annuus*, *Iva xanthifolia*, *Kochia scoparia* subsp. *scoparia*, *Rumex patientia*. Of alien expansive weeds, occurring in the Czech Republic and in Slovakia in river harbours (total 30 species – Jehlík 1998: 64-65), not quite 1/3 (9) of all these species grow on the banks outside the harbours. For their spreading, broad areas of the Podunajská nížina Lowland are especially favourable, while on its fields, there are already many expensive weeds naturalised that we cannot state in case of planar Polabí Lowland in the part Mělník – Hřensko where harbours cover, in comparison with the harbours of Slovakia, relatively small areas. In addition, spreading of adventive species is very limited there, as with regard to adverse technical and economic situation, the Elbe navigation is stagnating.

To conclude, it can be stated that, in cultivated landscape, watercourses with shipping activities represent an important route for spreading of neophyte adventive species, especially of invasive species.

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**Tab. 1. Occurrence of some adventive species (neophytes) on the banks of the Elbe River (Czech Republic) and Danube River (Slovak Republic) on open river bank out of harbours.**

	Elbe	Danube
<i>Acer negundo</i>	X	X
<i>Acorus calamus</i>	X	X
<i>Amaranthus albus</i>	.	X
<i>Amaranthus blitum</i> subsp. <i>emarginatus</i> var. <i>pseudogracilis</i>	.	X
<i>Amaranthus hybridus</i>	.	X
<i>Amaranthus powellii</i>	X	X
<i>Amaranthus retroflexus</i>	X	X
<i>Ambrosia artemisiifolia</i>	.	X
<i>Amorpha fruticosa</i>	.	X
<i>Angelica archangelica</i> subsp. <i>archangelica</i>	X	.
<i>Armoracia rusticana</i>	X	.
<i>Artemisia annua</i>	.	X
<i>Aster novi-belgii</i>	X	.
<i>Aster xsalignus</i>	X	X
<i>Atriplex tatarica</i>	.	X
<i>Bidens frondosa</i>	X	X
<i>Brassica napus</i> subsp. <i>napus</i>	X	.
<i>Calendula officinalis</i>	X	.
<i>Chenopodium pedunculare</i>	.	X
<i>Citrullus lanatus</i>	X	.
<i>Conyza canadensis</i>	X	X
<i>Cucurbita pepo</i>	X	.
<i>Cynodon dactylon</i>	.	X
<i>Echinocystis lobata</i>	.	X
<i>Echinops sphaerocephalus</i>	X	.
<i>Epilobium dodonaei</i>	.	X
<i>Eragrostis albensis</i>	X	.

<i>Eragrostis minor</i>	.	X
<i>Erigeron annuus</i> subsp. <i>annuus</i>	X	X
<i>Galingsoga ciliata</i>	X	.
<i>Galingsoga parviflora</i>	X	.
<i>Helianthus annuus</i> var. <i>macrocarpus</i> (DC.) COCKERELL	X	X
<i>Helianthus tuberosus</i>	X	X
<i>Impatiens glandulifera</i>	X	X
<i>Impatiens parviflora</i>	X	X
<i>Iva xanthiifolia</i>	.	X
<i>Kochia scoparia</i> subsp. <i>scoparia</i>	.	X
<i>Matricaria discoidea</i>	X	.
<i>Oenothera biennis</i>	X	.
<i>Oenothera depressa</i>	.	X
<i>Oenothera pycnocarpa</i>	X	.
<i>Oenothera rubricaulis</i>	X	.
<i>Reynoutria japonica</i>	X	.
<i>Robinia pseudacacia</i>	X	X
<i>Rumex patientia</i>	.	X
<i>Rumex thyrsiflorus</i>	X	.
<i>Setaria macrocarpa</i> (= <i>S. faberi</i> auct.)	X	.
<i>Sisymbrium loeselii</i>	X	X
<i>Solanum decipiens</i>	X	.
<i>Solanum lycopersicum</i>	X	X
<i>Solidago canadensis</i>	X	.
<i>Solidago gigantea</i>	.	X
<i>Xanthium albinum</i>	X	.
<i>Xanthium saccharatum</i>	.	X
<b>Total</b>	<b>36</b>	<b>33</b>