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DYNAMICS AND DISTRIBUTION OF NEOPHYTES IN RUDERAL VEGETATION OF THE HORNÁ ORAVA REGION (NORTHERN SLOVAKIA)

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Abstract

Based on research of ruderal vegetation in the Horná Orava region in the 1980s and in 2005–2007, a list of neophytes was compiled. Thirty-three species of neophytes have been found, representing 6 % of the overall flora. The geographical origin, family, life-history, life-form and status of invasion of these species were assessed. The biggest proportion of the species was of North American origin (49 %), therophytes (49 %) and members of the family *Asteraceae* (38 %). Most of the neophytes are garden "escapees" and only few of them may be considered to be of potential hazard to the studied region, most particularly *Fallopia japonica*, *Impatiens glandulifera* and *Solidago canadensis*. Types of plant communities, where particular neophytes were found, and the foci of their distribution were evaluated as well. Neophytes are most abundant in communities of the class *Galio-Urticetea*, and especially of the alliance *Senecionion fluviatilis*. Comparing older and present data, trends in the progression of non-indigenous species in the Horná Orava region were predicted. It is apparent that the number of localities of invasive species is increasing and even other species that in the literature from the other regions are mentioned as invasive tend to spread through the area.

Keywords: alien, neophyte, invasive species, invasive status, ruderal vegetation, Horná Orava region, Northern Slovakia.

Izvleček

Na podlagi raziskav ruderalne vegetacije območja Horná Orava v osemdesetih letih prejšnjega stoletja in med letoma 2005 in 2007 smo sestavili seznam neofitskih vrst. Ugotovili smo triintrideset neofitov, ki pomenijo šest odstotkov celotne flore območja. Prikazali smo zemljepisni izvor, taksonomsko pripadnost, življenjsko dobo in obliko rastlin in status invazivnosti. Največji delež vrst je severnoameriškega izvora (49 odstotkov), so terofiti (49 odstotkov) in jih uvrščamo v družino *Asteraceae* (38 odstotkov). Večina neofitov je "ubežnikov" z vrtov in le nekaj jih je potencialno nevarnih za obravano območje, to so predvsem vrste *Fallopia japonica*, *Impatiens glandulifera* in *Solidago canadensis*. Ovrednotili smo tudi rastlinske združbe, v katerih se neofiti pojavljajo, in žarišča njihovega razširjanja. Neofiti so najbolj pogosti v združbah razreda *Galio-Urticetea* in še posebej zveze *Senecionion fluviatilis*. S primerjavo starejših in sedanjih podatkov smo napovedali trende v razširjanju tujerodnih rastlinskih vrst na območju Horná Orava. Število rastišč z invazivnimi vrstami se je očitno povečalo, prav tako smo opazili razširjanje vrst, omenjenih v literaturi kot invazivne z drugih območj.

Ključne besede: tujerodne vrste, neofiti, invazivne vrste, invazivni status, ruderalna vegetacija, območje Horná Orava, severna Slovaška.

1. INTRODUCTION

At present, alien species are considered to be one of the major threats to biodiversity. Their impact is both ecological and economical, as they threaten native biodiversity, compete with indigenous species for resources and may even change ecosystem variables (Hobbs & Humphries 1995; Levine et al. 2003). Therefore each country tries to prepare a list of present alien species (Sanz-Elorza et al. 2001; Pyšek et al. 2002b; Kühn & Klotz 2003; Török et al. 2003; Wittenberg 2006; Proto-

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popova et al. 2006). Local and regional alien floras are being published as well. However, not all of the non-indigenous species present the same danger for native flora. Most of the introduced species hardly survive and reproduce in the new region, and only a small proportion may become invasive in the region [as stated by Williamson's (1996) tens rule], which means that, they start to spread rapidly as a result of very good competitiveness and may even become a threat to native biodiversity. Therefore it is absolutely crucial to distinguish between species casual, naturalised and invasive, as defined according to Richardson et al. (2000), because only the taxa found in the last group represent an actual and real problem for native ecosystems. The other two groups are "only" potentially dangerous. That is the reason why authors in lists of alien flora often include information about the invasive status of each taxon. Gojdičová et al. (2002) published a national list of alien, invasive and expansive species of Slovakia. What is more, local alien floras are being published (Kuderavá 1997; Solár 1997; Eliáš 1999; Feráková 1999; Jarolímek et al. 1999; Kliment et al. 2008).

The vulnerability of a community to colonisation by non-indigenous species is called invasibility (Lonsdale 1999). Many scientific papers have been devoted to the causes, and to why some communities are more invasible than the others. The most influential and well known are the theories about the influence of diversity of the invaded community, theories about the effect of resources availability and theories about the effect of disturbance.

There is a constant scientific discussion about the role of native plant diversity in the invasibility of a community. Some authors suggest that communities with smaller biodiversity tend to be more invasible (Case 1990, Tilman 1997, Knops et al. 1999), while other results prove the opposite (Lonsdale 1999, Stohlgren et al. 1999). Nowadays it is agreed that results depend on the spatial scale of observation, and research should be more focused on the importance of species identities and mechanisms of coexistence (Richardson & Pyšek 2006).

What tends to play a bigger role than species richness is the effect of disturbance, which increases the probability of colonising by adventitious species. This effect was proved by many scientific papers (e.g. Hobbs & Huenneke 1992; Norton et al. 1995). Another factor affecting the number of alien species is the propagule pressure (Lonsdale 1999). Availability of resources, such as water and nitrogen, plays a key role according to various authors (Huenneke et al. 1990, Seabloom et al. 2003). To expand this concept, Davis et al. (2000) introduced the theory of fluctuating resources, stating that fluctuation in resource availability plays the key role in the invasion process. It is hard to determine the relevance of individual factors in determining invasibility as they most probably combine, and ruderal sites are in general usually both disturbed and rich in nitrogen and other nutrients.

As most of the studied region belongs to the nature conservation area of Horná Orava, research on the presence and distribution of neophytes is of key importance and, especially in the case of competitively strong species, it enables their early eradication at least from protected areas. Despite the mentioned facts, alien species in this region were not very well covered in the literature, even though many scientific works were dedicated to the natural vegetation and rare and endangered species of this region. A survey on the distribution of invasive alien species for purposes of the State Nature Conservancy of the Slovak Republic has been done for several years; however, its results have not yet been published. Bohušová (1992) mentioned the presence of neophyte *Impatiens glandulifera* in the Orava region. Zaliberová and Jarolímek conducted a survey on ruderal vegetation (including alien species) in 1980s, though their results have been published only partially (Jarolímek & Zaliberová 1991; Jarolímek et al. 1997; Jarolímek & Zaliberová 2001). As ecesis and spreading of alien flora are very dynamic processes, almost two decades is long enough time to perform new research about the present state of alien species in the region. A new survey was done in the years 2005–2007, and the purpose of this paper is to summarize the results on the alien species. We have concentrated solely on neophytes, as they are considered to be more dangerous as potential invaders to nature reserves than archaeophytes (Pyšek et al. 2002a). In fact, many authors use the term "alien species" exclusively for neophytes (Richardson et al. 2000). The results of the survey include a list of neophytes recorded in the area, their basic ecological characteristics, invasive status and potential to spread in future. Even though the survey was not primarily concentrated on alien flora but on the ruderal vegetation, it may be presumed that we man-

aged to record nearly all neophytes occurring in the Horná Orava region, as the majority of the naturalized alien species is bound to ruderal sites (cf. Kornas 1990). Still some species may be absent, especially species from segetal communities in fields. However, a survey on field vegetation took place parallel to our research and its results have been already partially published (Májeková & Zaliberová 2007, 2009) and thus contributed to completion of the list of alien species.

2. MATERIAL AND METHODS

Data used in the analysis consist of older data from the Slovak vegetation database (Hegedüšová 2007), most of them collected during years 1986–1990 and their authors are Jarolímek (89 relevés), Zaliberová (34), Grebenščikov et al. (1956) (1), Kliment (1) and unpublished recent data recorded by authors of the article in years 2005–2007 (226). This data structure enables us to evaluate the development of alien flora throughout decades and predict future trends.

Relevés were done according to the methodology of Braun-Blanquet (1964), revised by Westhoff & Van Der Maarel (1978). Afterwards they were classified into the ruderal syntaxa according to the results of numerical classification and a list of present taxa was made.

A list of neophytes was prepared according to Pyšek et al. (2002b). The status of questionable species that are considered to be alien for the Czech Republic but indigenous for Slovakia, e.g. *Rumex alpinus*, was evaluated after comparison with other literature resources (Goliašová & Šípošová 2002; Gojdičová et al. 2002; Kliment et al. 2008). Other characteristics, such as origin, family, life-history and life-forms were characterised according to Jehlík et al. (1998), Dostál & Červenka (1991, 1992). Invasion statuses were stated according to the definitions of Richardson et al. (2000).

The nomenclature of taxa follows Marhold (1998). Names of syntaxa are used according to Jarolímek et al. (2008).

3. STUDY AREA

The Horná Orava region lies in the North of Slovakia, bordering Poland. It is a mountainous region, lying primarily on sandstones, claystones, conglomerates and shales, creating a flysch bed, divided into Inner (Inner Carpathian Paleogene) and Outer (Magura Flysch belt) Carpathians by the Pieniny Klippen belt (Miklós 2002). Soils on the studied sites were of various types of anthropogenic soils (in ruderal sites) and cambisols (in clearings).

The area belongs to a temperate moderately cool climatic region (Miklós 2002) with mean temperatures from −4 to −7°C in January and from 12°C to 16°C in July. Mean precipitation levels are fairly high from 700 to 1600 mm. As was mentioned above, most of the studied region belongs to the protected landscape area of Horná Orava. The region is protected for its peat bogs, old growth spruce forests and species-rich avifauna.

4. RESULTS AND DISCUSSION

4.1 Characteristics of Alien Species

Of the total number of 566 recorded species, 33 species (6 %) were neophytes and 65 (11 %) were archaeophytes. Most of the neophytes belong to the family *Asteraceae* (38 %), which is quite understandable, as it is a big and relatively young family. The rest of the families have only one or two representatives: *Amaranthaceae* (2), *Balsaminaceae* (2), *Fabaceae* (2), *Polygonaceae* (2), *Scrophulariaceae* (2), *Solanaceae* (2), *Brassicaceae* (1), *Caprifoliaceae* (1), *Chenopodiaceae* (1), *Cucurbitaceae* (1), *Juncaceae* (1), *Onagraceae* (1), *Oxalidaceae* (1) and *Poaceae* (1).

The biggest group of found neophytes (almost one half) originates from North America (Fig. 1), together with South America it is 61 %. Asian species are markedly represented as well (21 %). Only few species (9 %) came from Southern Europe. The rest (9 %) are cosmopolitan species, whose exact origin is unknown. Concerning life-history characteristics, annuals and perennials were almost equally present, 52 % to 42 % respectively (6 % were both annuals and perennials). Regarding Rankiaer's system of life-forms, most of the analysed neophytes are therophytes (Fig. 2). The second most abundant group are hemicryptophytes (35 %). The small proportion of phanerophytes is due to the omission of foreign timber and ornamental park species, as the research was focused on synanthropic and not forest and park vegetation. Considering the invasive status, the most invasive species are hemicryptophytes (2 taxa) and therophytes (2 taxa).

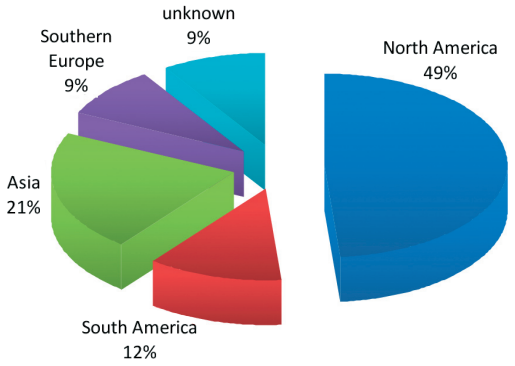

Figure 1: Geographical origin of neophytes in the Horná Orava region.

Slika 1: Zemljepisni izvor neofitov v območju Horná Orava.

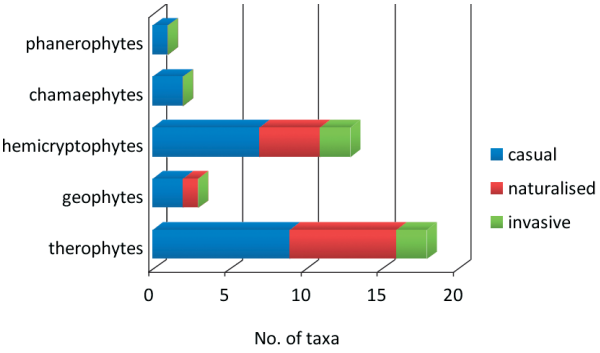

Figure 2: Representation of life-forms in various invasive statuses.

Slika 2: Zastopanost življenjskih oblik in njihova členitev glede na invazivni status.

The invasive status of species was evaluated according to the principles and terminology recommended by Richardson et al. (2000). Most of the species were classified as casual (55 %), meaning they may survive within the area and even reproduce, but do not form self-sustaining populations over longer periods of time (Fig. 3). As casual we consider these species: *Amaranthus cruentus*, *A. powellii*, *Aster lanceolatus*, *Calendula officinalis*, *Datura stramonium*, *Echinocystis lobata*, *Echinops sphaerocephalus*, *Fallopia sachalinensis*, *Hesperis matronalis* subsp. *matronalis*, *Lolium multiflorum*, *Lonicera tatarica*, *Medicago sativa*, *M. ×varia*, *Solanum tuberosum*, *Stenactis annua*, *Tagetes patula*, *Veronica peregrina* and *Xanthoxalis stricta*, even though this list may be longer. The main reason is that it is difficult to record all the casual species, as they survive in the region only for shorter periods of time, as is apparent from the definition of casual species. Naturalised species, which are able to survive and reproduce within the area over longer period of time, form quite a numerous group as well (33 %). Species included in this category are: *Bidens frondosa*, *Chenopodium strictum*, *Conyza canadensis*, *Epilobium ciliatum*, *Galinsoga parviflora*, *G. urticifolia*, *Helianthus tuberosus* agg., *Impatiens parviflora*, *Juncus tenuis*, *Solidago gigantea* and *Veronica persica*. The smallest group (only 12 %) could be defined as invasive, producing many offspring and having the potential to spread quickly over a considerable area. However, their number may increase over time as more species have the potential to flourish within the area and even become invasive. It is mostly a case of species that are reported to be invasive elsewhere in similar ecological conditions and are present in the Horná Orava region, though only as casual or naturalised. Examples of such species are *Aster lanceolatus*, *Bidens frondosa*, *Echinocystis lobata*, *Fallopia sachalinensis*, *Solidago gigantea* and *Stenactis annua*. As invasive were classified the following species: *Fallopia japonica*, *Impatiens glandulifera*, *Matricaria discoidea* and *Solidago canadensis*. This ratio only remotely approaches the tens rule (Williamson 1996), stating that only one tenth of species succeeds in overcoming each consecutive barrier in the invasion process. That means that only 1/10 of imported species will escape and become casual, only 1/10 of casual species will become naturalised and only 1/10 of naturalised species will become invasive. However, this number is only a very rough approximate and real numbers tend to differ, especially for animals. Jeschke & Strayer (2005) suggest that about 25 % of introduced animal species may be-

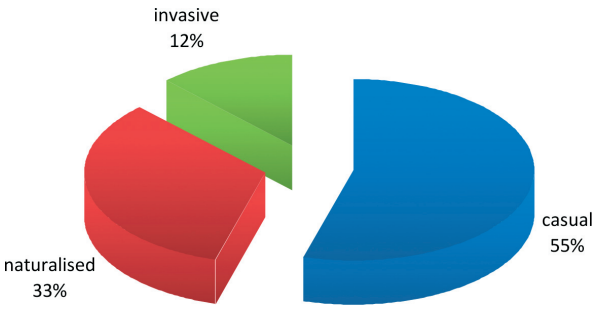

Figure 3: Invasive statuses of neophytes in the Horná Orava Region.

Slika 3: Invazivni status neofitov v območju Horná Orava.

come invasive. Richardson & Pyšek (2006) found the concept of the tens rule to be limited to the particular stage of invasions worldwide, which tends to change over time. Despite the wide limits and many exceptions, they consider the tens rule to be "a useful generalization that can be used as a benchmark to which real data can be related; deviations indicate taxa with higher or lower invasiveness and regions/habitats with lower or higher invasibility". Pyšek et al. (2002b) introduced the term post-invasive status mainly for archaeophytes, which have stable or even declining populations, but their population dynamics and types of occurrence suggest that they might have been invasive in the past. This is probably the case of some species, but, due to lack of data, we did not include this category.

Probably the most dangerous neophyte right now is *Fallopia japonica*. Apparently it has found suitable conditions in the Horná Orava, as it creates stable, viable and flourishing populations with abundance of mostly 100 %, where almost no other plant species is able to survive in competition. It is spreading even naturally and we consider it to be invasive in the region. Another potentially problematic species is *Impatiens glandulifera*, a popular garden ornamental. Subsequently it escapes from gardens and spreads along the streams to the surrounding countryside. Both of the mentioned species have been recorded even during the earlier survey. Species of genus *Solidago* (*S. canadensis* and *S. gigantea*) have only limited occurrence right now. In the past, only species *S. canadensis* was recorded. However, they have started to spread rapidly in the last few years. *S. canadensis* we consider to be invasive nowadays, and *S. gigantea* as naturalised with a high potential of becoming invasive soon. Species of genus *Galinsoga* (*G. parviflora* and *G. urticifolia*) are not very common in the ruderal vegetation, but they are widespread among segetal communities in the Horná Orava region and are considered to be naturalised. There is a group of a few species that are reported to be invasive in other areas but do not represent a big problem in the Horná Orava, most probably because they do not find there conditions suitable for growth. An example of such a plant is *Echinocystis lobata*, a species that is invasive in riparian habitats of lowland rivers (Ťavoda et al. 1999; Uherčíková 2001; Török et al. 2003). It was recorded only recently in two localities in Vavrečka village, even though it is frequently planted along garden fences. It was found in the garden waste deposits. Recorded populations were most probably casual and not surviving in long term. A possible reason may be the fact that it needs relatively high soil temperatures for seeds to germinate in spring (Klotz 2007). Ťavoda et al. (1999) presume that it may freeze in spring in the northern parts of Slovakia. Another taxon that is considered to be invasive in the southern parts of Slovakia, but does not appear to be invasive in the Horná Orava, is *Helianthus tuberosus* agg. It has been recorded both during earlier and recent surveys, but the number of its localities is not rising conspicuously. What is more, even the older populations often do not bring any flowers and do not reach heights reported from the lowlands. Therefore, it may be deduced that it did not find optimal conditions for further spreading in the region, though it is considered to be naturalised. Among other neophytes occurring in the Horná Orava region and considered to be invasive in the surrounding regions (e.g. Jehlík et al. 1998; Šípošová et al. 1999; Uherčíková 2001; Gojdičová et al. 2002; Pyšek et al. 2002b; Török et al. 2003; Protopovova et al. 2006; Kliment et al. 2008) are *Aster lanceolatus*, *Bidens frondosa*, *Conyza canadensis*, *Fallopia sachalinensis* and *Stenactis annua*. As they were recorded only recently and their presence is limited to one or very few localities, we consider them to be casual right now. However, they have the potential to spread and even become invasive in future.

4. 2 Distribution of aliens

The positive result of the survey was the discovery that most of the species were found in one or only few localities and usually with small abundance (Tab. 1). Only a small proportion of neophytes are considered to be potentially dangerous and invasively spreading. Most of the localities were fixed to the close proximity of settlements and garden rubbish dumps, an environment highly affected and partially degraded by man.

The distribution of neophytes among various syntaxonomic classes of ruderal vegetation is shown in Fig. 4. Success of alien species in the process of colonising new sites depends on the properties of the colonised communities. The main theories dealing with vulnerability of a community to an invasion, called invasibility, have been mentioned above. It is not within the scope of this paper to state which of the mentioned fac-

Table 1: Syntaxonomical affinity, occurrence in past and recent survey and invasive status of neophytes in the Horná Orava region.

Tabela 1: Sintaksonomska pripadnost, pojavljanje v obeh raziskovanih obdobjih in invazivni status neofitskih vrst v območju Horná Orava.

Taxa/Syntaxa	BT	PP	SM	AV	GU	EA	MA	Occurrence	Inv. status
Amaranthus powellii			c					recent	cas
Amaranthus cruentus			c					recent	cas
Aster lanceolatus					c			recent	cas
Bidens frondosa	r						c	both	nat
Calendula officinalis					c			recent	cas
Chenopodium strictum	c	r	a	r	r		r	both	nat
Conyza canadensis	c	c	c	c				both	nat
Datura stramonium			c					recent	cas
Echinocystis lobata					c			recent	cas
Echinops sphaerocephalus				c				past	cas
Epilobium ciliatum	f		c	r	r	r	r	both	nat
Fallopia japonica					r			both	inv
Fallopia sachalinensis					c			recent	cas
Galinsoga parviflora			r	c		c	c	both	nat
Galinsoga urticifolia	r	c	f		c	c		recent	nat
Helianthus tuberosus agg.				c	c			both	nat
Hesperis matronalis subsp. *matronalis*			c					recent	cas
Impatiens glandulifera					c			both	inv
Impatiens parviflora				c	c			both	nat
Juncus tenuis	c						c	both	nat
Lolium multiflorum	c							past	cas
Lonicera tatarica					c			recent	cas
Matricaria discoidea	r	a	f	r			a	both	inv
Medicago sativa				c				recent	cas
Medicago × varia				c				recent	cas
Solanum tuberosum			c					recent	cas
Solidago canadensis				c	c			recent	inv
Solidago gigantea					c			both	nat
Stenactis annua	r			c	c		c	both	cas
Tagetes patula			c					recent	cas
Veronica peregrina	c							recent	cas
Veronica persica		r	f	c	c		c	recent	nat
Xanthoxalis stricta		c		c				recent	cas

Explanations: syntaxonomical affinity and frequency: BT – *Bidentetea tripartitae*, PP – *Polygono arenastri-Poetea annuae*, SM – *Stellarietea mediae*, AV – *Artemisietea vulgaris*, GU – *Galio-Urticetea*, EA – *Epilobietea angustifolii*, MA – *Molinio-Arrhenatheretea*, c – casual, r – rare, f – frequent, a – abundant; occurrence: past – found during 1986-1990, recent – found during years 2005-2007, both – found both during years 1986-1990 and 2005-2007; invasive status (according to Richardson et al. 2000): cas – casual, nat – naturalised, inv – invasive.

Okrajšave: sintaksonomska pripadnost in frekvenca: BT – *Bidentetea tripartitae*, PP – *Polygono arenastri-Poetea annuae*, SM – *Stellarietea mediae*, AV – *Artemisietea vulgaris*, GU – *Galio-Urticetea*, EA – *Epilobietea angustifolii*, MA – *Molinio-Arrhenatheretea*, c – slučajna, r – redka, f – pogosta, a – obilna; pojavljanje: past – najdena med 1986–1990, recent – najdena med 2005–2007, both – najdena med 1986–1990 in 2005–2007; invazivni status (po Richardson et al. 2000): cas – slučajna, nat – naturalizirana, inv – invazivna.

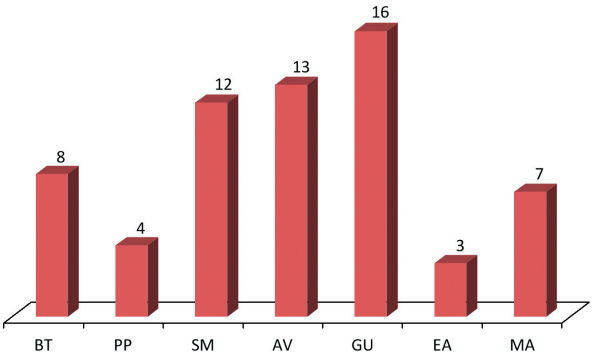

Figure 4: Level of invasion in ruderal vegetation on class level.

Slika 4: Invazivnost ruderalne vegetacije na nivoju razreda. Explanation (Okrajšava): BT – *Bidentetea tripartitae*, PP – *Polygono arenastri-Poetea annuae*, SM – *Stellarietea mediae*, AV – *Artemisietea vulgaris*, GU – *Galio-Urticetea*, EA – *Epilobietea angustifolii*, MA – *Molinio-Arrhenatheretea*.

tors are the most important. Still, it is important to mention them, as they may differently affect the communities of individual classes in various conditions. Therefore we have tried to state the most probable causes, which made some classes more or less invaded than the others.

Neophytes are most abundant in communities of the class *Galio-Urticetea* (Fig. 4). The main reason is the fact that it includes also nitrogen-rich and disturbed riparian habitats from the alliance *Senecionion fluviatilis*, which often tend to be affected by non-indigenous species even elsewhere, and many alien species are bound to this biotope at least in one part of the process of colonisation (Pyšek & Prach 1993, 1994). It is caused by the surplus of nutrients and sufficient amount of ground water (Jarolímek & Zaliberová 2001), which are crucial factors for the growth of some alien species, such as *Impatiens glandulifera*. Additionally, riparian habitats are often disturbed by the removal of original plant cover both by floods and human activities and thus tend to be more vulnerable to invasion. What is interesting though, is that mesic and nitrogen-rich alliances of class *Galio-Urticetea* were almost unaffected, probably because of strong competition from autochthonous species, such as *Aegopodium podagraria*, *Chaerophyllum aromaticum*, *Heracleum sphondylium*, *Rumex obtusifolius* and *Urtica dioica*. Apparently less affected were communities of the classes *Artemisietea vulgaris* and *Stellarietea mediae* (Fig. 4), where hydrophilic species, such as *Fallopia japonica*, *F. sachalinensis* and *Impatiens glandulifera* were absent, as the class *Artemisietea vulgaris* presents a more xerothermophilous alternative of *Galio-Urticetea*, and the ruderal part of the class *Stellarietea mediae* consists of communities of newly disturbed habitats. Still both of them are considerably invaded. Especially the class *Stellarietea mediae* contains many empty niches, where neophytes can survive at least for a short period of time. Some species, such as *Amaranthus cruentus*, *A. powellii*, *Datura stramonium* and *Conyza canadensis* were bound only to this class. On the other hand, classes *Epilobietea angustifolii* and *Polygono arenastri-Poetea annuae* were almost unaffected (Fig. 4). The first one represents a group of plant communities of clearings that are rather stable, and in which forest shrub and herb species play a crucial role. Moreover, these sites are usually isolated from areas that might be a source of propagules of alien species. These are probable reasons why only three neophyte species were found there. The most widespread neophyte is *Epilobium ciliatum*. *Galinsoga parviflora* and *G. urticifolia* were occurring casually. Class *Polygono arenastri-Poetea annuae* comprises trampled habitats with a very high level of disturbance, where only very few stress-tolerant species can survive. The most prevalent species within the class is neophyte *Matricaria discoidea*. It is widespread and considered to be invasive among this class, however, there is a low probability that this inconspicuous species would represent a big danger for native biodiversity as it is bound to trampled habitats. Classes *Bidentetea tripartitae* and *Molinio-Arrhenatheretea* are moderately invaded and do not seem to be seriously threatened by invasion.

Table 1 demonstrates that even though some species can be found in communities of more classes, they tend to be most frequent and abundant only in one (*Chenopodium strictum*, *Galinsoga parviflora*, *G. urticifolia*) or maximally two (*Solidago canadensis*), and most of them are strictly bound to one class (*Fallopia japonica*, *F. sachalinensis*, *Impatiens glandulifera*, *Echinocystis lobata*).

According to the comparison of results of earlier and recent work, we may conclude that the number of neophytes found in the region has increased in the last decades (Tab. 1). Even though the percentage of relevés containing neophytes has not changed, the proportion of relevés dominated by neophytes has increased significantly (Fig. 5). When comparing the distribution of the most problematic species (meaning invasive and potentially invasive species) from older and

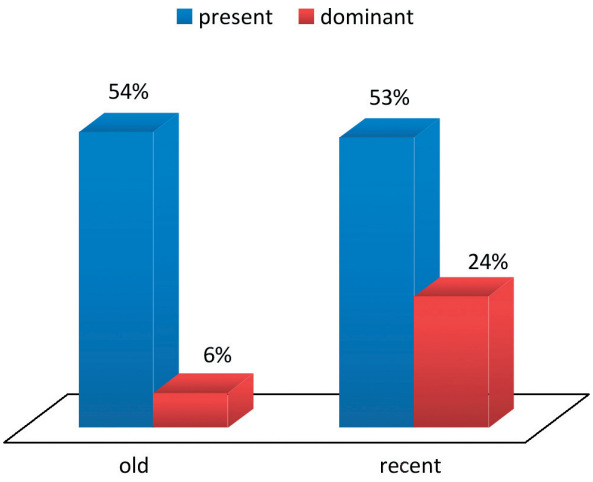

Figure 5: Increase in the proportion of localities with neophytes and proportion of localities, where they dominated, in time.

Slika 5: Porast deleža rastišč z neofitskimi vrstami in deleža rastišč, kjer te prevladujejo v rziskovanem obdobju v času.

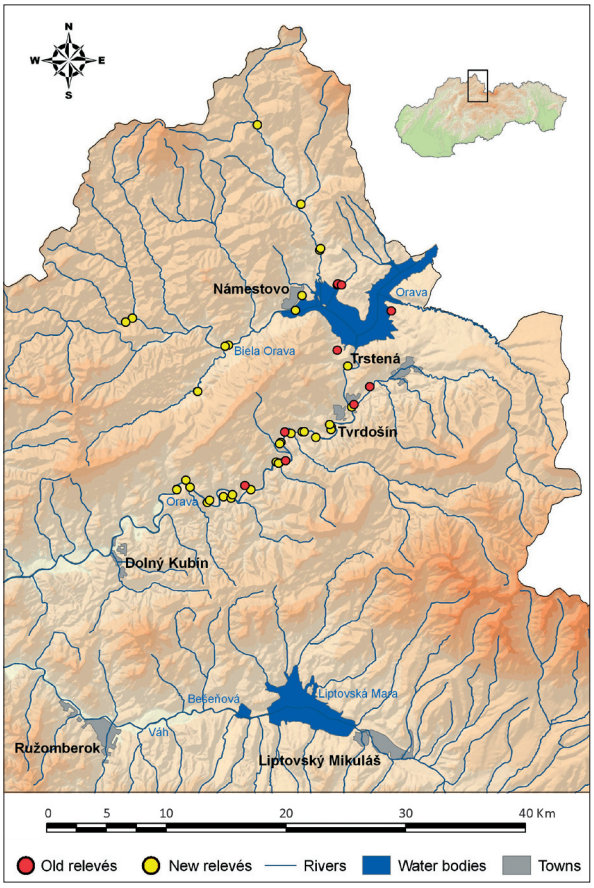

Figure 6: Spreading of the most problematic species (invasive and potentially invasive species) based on the comparison of older and recent data.

Slika 6: Razširjanje najbolj nevarnih vrst (invazivnih in potencialno invazivnih) na podlagi primerjave starih in novejših podatkov.

recent data, it is apparent that the number of localities where they were recorded is rising and that species that are mentioned in the literature as invasive tend to spread throughout the area (Fig. 6). In spite of all the mentioned facts, the Horná Orava region is still relatively unaffected by neophytes in comparison to other regions (Jarolímek & Zaliberová 2001). One of the reasons is the geographic isolation of the region, encircled by mountain ranges from almost all sides. Additionally, a considerable part of its borders belongs to the state border with Poland, which had been closed for transport of people and goods for many decades. Most of the neophytes, found in the Horná Orava region, have been introduced to this region intentionally as garden ornamentals. Subsequently they escaped from gardens and garden waste deposits to the surrounding landscape. Majority of their localities is limited to the close proximities of these deposits even at present. However, some of the species (e.g. *Fallopia japonica*, *Impatiens glandulifera*, *Solidago canadensis* and *S. gigantea*) are already spreading spontaneously especially along rivers. We must not forget to mention the great effort of employees of the administration of the protected landscape area of Horná Orava, who are trying to eradicate or at least control the spread of the most dangerous species from the area. Despite all the mentioned facts, from the development in last decades and even the last few years, we may presume a further spread of neophytes in the Horná Orava region, especially in the biotopes that are the most vulnerable to colonisation by alien species.

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