Thaiszia - J. Bot., Košice, 25 (2): 143-151, 2015
http://www.bz.upjs.sk/thaiszia

THAISZIA
JOURNAL OF
BOTANY

Spreading of alien species in disturbed area: a case study from Opatovce nad Nitrou (SW Slovakia)

MICHAL ŽABKA, ĽUBA ĎURIŠOVÁ & PAVOL ELIÁŠ JUN.

Department of Botany, Slovak University of Agriculture, Tr. A. Hlinku 2, SK-94976, Nitra, Slovakia; michalzabka89@gmail.com, luba.durisova@uniag.sk, pavol.elias.jun@gmail.com

Žabka M., Ďurišová Ľ. & Eliáš P. jun. (2015): Spreading of alien species in disturbed area: a case study from Opatovce nad Nitrou (SW Slovakia). – Thaiszia – J. Bot. 25 (2): 143-151. – ISSN 1210-0420.

Abstract: This work presents comprehensive study of floristic composition of a disturbed area, primary aimed on the spreading of alien species. Moreover, alien species have been sorted into the categories based on their environmental effects to the native biodiversity. Floristic exploration of vascular plants was conducted during growing season in a territory near the village of Opatovce nad Nitrou in years 2010–2012. Part of this area was affected by an anthropogenic disturbance during construction of new confluence of the rivers Nitra and Handlovka. Through these activities the river beds, adjacent ecotones and also agrocoenosis have been disrupted. During the floristic survey 172 species of vascular plants were found, 44 species were evaluated as an alien (4 species belonged to casual, 30 species were naturalized, 7 species were invasive and 3 species with uncertain classification). This work is bringing the attention to the negative impact of an anthropogenic interventions to the native and semi-native plant communities which resulted to the threat of biodiversity due to spreading of alien species, especially invasive plants.

Keywords: floristic survey, alien species, anthropogenic disturbance

Introduction

Along with the vast global changes that have resulted from the dramatic increase in numbers of people worldwide over the last few centuries and decades, there has been an increasing concern about the consequences of the

introduction and spreading of alien species. As numerous studies have shown, both intentionally and accidentally introduced alien species of plants may have huge environmental effects on the native biodiversity, through changes in the community structure, nutrient cycles, trophic levels, hydrology, fire regimes, allelopathy, competition, hybridization and others (MACK et al. 2000, PIMENTEL 2002).

The invasion of alien species into new ecosystems is accelerating as the world's human population multiplies and goods are transported even more rapidly on an increasingly global scale. The invasive species are partially the cause of the loss of biodiversity throughout in the world (PIMENTEL 2002).

It is possible to avoid damage to native ecosystems by exotic species and the associated costs if such harmful species are not used and planted in the first place. However, this step requires knowledge as to whether a particular species will become invasive where it has been introduced but is not yet widespread, or where it is intended for introduction, e.g., the species must be recognised as potentially invasive (RICHARDSON et al. 1990).

Three stages of an invasion status are known: casual, naturalized and invasive, following the definition of RICHARDSON et al. (2000). The casual taxa are defined as alien taxa that may flourish and eventually reproduce in an area but do not form self-reproducing populations and therefore are dependent on the repeated introductions. The naturalized aliens reproduce regularly, forming stable populations lasting for many life cycles. The invasive taxa are naturalized aliens whose propagules are able to spread over a considerable area (MEDVECKÁ et al. 2012).

Our research was aimed on the comprehensive characterization of flora, especially on the presence and spreading of alien plants in a disturbed area.

Material and methods

Floristic exploration of the vascular plants was conducted during vegetation season during the years 2010-2012. A studied territory is near the village Opatovce nad Nitrou, in confluence of the rivers Nitra and Handlovka (GPS coordinates: N 48.747238, E 18.558911). This area was very affected by anthropogenic influence in 2009. The research area was divided into the three sections according to different environmental conditions: i) *Riverside* (1) – a new man-made confluence of the rivers since 2009, ii) *Glade* (2) – there was a forest, but it was thoroughly cut down in 2009, iii) *Forest* (3) – this section was not disrupted. For better understanding see the map below (Fig. 1).

All taxa of vascular plants founded in the location have been stored in the Herbarium at the Department of Botany, Slovak University of Agriculture in Nitra (NI). All of the species were collected and divided into the three sections mentioned above. The nomenclature of taxa follows MARHOLD et al. (1998).

Alien taxa were identified according to MEDVECKÁ et al. (2012). The definitions proposed by RICHARDSON et al. (2000) and further elaborated by PYŠEK et al. (2004), BLACKBURN et al. (2011) and MEDVECKÁ et al. (2012) were used to characterize invasion status of the each sampled taxon. Every taxon of alien

plant was determined and divided in the following four categories: casual, naturalized, invasive and with uncertain classification.

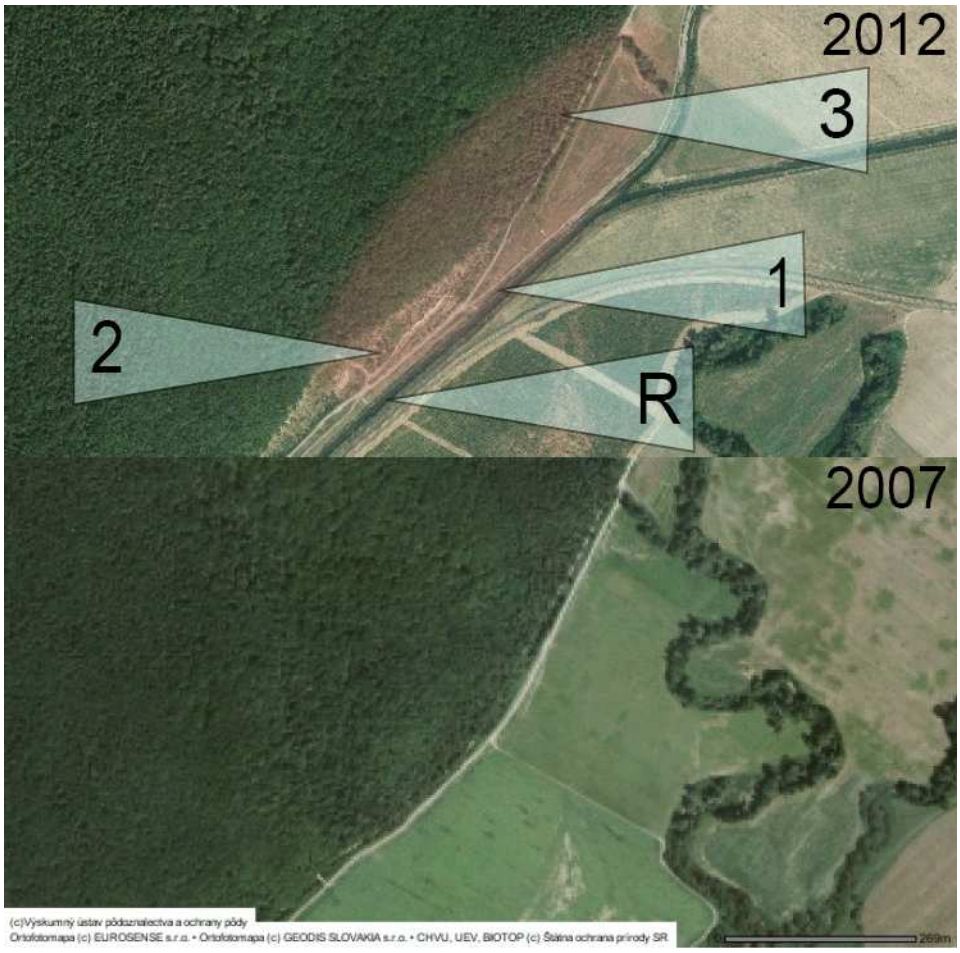

Fig. 1. Map of studied area in surrounding of confluence of the rivers Nitra and Handlovka before and after anthropogenic disturbance (VÝSKUMNÝ ÚSTAV PÔDOZNALECTVA A OCHRANY PÔDY 2015).
Explanatory of signs: 1 – riverside, **2** – glade, **3** – forest. Letter **R** points out position of river.

Results and discussion

172 taxa of vascular plants were found during the floristic exploration. According to MEDVECKÁ et al. (2012) 44 species of alien plants were identified from all of taxa. Complete list of alien taxa is presented with more information in the Tab. 1.

Tab. 1. The list of the alien vascular plant species in surrounding of confluence of the rivers Nitra and Handlovka during the years 2010-2012.

Name of taxon	Year	SE	IS	RT	TolI	LU	Origin
Amaranthus retroflexus L.	11/12	1,2	inv	neo	1830	H	CAm SAm
Anagallis arvensis L.	10/11/12	1	nat	arch	R	H S N	E As Af
Apera spica-venti (L.) P.Beauv.	10/11/12	1	inv	arch	–	H S N	E As
Arctium tomentosum Mill.	10/11/12	3,2	nat	arch	–	H S N	E As
Ballota nigra L.	10/11/12	3	nat	arch	–	H S N	E As Af
Brassica napus L.	10/11	1	cas	neo	1913	H	C
Bromus sterilis L.	10/11/12	1	nat	arch	–	H S N	E As
Capsella bursa-pastoris (L.) Medik.	10/11/12	1,3	nat	arch	–	H S N	E
Carduus acanthoides L.	10/11/12	1,2	nat	arch	–	H S N	E As
Cichorium intybus L.	10/11/12	2,3	nat	arch	–	H S N	E As Af
Convolvulus arvensis L.	10/11	1	nat	arch	I	H S N	E As Af
Daucus carota L.	10/11/12	2,3	nat	arch	M	H	C
Echinochloa crus-galli (L.) P. beauv.	11	1	inv	arch	N	H S N	E As
Fallopia japonica (Houtt.) Ronse Decr.	10/11/12	3	inv	neo	1920	H S N	As
Geranium dissectum L.	12	1,2	nat	arch	–	H S	E As
Helianthus annuus L.	10	1	cas	neo	1830	H S	NAm
Helianthus tuberosus L.	10/11/12	3	inv	neo	1830	H S N	NAm
Chelidonium majus L.	10/11/12	3	nat	arch	R	H S N	E As
Chenopodium album L.	12	1	unc	–	–	–	–
Impatiens glandulifera Royle	10/11/12	1	inv	neo	1858	H S N	As
Impatiens parviflora DC.	10/11/12	3	inv	neo	1897	H S N	As
Iva xanthiifolia Nutt.	11/12	2	nat	neo	1934	H S N	NAm
Lamium album L.	12	2	nat	arch	–	H S N	E As
Lamium purpureum L.	10/11/12	2,3	nat	arch	R	H S N	E As Af
Lathyrus tuberosus L.	10/11/12	1	nat	arch	–	H S N	E As
Medicago sativa L.	10/11/12	1	nat	neo	1830	H S N	As
Melilotus albus Medik.	10/11/12	1,2	nat	arch	–	H S N	E As Af
Papaver rhoeas L.	10/11/12	2	nat	arch	–	H S N	E As Af
Setaria pumila (Poir.) Roem. et Schult.	10/11/12	2,1	nat	arch	N	H S N	E As
Silene latifolia subsp. *alba* (Mill.) Greuter et Burdet	10/11/12	3	nat	arch	–	H S N	E As Af
Sisymbrium officinale (L.) Scop.	11	2	nat	arch	–	H S	E As Af
Sonchus oleraceus L.	10	1,2	nat	arch	R	H S N	E As Af
Tanacetum vulgare L.	10/11/12	2,3	unc	–	–	–	–
Thlaspi arvense L.	10/11/12	1,3	nat	arch	B	H S N	E As Af
Triticum aestivum L.	10/11	1,2	cas	arch	N	H	C
Verbena officinalis L.	10/11/12	2,3	nat	arch	–	H S N	E As Af
Veronica hederifolia L.	10/11/12	1,2,3	unc	–	–	–	–
Veronica persica Poir.	10/11/12	1,2,3	nat	neo	1844	H S N	As
Veronica polita Fr.	10/11/12	1,2,3	nat	arch	–	H S N	E As Af
Vicia hirsuta (L.) Gray	10	1	nat	arch	R	H S N	E As Af
Vicia tetrasperma (L.) Schreb.	10/11/12	1	nat	arch	M	H S N	E As Af

Tab. 1. – cont.

Name of taxon	Year	SE	IS	RT	ToI	LU	Origin
Vicia villosa Roth	10/11/12	1	nat	arch	–	H S N	E As
Viola arvensis Murray	10/11/12	1,2	nat	arch	–	H S N	E As Af
Zea mays L.	10/11	1	cas	neo	1830	H S	CAm

Explanatory of abbreviations: Year of occurrence. **Section (SE)**: (1) – riverside, (2) – glade, (3) – forest. **Invasion status (IS)**: cas – casual, nat – naturalized, inv – invasive, unc – uncertain. **Residence time (RT)**: arch – archaeophyte, neo – neophyte. The **time of introduction (ToI)** for neophytes informs about the year of the first occurrence of the taxon within the Slovakia. We mention the era from which is the first archaeological evidence of the occurrence for archaeophytes: N – Neolithic and Aeneolithic era (5700-1900 BC), B – Bronze Age (1900-700 BC), I – Iron Age (700-0 BC), R – Roman and Migration period (0-565 AD), M – Medieval period (565–1500 AD). **Land-use (LU)** category shows the type of invaded habitat: H – human-made, S – semi-natural, N – natural. **Origin**: Af – Africa, As – Asia, C – from cultivation (anecophyte), CAm – Central America, E – Europe, NAm – North America, SAm – South America; some categories are not given for the taxa of uncertain origin. (MEDVECKÁ et al. 2012)

Important factor determining influence to the ecotons and agrocoenosis is proportion of alien species from all taxa (Fig. 2). There is relatively high ratio of non-native taxa in the area. Then, there is also necessary to divide alien species in the subgroups according to invasion status (Fig. 3).

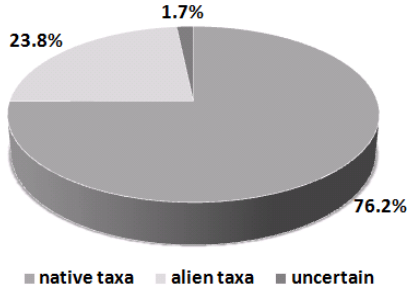

Fig. 2. Proportion of alien species on total floristic composition in surrounding of confluence of the rivers Nitra and Handlovka during the years 2010-2012.

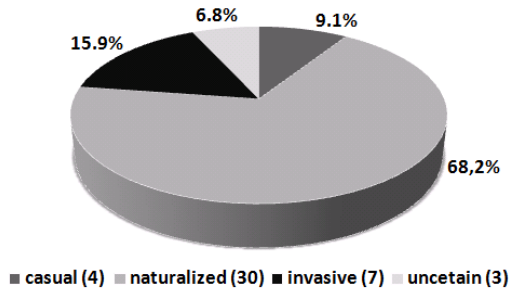

Fig. 3. Dividing of alien species in subgroups according to invasion status in surrounding of confluence of the rivers Nitra and Handlovka during the years 2010-2012. Numbers in brackets express count of taxa for subgroups.

Seven alien species with status invasive were determined, thus seven the most dangerous from the whole floristic composition: *Amaranthus retroflexus*, *Apera spica-venti*, *Echinochloa crus-galli*, *Helianthus tuberosus*, *Fallopia japonica*, *Impatiens glandulifera* and *I. parviflora*. Summary numbers of taxa divided according to invasion status and residence time (archaeophytes/neophytes) are given in Tab. 2.

Tab. 2. Number and ratio of various subgroups of alien taxa in surrounding of confluence of the rivers Nitra and Handlovka during the years 2010-2012.

Status	2010	2011	2012	Entire period (2010-2012)	Proportion from all alien taxa [%]
archaeophytes	27	27	25	30	68.2
neophytes	9	10	8	11	25
uncertain	2	2	3	3	6.8
casual	4	3	0	4	9.1
naturalized	27	27	27	30	68.2
invasive	5	7	6	7	15.9
uncertain	2	2	3	3	6.8
together	38	39	36	44	100

Subgroup of archaeophytes had the highest abundance in the area; by contrast neophytes had the most significant effect because there were five from the seven taxa with status invasive. Number of taxa with invasion status casual decreased over the years of research; there already were not any of them in year 2012. That is related to their temporarily occurrence in the natural conditions.

There are some plant families with bigger proportion of the alien species in area (Tab. 3). Especially *Asteraceae, Fabaceae, Poaceae* and *Brassicaceae* are families with the most significant effect; nearly half of all taxa recorded during field research belong to these families.

Tab. 3. Sorting of alien species by most frequent families and their ratio in surrounding of confluence of the rivers Nitra and Handlovka during the years 2010-2012.

Family	Number of alien taxa	Total number of all taxa in family	Proportion of alien taxa in family [%]	Proportion from all alien taxa [%]
Asteraceae	6	19	31.6	13.6
Fabaceae	6	15	40	13.6
Poaceae	5	21	23.8	11.4
Brassicaceae	4	5	80	9.1
Lamiaceae	3	9	33.3	6.8
Scrophulariaceae	3	9	33.3	6.8
Balsaminaceae	2	2	100	4.5
Cichoriaceae	2	5	40	4.5
Papaveraceae	2	2	100	4.5

Tab. 4. Number and relative number of alien species by sections and invasion status in surrounding of confluence of the rivers Nitra and Handlovka during the years 2010-2012.

Section	Number of alien species	Alien species [%]	Casual [%]	Naturalized [%]	Invasive [%]	Uncertain [%]
Riverside (1)	28	63.6	6.8	38.6	9.1	6.8
Glade (2)	21	47.7	2.3	40.9	2.3	4.5
Forest (3)	17	38.6	0	27.3	6.8	4.5

Alien species were sorted by their occurrence in the three sections of area (Tab. 4). Presence of alien species in the anthropogenically disturbed sections Riverside (63.6%) and Glade (47.7%) was larger, than in the section Forest (38.6%). Most of taxa with status invasive were in section Riverside. On the other hand taxa with status casual were not found in the section Forest.

In general, different authors mentioned higher ratio of the non-native taxa in a disturbed or ruderalized habitats (e.g. fields, waste dumps etc.) (CHYTRÝ et al. 2005, MÁJEKOVÁ & ZALIBEROVÁ 2008, DAR et al. 2015). In the first place, with the biggest number of invasive species, there were habitats of the riverbank and littoral communities (MASKELL et al. 2006, LAPOINTE et al. 2012, UHLIAROVÁ et al. 2012). Riverbanks are also corridors for the spreading of alien species (PYŠEK & PRACH 1993, 1994). These findings correspond very well with our data, where the largest number of alien species was found in the section Riverside.

Casual species, that does not form steady self-reproducing populations in the natural environments (RICHARDSON et al. 2000, PYŠEK et al. 2004), were not spread at the section Forest. The strongest competition was in this habitat so that casual species could not succeed. On the other hand, higher number of the taxa with status invasive was found in semi-natural habitats of the sections Riverside and Glade. Our data confirm the known theory that disturbed habitats are more prone to the invasion of alien species than relatively stable native communities (CHYTRÝ et al. 2005, MÁJEKOVÁ & ZALIBEROVÁ 2008), because disturbance of the natural habitat cause decline of native species and create place for the invasion of aliens (DIDHAM et al. 2007).

ELIÁŠ et al. (1999) performed similar research along the Nitra River. They found large abundance of the species *Helianthus tuberosus.* Presence of *Impatiens parviflora, I. glandulifera* and *Fallopia japonica* was only minimal. ŽGANČÍKOVÁ et al. (2012) found *H. tuberosus* in habitats in surrounding of the Prievidza Town. One of the areas monitored by them is the same area where our research was conducted. ČARVAŠ (2011) detected three invasive alien species in basin of the Morava River: *Impatiens parviflora, Helianthus tuberosus,* and *Fallopia japonica*. Similarly, UHERČÍKOVÁ (1997, 1999, 2001) pointed out some invasive neophytes also from surrounding of the Dunaj River and several authors (UHERČÍKOVÁ & KUBALOVÁ 2001, KRAMÁROVÁ 2004) from inundation area of the Hron River. Based on our and the above mentioned data we can conclude that water flows represent a significant source of invasive neophytes in the landscape in Slovakia, and their impact to the spreading of alien species increases significantly after disturbance of their surroundings.

Conclusion

In total, 44 taxa of alien plants were found during our floristic survey, it represents 23.8% from all recorded taxa. Seven of them were invasive, thirty were naturalised, four were casual and three uncertain species. Thirty archaeophytes, eleven neophytes and three unclassified taxa were recorded during the research. Quantity of the non-native taxa over the years was nearly

balanced, except casual taxa with temporary abundance in the habitats. Most of alien taxa belonged to families *Asteraceae* and *Fabaceae* in the aimed area.

Finally, there is apparent negative impact of the anthropogenic intervention to the relatively stable riverside habitat. Adjacent ecotones and also agrocoenosis have been disrupted through these activities. This was confirmed by high ratio of the alien species in the area, especially invasive plants. Development of the populations of alien taxa should be monitored in the area; especially those with status invasive.

Acknowledgements

This work was co-funded by grant VEGA no. 1/0731/14.

References

BLACKBURN T. M., PYŠEK P., BACHER S., CARLTON J. T., DUNCAN R. P., JAROŠÍK V., WILSON J. R. U. & RICHARDSON D. M. (2011): A proposed unified framework for biological invasions. – Trends Ecol. Evol. 26: 333-339.

ČARVAŠ M. (2011): Dopad šíření invazních druhů rostlin na poříční ekosystém Moravy. – Diploma thesis, Masaryk University, Brno, 70 pp.

DAR A. P., RESHI A. Z. & SHAN A. M. (2015): Roads act as corridors for the spread of alien plant species in the mountainous regions: A case study of Kashmir Valley, India. – Trop. Ecol. 56(2): 183-190.

DIDHAM K. R., TYLIANAKIS M. J., GEMMELL J. N,. RAND A. T. & EWERS M. R. (2007): Interactive effects of habitat modification and species invasion on native species decline. – Trends Ecol. Evol. 22(9): 489-496.

ELIÁŠ P., FEHÉR A. & KONČEKOVÁ L. (1999): Rozšírenie a inváz̆ne správanie sa zavlečených druhov rastlín v povodí rieky Nitra. – In: ELIÁŠ P. (ed.): Inváz̆ia a inváz̆ne organizmy. Sekos, Nitra, p. 158-164.

CHYTRÝ M., PYŠEK P., TICHÝ L., KNOLLOVÁ I. & DANIHELKA J. (2005): Invasions by alien plants in the Czech Republic: a quantitative assessment across habitats. – Preslia, 77: 339-354.

KRAMÁROVÁ J. (2004): Súčasný výskyt a rozšírenie inváznych druhov rastlín pozdĺž rieky Hron. – In: Regióny-vidiek-životné prostredie 2004: zborník príspevkov z medzinárodnej vedeckej konferencie, Nitra, 11. – 12. November 2004. [CD-ROM]. Nitra: FEŠRR SPU v Nitre.

LAPOINTE N. W. R., THORSON J. T. & ANGERMEIER P. L. (2012): Relative roles of natural and anthropogenic drivers of watershed invasibility in riverine ecosystems. – Biol. Inv. 14: 1931-1945.

MACK R. N., SIMBERLOFF D., LONSDALEW M., EVANS H., CLOUT M. & BAZZAZ F. A. (2000): Biotic invasions: causes, epidemiology, global consequences, and control. – Ecol. Appl. 1: 689-710.

MÁJEKOVÁ J. & ZALIBEROVÁ M. (2008): Invasive and expansive plant species in Slovakian agrocoenoses. – Biodiv. Res. Conserv. 9-10: 51-56.

MARHOLD K., GOLIAŠOVÁ K., HEGEDÜŠOVÁ Z., HODÁLOVÁ I., JURKOVIČOVÁ V., KMEŤOVÁ E., LETZ R., MICHALKOVÁ E., MRÁZ P., PENIAŠTEKOVÁ M., ŠÍPOŠOVÁ H. & ŤAVODA O. (1998): Papraďorasty a semenné rastliny. – In: MARHOLD K. & HINDÁK F. (eds), Zoznam nižších a vyšších rastlín Slovenska - Checklist of non-vascular and vascular plants of Slovakia. – Veda, Bratislava, p. 333-687.

MASKELL L. C., BULLOCK J. M., SMART S. M., THOMPSON K. & HULME P. E. (2006): The distribution and habitat associations of non-native plant species in urban riparian habitats. – J. Veg. Sci. 17: 499-508.

MEDVECKÁ J., KLIMENT J., MÁJEKOVÁ J., HALADA Ľ., ZALIBEROVÁ M., GOJDIČOVÁ E., FERÁKOVÁ V. & JAROLÍMEK I. (2012): Inventory of the alien flora of Slovakia. – Preslia, 84: 257-309.

PIMENTEL D. (2002): Biological Invasions: Economic and Environmental Costs of Alien Plant, Animal, and Microbe Species. CRC Press, 384 pp.

PYŠEK P. & PRACH K. (1993): Plant Invasions and the Role of Riparian Habitats: A Comparison of Four Species Alien to Central Europe. – J. Biogeogr. 20(4): 413-420.

PYŠEK P. & PRACH K. (1994): How important are rivers for supporting plant invasions? – In: DE WAAL L. C., CHILD L. E., WADE P. M. & BROCK J. H. (eds), Ecology and management of invasive riverside plants, p. 19-26.

PYŠEK P., RICHARDSON D. M., REJMÁNEK M., WEBSTER G. L., WILLIAMSON M. & KIRSCHNER J. (2004): Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. – Taxon 5: 131-143.

RICHARDSON D. M., COWLING R. M. & LE MAITRE D. C. (1990): Assessing the risk of invasive success in *Pinus* and *Banksia* in South African mountain fynbos. – J. Veg. Sci. 1: 629-642.

RICHARDSON D. M., PYŠEK P., REJMÁNEK M., BARBOUR M. G., PANETTA F. D. & WEST C. J. (2000): Naturalization and invasion of alien plants: concepts and definition. – Diversity Distrib. 6: 93-107.

UHERČÍKOVÁ E. & KUBALOVÁ S. (2001): K výskytu niektorých vzácnych a neofytných druhov dolného Pohronia. – Bull. Slov. Bot. Spoločn. 23: 71-76.

UHERČÍKOVÁ E. (1997): *Impatiens glandulifera* Royle v lužných lesoch na Dunaji. –Bull. Slov. Bot. Spoloč. 19: 149-154.

UHERČÍKOVÁ E. (1999): Invázia neofytných astier v alúviu Moravy a Dunaja. – In: LESKOVJANSKÁ A. (ed.): Zborník referátov zo 7. zjazdu SBS. Slovenská botanická spoločnosť, Bratislava, p. 248-252.

UHERČÍKOVÁ E. (2001): Inváz ne druhy rastlín v lužných lesoch na Dunaji – Život. Prostr. 35: 78-82.

UHLIAROVÁ E., SABO P., TURISOVÁ I., HLADKÁ D. & MARTINCOVÁ E. (2012): Distribution of alien species in habitats of the Piešťany spa town surroundings. – Thaiszia – J. Bot. 22(2): 255-269.

VÝSKUMNÝ ÚSTAV PÔDOZNALECTVA A OCHRANY PÔDY: PÔDNY PORTÁL – REGISTER PÔDY LPIS [online]. [cit. 10.3.2015]. Dostupné: < http://www.podnemapy.sk/lpis_verejnost/viewer.htm >

ŽGANČÍKOVÁ I., VEREŠ T. & ČURNÁ V. (2012): Monitoring of the *Helianthus tuberosus* (L.) – as an invasive weed of natural ecosystems. – J. Agri. Sc. 44(2): 127-130.

Received: April 16th 2015
Revised: October 12th 2015
Accepted: October 14th 2015