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Influence of railway transport in the South-East of Slovakia on formation of adventive flora in Central Europe

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Abstract: The contribution features data on the occurrence of plants introduced mostly by the year 1979 via grain railway transports from the territory of former USSR (mostly south of Ukraine, South-East of the European part of Russia, Central Asia) to the areas of 3 selected railway transhipment stations (Čierna nad Tisou and its wider vicinity) in the „Východoslovenská nížina" (East-Slovakian Plain), in the Slovak Republic. On these localities, approximately 500 species of vascular plants are present, of which around one third is recognized as phytogeographically important (in total, 144 taxa). This new reservoir of diasporas of eastern synanthropic plant species can have a significant impact on the present diversity of Slovak flora as well as flora of neighbouring countries. Almost half of those 144 species, listed in the contribution, have more or less continental distribution. In majority it concerns thermophilous steppe and forest-steppe to semi-desert species (the latter ones only very rarely) of southern territories, which is correlated of the South-East of Slovakia. Moreover, for the first time, two following species, introduced into the transhipment station in Čierna nad Tisou from the East, are published for the flora of Slovakia: *Artemisia dniproica* Klokov and *Centaurea adpressa* (Ledeb.) Prodan. Apart from continental species, also Mediterranean species s.l. are frequently present. In addition, the number of North American species is relatively high. They were spreading in a westerly direction, probably from the East, where they have already become occasionally naturalised. All these species gradually enrich the eastern migration route of adventive plants in Central Europe.

Key words: alien plants, continental species, eastern migration route, Slovakia, Central Europe

1. Introduction

Particularly after the World War Two, apart from other commodities, also grain (mostly wheat for human consumption – cf. Jehlík 1981) was imported westward – from the East (Soviet Union at that time) through the East of Slovakia (Čierna nad Tisou and other transhipment stations) into former Czechoslovakia by railway. In the work, we summarize data, mostly from the years 1964-1998, on the occurrence of selected plant species introduced predominantly with imported grain, rarely by another means, to 3 important localities in the South-East of Slovakia (Čierna nad Tisou, Dobrá at Čierna nad Tisou, Veľké Kapušany) (Appendix 1). For the most part, a continuous introduction of these species ceased in the years 1978-1979, when Czechoslovakia stoppped its dependence on import of grain for human consumption from abroad (cf. Jehlík 1998).

2. Characteristic of the study area

2.1. Climatic characteristics

All three studied localities are situated along railway lines, close to Slovakia – Ukraine border crossings on the territory of the "Východoslovenská nížina" or "Potiská nížina" (The Tisa River Plain) that is characterised by warm, moderately dry climate with a relatively cold winter, plain terrain and fertile soils. The "Východoslovenská nížina" represents a northern edge of the Velká uherská nížina (Great Hungarian Plain) (Alföld) while its boundary on the North is formed by the Vihorlat Mountains. A significant part of the plain consists of an alluvium while its lowest point lies at the height of 95 m a.s.l. (Streda nad Bodrogom) (Briedoň in Petrovič 1966). The climate of 3 localities is well characterized by climatic data from the nearby meteorological station in Kráľovský Chlmec (122 m s.m., 48°

25˙N, 21°59˙E) (Vesecký *et al*. 1961) (Table 1). Compared with other localities on the territory of Slovakia, the "Východoslovenská nížina" belongs to the territories with a relatively higher continental impact, which is evidenced by the respective values of thermic continentality (in accordance with the formula of Gorczyński and Hrudička 1932) for the East of Slovakia. Thermic continentality for Kráľovský Chlmec is approximately 35% (Petrovič 1966), while continentality significantly declines in a westerly direction (e.g.: 31.4% in Bratislava, 25.5% in Prague (Klementinum) and only 21.8% in Benešov nad Ploučnicí (all Hrudička 1932).

Table 1. Climatic data from the meteorological station in Kráľovský Chlmec

Mean temparature [°C]					Mean precipitation [mm]			
annual	coldest month (January)	warmest month (July)	growing season (IV-IX)	≥10°C (IV-X)	annual	monthly maximum (June)	growing season	winter (X-III)
9.3	–3.1	20.3	16.5	7 months	626	73	326	257

When calculating thermic continentality, the data are used from the meteorological station in Verkhoyansk, in Eastern Siberia, for which a continentality of 100% is considered. It results clearly from the above mentioned comparison that on the territory of Central Europe, and also in the East, prevails the impact of the ocean circulation, despite the fact that continentality significantly increases here, which is manifested also by a more frequent occurrence of thermophilous plants from the steppe areas of Ukraine, South-East of Russia and, possibly very rarely, also from the steppes and semi-deserts of Central Asia. Moreover, in accordance with Alisov (1950), former Czechoslovakia is located in the moderate climate zone, in its Atlantic-continental or continental-European region (Alisov *et al*. 1954), for which significant alteration of seasons is typical, i.e., from cold winter with snow cover to warm summer and relatively long transitional seasons (cf. Petrovič 1966). Similarity of climatic characteristics of the "Východoslovenská nížina" with the features of the "Velká uherská nížina" (Alföld) are clearly visible when comparing maps of climatic regions in both climatically related territories (Petrovič 1966; Réthly 1937). Also in accordance with the newer classification of world climate, our localities are situated in the temperate-continental climate zone (Rudloff 1981).

2.2. Remarks to individual localities

The railway station Čierna nad Tisou (103 m a.s.l.; in the past, Čierna at Čop) was built as early as in the year 1872, as a border crossing station on the railway Slovenské Nové Město – Čierna at Čop – Čop (Štěpán 1959). In the year 1947, the station was connected by a broad-gauge railway with the Ukrainian Čop. At that time, 3,500 tons of goods were trans-shipped daily. A big transhipment railway station in this area was built in the years 1948-1959. As an example, by the year 1965, in total, 11.7 million tons per year were already trans-shipped at this place. Common goods (including grain), imported from USSR, were trans-shipped in Čierna nad Tisou, while goods exported into USSR were trans-shipped in Čop (Kubáček *et al*. 1999). The volume of trans-shipped goods clearly shows that Čierna nad Tisou represented a kind of an "inland port", often facilitating also migration of eastern adventive species and, possibly, the process of apophytization of some native thermophilous species from agricultural areas. In the year 1949, Slavomil Hejný, carried out his first botanical observations at the station and he visited the locality also in the year 1957 (both Hejný, verbal communication). Some plants collected by S. Hejný on his second excursion, such as *Sisymbrium polymorphum*, can be found in the herbarium collection in Prague (PR). In the years 1964 to 1998, V. Jehlík carried out his botanical research at this locality on several occassions, sometimes also with his colleagues: in September 1980 with S. Hejný and in the years 1984 and 1989 with J. Dostálek, I. Landa and J. Smažík.

Dobrá – a grain transhipment station with a silo and a railway yard, situated at the western end of the railway station premises in Čierna nad Tisou, near the village Dobrá, at the railway stop Biel, 100 m a.s.l. This transhipment station has been operating probably since the year 1974. The checklist of eastern species is similar at this place to the list of species from the transhipment station in Čierna nad Tisou. V. Jehlík carried out botanical research in this locality for the first time on September 9, 1977.

Veľké Kapušany – a coal transhipment station, situated east of a railway station of the same name, 110 m a.s.l. It is the broad-gauge railway station, which originally served, at least until April 30, 1961, or possibly even 1962, for transhipment of grain from the former USSR. Later on, it was used mostly as coal transhipment station. In the localities 2 and 3 field studies were carried out by V. Jehlík, sometimes in cooperation with his colleagues mentioned above.

3. Data collecting

In the years 1964-1998, the flora of localities in Čierna nad Tisou and at the coal transhipment station in Veľké Kapušany was studied while in the years 1977-1998, at the grain transhipment station in Dobrá next to

Čierna nad Tisou. The particular attention was paid to the plants introduced with eastern grain. This phenomenon intensified significantly in the years 1945-1979 (Jehlík 1998). Apart from this, the "Eastern Route" was responsible also for some occasional introduction of plants with American grain, imported from the former USSR through Čierna nad Tisou to the West, for example, in the year 1980. All material was collected and revised or identified for the most part by the first of the authors. All herbarium specimens (several thousand) are deposited in the herbarium collection of the Institute of Botany, Academy of Sciences of the Czech Republic in Průhonice (PRA), the collections of S. Hejný, and partially also of V. Jehlík in the herbarium of National Museum in Prague (PR). To characterize so called "Eastern migration route of adventives" (Jehlík & Hejný 1974; Jehlík 1998, 2005), an overview of the most important thermophilous plants was provided for three important localities. On the basis of floristic, economic-geographical and climatic data, importance of East-Slovakian localities for biodiversity of the Flora of Slovakia was interpreted (see Appendix 1). With only minor exceptions, the list of species does not include commonly cultivated cultural plants, although, together with their seeds, diasporas of alien plants were usually introduced. Botanical nomenclature is used in accordance with Kubát (2002), Komarov (1934-1966) and Tutin *et al*. (1964, 1968, 1972, 1976, 1980).

4. Results and discussion

The Appendix 1 lists 144 important introduced plants from three East-Slovakian localities. In addition, the Appendix lists some thermophilous apophytes, frequently introduced from the East, among others, with grain, while their original occurrence in the South-East of Slovakia is sometimes questionable. It lists also some rare archaeophytes that are still more frequent in Ukraine and in the South-East of the European part of Russia but, along with grain, they can spread from these regions to the West. The species introduced with eastern grain to Slovakia can be divided into 3 groups: (*i*) Ukrainian, particularly from steppe regions; (*ii*) South-East of the European part of Russia, (*iii*) Central Asian (e.g. from Kazakhstan). The 3rd group (originating from Central Asia) includes, for example: *Acroptilon repens, Artemisia sieversiana, Atriplex micrantha, Kochia scoparia* subsp. *densiflora, Lepyrodiclis holosteoides, Salsola collina*. It means that the highly continental species present in Central Europe occur frequently only as temporary species. The larger group of species listed in the Appendix 1 originate from North America, however, in Ukraine and Russia they tend to get occasionally naturalised, so it can be assumed that they came to the East of Slovakia already from their secondary area in the East (South of Ukraine and Russia). This group comprises, e.g.: *Acer negundo, Amaranthus* sp. div., *Ambrosia artemisiifolia, Bidens frondosa, Conyza canadensis, Cuscuta campestris, Erigeron annuus* (mostly subsp. *annuus*), *Galinsoga parviflora, G. ciliata, Helianthus tuberosus* s.l., *Iva xanthiifolia, Juncus tenuis, Lepidium densiflorum, Oenothera depressa, Panicum capilare* s.l., *P. dichotomiflorum, Robinia pseudoacacia, Xanthium* sp. div. Moreover, around the year 1979, also North-American grain (including maize) was, from time to time, imported through Čierna nad Tisou from the former USSR and, in this way, also some overseas weed species were introduced, like for example: *Amarantus palmeri, Ambrosia trifida, Ipomoea hederacea* var. *hederacea, Chenopodium missouriense*, perhaps due to the above mentioned relatively continental climate.

Around 500 species of vascular plants have been recorded at three East-Slovakian transhipment stations. Out of them, in the Appendix 1 we list approximately one third, i.e. 144 taxa (100%) most important with regard to phytogeography. From among these, almost half (66 taxa, 46.5%) constitute continental, possibly sub-continental species, originating from the area extending from the South-East of Europe to Central Asia (in particular, with reference to Protopopova 1991 and Oberdorfer 1994). The number of species found, correlates with the meso-climate of "Východoslovenská nížina". There are frequently present also Mediterranean species s.l., i.e. East-Mediterranean species, less frequently West-Mediterranean species and sub-Mediterranean species, often also partly showing continental distribution. There is also a large group of American species which has been already discussed above.

For the first time, two following species introduced from the East have been recorded for the Flora of Slovakia (Appendix 1): *Artemisia dniproica* and *Centaurea adpressa*.

Artemisia dniproica Klokov (description: Klokov 1962: 330-333, cf. Fig. 61: panicle narrow, sed cf. incorrectly Tutin 1976: 462 ut *Artemisia campestris* L. subsp. *campestris*) was discovered and collected in the surroundings of the transhipment station in Čierna nad Tisou (only several plants that later vanished) (27.09.1968, leg. V. Jehlík, det. M. V. Klokov, PRA). *Centaurea adpressa* (Ledeb.) Prodan (description: Prodan & Nyárády 1964: 831-832, Table 168; Mądalski & Ciaciura 1972: 59-61, 41; Tzvelev 1963: 507-508, 497; Dostál 1976: 268) was collected at the transhipment station in Čierna nad Tisou (syn.: *C. apiculata* Ledeb. subsp. *adpressa* (Ledeb.) Dostál, *Colymbada adpressa* (Ledeb.) Holub) (2.07.1979, leg. V. Jehlík, det. V. Jehlík, PRA). The listed 3 species belong to the group of adventives spreading along the Eastern Migration Route (cf. Jehlík & Hejný 1974; Jehlík 1998, 2005).

The contribution represents the first summary work on the species composition of the Eastern adventives

on the territory of the Slovak Republic. Another research on the issues resolved is carried out on the territory of the Slovakia and the Czech Republic. The research is especially important for acquiring information on the biodiversity of Slovak flora, invasive species and for crop protection.

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Appendix 1. Occurrence of important adventive species originating from the East at three major railway localities in Eastern Slovakia

Taxon	1	2	3	4
Abutilon theophrasti Med.	.	×	×	.
Acer negundo L.	.	×	×	.
Acroptilon repens (L.) DC.	×	×	.	.
Aegilops cylindrica Host	×	×	×	×
Ailanthus altissima (Mill.) Swingle	.	×	.	.
Amaranthus albus L.	.	×	×	×
Amaranthus blitoides S.Watson	.	×	×	.
Amaranthus powellii S.Watson	.	×	×	.
Amaranthus retroflexus L.	.	×	×	×
Ambrosia artemisiifolia L.	.	×	×	×
Anthemis ruthenica M. Bieb.	×	×	.	.
Artemisia abrotanum L.	.	×	.	.
Artemisia annua L.	×	×	.	.
Artemisia campestris L. s.l.	×	.	×	.
Artemisia dniproica Klokov	×	×	.	.
Artemisia dracunculus L.	×	×	.	.
Artemisia repens Willd.	×	×	.	×
Artemisia scoparia W. et K.	×	×	.	.
Artemisia sieversiana Willd.	×	×	×	.
Atriplex micrantha Ledeb.	×	×	×	.
Atriplex sagittata Borkh.	×	×	.	.
Atriplex tatarica L.	×	×	.	×
Avena fatua L.	.	×	×	×
Bidens frondosa L.	.	.	.	×
Brassica armoracioides Czern. ex Turcz.	×	×	×	.
Brassica nigra (L.) Koch	.	.	.	×
Bromus arvensis L.	.	×	×	.
Bromus japonicus Thunb.	×	×	×	×
Bromus secalinus L.	.	×	×	.
Bunias orientalis L.	.	×	.	×
Camelina microcarpa DC. s.l.	×	×	×	.
Camelina rumelica Velen.	×	×	.	.
Cannabis ruderalis Janisch.	×	×	×	.
Centaurea adpressa (Ledeb.) Prodan	×	×	.	.
Centaurea cyanus L.	.	×	.	.
Centaurea diffusa Lamk.	×	×	.	×
Cerinthe minor L.	×	×	.	.
Chenopodium botrys L.	.	×	.	.
Chenopodium probstii Aellen	.	×	×	.
Chenopodium strictum Roth	×	×	×	×
Chenopodium suecicum J. Murr	×	×	.	.
Chenopodium urbicum L. s.l.	×	×	×	.
Chorispora tenella (Pallas) DC.	.	×	.	.
Commelina communis L.	.	×	.	.
Conringia orientalis (L.) Dum.	×	×	.	.
Consolida orientalis (Gr. et Godr.) Schödinger	×	×	.	.
Consolida regalis S. F. Gray	×	×	×	×
Conyza canadensis (L.) Cronquist	.	×	×	×
Crepis setosa Haller fil.	.	×	.	.
Cuscuta campestris Yuncker	.	×	.	.
Cynodon dactylon (L.) Pers.	.	×	×	.
Datura stramonium L.	.	×	×	.
Dracocephalum thymiflorum L.	×	×	×	.
Echinochloa crus-galli (L.) P. B.	.	×	×	×
Echinops sphaerocephalus L.	.	.	×	.
Eragrostis minor Host	.	×	×	×
Eragrostis pilosa (L.) P. B.	.	×	×	×
Erigeron annuus (L.) Pers. subsp. *annuus*	.	×	×	×
Eruca sativa Mill.	.	×	.	.
Eryngium planum L.	×	×	.	×
Erysimum diffusum Ehrh.	×	×	×	.
Erysimum repandum L.	×	×	×	.
Euphorbia exigua L.	.	×	.	.
Euphorbia platyphyllos L.	.	.	×	.
Euphorbia waldsteinii (Soják) A. R. Smith	×	×	.	×
Fagopyrum esculentum Moench	×	×	×	.
Fagopyrum tataricum (L.) Gaertn.	×	×	.	.
Fumaria schleicheri Soy.-Will.	×	×	.	.
Fumaria vaillantii Loisel.	×	×	.	.
Galega officinalis L.	.	×	.	×
Galinsoga ciliata (Rafin) Blake	.	.	×	.

Galinsoga parviflora Cav.	.	×	×	.
Galium rubioides L.	×	×	.	.
Galium tricornutum Dandy	×	×	.	.
Glaucium corniculatum (L.) Rudolph	.	×	.	.
Glycine max (L.) Merrill	.	×	×	.
Gypsophila perfoliata L. s.l.	×	×	.	.
Helianthus annuus L. var. *annuus* (= f. *silvester* Thell.)	.	×	.	.
Helianthus tuberosus L. s.l.	.	×	.	.
Hibiscus trionum L.	.	×	.	.
Hyoscyamus niger L.	×	×	×	.
Iva xanthiifolia Nutt.	.	×	×	.
Juncus tenuis Willd.	.	.	.	×
Kickxia elatine (L.) Dum.	.	×	.	.
Kochia scoparia (L.) Schrader subsp. *densiflora* (Moq.) Aellen	×	×	×	.
Kochia scoparia (L.) Schrader subsp. *scoparia*	×	×	×	×
Lactuca tatarica (L.) C. A. Meyer	×	×	×	×
Lappula consanguinea (Fisch. et C. A. Meyer) Gürke	×	×	.	.
Lappula squarrosa (Retz.) Dum.	×	×	.	.
Lathyrus tuberosus L.	×	×	×	×
Lavatera thuringiaca L.	×	×	.	.
Lepidium campestre (L.) R.Br.	.	×	×	.
Lepidium densiflorum Schrader	.	×	×	×
Lepidium latifolium L.	.	×	.	.
Lepidium perfoliatum L.	×	×	.	.
Lepyrodiclis holosteoides (C. A. Meyer) Fisch et Meyer	×	×	.	.
Melilotus wolgicus Poiret	.	×	.	.
Misopates orontium (L.) Rafin.	.	×	.	.
Nigella arvensis L.	.	×	.	.
Oenothera depressa Greene	.	×	×	×
Oryza sativa L.	.	.	×	.
Oxalis dillenii Jacq. s.l.	.	×	×	.
Panicum capillare L. subsp. *capillare*	.	×	×	.
Panicum capillare L. subsp. *barbipulvinatum* (Nash) Tzvelev	.	×	.	×
Panicum dichotomiflorum Michx. var. *dichotomiflorum*	.	×	.	.
Panicum miliaceum L. s.l., incl. subsp. *agricola* H. Scholz et Mikoláš	×	×	×	.
Papaver maculosum Schur subsp. *austromoravicum* (Kubát) Kubát	.	×	.	.
Plantago arenaria W. et K.	×	×	×	.
Portulaca oleracea L. subsp. *oleracea*	.	×	×	.
Potentilla intermedia L.	.	×	.	.
Puccinellia distans (Jacq.) Parl.	.	×	.	×
Rapistrum perenne (L.) All.	×	×	.	.
Reseda lutea L.	.	×	×	×
Robinia pseudacacia L.	.	×	.	.
Rorippa austriaca (Crantz) Besser	.	×	×	.
Rumex patientia L. subsp. *patientia*	.	×	×	.
Rumex stenophyllus Ledeb.	×	×	.	.
Rumex thyrsiflorus Fingerh.	.	×	×	×
Salsola collina Pallas	×	×	.	.
Salsola kali L. subsp. *rosacea* Čelak.	×	×	.	.
Salvia nemorosa L. s.l.	×	×	.	×
Salvia verticillata L.	×	×	×	.
Setaria macrocarpa Lucznik	.	×	×	.
Setaria viridis (L.) P. B. subsp. *pycnocoma* (Steud.) Tzvelev	.	×	×	.
Setaria viridis (L.) P. B. subsp. *viridis*	.	×	×	.
Sideritis montana L.	×	×	×	.
Silene dichotoma Ehrh.	.	×	.	.
Sisymbrium altissimum L.	×	×	×	.
Sisymbrium loeselii L.	×	×	×	×
Sisymbrium orientale L.	.	×	×	×
Sisymbrium polymorphum (Murray) Roth	×	×	.	.
Sisymbrium volgense E. Fourn.	×	×	×	×
Solanum decipiens Opiz	.	×	.	.
Solidago canadensis L.	.	.	×	×
Solidago gigantea Ait.	.	×	.	×
Sorghum halepense (L.) Pers.	.	×	×	.
Stachys annuua (L.) L.	.	×	×	.
Stachys recta L.	.	×	.	.
Tragopogon dubius Scop.	.	×	.	.
Verbascum blattaria L.	×	×	×	×
Vicia grandiflora Scop.	×	.	.	×
Xanthium albinum (Widd.) H. Scholz et Sukopp	.	×	×	×
Xanthium spinosum L.	.	×	×	.
Xanthium strumarium L.	×	×	.	×

Explanations: 1 – continental steppe species of Euro-Asian origin, 2 – Čierna nad Tisou, 3 – Dobrá at Čierna nad Tisou, 4 – Veľké Kapušany, transhipment stadion