

University of South Bohemia
Faculty of Science



Master thesis:

*Arbuscular mycorrhizal symbiosis of herbaceous
invasive neophytes in the Czech Republic*

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Annotation:

I have studied arbuscular mycorrhizal symbiosis of 44 herbaceous invasive neophytes occurring in the Czech Republic. My results show that about 70% of the examined species are capable to form symbiotic association with arbuscular mycorrhizal fungi (AMF) in the field. To my knowledge, mycorrhizal status of 23 invasive species is reported here for the first time. I predicted, based on the hypothesis of Urcelay & Díaz (2003), that the intensity of AMF in the roots of invasive species will be correlated with that of the native dominant species of invaded plant community, but collected data did not support this hypothesis. In addition, the effects of habitat and community characteristics on the intensity of AMF colonization of the invasive species' roots were tested. My results show that, at the within-species level, plants in the habitats with higher light and temperature conditions have less colonized roots whereas intensity of mycorrhizal colonization increases with habitat moisture. At the among-species level, invasive species occurring in the habitats with elevated nitrogen availability have higher mycorrhizal colonization of their roots. The effect of nitrogen availability is revealed at the among-species level and stays significant even after phylogenetic correction, suggesting this is an evolutionary adaptation rather than a phenotypic plasticity.

Prohlašuji, že jsem svoji diplomovou práci vypracovala samostatně pouze s použitím pramenů a literatury uvedených v seznamu citované literatury (I hereby declare that the present thesis have been worked out by myself using the cited literature only).

Prohlašuji, že v souladu s § 47b zákona č. 111/1998 Sb. v platném znění souhlasím se zveřejněním své diplomové práce, a to v úpravě vzniklé vypuštěním vyznačených částí archivovaných přírodovědeckou fakultou, elektronickou cestou ve veřejně přístupné části databáze STAG provozované Jihočeskou univerzitou v Českých Budějovicích na jejích internetových stránkách.

V Českých Budějovicích, 7.1.2009

Podpis studenta (signature)

Dedicated to all dwarfs in the Czech gardens...

(For explanation, see Appendix 5)

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Arbuscular mycorrhizal symbiosis of herbaceous invasive neophytes in the Czech Republic

Arbuskulární mykorhizní symbióza bylinných invazních neofytů v České republice

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I have studied arbuscular mycorrhizal symbiosis of 44 herbaceous invasive neophytes occurring in the Czech Republic. My results show that about 70% of the examined species are capable to form symbiotic association with arbuscular mycorrhizal fungi (AMF) in the field. To my knowledge, mycorrhizal status of 23 invasive species is reported here for the first time, there are *Amaranthus powellii*, *Bunias orientalis*, *Cannabis ruderalis*, *Echinocystis lobata*, *Echinops sphaerocephalus*, *Galeobdolon argentatum*, *Geranium pyrenaicum*, *Helianthus tuberosus*, *Heracleum mantegazzianum*, *Juncus tenuis*, *Kochia scoparia* subsp. *scoparia*, *Lupinus polyphyllus*, *Matricaria discoidea*, *Parthenocissus inserta*, *Persicaria polystachya*, *Reynoutria × bohemica*, *Reynoutria japonica*, *Reynoutria sachalinensis*, *Rudbeckia laciniata*, *Rumex thyrsoiflorus*, *Sedum hispanicum*, *Telekia speciosa* and *Virga strigosa*. I predicted, based on the hypothesis of Urcelay & Díaz (2003), that the intensity of AMF in the roots of invasive species will be correlated with that of the native dominant species of invaded plant community, but collected data did not support this hypothesis. In addition, the effects of habitat and community characteristics on the intensity of AMF colonization of the invasive species' roots were tested. My results show that, at the within-species level, plants in the habitats with higher light and temperature conditions have less colonized roots whereas intensity of mycorrhizal colonization increases with habitat moisture. At the among-species level, invasive species occurring in the habitats with elevated nitrogen availability have higher mycorrhizal colonization of their roots. The effect of nitrogen availability is revealed at the among-species level and stays significant even after phylogenetic correction, suggesting this is an evolutionary adaptation rather than a phenotypic plasticity.

Keywords: alien, arbuscular mycorrhiza, community, dominant species, habitat, light, moisture, mycorrhizal status, nitrogen, non-native, temperature

INTRODUCTION

With the growing movement of world biota (including the man), many plant species establish themselves far outside their native ranges. In some cases, these species become invasive, crucially affecting native species and their communities (Drake et al. 1989, di Castri et al. 1990, Pyšek et al. 1995, Chytrý et al. 2005, Radosewich et al. 2007), often with the result of biodiversity and economic losses (Vitousek et al. 1997, Mooney & Hobbs 2000, Pyšek et al. 2006, Richardson & Pyšek 2006). The extent of this problem demands thorough understanding what factors influence the process of invasion.

Although much of the work has been focused on the aboveground level, several recent studies deal with the potential role of belowground biota, particularly the arbuscular mycorrhizal fungi, hereinafter AMF (e.g. Marler et al. 1999, Richardson et al. 2000, Stampe & Daehler 2003, Callaway et al. 2004a, Belnap et al. 2005, Klein et al. 2006, Wolfe & Klironomos 2005, Koske & Gemma 2006, van der Putten et al. 2007, MacKay & Kotanen 2008).

Arbuscular mycorrhiza (hereinafter AM) is the most ancestral and the commonest type of mycorrhizal symbiosis (e.g. Brundrett 2002), in which the fungal hyphae penetrate the cortical cells' wall of the host plant root. It is characterized by the typical structures of arbuscules and vesicles formed by the aseptate, obligately symbiotic fungi of the phylum Glomeromycota (Schüßler et al. 2001). The nature of interaction between the plant and these fungi can vary from mutualistic to parasitic form (Johnson et al. 1997), depending on the genotype of both partners and various environmental factors (Jakobsen et al. 2002, Klironomos 2003). AMF help plants to obtain nutrients such as phosphorus (this is important because of its low mobility in the soil), nitrogen, potassium, and zinc from the soil in exchange for photosynthates (organic carbon) supplied by the host plant (Smith & Read 1997, Gryndler et al. 2004). The AMF have been also shown to protect the host plants against the attack of soil-borne pathogens (Azcón-Aguilar & Barea 1996) and to have direct effects (positive or negative) on growth and biotic interactions of plant species (van der Heijden et al. 1998).

It is estimated that more than 80% of terrestrial plant species, including invasive ones, enter the symbiotic relation with mycorrhizal fungi (e.g. Wang & Qiu 2006). Moreover, the AMF traits such as their ubiquity, cosmopolitanism, and low host-plant specificity provide a good chance for invasive plants to form mycorrhiza in the new ranges (Richardson et al. 2000). Therefore, arbuscular mycorrhiza can be expected to have a favorable role in the process of plant invasion. On the other hand, this role is not probably so crucial; see Pyšek (1998), who listed Amaranthaceae, Brassicaceae, Chenopodiaceae and Polygonaceae, generally known as non-mycorrhizal families, among the six most invasive plant families of the world.

Invasive mycorrhizal plants cannot take any competitive advantage of mycorrhizal symbiosis over native species, unless they utilize it in unusual way (Richardson et al. 2000). Such mechanism can determine their success and further effects on the resident plant community as well as on ecosystem functioning (Callaway et al. 2004b). For instance, invading plants are capable to influence the network of AMF hyphae in the soil,

common to themselves and native species as well, through the earlier root activity or unusual amount of carbon provision (Hawkes et al. 2006).

While mycorrhizal species might be prominent among invasive plants, absence of mycorrhizal dependence seems to be advantageous in particular cases. The African fynbos is an example of habitat invaded by non-mycorrhizal alien species, owing to the extremely poor soils unacceptable for most introduced plants that form associations with AMF (Allsopp & Stock 1993, Allsopp & Holmes 2001). In temperate zone, most non-mycorrhizal species are expected to prefer disturbed sites, where low mycorrhizal propagule density has been found, e.g. ruderal sites or dumps (Gange et al. 1990). On the other hand, few non-mycorrhizal invasive species are able to establish themselves in later successional stages, too. Such species is the garlic mustard *Alliaria petiolata*, successful invader of mature temperate forest in the North America. This species seems to profit from its ability to decrease abundance and function of AMF communities in the soil, especially through its released exudates (Roberts and Anderson 2001, Stinson et al. 2006, Burke 2008), which are expressed more in invasive genotypes in comparison to native ones (Cipollini et al. 2005).

Based on various empirical data, such as those mentioned above and many more from different habitat types, countries and continents, Urcelay & Díaz (2003) suggested a simple conceptual model predicting the diversity response of natural plant communities (with different degrees of mycorrhizal dependence and positions in the dominance hierarchy) to AMF. Their hypothesis refers to the mycorrhizal dependence of subordinates, as determined by the dependence of dominants. The same model could be also used to predict the response of plant community invaded by non-native species and/or to predict their invasive success, based on the interaction of its AM dependence and that of the momentarily dominant native species.

The first aim of my study was to evaluate the mycorrhizal status of herbaceous invasive neophytes in the Czech Republic because this information is missing for most of them. Indirect and limited sources are the check-list of mycorrhiza in the British flora (Harley & Harley 1987), compilation work of Wang & Qiu (2006) and several other papers, e.g. Fumanal et al. (2006), who studied invasive neophyte *Ambrosia artemisiifolia* L. and its mycorrhizal status in France. The second aim was to compare the intensity of mycorrhizal colonization in the roots of invasive species with that of the dominant species of invaded plant community, and the third one was to assess which habitat characteristics correlate with the intensity of AMF colonization in the roots of studied invasive species.

MATERIALS AND METHODS

Target species and site selection

44 herbaceous invasive neophyte species, including two lianas and excluding post-invasive species (these used to be invasive, but now without obvious spreading) and water macrophytes, were selected based on Pyšek et al. (2002). Their roots were collected in the years 2007 and 2008 all over the Czech Republic (see Appendix 1).

Common species have been sampled mainly in the vicinity of large cities and on the route to the sites of less abundant species. Localities of less abundant species (e.g. *Cannabis ruderalis*) were found using Hejný & Slavík (1988, 1990, 1992), Slavík (1995, 1997, 2000), Kubát et al. (2002), Slavík & Štěpánková (2004), Mlíkovský & Stýblo (2006), as well as based on personal advice of local botanists. Characteristics of studied sites such as sampling date, locality name, elevation, geographic location data and habitat type of the sampling site are summarized in Appendix 2.

Sample collection and processing

At each sampling site, roots of both the studied invasive neophyte and the dominant native species were sampled with three replicates to assess their AMF colonization, for a total of 798 samples processed in this study. As far as possible, roots were sampled from adult plants in the flowering stage, because AMF development in host roots depends on the host species phenology (e.g. Šmilauer 2001).

In addition, a phytosociological relevé was recorded in each locality, using a plot of size 16 m². Abundance and dominance of each species were estimated visually, using the combined scale (r, +, 1-100%).

Plant species nomenclature follows Kubát et al. (2002). The term *Aster novi-belgii* agg. as used in this study includes all invasive *Aster* species occurring in the Czech Republic (Pyšek et al. 2002); there are *A. lanceolatus*, *A. novi-belgii*, *A. × salignus* and *A. versicolor*.

Community composition recorded in phytosociological relevés was used to estimate site characteristics (based on the Ellenberg indicator values characterizing ecological preferences of individual species, Ellenberg 1988), community diversity (Shannon-Wiener index) and richness, using the software Turboveg (Hennekens & Schaminée 2001, Hennekens 2008) and JUICE (Tichý 2002, Tichý & Holt 2006).

Root samples were washed from the soil and at least ten fine roots were stained with Chlorazol Black E using the method of Vierheilig et al. (2005) with the following

modifications: clearing 16 hours in 10% KOH at the room temperature, neutralization in 3.5% HCl for 2 minutes, staining in lactoglycerol (a mixture of lactic acid, glycerol, and deionized water in the ratio of 14:1:1) with a pinch of Chlorazol Black E in the 90°C water bath for an hour, and destaining in lactoglycerol for several days in a fridge.

For each sample, about 10 stained root fragments, each with the length approximately 1.5 cm, were randomly selected and mounted in destaining solution (lactoglycerol) onto slides. Semi-permanent slides of stained roots were made, sealed with nail polish, and later examined.

The presence of arbuscules was investigated under 200× and 400× magnification to distinguish AMF from other, especially non-mycorrhizal fungi assemblages presented in the root. The intensity of AMF colonization was then assessed under the 100× magnification, by estimating the percentage of root length with AMF structures (namely arbuscules, vesicles, and hyphae) within each visual field.

The fraction of the colonized root length was estimated for the whole root sample as weighted average $P = \sum_j(P_j \cdot L_j) / \sum_j L_j$ (similarly to Lokvencová 2007), where P_j is the estimated infection intensity of the j -th root segment and L_j is its length, expressed for example as the number of visual fields that the j -th root spans when observed under the 100× magnification. This formula was used to estimate infection intensity of all mycorrhizal structures: arbuscules, vesicles, as well as the total AM infection (including arbuscules, vesicles, and hyphae together). The term “relative arbuscular (vesicular) infection” means the relative rate of arbuscules (vesicles) in the total AM infection extent.

Each studied species was classified as mycorrhizal on the condition that arbuscules were observed in its roots. These structures are the key features defining the AM association (Brundrett 2004). My observations were compared mainly with two compilation studies of Harley and Harley (1987) and Wang & Qiu (2006).

Statistical analyses

To reliably assess the presence and extent of AM symbiosis and to compare it both at the among-species level and at the within-species level over different site conditions, each species must be represented by multiple populations. This condition was fulfilled only by 15 of the studied invasive species (see Tab. 1), which were further used in statistical analyses.

The sampling sites were used as independent observations in all statistical analyses. Therefore the information obtained from the three specimens of invasive plants or from the three specimens of corresponding native dominant species was averaged.

Hypotheses about the relation of mycorrhizal infection of the invasive species to the infection of the most dominant native species as well as to site factors (estimated using Ellenberg indicator values) were tested using mixed-effect linear models with a random effect of the populations (sites). Therefore, effects of most tested explanatory variables could be studied at two levels: within-species (among-population) level representing the response of invasive species to particular site conditions, and among-species level representing differences between individual invasive species.

For each tested hypothesis, phylogenetic correction was also performed, using the method of Desclères et al. (2003), with the phylogenetic tree (Appendix 3) based on the data provided by the BioFlor database (Klotz et al. 2002).

All estimates of mycorrhizal infection (both for invasive and local dominant species) were transformed by arcsin-transformation to decrease heterogeneity of variances. Statistical analyses were performed with the R program, version 2.8 (R Development Core Team 2008).

Table 1. Summary of the AM status of the studied invasive neophytes, reported in the main literature sources and this study. Abbreviations: *H&H*, Harley & Harley (1987); *W&Q*, Wang & Qiu (2006); *KS*, the present study; *AMF*, AMF dependence of the studied invasive neophytes based on the definition in Wang & Qiu (2006); *NO*, non-mycorrhizal species; *YES*, mycorrhizal species; *YES/NO*, both information on AM status cited therein but found in different literature sources; *?*, no information about AM status; *F*, facultatively mycorrhizal species - no AMF structures found at least in one root sample; *N*, non-mycorrhizal species, no AMF structures found within the roots of any samples; *O*, obligately mycorrhizal species, AMF structures presented in all examined samples; *bold face type*, invasive neophytes used in the statistical analyses; *asterisk*, to my knowledge, AMF status reported for the first time.

Invasive species	Family	H&H	W&Q	KS	AMF
<i>*Amaranthus powellii</i>	Amaranthaceae	?	?	NO	N
Amaranthus retroflexus	Amaranthaceae	NO	NO	NO	N
<i>Ambrosia artemisiifolia</i>	Asteraceae	?	YES	YES	F
<i>Angelica archangelica</i>	Apiaceae	YES	YES	YES	O
<i>Aster novi-belgii</i> agg.	Asteraceae	YES	YES	YES	O
<i>Bidens frondosa</i>	Asteraceae	?	YES	YES	F
<i>*Bunias orientalis</i>	Brassicaceae	?	?	NO	N
<i>*Cannabis ruderalis</i>	Cannabaceae	?	?	YES	F
Conyza canadensis	Asteraceae	?	YES	YES	O
<i>Digitalis purpurea</i>	Scrophulariaceae	YES/NO	YES/NO	YES	F
<i>*Echinocystis lobata</i>	Cucurbitaceae	?	?	YES	F
*Echinops sphaerocephalus	Asteraceae	?	?	YES	F
<i>Epilobium ciliatum</i>	Onagraceae	YES	YES	YES	F
Erigeron annuus	Asteraceae	YES	YES	YES	O
*Galeobdolon argentatum	Lamiaceae	?	?	YES	F
Galinsoga ciliata	Asteraceae	YES	YES	YES	F
Galinsoga parviflora	Asteraceae	YES	YES	YES	F
<i>*Geranium pyrenaicum</i>	Geraniaceae	?	?	YES	F
*Helianthus tuberosus	Asteraceae	?	?	YES	F
<i>*Heracleum mantegazzianum</i>	Apiaceae	?	?	YES	F
Impatiens glandulifera	Balsaminaceae	YES/NO	YES/NO	YES	F
Impatiens parviflora	Balsaminaceae	YES/NO	YES/NO	YES	F
<i>*Juncus tenuis</i>	Juncaceae	?	?	YES	F
*Kochia scoparia subsp. <i>scoparia</i>	Chenopodiaceae	?	?	NO	N
<i>*Lupinus polyphyllus</i>	Fabaceae	?	?	NO	N
*Matricaria discoidea	Asteraceae	?	?	YES	O
<i>Oenothera biennis</i>	Onagraceae	YES	YES	YES	O
<i>*Parthenocissus inserta</i>	Vitaceae	?	?	YES	F
<i>*Persicaria polystachya</i>	Polygonaceae	?	?	NO	N
<i>*Reynoutria × bohemica</i>	Polygonaceae	?	?	NO	N
<i>*Reynoutria japonica</i>	Polygonaceae	?	?	NO	N
<i>*Reynoutria sachalinensis</i>	Polygonaceae	?	?	NO	N
<i>*Rudbeckia laciniata</i>	Asteraceae	?	?	YES	O
<i>Rumex alpinus</i>	Polygonaceae	YES/NO	YES/NO	YES	F
<i>Rumex longifolius</i>	Polygonaceae	?	YES	NO	N
<i>*Rumex thyrsiflorus</i>	Polygonaceae	?	?	NO	N
<i>*Sedum hispanicum</i>	Crassulaceae	?	?	NO	N
Sisymbrium loeselii	Brassicaceae	NO	NO	NO	N
Solidago canadensis	Asteraceae	?	YES	YES	F
Solidago gigantea	Asteraceae	?	YES	YES	F
<i>*Telekia speciosa</i>	Asteraceae	?	?	YES	F
<i>Veronica filiformis</i>	Scrophulariaceae	YES	YES	YES	O
Veronica persica	Scrophulariaceae	YES	YES	YES	O
<i>*Virga strigosa</i>	Dipsacaceae	?	?	YES	O
TOTAL		15	21	44	

RESULTS

Mycorrhizal status of the studied invasive species

This study provides new records of mycorrhizal status for 29 invasive neophyte species, when compared to the work of Harley & Harley (1987), and for 23 invasive neophyte species in comparison to Wang & Qiu (2006): *Amaranthus powellii*, *Bunias orientalis*, *Cannabis ruderalis*, *Echinocystis lobata*, *Echinops sphaerocephalus*, *Galeobdolon argentatum*, *Geranium pyrenaicum*, *Helianthus tuberosus*, *Heracleum mantegazzianum*, *Juncus tenuis*, *Kochia scoparia* subsp. *scoparia*, *Lupinus polyphyllus*, *Matricaria discoidea*, *Parthenocissus inserta*, *Persicaria polystachya*, *Reynoutria × bohemica*, *Reynoutria japonica*, *Reynoutria sachalinensis*, *Rudbeckia laciniata*, *Rumex thyrsiflorus*, *Sedum hispanicum*, *Telekia speciosa* and *Virga strigosa* (summarized in Tab.1). In addition, mycorrhizal status of four invasive neophytes (*Digitalis purpurea*, *Impatiens glandulifera*, *I. parviflora* and *Rumex alpinus*) was clarified. Different AM status was determined for one species (*Rumex longifolius*) in comparison to its record in Wang & Qiu (2006), referring to Eriksen et al. (2002).

Based on my source data and according to the classification in Wang & Qiu (2006), 10 studied invasive neophytes can be considered to be obligately mycorrhizal, 21 facultatively mycorrhizal and 13 as non-mycorrhizal. Mycorrhizal status of individual species is listed in Tab. 1.

My results indicate that about 70 % of the examined invasive species are capable to be mycorrhizal under field conditions. The majority of them belongs to plant family Asteraceae. On the other hand, most of the studied invasive species of the family Polygonaceae (second most numerous plant family in the set of studied species) have been found non-mycorrhizal.

Hypothesis of Urcelay & Díaz (2003)

Collected data do not support the hypothesis that the extent of mycorrhizal infection of invading plant species is correlated with that of the native species dominating the invaded community (Tab. 2, first two rows).

I found positive correlation between the relative arbuscular and relative vesicular infection (InvArb/InvTot and InvVes/InvTot) of invasive species' roots (Tab. 2, the last row).

Table 2. Relations between AMF infection extent of the native dominant species and the infection of invasive neophytes and the relation between relative arbuscular and vesicular infection of invasive neophytes. Abbreviations: *InvArb/InvTot~DomTot*, correlation between total AMF infection of the dominant species and the relative arbuscular infection of the invasive neophytes; *InvArb~DomArb*, effect of arbuscular infection of the dominant species on that of the invasive neophytes; *InvArb/InvTot~InvVes/InvTot*, relation between relative arbuscular infection and relative vesicular infection of the invasive neophytes; *InvSpec*, relation at the among-species level; *InvSpec/FC*, ditto, after phylogenetic correction; *Within*, relation at the within-species level; ▲, positive correlation. The number of residual dfs is 13 at the the among-species level, 12 after phylogenetic correction and 63 at the within-species level.

	InvSpec	InvSpec/FC	Within
InvArb/InvTot~DomTot	F=1.95 (n.s.)	F=0.10 (n.s.)	F=0.16 (n.s.)
InvArb~DomArb	F=2.02 (n.s.)	F=0.06 (n.s.)	F=2.70 (n.s.)
InvArb/InvTot~InvVes/InvTot	F=1.32 (n.s.)	F=0.13 (n.s.)	F=6.24 (0.02) ▲

Correlations between the intensity of AMF colonization of invasive species and the characteristics of habitat and community

I found only one significant correlation at the among-species level – the relative arbuscular infection in invasive species' roots increases with the nitrogen availability in the habitat (Tab. 3, last row) – and this relation is significant even after phylogenetic correction. At the within-species level, I found negative correlation between the relative arbuscular infection in invasive plant roots and the light and temperature conditions of the habitat (Tab. 3, third and fourth rows), while moisture availability had a positive correlation (Tab. 3, fifth row).

Table 3. Effects of habitat and community characteristics on the relative arbuscular infection of invasive neophyte species. Abbreviations: *Richness*, species richness of the community; *Diversity*, species diversity of the community (Shannon-Wiener index); *EL*, Ellenberg indicator value for light conditions; *ET*, Ellenberg indicator value for the temperature demands; *EM*, Ellenberg indicator value for moisture; *ER*, Ellenberg indicator value for soil reaction; *EN*, Ellenberg indicator value for nitrogen availability; *InvSpec*, relations at the among-species level; *InvSpec/FC*, ditto, after phylogenetic correction; *Within*, relations at the within-species level; ▲, positive correlation; ▼, negative correlation. The number of residual dfs is 11 at the among-species level, 10 ditto, after phylogenetic correction and 51 at the within-species level.

	InvSpec	InvSpec/FC	Within
Richness	F=0.42 (n.s.)	F=0.42 (n.s.)	F=0.02 (n.s.)
Diversity	F=0.11 (n.s.)	F=0.08 (n.s.)	F=0.54 (n.s.)
EL	F=0.32 (n.s.)	F=0.22 (n.s.)	F=5.93 (0.02) ▼
ET	F=0.04 (n.s.)	F=0.73 (n.s.)	F=14.79 (<10 ⁻³) ▼
EM	F=1.20 (n.s.)	F=0.05 (n.s.)	F=4.06 (<0.05) ▲
ER	F=0.53 (n.s.)	F=0.45 (n.s.)	F=0.01 (n.s.)
EN	F=14.00 (<10 ⁻²) ▲	F=7.48 (0.02) ▲	F=0.80 (n.s.)

DISCUSSION

Mycorrhizal status of the studied invasive species

I assessed the mycorrhizal status of 44 invasive neophyte species in the Czech Republic. To my knowledge, AM status of 23 invasive species (marked with asterisk in Tab. 1) have been reported for the first time.

Mycorrhizal dependence of plant species is traditionally determined by comparing plant growth (under experimental conditions) with and without AM symbionts (e.g. Fitter & Nichols 1988). Therefore, field sampling can be used to identify species, which are not fully AM dependent, but in particular cases enter into symbiotic relation with AMF anyway. In my study, focused on a broad range of information on the AM symbiosis of multiple plant species over wide geographical area, only the observations on presence and extent of AM symbiosis under field conditions have been used to hint on AM dependency (adopting the approach of Wang & Qiu 2006). Therefore, they cannot be compared with the results based on experimental procedures.

My findings on AM status of invasive neophytes are not in conflict with the results of two main compilation studies, Harley & Harley (1987) and Wang & Qiu (2006), with few exceptions. I clarified the AM status of four species recorded in the earlier published study and later cited by Wang & Qiu (2006). There are *Digitalis purpurea*, *Impatiens glandulifera*, *I. parviflora* and *Rumex alpinus*, which had both information on AM status cited therein but found in different literature sources.

Digitalis purpurea was twice recorded as mycorrhizal and once as non-mycorrhizal in Harley & Harley (1987). I examined its roots from three localities and found noticeable differences – no arbuscules have been found in the roots from the locality No. 34 and a weak infection was recorded from the locality No. 86 while samples from the locality No. 73 had more than 20% infection. I think that the most important difference among these localities is the different extent of disturbances - locality No. 34 is a forest margin, No. 86 is a road margin with a steep slope about 30%, while No. 73 is a meadow with a quite steep slope about 25%. Eriksson (2001) also found lower AMF colonization of the host plants in more disturbed sites.

Harley & Harley (1987) also provides diverse information on AM status of two congeners *Impatiens glandulifera* and *I. parviflora*. The last mentioned was once recorded with absent and once with present AMF in its roots while *I. parviflora* was three times recorded with present and once with absent AMF in its roots. Collected data support this variation in AMF colonization and do not support my expectation that the response to AMF

of these two species would be different, based on the different habitat demands (e.g. water table) of *I. glandulifera* and *I. parviflora*.

Rumex alpinus was in Harley & Harley (1987) three times recorded with absent and once with observed AMF in its roots similarly to the examined specimens in this study, which showed no or weak AMF infection in its roots. This is promoted by Bohner (2005), who also found roots of this species colonized by AMF but he did not show any significant differences in its response to acid, nutrient-poor and -rich soils.

Rumex longifolius, another species from the plant family Polygonaceae, was recorded AM dependent in Wang & Qiu (2006), referring to Eriksen et al. (2002), while I did not observe any AMF structures in the roots of this species. One explanation of no observed AM structures in its roots is the low number of samples in my study (only three specimens from one locality while Eriksen et al. 2002 examined ten specimens within one locality). Nevertheless, their results also indicate weak or no AMF colonization (AMF structures were presented only in a very few specimens, with a weak infection below 1%).

I have also compared sample processing used in the present study with that of Eriksen et al. (2002) and I found several differences. First of all, Eriksen et al. (2002) stained the roots with widely used trypan blue, while I used Chlorazol Black E dye. Nevertheless, Gange et al. (1999) have shown no significant differences between these two stains. However, my observation could be influenced by heavy pigmentation of the roots of *Rumex longifolius* due to the secondary metabolites that I was not able to remove and, therefore, arbuscules could not be clearly seen, even if present. I have tried to clear such darkly pigmented roots by prolonged maceration in KOH (Vierheiling et al. 2005) but with variable results, probably because of the varying age and diameter of the roots. In contrast, Eriksen et al. (2002) bleached them with alkaline hydrogen peroxide. This method is promoted by Vierheiling et al. (2005) who suggested it as the second step after heating the roots in KOH, if all secondary metabolites are not removed.

Note, however, that AMF colonization depends on many factors, e.g. the host plant species phenology (Sanders & Fitter 1992a, 1992b, Šmilauer 2001, Ruotsalainen et al. 2002), AMF diversity and species composition within different habitats and communities (Nicholson 1958) as well as their seasonal and ontogenetic variations (Jacobsen et al. 2002). Therefore, the absence of AMF in the roots of *Rumex longifolius* (or any other species with low number of studied localities) could be influenced by specific habitat conditions. Moreover, the general lack of AMF is in agreement with the fact that the Polygonaceae family is often considered as non-mycorrhizal (Smith & Read 1997).

I found most mycorrhizal invasive species belonging to the family Asteraceae. This finding is partly influenced by the fact that most of the studied invasive species (14 from the total of 44) belong to this family. This is also in accord with Pyšek (1998) who considers Asteraceae among the four families most contributing by alien species to local floras.

Hypothesis of Urcelay & Díaz (2003)

My prediction based on Urcelay and Díaz hypothesis (Urcelay & Díaz 2003) that AM status of the studied invasive species would be correlated with that of native dominants has not been supported by collected data. This could be due to a high variability in the data set and relatively low number of studied samples. Evolutionary inertia (sensu Harvey & Pagel, 1991) could also have substantial effect as indicated by the reduction of effect sizes after phylogenetic correction and also by the fact that both the group of invasive plant species with absent AM symbiosis and the group of species with higher AM infection rates are clumped in different parts of the phylogram (see Appendix 3). On the other hand, Wolfe et al. (2006) suggest that it is important to note that this model considers only absolute positive or neutral effect of AMF only.

Although the collected data do not show any significant correlation between AM symbiosis of the invasive plant and that of the community dominant (Tab. 2, first two analyses), I can still consider four scenarios, based on the work of Urcelay & Díaz (2003), and hypothesize what effect could have an experimental suppression of AM symbiosis with a selective fungicide, such as the benomyl (see Fitter & Nichols 1988).

(1) When both the studied invasive species and the native dominants are non-mycorrhizal or with a low mycorrhizal dependence, AMF could hardly play an important role in the invasion of introduced species. Consequently, suppression of AM symbiosis should not affect the relation between the dominant and invasive species. This scenario corresponds to early successional stages such as those found at railway and ruderal sites, pond bottoms, and road margins - the sites most preferred by invasive species within this study.

(2) Different situation occurs when the dominant is highly mycorrhizal, while the invasive species is weakly mycorrhizal or non-mycorrhizal. Then the suppression of AMF should have a negative effect on the abundance of dominant while positive effect on the abundance of invasive species, promoting a successful invasion.

(3) The third possibility is the non-mycorrhizal native dominant and strongly mycorrhizal invasive species. Then, if AMF are available at the locality, they could have a positive effect on the invasion process (especially in symbiosis with other, non-dominant plant species). Lack of AMF at the site or their suppression with a selective fungicide should decrease the invasion success.

(4) The systems where both invasive and native species are AM-dependent are represented mainly by the late-successional communities (Janos 1980), e.g. grasslands and mature forests. Under this scenario, suppression of AMF should have similar effect on both the invasive and the native dominant species, and therefore no effect on their competitive balance (if the used fungicide did not disturb specific relationship of some of the sampled species to its pathogens).

Only the last analysis in Tab. 2 showed positive correlation between the relative arbuscular and relative vesicular mycorrhizal infection in invasive species' roots. This is probably partly influenced by the fact that vesicles were quantified only if arbuscules (AM key features) were observed in the roots.

Correlations between the intensity of AMF colonization of invasive species and the characteristics of habitat and community

My observations revealed noticeable variability in the intensity of AMF colonization in the roots of studied invasive neophytes over different sampling sites.

Nitrogen is one of the most limiting elements for the plant growth in terrestrial ecosystems (Schulze et al. 2002). My results (Tab. 3, last row) show that invasive plant species occurring in the habitats with elevated nitrogen availability have higher relative arbuscular infection in their roots. The effect of nitrogen availability is revealed at the among-species level, suggesting this is an evolutionary adaptation (relation stays significant after phylogenetic correction), rather than a phenotypic plasticity. My results contradict the findings of Chambers et al. (1980), Azcón et al. (1982) and Blanke et al. (2005), who claim that the nitrogen fertilization (similarly to the phosphorus fertilization) suppresses the root colonization by AMF. However, according to Rillig et al. (2002), higher nitrogen availability in the soil (as ammonium or nitrate) could have various effect (no, positive or negative) on the intensity of AMF colonization in plant roots, with noticeable differences among different localities. Another example was published by Egerton-Warburton & Allen (2000), who found that nitrogen enrichment reduced hyphal and vesicular infection of AMF and could alter AMF diversity and composition. Such

belowground shifts in the soil communities could evoke aboveground changes in the plant community structure (Gange et al. 1990, O'Conner et al. 2002, Urcelay & Díaz 2003, Wolfe et al. 2006) and, further, these "nonequilibrium" communities (with reduced species evenness, richness and diversity) could be more susceptible to the invasion by non-native species (e.g. Rejmánek 1989, van Ruijven et al. 2003).

In addition, Sigüenza et al. (2006) showed different responses of two plant species to nitrogen enrichment, namely increased seedling biomass of the invasive annual grass together with decreased biomass of the native shrub. This better utilization of nitrogen by invasive species in comparison to native ones can play a potential role in the facilitation of introduced species in the new areas. This is promoted by Suding et al. (2004), who revealed that *Centaurea diffusa*, the invasive species in the North America, is less limited by nitrogen in comparison to other native species in grasslands.

The intensity of AMF colonization in the plant roots is also influenced by other factors as light, temperature and water availability (Smith & Read 1997). The results of my analyses on these specific habitat characteristics indicate that roots of invasive neophyte species have lower relative arbuscular infection in the habitats with higher light and temperature conditions (Tab. 3, third and fourth rows) whereas this infection is higher in moist habitats (Tab. 3, fifth row).

Rillig et al. (2002) consider moisture and temperature as two soil characteristics with a strong effect on mycorrhiza. The positive effect of soil moisture on the AMF root colonization is in agreement with the results of Apple et al. (2005), who studied the seasonal dynamics of AMF in the roots of two Mojave desert's species. They found significant changes due to soil moisture in proportion of all AMF structures (arbuscules, vesicles and also hyphae). In the case of light and temperature demand, very few published results are available to compare with my data. Those studies focus mainly on the effect of global warming (i.e. temperature increase) on the AMF and the shifts in the composition and function of their communities (e.g. Fitter et al. 2000, Rillig et al. 2002).

It seems to be too early to reliably assess how the success of alien plant species is influenced by AMF in comparison to other factors (studied in more detail till today), such as the other symbiotic association, dispersal and propagule production, and susceptibility of native plant community to introduced species. However, the role of AMF in the invasion process cannot be overlooked.

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SOUHRN

V rámci této studie jsem se zabývala arbuskulární mykorhizní symbiózou 44 invazních neofytů, které se vyskytují na území České republiky. Z mých výsledků vyplývá, že přibližně 70% sledovaných druhů je schopno tvořit symbiotický vztah s arbuskulárními houbami (dále AMF). Ve srovnání s dosud publikovanými údaji tato práce předkládá nové informace o mykorhizním statutu pro 23 invazních neofytů: *Amaranthus powellii*, *Bunias orientalis*, *Cannabis ruderalis*, *Echinocystis lobata*, *Echinops sphaerocephalus*, *Galeobdolon argentatum*, *Geranium pyrenaicum*, *Helianthus tuberosus*, *Heracleum mantegazzianum*, *Juncus tenuis*, *Kochia scoparia* subsp. *scoparia*, *Lupinus polyphyllus*, *Matricaria discoidea*, *Parthenocissus inserta*, *Persicaria polystachya*, *Reynoutria × bohémica*, *Reynoutria japonica*, *Reynoutria sachalinensis*, *Rudbeckia laciniata*, *Rumex thyrsiflorus*, *Sedum hispanicum*, *Telekia speciosa* a *Virga strigosa*. Můj předpoklad, založený na hypotéze Urcelay & Díaz (2003), že míra infestace AMF v kořenech invazivního druhu bude závislá na rozsahu výskytu AMF v kořenech dominantního druhu invadovaného společenstva, nebyl sebranými daty podpořen. Dále jsem testovala vliv vlastností biotopu a rostlinného společenstva na míru infestace AMF v kořenech invazních neofytů. Na základě získaných výsledků lze usuzovat, že na vnitrodruhové úrovni mají invazivní druhy v biotopech se světlomilnějšími a teplomilnějšími rostlinami nižší podíl arbuskulů ve své kolonizaci AMF, zatímco ve vlhčích mají podíl arbuskulů vyšší. V dusíkem bohatých biotopech, kde se AMF houby uplatňují obecně méně, mají také podíl arbuskulů vyšší. Vliv dostupnosti dusíku na AMF se oproti předešlým vztahům k charakteristikám prostředí objevil na mezidruhové úrovni, což poukazuje spíše na evoluční závislost než na fenotypovou plasticitu těchto druhů. Tento vztah zůstal průkazný i po fylogenetické korekci.

REFERENCES

- Allsopp N. & Stock W. D. (1993): Mycorrhizal status of plants growing in the Cape Floristic Region, South Africa. – *Bothalia* **23**: 91-104.
- Allsopp N. & Holmes (2001): The impact of alien plant invasion on mycorrhizas in mountain fynbos vegetation. – *South African Journal of Botany* **67**: 150-156.
- Apple M. E., Thee Ch. I., Smith-Longozo V. L., Cogar C. R., Wells CH. E. & Nowak R. S. (2005): Arbuscular mycorrhizal colonization of *Larrea tridentata* and *Ambrosia dumosa* roots varies with precipitation and season in the Mojave Desert. – *Symbiosis* **39**: 1-5.
- Azcón R., Gomez-Ortega M. & Barea J. M. (1982): Comparative effects of foliar- or soil-applied nitrate on vesicular-arbuscular mycorrhizal infection in maize. – *New Phytologist* **92**: 553-559.
- Azcón-Aguilar C. & Barea J. M. (1996): Arbuscular mycorrhizas and biological control of soil-borne plant pathogens – an overview of the mechanisms involved. – *Mycorrhiza* **6**: 457-464.
- Belnap J., Phillips S. L., Sherrod S. K., Moldenke A. (2005): Soil biota can change after exotic plant invasion: does this affect ecosystem processes? – *Ecology* **86**: 3007-3017.
- Blanke V., Renker C, Wagner M., Füllner K., Held M., Kuhn A. J. & Buscot F. (2005): Nitrogen supply affects arbuscular mycorrhizal colonization of *Artemisia vulgaris* in a phosphate-polluted field site. – *New Phytologist* **166**: 981-992.
- Bohner A. (2005): *Rumicetum alpini* Beger 1922 – species composition, soil-chemical properties, and mineral element content. – *Wulfenia* **12**: 113-126.
- Brundrett M. C. (2002): Coevolution of roots and mycorrhizas of land plants. – *New Phytologist* **154**: 275-304.
- Brundrett M. C. (2004): Diversity and classification of mycorrhizal associations. – *Biological Reviews* **78**: 473-495.
- Burke D. J. (2008): Effects of *Alliaria petiolata* (garlic mustard; Brassicaceae) on mycorrhizal colonization and community structure in three herbaceous plants in a mixed deciduous forest. – *American Journal of Botany* **95**: 1416-1425.
- Callaway R. M., Thelen G. C., Rodriguez A., Holben W. E. (2004a): Soil biota and exotic plant invasion. – *Nature* **427**: 731-733.
- Callaway R. M., Giles C. T., Barth S., Ramsey P. W., Gannon J. E. (2004b): Soil fungi alter interactions between the invader *Centaurea maculosa* and North American natives. – *Ecology* **85**: 1062-1071.
- Chambers C. A., Smith S. E. & Smith F. A. (1980): Effects of ammonium and nitrate ions on mycorrhizal infection, nodulation and growth of *Trifolium subterraneum*. – *New Phytologist* **85**: 47-62.
- Chytrý M., Pyšek P., Tichý L., Knollová I. & Danihelka J. (2005): Invasions of the Czech Republic by alien plants: a quantitative assessment across habitats. – *Preslia* **77**: 339-354.
- Cipollini D., Mbagwu J., Barto K., Hillstrom C. & Enright S. (2005): Expression of constitutive and inducible chemical defenses in native and invasive populations of *Alliaria petiolata*. – *Journal of Chemical Ecology* **31**: 1255-1267.
- Desdevises Y., Legendre P., Azouzi L. & Morand S. (2003): Quantifying phylogenetically-structured environmental variation. – *Evolution* **57**: 2647-2652.
- di Castri F., Hansen A. J. & Debussche M. (1990): *Biological invasions in Europe and the Mediterranean Basin*. – Kluwer Academic Publishers, Dordrecht.

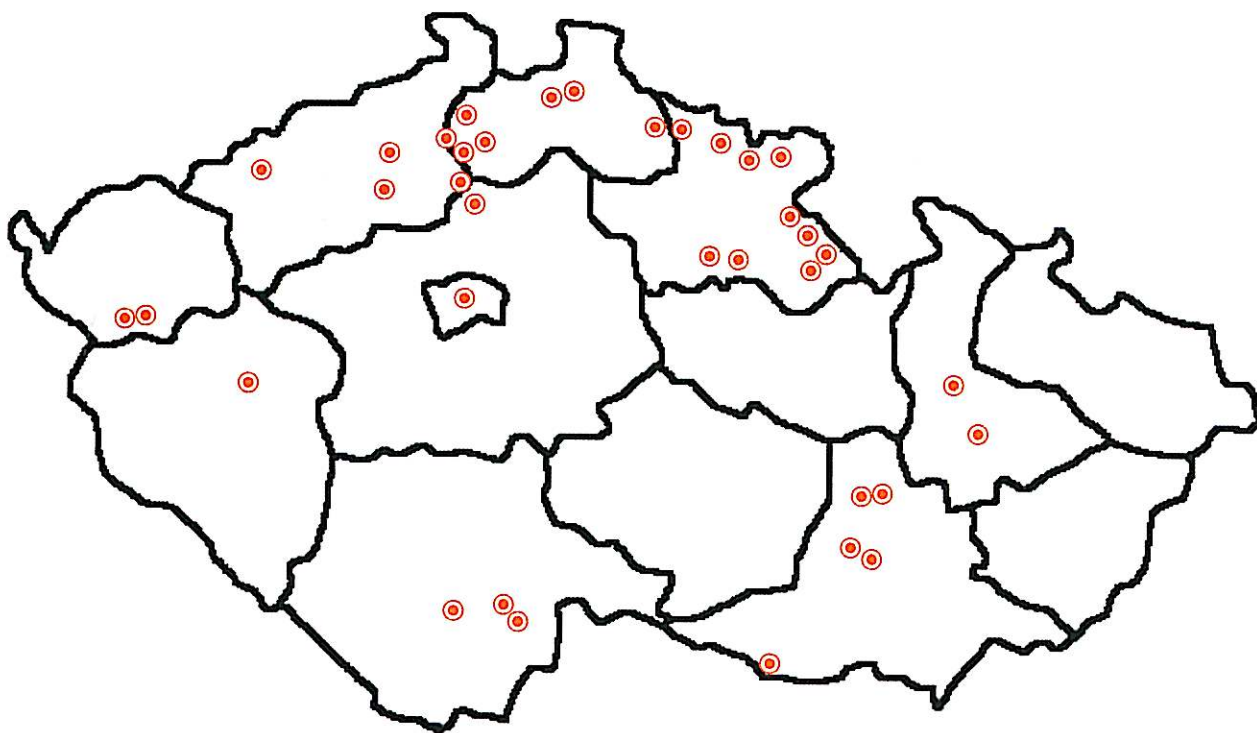
- Drake J. A., Mooney H. A., di Castri F., Groves R. H., Kruger F. J., Rejmánek M. & Williamson M. (1989): *Biological invasions: a global perspective*. – Wiley, Chirester.
- Egerton-Warburton L. M. & Allen E. B. (2000): Shifts in arbuscular mycorrhizal communities along an anthropogenic nitrogen deposition gradient. – *Ecological Application* **10**: 484-496.
- Ellenberg H. (1988): *Vegetation of Central Europe*. – Cambridge University Press, Cambridge.
- Eriksen M., Bjureke K. E. & Dhillion S. S. (2002): Mycorrhizal plants of traditionally managed boreal grasslands in Norway. – *Mycorrhiza* **12**: 117-123.
- Eriksson A. (2001): Arbuscular mycorrhiza in relation to management history, soil nutrients and plant species diversity. – *Plant Ecology* **155**: 129-137.
- Fitter A. H. & Nichols R. (1988): The use of benomyl to control infection by vesicular-arbuscular mycorrhizal fungi. – *New Phytologist* **110**: 201-206.
- Fitter A. H., Heinemeyer A. & Staddon P. L. (2000): The impact of elevated CO₂ and global climate change on arbuscular mycorrhizas: a myco-centric approach. – *New Phytologist* **147**: 179-187.
- Fumanal B., Planchette C., Chauvel B. & Bretagnolle F. (2006): Which role can arbuscular mycorrhizal fungi play in the facilitation of *Ambrosia artemisiifolia* L. invasion in France? – *Mycorrhiza* **17**: 25-35.
- Gange A. C., Brown V. K. & Farmer L. M. (1990): A test of mycorrhizal benefit in an early successional plant community. – *New Phytologist* **115**: 85-91.
- Gange A. C., Bower E., Stagg P. G., Aplin D. M., Gillam A. E., Bracken M. (1999): A comparison of visualization techniques for recording arbuscular mycorrhizal colonization. – *New Phytologist* **142**: 123-132.
- Gryndler M., Baláž M., Hršelová H., Jansa J., Vosátka M. (2004): *Mykorhizní symbióza: o soužití hub s kořeny rostlin [Mycorrhizal symbiosis: about coexistence of fungi and plant roots]*. – Academia, Praha [in Czech].
- Harley J. L. & Harley E. L. (1987): A check-list of mycorrhiza in the British flora. – *New Phytologist* (Suppl.) **105**: 1-102.
- Harvey P. H. & Pagel M. D. (1991): *The comparative method in evolutionary biology*. – Oxford University Press.
- Hawkes V. H., Belnap J., D'Antonio C., Firestone M. K. (2006): Arbuscular mycorrhizal assemblages in native plant roots change in the presence of invasive exotic grasses. – *Plant and Soil* **281**: 369-380.
- Hejný S., Slavík B. (eds.) (1988): *KVĚTENA ČR, díl 1. [Flora of the Czech Republic, volume 1]*. – Academia, Praha [in Czech].
- Hejný S., Slavík B. (eds.) (1990): *KVĚTENA ČR, díl 2. [Flora of the Czech Republic, volume 2]*. – Academia, Praha [in Czech].
- Hejný S., Slavík B. (eds.) (1992): *KVĚTENA ČR, díl 3. [Flora of the Czech Republic, volume 3]*. – Academia, Praha [in Czech].
- Hennekens S. M. (2008): *Turboveg for Windows, version 2*. – available from: <http://www.synbiosys.alterra.nl/turboveg/twin.pdf>.
- Hennekens S. M. & Schaminée J. H. J. (2001). TURBOVEG, a comprehensive database management system for vegetation data. – *Journal of Vegetation Science* **12**: 589-591.
- Jakobsen I., Smith S. E., Smith F. A. (2002): Function and diversity of arbuscular mycorrhizae in carbon and mineral nutrition. – In: van der Heijden M. G. A., Sanders I. R. (eds.), *Mycorrhizal ecology*, p. 75-88, Springer, Berlin.

- Janos D. P. (1980): Mycorrhizae influence tropical succession. – *Biotropica* **12**: 56-64.
- Johnson N. C., Graham J. H., Smith F. A. (1997): Functioning of mycorrhizal associations along the mutualism-parasitism continuum. – *New Phytologist* **135**: 575-585.
- Klein D. A., Paschke P. W. & Hessket T. L. (2006): Comparative fungal responses in managed plant communities infested by spotted (*Centaurea maculosa* Lam.) and diffuse (*C. diffusa* Lam.) knapweed. – *Applied Soil Ecology* **32**: 89-97.
- Klironomos J. N. (2003): Variation in plant response to native and exotic arbuscular mycorrhizal fungi. – *Ecology* **84**: 2292-2301.
- Klotz S., Kühn I. & Durka W. (eds.) (2002): BIOLFLOR – Eine Datenbank zu biologisch-ökologischen Merkmalen der Gefäßpflanzen in Deutschland. – *Schriftenreihe für Vegetationskunde* **38**: 41-46.
- Koske R. E. & Gemma J. N. (2006): Arbuscular mycorrhizae effects on growth of two Hawaiian species: indigenous *Osteomeles anthyllidifolia* (Rosaceae) and invasive *Psidium cattleianum* (Myrtaceae). – *Pacific Science* **60**: 471-482.
- Kubát K., Hrouda L., Chrtek J. jr., Kaplan Z., Kirschner J., Štěpánek J. (eds.) (2002): *Klíč ke květeně České republiky [Key to the flora of the Czech Republic]*. – Academia, Praha [in Czech].
- Lokvencová M. (2007): *Mycorrhizal infection of Plantago lanceolata seedlings in a managed grassland*. – 46 pp., Faculty of Biological Sciences, University of South Bohemia, České Budějovice [in Czech, English annotation].
- Marler M. J., Zabinski C. A., Callaway R. M. (1999): Mycorrhizae indirectly enhance competitive effects of an invasive forb on a native bunchgrass. – *Ecology* **80**: 1180-1186.
- MacKay J. & Kotanen P. M. (2008): Local escape of an invasive plant, common ragweed (*Ambrosia artemisiifolia* L.), from above-ground and below-ground enemies in its native area. – *Journal of Ecology* **96**: 1152-1161.
- Mlíkovský J. & Stýblo P. (eds.) (2006): *Nepůvodní druhy fauny a flóry České republiky [Non-native species of fauna and flora in the Czech Republic]*. – ČSOP, Praha [in Czech].
- Mooney H. A. & Hobbs R. J. (eds.) (2000): *Invasive species in a changing world*. – Island Press, Washington, D.C.
- Nicholson T. H. (1958): Vesicular-arbuscular mycorrhiza in the Gramineae. – *Nature* **181**: 718-719.
- O'Conner P. J., Smith S. E. & Smith S. A. (2002): Arbuscular mycorrhizas influence plant diversity and community structure in a semiarid herbland. – *New Phytologist* **154**: 209-218.
- Pyšek P. (1998): Is there a taxonomic pattern to plant invasions? – *Oikos* **82**: 282-294.
- Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.) (1995): *Plant invasions - General aspects and special problems*. – SPB Academic Publishers, Amsterdam.
- Pyšek P., Sádlo J. & Mandák B. (2002): Catalogue of alien plants of the Czech Republic. – *Preslia* **74**: 97-186.
- Pyšek P., Richardson D. M. & Jarošík V. (2006): Who cites who in the invasion zoo: insights from an analysis of the most highly cited papers in invasion ecology. – *Preslia* **78**: 437-468.
- R Development Core Team (2008): *R: a language and environment for statistical computing*. – R Foundation for Statistical Computing, Vienna.
- Radosevich S. R., Holt J. S., Ghersa C. M. (2007): *Ecology of weeds and invasive plants: relationship to agriculture and natural resource management, 3rd edition*. – John Wiley & Sons, Hoboken, New Jersey.

- Rejmánek M. (1989): Invasibility of plant communities. – *In: Drake J. A., Mooney H. A., di Castri F., Gross R. H., Kruger F. J., Rejmánek M. & Williamson M. (eds), Biological invasions: a global perspective*, p. 369–388, John Wiley & Sons, Chichester.
- Richardson D. M., Allsopp N., D'Antonio C., Milton S. J. & Rejmánek M. (2000): Plant invasion: the role of mutualism. – *Biological Reviews* **75**: 65-93.
- Richardson D. M. & Pyšek P. (2006): Plant invasions: merging the concepts of species invasiveness and community invasibility. – *Progress in Physical Geography* **30**: 409-431.
- Rillig M. C., Treseder K. K. & Allen M. F. (2002): Global change and mycorrhizal fungi. – *In: van der Heijden M. G. A., Sanders I. R. (eds.), Mycorrhizal ecology*, p. 75-88, Springer, Berlin.
- Roberts K. J. & Anderson R. C. (2001): Effect of garlic mustard [*Alliaria petiolata* (Bieb. Cavara & Grande)] extracts on plants and arbuscular mycorrhizal (AM) fungi. – *The American Midland Naturalist* **146**:146-152.
- Ruotsalainen A. L., Väre H. & Vestberg M. (2002): Seasonality of root fungal colonization in low-alpine herbs. – *Mycorrhiza* **12**: 29-36.
- Sanders I. R. & Fitter A. H. (1992a): The ecology and functioning of vesicular-arbuscular mycorrhizas in co-existing grassland species. I. Seasonal patterns of mycorrhizal occurrence and morphology. – *New Phytologist* **120**: 517–524.
- Sanders I. R. & Fitter A. H. (1992b): The ecology and functioning of vesicular-arbuscular mycorrhizas in co-existing grassland species. II. Nutrient uptake and growth of vesicular-arbuscular mycorrhizal plants in a semi-natural grassland. – *New Phytologist* **120**: 525–533.
- Schüßler A., Schwarzott D. & Walker C. (2001): A new fungal phylum, the Glomeromycota: phylogeny and evolution. – *Mycological Research* **105**: 1413-1421.
- Schulze E.-D., Beck E. & Muller-Hohenstein K. (2002): *Plant ecology*. – Spektrum Akademischer Verlag GmbH, Heidelberg.
- Sigüenza C., Corkidiki L. & Allen E. B. (2006): Feedbacks of soil inoculum of mycorrhizal fungi altered by N deposition on the growth of a native shrub and an invasive annual grass. – *Plant Soil* **286**: 153-165.
- Slavík B. (eds.) (1995): *KVĚTENA ČR, díl 4. [Flora of the Czech Republic, volume 4]*. – Academia, Praha [in Czech].
- Slavík B. (eds.) (1997): *KVĚTENA ČR, díl 5. [Flora of the Czech Republic, volume 5]*. – Academia, Praha [in Czech].
- Slavík B. (eds.) (2000): *KVĚTENA ČR, díl 6. [Flora of the Czech Republic, volume 6]*. – Academia, Praha [in Czech].
- Slavík B. & Štěpánková J. (eds.) (2004): *KVĚTENA ČR, díl 7. [Flora of the Czech Republic, volume 7]*. – Academia, Praha [in Czech].
- Smith S. E. & Read D.J. (1997): *Mycorrhizal symbiosis*. – Academic Press, London.
- Stampe E. D. & Daehler C. C. (2003): Mycorrhizal species identity affects plant community structure and invasion: a microcosm study. – *Oikos* **100**: 362-372.
- Stinson K. A., Campbell S. A., Powell J. R., Wolfe B. E., Callaway R. M., Thelen G. S., Hallett S. G., Prati D. & Klironomos J. N. (2006): Invasive plant suppresses the growth of native tree seedlings by disrupting belowground mutualisms. – *Plos Biology* **4**: e140. DOI: 10.1371/journal.pbio.0040140.
- Suding K. N., LeJeune K. D. & Seastedt T. R. (2004): Competitive impacts and responses of an invasive weed: dependencies on nitrogen and phosphorus availability. – *Oecologia* **141**: 526-535.

- Šmilauer P. (2001): Communities of arbuscular mycorrhizal fungi in grassland: seasonal variability and effects of environment and host plants. – *Folia Geobotanica* **36**: 243-263.
- Tichý L. (2002): JUICE, software for vegetation classification. – *Journal of Vegetation Science* **13**: 451-453.
- Tichý L. & Holt J. (2006): *JUICE, program for management, analysis and classification of ecological data.* – available from: http://www.sci.muni.cz/botany/juice/JUICEman_all.pdf.
- Urcelay C. & Díaz S. (2003): The mycorrhizal dependence of subordinates determines the effects of arbuscular mycorrhizal fungi on plant diversity. – *Ecology Letters* **6**: 388-391.
- van der Heijden M. G. A., Klironomos J. N., Ursic M., Moutoglis P., Streitwolf-Engel R., Boller T., Wiemken A. & Sanders I. R. (1998): Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. – *Nature* **396**: 69-72.
- van der Putten W. H., Klironomos J. N., Wardle D. A. (2007): Microbial ecology of biological invasions. – *ISME Journal* **1**: 28-37.
- van Ruijven J., de Deyn G. B. & Berendse F. (2003): Diversity reduces invasibility in experimental plant communities: the role of plant species. *Ecology Letters* **6**: 910-918.
- Vierheilig H., Schweiger P., Brundrett M. (2005): An overview of methods for the detection and observation of arbuscular mycorrhizal fungi in roots. – *Physiologia Plantarum* **125**: 393-404.
- Vitousek P. M., D'Antonio M. C., Loope L. L., Rejmánek M. & Westbrooks A. (1997): Introduced species: a significant component of human-caused global change. – *New Zealand Journal of Ecology* **21**: 1-16.
- Wang B. & Qiu Y.-L. (2006): Phylogenetic distribution and evolution of mycorrhizas in land plants. – *Mycorrhiza* **16**: 299-363.
- Wolfe B. E. & Klironomos J. N. (2005): Breaking new ground: soil communities and exotic plant invasions. – *BioScience* **55**: 477-487.
- Wolfe B. E., Weishampel P. A. & Klironomos J. N. (2006): Arbuscular mycorrhizal fungi and water table affect wetland plant community composition. – *Journal of Ecology* **94**: 905-914.

APPENDIX



Appendix 1. Map of the Czech Republic with marked sampling sites.

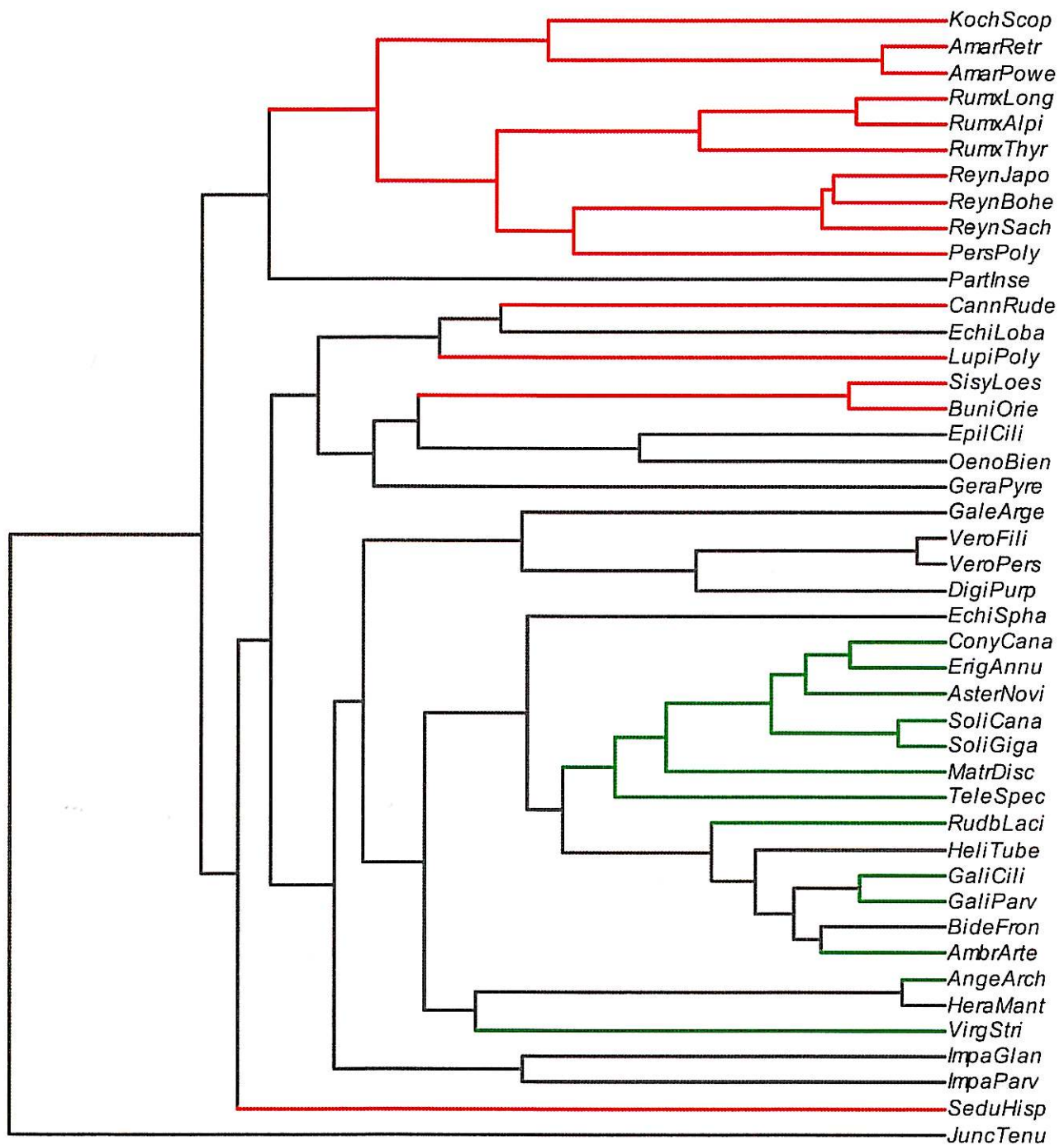
Appendix 2. The list of selected characteristics of all sampling sites. Abbreviations: No., number of the sampling site; Date, sampling date; Location, locality name; Elev., elevation of the sampling site [m a.s.l.]; GPS, rough position data of the sampling site; Habitat type, habitat type of the sampling site. Habitat categories: dwarf wall, all types of small walls in urban areas; field margin, coupon-free surrounding vegetation adjacent to all types of fields; forest margin, vegetation of forest margin; grass plot, man-made grassy site with compact turf, especially within the city or village; meadow, all types of meadows, especially outside the city or village; path margin, vegetation of path borders - usually in public parks and gardens; pond bottom, spontaneous vegetation of empty ponds; railway site, vegetation near railway buildings and railway tracks; road margin, vegetation of road borders, pitches and pavements; ruderal site, disturbed place near built-up areas, industrial facilities and dumps; water margin, vegetation of river banks and other water sites.

No.	Date	Location	Elev.	GPS	Habitat type	Invasive species	Dominant species
1	23-Jul-07	České Budějovice	390	N48 58.469 E14 28.462	path margin	<i>Impatiens parviflora</i>	<i>Urtica dioica</i>
2	25-Jul-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	water margin	<i>Impatiens glandulifera</i>	<i>Artemisia vulgaris</i>
3	25-Jul-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	meadow	<i>Solidago canadensis</i>	<i>Arrhenatherum elatius</i>
4	25-Jul-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	railway site	<i>Sisymbrium loeselii</i>	<i>Daucus carota</i>
5	1-Aug-07	České Budějovice	390	N48 58.469 E14 28.462	ruderal site	<i>Amaranthus retroflexus</i>	<i>Chenopodium album</i> agg.
6	1-Aug-07	České Budějovice	390	N48 58.469 E14 28.462	meadow	<i>Geranium pyrenaicum</i>	<i>Carex hirta</i>
7	1-Aug-07	České Budějovice	390	N48 58.469 E14 28.462	water margin	<i>Bidens frondosa</i>	<i>Carex hirta</i>
8	1-Aug-07	České Budějovice	390	N48 58.469 E14 28.462	grass plot	<i>Sisymbrium loeselii</i>	<i>Poa annua</i>
9	2-Aug-07	České Budějovice	390	N48 58.469 E14 28.462	grass plot	<i>Erigeron annuus</i>	<i>Lolium perenne</i>
10	9-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	railway site	<i>Galinsoga parviflora</i>	<i>Digitaria sanguinalis</i>
11	9-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	railway site	<i>Amaranthus retroflexus</i>	<i>Digitaria sanguinalis</i>
12	9-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	ruderal site	<i>Helianthus tuberosus</i>	<i>Dactylis glomerata</i>
13	9-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	ruderal site	<i>Rumex thyrsiflorus</i>	<i>Arrhenatherum elatius</i>
14	10-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	ruderal site	<i>Bidens frondosa</i>	<i>Urtica dioica</i>
15	10-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	meadow	<i>Solidago canadensis</i>	<i>Calamagrostis epigejos</i>
16	10-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	ruderal site	<i>Solidago gigantea</i>	<i>Poa pratensis</i>
17	10-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	path margin	<i>Juncus tenuis</i>	<i>Poa annua</i>
18	10-Aug-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	forest margin	<i>Impatiens parviflora</i>	<i>Scirpus sylvaticus</i>
19	14-Aug-07	Třeboň	438	N49 00.219 E14 46.239	ruderal site	<i>Amaranthus powellii</i>	<i>Chenopodium album</i> agg.
20	14-Aug-07	Třeboň	438	N49 00.219 E14 46.239	ruderal site	<i>Conyza canadensis</i>	<i>Polygonum aviculare</i> agg.
21	14-Aug-07	Třeboň	438	N49 00.219 E14 46.239	ruderal site	<i>Solidago canadensis</i>	<i>Calamagrostis epigejos</i>
22	14-Aug-07	Třeboň	438	N49 00.219 E14 46.239	ruderal site	<i>Impatiens glandulifera</i>	<i>Alopecurus pratensis</i>
23	14-Aug-07	Třeboň	438	N49 00.219 E14 46.239	dwarf wall	<i>Sedum hispanicum</i>	<i>Festuca rubra</i> agg.
24	16-Aug-07	Brno	275	N49 11.711 E16 35.982	grass plot	<i>Amaranthus retroflexus</i>	<i>Chenopodium album</i> agg.
25	16-Aug-07	Brno	275	N49 11.711 E16 35.982	path margin	<i>Solidago canadensis</i>	<i>Arrhenatherum elatius</i>
26	16-Aug-07	Brno	275	N49 11.711 E16 35.982	ruderal site	<i>Amaranthus powellii</i>	<i>Setaria pumila</i>
27	16-Aug-07	Brno	275	N49 11.711 E16 35.982	ruderal site	<i>Echinops sphaerocephalus</i>	<i>Arrhenatherum elatius</i>
28	16-Aug-07	Brno	275	N49 11.711 E16 35.982	ruderal site	<i>Helianthus tuberosus</i>	<i>Tripleurospermum inodorum</i>

No.	Date	Location	Elev.	GPS	Habitat type	Invasive species	Dominant species
29	29-Aug-07	Liberec	360	N50 46.026 E15 03.372	grass plot	<i>Erigeron annuus</i>	<i>Trifolium repens</i>
30	29-Aug-07	Liberec	360	N50 46.026 E15 03.372	water margin	<i>Impatiens glandulifera</i>	<i>Agrostis stolonifera</i>
31	29-Aug-07	Liberec	360	N50 46.026 E15 03.372	forest margin	<i>Impatiens parviflora</i>	<i>Poa annua</i>
32	31-Aug-07	Liberec	360	N50 46.026 E15 03.372	grass plot	<i>Geranium pyrenaicum</i>	<i>Aegopodium podagraria</i>
33	31-Aug-07	Liberec	360	N50 46.026 E15 03.372	road margin	<i>Epilobium ciliatum</i>	<i>Lolium perenne</i>
34	2-Sep-07	Proseč	478	N50 41.834 E15 01.057	forest margin	<i>Digitalis purpurea</i>	<i>Festuca ovina</i>
35	18-Sep-07	Kokořínský důl	245	N50 26.397 E14 34.852	road margin	<i>Galinsoga ciliata</i>	<i>Anthriscus sylvstris</i>
36	19-Sep-07	Kokořínský důl	245	N50 26.397 E14 34.852	road margin	<i>Solidago gigantea</i>	<i>Anthriscus sylvstris</i>
37	19-Sep-07	Kokořínský důl	245	N50 26.397 E14 34.852	road margin	<i>Impatiens parviflora</i>	<i>Urtica dioica</i>
38	3-Oct-07	České Budějovice	390	N48 58.469 E14 28.462	path margin	<i>Matricaria discoidea</i>	<i>Poa annua</i>
39	3-Oct-07	České Budějovice	390	N48 58.469 E14 28.462	ruderal site	<i>Conyza canadensis</i>	<i>Persicaria maculosa</i>
40	7-Oct-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	grass plot	<i>Conyza canadensis</i>	<i>Poa annua</i>
41	7-Oct-07	Třebechovice.p.O.	242	N50 12.057 E15 59.534	meadow	<i>Erigeron annuus</i>	<i>Arrhenatherum elatius</i>
42	10-Oct-07	České Budějovice	390	N48 58.469 E14 28.462	meadow	<i>Veronica persica</i>	<i>Agrostis stolonifera</i>
43	11-Oct-07	České Budějovice	390	N48 58.469 E14 28.462	road margin	<i>Epilobium ciliatum</i>	<i>Poa palustris</i>
44	14-Oct-07	České Budějovice	390	N48 58.469 E14 28.462	path margin	<i>Juncus tenuis</i>	<i>Poa annua</i>
45	3-Jul-08	Hradec Králové	247	N50 12.554 E15 49.965	ruderal site	<i>Parthenocissus inserta</i>	<i>Urtica dioica</i>
46	3-Jul-08	Hradec Králové	247	N50 12.554 E15 49.965	ruderal site	<i>Heracleum mantegazzianum</i>	<i>Arrhenatherum elatius</i>
47	4-Jul-08	Dolce u Trutnova	414	N50 32.806 E15 53.181	road margin	<i>Matricaria discoidea</i>	<i>Plantago major</i>
48	4-Jul-08	Dolce u Trutnova	414	N50 32.806 E15 53.181	meadow	<i>Lupinus polyphyllus</i>	<i>Chaerophyllum aureum</i>
49	5-Jul-08	Hradec Králové	247	N50 12.554 E15 49.965	ruderal site	<i>Oenothera biennis</i>	<i>Deschampsia cespitosa</i>
50	5-Jul-08	Hradec Králové	247	N50 12.554 E15 49.965	ruderal site	<i>Echinops sphaerocephalus</i>	<i>Arrhenatherum elatius</i>
51	6-Jul-08	Hradec Králové	247	N50 12.554 E15 49.965	ruderal site	<i>Virga strigosa</i>	<i>Elymus cf. caninus</i>
52	7-Jul-08	Hradec Králové	247	N50 12.554 E15 49.965	ruderal site	<i>Bunias orientalis</i>	<i>Arrhenatherum elatius</i>
53	10-Jul-08	Kosí potok	494	N49 52.352 E12 48.345	meadow	<i>Lupinus polyphyllus</i>	<i>Lolium multiflorum</i>
54	10-Jul-08	Planá u M.L.	511	N49 52.095 E12 44.551	forest margin	<i>Impatiens parviflora</i>	<i>Aegopodium podagraria</i>
55	10-Jul-08	Planá u M.L.	511	N49 52.095 E12 44.551	road margin	<i>Echinops sphaerocephalus</i>	<i>Arrhenatherum elatius</i>
56	10-Jul-08	Planá u M.L.	511	N49 52.095 E12 44.551	road margin	<i>Epilobium ciliatum</i>	<i>Arrhenatherum elatius</i>
57	10-Jul-08	Planá u M.L.	511	N49 52.095 E12 44.551	road margin	<i>Matricaria discoidea</i>	<i>Plantago major</i>
58	10-Jul-08	Planá u M.L.	511	N49 52.095 E12 44.551	ruderal site	<i>Helianthus tuberosus</i>	<i>Cirsium arvense</i>
59	10-Jul-08	Planá u M.L.	511	N49 52.095 E12 44.551	grass plot	<i>Veronica persica</i>	<i>Elytrigia repens</i>
60	11-Jul-08	Planá u M.L.	511	N49 52.095 E12 44.551	field margin	<i>Heracleum mantegazzianum</i>	<i>Urtica dioica</i>
61	12-Jul-08	Chomutov	339	N50 27.628 E13 25.067	ruderal site	<i>Conyza canadensis</i>	<i>Bromus tectorum</i>
62	12-Jul-08	Chomutov	339	N50 27.628 E13 25.067	forest margin	<i>Galeobdolon argentatum</i>	<i>Geum urbanum</i>
63	12-Jul-08	Chomutov	339	N50 27.628 E13 25.067	grass plot	<i>Rumex thyrsiflorus</i>	<i>Achillea cf. millefolium</i>
64	12-Jul-08	Chomutov	339	N50 27.628 E13 25.067	grass plot	<i>Reynoutria japonica</i>	<i>Lolium multiflorum</i>
65	12-Jul-08	Chomutov	339	N50 27.628 E13 25.067	grass plot	<i>Amaranthus retroflexus</i>	<i>Lolium multiflorum</i>
66	12-Jul-08	Chomutov	339	N50 27.628 E13 25.067	grass plot	<i>Geranium pyrenaicum</i>	<i>Artemisia vulgaris</i>
67	12-Jul-08	Chomutov	339	N50 27.628 E13 25.067	road margin	<i>Sisymbrium loeselii</i>	<i>Lolium multiflorum</i>
68	25-Jul-08	České Budějovice	390	N48 58.469 E14 28.462	grass plot	<i>Veronica filiformis</i>	<i>Festuca rubra</i> agg.

No.	Date	Location	Elev.	GPS	Habitat type	Invasive species	Dominant species
69	28-Jul-08	Mělník	435	N49 53.711 E14 54.744	ruderal site	<i>Conyza canadensis</i>	<i>Lactuca serriola</i>
70	28-Jul-08	Mělník	435	N49 53.711 E14 54.744	ruderal site	<i>Erigeron annuus</i>	<i>Medicago sativa</i>
71	28-Jul-08	Nebořely	304	N50 23.418 E14 35.447	field margin	<i>Heracleum mantegazzianum</i>	<i>Urtica dioica</i>
72	28-Jul-08	Tuboř	313	N50 29.417 E14 35.715	forest margin	<i>Telekia speciosa</i>	<i>Melampyrum pratense</i>
73	28-Jul-08	Myší díra	326	N50 29.780 E14 37.597	meadow	<i>Digitalis purpurea</i>	<i>Agrostis capillaris</i>
74	28-Jul-08	Myší díra	326	N50 29.780 E14 37.597	meadow	<i>Reynoutria sachalinensis</i>	<i>Aegopodium podagraria</i>
75	29-Jul-08	Jestřebí	259	N50 36.516 E14 35.074	grass plot	<i>Matricaria discoidea</i>	<i>Poa annua</i>
76	29-Jul-08	Holany	273	N50 37.080 E14 29.579	ruderal site	<i>Galinsoğa parviflora</i>	<i>Potentilla anserina</i>
77	29-Jul-08	Holany	273	N50 37.080 E14 29.579	ruderal site	<i>Amaranthus retroflexus</i>	<i>Chenopodium album</i> agg.
78	29-Jul-08	Blíževedly	363	N50 36.504 E14 23.791	railway site	<i>Veronica persica</i>	<i>Poa annua</i>
79	29-Jul-08	Tuhaň	273	N50 32.188 E14 28.039	meadow	<i>Solidago canadensis</i>	<i>Arrhenatherum elatius</i>
80	29-Jul-08	Tuhaň	273	N50 32.188 E14 28.039	road margin	<i>Heracleum mantegazzianum</i>	<i>Dactylis glomerata</i>
81	29-Jul-08	Chudolazy	210	N50 28.488 E14 28.570	ruderal site	<i>Helianthus tuberosus</i>	<i>Aegopodium podagraria</i>
82	29-Jul-08	Tupadly	203	N50 26.508 E14 28.495	meadow	<i>Solidago canadensis</i>	<i>Phalaris arundinacea</i>
83	30-Jul-08	Litoměřice	165	N50 32.010 E14 07.908	ruderal site	<i>Echinops sphaerocephalus</i>	<i>Arrhenatherum elatius</i>
84	30-Jul-08	Litoměřice	165	N50 32.010 E14 07.908	ruderal site	<i>Bunias orientalis</i>	<i>Lolium perenne</i>
85	31-Jul-08	Benecko	791	N50 39.980 E15 32.891	meadow	<i>Rumex alpinus</i>	<i>Agrostis capillaris</i>
86	31-Jul-08	Benecko	791	N50 39.980 E15 32.891	road margin	<i>Digitalis purpurea</i>	<i>Petasites albus</i>
87	31-Jul-08	Žalý	1012	N50 39.980 E15 32.891	road margin	<i>Galeobdolon argentatum</i>	<i>Veronica chamaedrys</i>
88	1-Aug-08	Vrchlabí	486	N50 39.503 E15 34.443	ruderal site	<i>Veronica persica</i>	<i>Apera spica-venti</i>
89	4-Aug-08	Praha	205	N50 05.270 E14 25.449	field margin	<i>Veronica persica</i>	<i>Polygonum aviculare</i> agg.
90	4-Aug-08	Praha	205	N50 05.270 E14 25.449	ruderal site	<i>Matricaria discoidea</i>	<i>Polygonum aviculare</i> agg.
91	4-Aug-08	Praha	205	N50 05.270 E14 25.449	ruderal site	<i>Sisymbrium loeselii</i>	<i>Lolium perenne</i>
92	5-Aug-08	Liberec	360	N50 46.026 E15 03.372	road margin	<i>Juncus tenuis</i>	<i>Agrostis stolonifera</i>
93	5-Aug-08	Liberec	360	N50 46.026 E15 03.372	grass plot	<i>Virga strigosa</i>	<i>Urtica dioica</i>
94	5-Aug-08	Liberec	360	N50 46.026 E15 03.372	ruderal site	<i>Solidago gigantea</i>	<i>Calamagrostis epigejos</i>
95	6-Aug-08	Liberec	360	N50 46.026 E15 03.372	ruderal site	<i>Galinsoğa ciliata</i>	<i>Spergularia rubra</i>
96	6-Aug-08	Hluboká (LBC)	553	N50 43.160 E15 01.552	road margin	<i>Telekia speciosa</i>	<i>Cirsium oleraceum</i>
97	12-Aug-08	Brno	275	N49 11.711 E16 35.982	meadow	<i>Conyza canadensis</i>	<i>Eragrostis minus</i>
98	12-Aug-08	Brno	275	N49 11.711 E16 35.982	railway site	<i>Oenothera biennis</i>	<i>Setaria viridis</i>
99	12-Aug-08	Brno	275	N49 11.711 E16 35.982	railway site	<i>Parthenocissus inserta</i>	<i>Clematis vitalba</i>
100	12-Aug-08	Brno	275	N49 11.711 E16 35.982	railway site	<i>Galinsoğa parviflora</i>	<i>Digitaria sanguinalis</i>
101	12-Aug-08	Brno	275	N49 11.711 E16 35.982	railway site	<i>Ambrosia artemisiifolia</i>	<i>Digitaria sanguinalis</i>
102	12-Aug-08	Brno	275	N49 11.711 E16 35.982	railway site	<i>Kochia scoparia</i> subsp. <i>scoparia</i>	<i>Chenopodium album</i> agg.
103	12-Aug-08	Brno	275	N49 11.711 E16 35.982	ruderal site	<i>Erigeron annuus</i>	<i>Artemisia vulgaris</i>
104	12-Aug-08	Brno	275	N49 11.711 E16 35.982	ruderal site	<i>Sisymbrium loeselii</i>	<i>Calamagrostis epigejos</i>
105	13-Aug-08	Blansko	276	N49 21.787 E16 38.590	road margin	<i>Impatiens parviflora</i>	<i>Anthriscus sylvestris</i>
106	13-Aug-08	Blansko	276	N49 21.787 E16 38.590	road margin	<i>Galinsoğa ciliata</i>	<i>Aegopodium podagraria</i>
107	13-Aug-08	Blansko	276	N49 21.787 E16 38.590	forest margin	<i>Solidago gigantea</i>	<i>Eupatorium cannabinum</i>
108	13-Aug-08	Blansko	276	N49 21.787 E16 38.590	forest margin	<i>Aster novi-belgii</i> agg.	<i>Eupatorium cannabinum</i>

No.	Date	Location	Elev.	GPS	Habitat type	Invasive species	Dominant species
109	13-Aug-08	Skalní Mlýn	352	N49 21.815E16 42.626	pond bottom	<i>Bidens frondosa</i>	<i>Poa palustris</i>
110	14-Aug-08	Blansko	276	N49 21.787 E16 38.590	water margin	<i>Galeobdolon argentatum</i>	<i>Urtica dioica</i>
111	14-Aug-08	Blansko	276	N49 21.787 E16 38.590	water margin	<i>Impatiens glandulifera</i>	<i>Festuca gigantea</i>
112	23-Aug-08	Roudnice n.L.	179	N50 25.516 E14 15.705	water margin	<i>Angelica archangelica</i>	<i>Urtica dioica</i>
113	26-Aug-08	Hradec Králové	247	N50 12.554 E15 49.965	ruderal site	<i>Reynoutria x bohemica</i>	<i>Aegopodium podagraria</i>
114	10-Sep-08	Třebechovice.p.O.	242	N50 12.057 E15 59.534	water margin	<i>Echinocystis lobata</i>	<i>Urtica dioica</i>
115	14-Sep-08	Dyjakovičky	215	N48 46.938 E16 05.737	field margin	<i>Cannabis ruderalis</i>	<i>Mercurialis annua</i>
116	15-Sep-08	Panské Pole	727	N50 11.104 E16 30.193	ruderal site	<i>Rumex longifolius</i>	<i>Rubus idaeus</i>
117	15-Sep-08	Orlické Záhoří	683	N50 16.720 E16 28.497	meadow	<i>Telekia speciosa</i>	<i>Phalaris arundinacea</i>
118	16-Sep-08	Orlické Záhoří	683	N50 16.720 E16 28.497	road margin	<i>Rumex alpinus</i>	<i>Anthriscus sylvstris</i>
119	16-Sep-08	Serlich	998	N50 19.508E16 23.201	meadow	<i>Solidago canadensis</i>	<i>Cirsium oleraceum</i>
120	20-Sep-08	Plzeň	317	N49 44.848 E13 22.657	ruderal site	<i>Galeobdolon argentatum</i>	<i>Dactylis glomerata</i>
121	20-Sep-08	Plzeň	317	N49 44.848 E13 22.657	road margin	<i>Conyza canadensis</i>	<i>Urtica dioica</i>
122	20-Sep-08	Plzeň	317	N49 44.848 E13 22.657	ruderal site	<i>Erigeron annuus</i>	<i>Lepidium ruderae</i>
123	20-Sep-08	Plzeň	317	N49 44.848 E13 22.657	grass plot	<i>Sisymbrium loeselii</i>	<i>Centaura stoebe</i>
124	20-Sep-08	Plzeň	318	N49 44.848 E13 22.658	ruderal site	<i>Galinsoğa ciliata</i>	<i>Artemisia vulgaris</i>
125	20-Sep-08	Plzeň	317	N49 44.848 E13 22.657	railway site	<i>Galinsoğa parviflora</i>	<i>Chenopodium album</i> agg.
126	21-Sep-08	Majdalena	436	N48 57.642 E14 51.680	grass plot	<i>Rudbeckia laciniata</i>	<i>Aegopodium podagraria</i>
127	21-Sep-08	Majdalena	436	N48 57.642 E14 51.680	meadow	<i>Aster novi-belgii</i> agg.	<i>Phalaris arundinacea</i>
128	21-Sep-08	Majdalena	436	N48 57.642 E14 51.680	ruderal site	<i>Galinsoğa parviflora</i>	<i>Agrostis stolonifera</i>
129	28-Sep-08	Olomouc	226	N49 35.632 E17 15.054	grass plot	<i>Conyza canadensis</i>	<i>Ballota nigra</i>
130	28-Sep-08	Olomouc	226	N49 35.632 E17 15.054	grass plot	<i>Bidens frondosa</i>	<i>Agrostis stolonifera</i>
131	28-Sep-08	Olomouc	226	N49 35.632 E17 15.054	water margin	<i>Helianthus tuberosus</i>	<i>Agrostis stolonifera</i>
132	28-Sep-08	Olomouc	226	N49 35.632 E17 15.054	ruderal site	<i>Erigeron annuus</i>	<i>Elymus cf. caninus</i>
133	29-Sep-08	Uničov	241	N49 46.254 E17 07.288	ruderal site		<i>Artemisia vulgaris</i>



Appendix 3. The phylogenetic tree of all studied invasive neophytes based on the data provided by the BioFlor database (Klotz et al. 2002). Abbreviations of the species names are based on the first four letters of their genera and the first four letters of the species epiteton. Colors: red, average total AM infection of the species not higher than 1%; grey, average total AM infection of the species between 1 and 20%; green, average total AM infection of the species at least 20%.

Appendix 4. The list of the AMF intensity for the studied invasive species and their corresponding native dominants within all sampling sites. The values in this table were obtained by averaging the observations of three specimens of invasive plant species and of three specimens of corresponding native dominant species. Abbreviations: No., number of the sampling site; Total, total AMF infection (including arbuscules, vesicles, and hyphae together); Arb., arbuscular infection; Ves., vesicular infection.

No.	Invasive species	Total	Arb.	Ves.	Dominant species	Total	Arb.	Ves.
19	<i>Amaranthus powellii</i>	0.000	0.000	0.000	<i>Chenopodium album</i> agg.	0.000	0.000	0.000
26	<i>Amaranthus powellii</i>	0.000	0.000	0.000	<i>Setaria pumila</i>	0.037	0.011	0.000
5	<i>Amaranthus retroflexus</i>	0.000	0.000	0.000	<i>Chenopodium album</i> agg.	0.000	0.000	0.000
11	<i>Amaranthus retroflexus</i>	0.000	0.000	0.000	<i>Digitaria sanguinalis</i>	0.477	0.446	0.000
24	<i>Amaranthus retroflexus</i>	0.000	0.000	0.000	<i>Chenopodium album</i> agg.	0.000	0.000	0.000
65	<i>Amaranthus retroflexus</i>	0.000	0.000	0.000	<i>Lolium multiflorum</i>	0.045	0.008	0.003
77	<i>Amaranthus retroflexus</i>	0.000	0.000	0.000	<i>Chenopodium album</i> agg.	0.000	0.000	0.000
101	<i>Ambrosia artemisiifolia</i>	0.397	0.077	0.057	<i>Digitaria sanguinalis</i>	0.000	0.000	0.000
112	<i>Angelica archangelica</i>	0.375	0.304	0.006	<i>Urtica dioica</i>	0.000	0.000	0.000
108	<i>Aster novi-belgii</i> agg.	0.044	0.010	0.015	<i>Eupatorium cannabinum</i>	0.042	0.012	0.001
128	<i>Aster novi-belgii</i> agg.	0.736	0.034	0.061	<i>Agrostis stolonifera</i>	0.012	0.005	0.000
7	<i>Bidens frondosa</i>	0.605	0.140	0.080	<i>Carex hirta</i>	0.000	0.000	0.000
14	<i>Bidens frondosa</i>	0.000	0.000	0.000	<i>Urtica dioica</i>	0.000	0.000	0.000
109	<i>Bidens frondosa</i>	0.011	0.006	0.008	<i>Poa palustris</i>	0.000	0.000	0.000
131	<i>Bidens frondosa</i>	0.123	0.042	0.007	<i>Agrostis stolonifera</i>	0.094	0.072	0.042
52	<i>Bunias orientalis</i>	0.000	0.000	0.000	<i>Arrhenatherum elatius</i>	0.007	0.004	0.000
84	<i>Bunias orientalis</i>	0.000	0.000	0.000	<i>Lolium perenne</i>	0.465	0.383	0.045
115	<i>Cannabis ruderalis</i>	0.002	0.002	0.000	<i>Mercurialis annua</i>	0.110	0.052	0.000
20	<i>Coryza canadensis</i>	0.556	0.262	0.084	<i>Polygonum aviculare</i> agg.	0.000	0.000	0.000
39	<i>Coryza canadensis</i>	0.359	0.020	0.054	<i>Persicaria maculosa</i>	0.000	0.000	0.000
40	<i>Coryza canadensis</i>	0.336	0.068	0.077	<i>Poa annua</i>	0.094	0.084	0.006
61	<i>Coryza canadensis</i>	0.378	0.025	0.030	<i>Bromus tectorum</i>	0.100	0.050	0.001
69	<i>Coryza canadensis</i>	0.562	0.199	0.039	<i>Lactuca serriola</i>	0.501	0.208	0.053
97	<i>Coryza canadensis</i>	0.509	0.077	0.044	<i>Eragrostis minus</i>	0.153	0.026	0.011
122	<i>Coryza canadensis</i>	0.759	0.140	0.085	<i>Lepidium ruderales</i>	0.000	0.000	0.000
130	<i>Coryza canadensis</i>	0.731	0.216	0.011	<i>Agrostis stolonifera</i>	0.222	0.158	0.029
34	<i>Digitalis purpurea</i>	0.000	0.000	0.000	<i>Festuca ovina</i>	0.000	0.000	0.000
73	<i>Digitalis purpurea</i>	0.232	0.155	0.017	<i>Agrostis capillaris</i>	0.011	0.009	0.000
86	<i>Digitalis purpurea</i>	0.021	0.012	0.000	<i>Petasites albus</i>	0.337	0.184	0.007

No.	Invasive species	Total	Arb.	Ves.	Dominant species	Total	Arb.	Ves.
114	<i>Echinocystis lobata</i>	0.043	0.033	0.010	<i>Urtica dioica</i>	0.000	0.000	0.000
27	<i>Echinops sphaerocephalus</i>	0.245	0.013	0.000	<i>Arrhenatherum elatius</i>	0.052	0.006	0.000
50	<i>Echinops sphaerocephalus</i>	0.032	0.015	0.008	<i>Arrhenatherum elatius</i>	0.025	0.013	0.000
55	<i>Echinops sphaerocephalus</i>	0.000	0.000	0.000	<i>Arrhenatherum elatius</i>	0.114	0.100	0.000
83	<i>Echinops sphaerocephalus</i>	0.248	0.010	0.000	<i>Arrhenatherum elatius</i>	0.065	0.008	0.000
33	<i>Epilobium ciliatum</i>	0.139	0.063	0.001	<i>Lolium perenne</i>	0.202	0.189	0.000
43	<i>Epilobium ciliatum</i>	0.097	0.025	0.013	<i>Poa palustris</i>	0.000	0.000	0.000
56	<i>Epilobium ciliatum</i>	0.016	0.007	0.000	<i>Arrhenatherum elatius</i>	0.010	0.005	0.000
9	<i>Erigeron annuus</i>	0.366	0.019	0.041	<i>Lolium perenne</i>	0.135	0.029	0.012
29	<i>Erigeron annuus</i>	0.908	0.073	0.133	<i>Trifolium repens</i>	0.698	0.476	0.059
41	<i>Erigeron annuus</i>	0.054	0.009	0.022	<i>Arrhenatherum elatius</i>	0.428	0.038	0.025
70	<i>Erigeron annuus</i>	0.372	0.125	0.047	<i>Medicago sativa</i>	0.016	0.003	0.000
103	<i>Erigeron annuus</i>	0.398	0.015	0.027	<i>Artemisia vulgaris</i>	0.000	0.000	0.000
123	<i>Erigeron annuus</i>	0.320	0.008	0.013	<i>Centaurea stoebe</i>	0.092	0.009	0.002
133	<i>Erigeron annuus</i>	0.215	0.021	0.002	<i>Artemisia vulgaris</i>	0.036	0.002	0.000
62	<i>Galeobdolon argentatum</i>	0.000	0.000	0.000	<i>Geum urbanum</i>	0.000	0.000	0.000
87	<i>Galeobdolon argentatum</i>	0.055	0.041	0.002	<i>Veronica chamaedrys</i>	0.122	0.042	0.004
110	<i>Galeobdolon argentatum</i>	0.026	0.006	0.000	<i>Urtica dioica</i>	0.000	0.000	0.000
121	<i>Galeobdolon argentatum</i>	0.121	0.080	0.001	<i>Urtica dioica</i>	0.000	0.000	0.000
35	<i>Galinsoga ciliata</i>	0.191	0.066	0.009	<i>Anthriscus sylvestris</i>	0.000	0.000	0.000
95	<i>Galinsoga ciliata</i>	0.301	0.124	0.005	<i>Spergularia rubra</i>	0.000	0.000	0.000
106	<i>Galinsoga ciliata</i>	0.399	0.246	0.007	<i>Aegopodium podagraria</i>	0.108	0.089	0.000
125	<i>Galinsoga ciliata</i>	0.057	0.005	0.002	<i>Chenopodium album</i> agg.	0.000	0.000	0.000
10	<i>Galinsoga parviflora</i>	0.603	0.171	0.000	<i>Digitaria sanguinalis</i>	0.000	0.000	0.000
76	<i>Galinsoga parviflora</i>	0.468	0.266	0.100	<i>Potentilla anserina</i>	0.526	0.367	0.177
100	<i>Galinsoga parviflora</i>	0.179	0.044	0.005	<i>Digitaria sanguinalis</i>	0.000	0.000	0.000
126	<i>Galinsoga parviflora</i>	0.008	0.003	0.000	<i>Aegopodium podagraria</i>	0.084	0.073	0.002
129	<i>Galinsoga parviflora</i>	0.077	0.059	0.014	<i>Ballota nigra</i>	0.147	0.028	0.005
6	<i>Geranium pyrenaicum</i>	0.037	0.014	0.000	<i>Carex hirta</i>	0.000	0.000	0.000
32	<i>Geranium pyrenaicum</i>	0.082	0.069	0.000	<i>Aegopodium podagraria</i>	0.242	0.212	0.001
66	<i>Geranium pyrenaicum</i>	0.020	0.019	0.007	<i>Artemisia vulgaris</i>	0.228	0.019	0.004
12	<i>Helianthus tuberosus</i>	0.019	0.012	0.000	<i>Dactylis glomerata</i>	0.042	0.003	0.000
28	<i>Helianthus tuberosus</i>	0.001	0.001	0.000	<i>Tripleurospermum inodorum</i>	0.133	0.047	0.000
58	<i>Helianthus tuberosus</i>	0.328	0.093	0.016	<i>Cirsium arvense</i>	0.479	0.099	0.030
81	<i>Helianthus tuberosus</i>	0.266	0.144	0.005	<i>Aegopodium podagraria</i>	0.261	0.196	0.000
132	<i>Helianthus tuberosus</i>	0.041	0.006	0.011	<i>Elymus cf. caninus</i>	0.000	0.000	0.000

No.	Invasive species	Total	Arb.	Ves.	Dominant species	Total	Arb.	Ves.
46	<i>Heracleum mantegazzianum</i>	0.168	0.120	0.007	<i>Arrhenatherum elatius</i>	0.000	0.000	0.000
60	<i>Heracleum mantegazzianum</i>	0.211	0.180	0.000	<i>Urtica dioica</i>	0.000	0.000	0.000
71	<i>Heracleum mantegazzianum</i>	0.000	0.000	0.000	<i>Urtica dioica</i>	0.000	0.000	0.000
80	<i>Heracleum mantegazzianum</i>	0.200	0.110	0.007	<i>Dactylis glomerata</i>	0.026	0.019	0.000
2	<i>Impatiens glandulifera</i>	0.021	0.010	0.000	<i>Artemisia vulgaris</i>	0.185	0.092	0.000
22	<i>Impatiens glandulifera</i>	0.071	0.044	0.015	<i>Alopecurus pratensis</i>	0.004	0.002	0.000
30	<i>Impatiens glandulifera</i>	0.052	0.032	0.003	<i>Agrostis stolonifera</i>	0.000	0.000	0.000
111	<i>Impatiens glandulifera</i>	0.000	0.000	0.000	<i>Festuca gigantea</i>	0.000	0.000	0.000
1	<i>Impatiens parviflora</i>	0.061	0.018	0.000	<i>Urtica dioica</i>	0.000	0.000	0.000
18	<i>Impatiens parviflora</i>	0.092	0.057	0.001	<i>Scirpus sylvaticus</i>	0.000	0.000	0.000
31	<i>Impatiens parviflora</i>	0.003	0.001	0.000	<i>Poa annua</i>	0.260	0.032	0.047
37	<i>Impatiens parviflora</i>	0.038	0.016	0.001	<i>Urtica dioica</i>	0.000	0.000	0.000
54	<i>Impatiens parviflora</i>	0.036	0.023	0.000	<i>Aegopodium podagraria</i>	0.000	0.000	0.000
105	<i>Impatiens parviflora</i>	0.050	0.008	0.000	<i>Anthriscus sylvestris</i>	0.247	0.184	0.001
17	<i>Juncus tenuis</i>	0.094	0.072	0.000	<i>Poa annua</i>	0.163	0.112	0.000
44	<i>Juncus tenuis</i>	0.103	0.082	0.000	<i>Poa annua</i>	0.151	0.026	0.000
92	<i>Juncus tenuis</i>	0.000	0.000	0.000	<i>Agrostis stolonifera</i>	0.253	0.159	0.017
102	<i>Kochia scoparia</i> subsp. <i>scoparia</i>	0.000	0.000	0.000	<i>Chenopodium album</i> agg.	0.000	0.000	0.000
48	<i>Lupinus polyphyllus</i>	0.000	0.000	0.000	<i>Chaerophyllum aureum</i>	0.371	0.218	0.011
53	<i>Lupinus polyphyllus</i>	0.000	0.000	0.000	<i>Lolium multiflorum</i>	0.011	0.009	0.000
38	<i>Matricaria discoidea</i>	0.559	0.361	0.146	<i>Poa annua</i>	0.041	0.023	0.001
47	<i>Matricaria discoidea</i>	0.111	0.049	0.008	<i>Plantago major</i>	0.784	0.272	0.036
57	<i>Matricaria discoidea</i>	0.171	0.128	0.003	<i>Plantago major</i>	0.275	0.123	0.010
75	<i>Matricaria discoidea</i>	0.075	0.039	0.004	<i>Poa annua</i>	0.083	0.016	0.026
90	<i>Matricaria discoidea</i>	0.184	0.054	0.014	<i>Polygonum aviculare</i> agg.	0.000	0.000	0.000
49	<i>Oenothera biennis</i>	0.044	0.013	0.007	<i>Deschampsia cespitosa</i>	0.000	0.000	0.000
98	<i>Oenothera biennis</i>	0.186	0.052	0.003	<i>Setaria viridis</i>	0.129	0.064	0.021
45	<i>Parthenocissus inserta</i>	0.087	0.053	0.000	<i>Urtica dioica</i>	0.000	0.000	0.000
99	<i>Parthenocissus inserta</i>	0.010	0.007	0.000	<i>Clematis vitalba</i>	0.017	0.010	0.000
116	<i>Persicaria polystachya</i>	0.000	0.000	0.000	<i>Rubus idaeus</i>	0.463	0.267	0.044
113	<i>Reynoutria × bohemica</i>	0.000	0.000	0.000	<i>Aegopodium podagraria</i>	0.143	0.137	0.000
64	<i>Reynoutria japonica</i>	0.000	0.000	0.000	<i>Lolium multiflorum</i>	0.013	0.007	0.002
74	<i>Reynoutria sachalinensis</i>	0.000	0.000	0.000	<i>Aegopodium podagraria</i>	0.000	0.000	0.000
127	<i>Rudbeckia laciniata</i>	0.329	0.020	0.005	<i>Phalaris arundinacea</i>	0.014	0.014	0.000
85	<i>Rumex alpinus</i>	0.010	0.002	0.000	<i>Agrostis capillaris</i>	0.085	0.034	0.008
119	<i>Rumex alpinus</i>	0.005	0.001	0.000	<i>Cirsium oleraceum</i>	0.225	0.050	0.002

No.	Invasive species	Total	Arb.	Ves.	Dominant species	Total	Arb.	Ves.
117	<i>Rumex longifolius</i>	0.000	0.000	0.000	<i>Phalaris arundinacea</i>	0.003	0.003	0.000
13	<i>Rumex thyrsiflorus</i>	0.000	0.000	0.000	<i>Arrhenatherum elatius</i>	0.081	0.056	0.000
63	<i>Rumex thyrsiflorus</i>	0.000	0.000	0.000	<i>Achillea millefolium</i> agg.	0.313	0.100	0.001
23	<i>Sedum hispanicum</i>	0.000	0.000	0.000	<i>Festuca rubra</i> agg.	0.019	0.012	0.000
4	<i>Sisymbrium loeselii</i>	0.000	0.000	0.000	<i>Daucus carota</i>	0.040	0.011	0.000
8	<i>Sisymbrium loeselii</i>	0.000	0.000	0.000	<i>Poa annua</i>	0.000	0.000	0.000
67	<i>Sisymbrium loeselii</i>	0.000	0.000	0.000	<i>Lolium multiflorum</i>	0.003	0.001	0.000
91	<i>Sisymbrium loeselii</i>	0.000	0.000	0.000	<i>Lolium perenne</i>	0.176	0.147	0.000
104	<i>Sisymbrium loeselii</i>	0.000	0.000	0.000	<i>Calamagrostis epigejos</i>	0.000	0.000	0.000
124	<i>Sisymbrium loeselii</i>	0.000	0.000	0.000	<i>Artemisia vulgaris</i>	0.039	0.022	0.001
3	<i>Solidago canadensis</i>	0.340	0.042	0.015	<i>Arrhenatherum elatius</i>	0.148	0.097	0.002
15	<i>Solidago canadensis</i>	0.080	0.012	0.002	<i>Calamagrostis epigejos</i>	0.126	0.035	0.003
21	<i>Solidago canadensis</i>	0.376	0.140	0.070	<i>Calamagrostis epigejos</i>	0.000	0.000	0.000
25	<i>Solidago canadensis</i>	0.122	0.009	0.001	<i>Arrhenatherum elatius</i>	0.258	0.014	0.031
79	<i>Solidago canadensis</i>	0.331	0.077	0.005	<i>Arrhenatherum elatius</i>	0.357	0.124	0.023
82	<i>Solidago canadensis</i>	0.350	0.039	0.013	<i>Phalaris arundinacea</i>	0.519	0.397	0.068
120	<i>Solidago canadensis</i>	0.089	0.025	0.000	<i>Dactylis glomerata</i>	0.042	0.029	0.011
16	<i>Solidago gigantea</i>	0.156	0.002	0.002	<i>Poa pratensis</i>	0.030	0.001	0.003
36	<i>Solidago gigantea</i>	0.031	0.010	0.002	<i>Anthriscus sylvstris</i>	0.019	0.016	0.000
94	<i>Solidago gigantea</i>	0.592	0.091	0.009	<i>Calamagrostis epigejos</i>	0.569	0.300	0.013
107	<i>Solidago gigantea</i>	0.075	0.004	0.003	<i>Eupatorium cannabinum</i>	0.098	0.012	0.000
72	<i>Telekia speciosa</i>	0.438	0.197	0.106	<i>Melampyrum pratense</i>	0.000	0.000	0.000
96	<i>Telekia speciosa</i>	0.261	0.031	0.004	<i>Cirsium oleraceum</i>	0.157	0.050	0.001
118	<i>Telekia speciosa</i>	0.268	0.098	0.013	<i>Anthriscus sylvstris</i>	0.027	0.014	0.007
68	<i>Veronica filiformis</i>	0.170	0.059	0.022	<i>Festuca rubra</i> agg.	0.184	0.032	0.050
42	<i>Veronica persica</i>	0.372	0.201	0.047	<i>Agrostis stolonifera</i>	0.025	0.012	0.000
59	<i>Veronica persica</i>	0.227	0.035	0.014	<i>Elytrigia repens</i>	0.014	0.007	0.000
78	<i>Veronica persica</i>	0.028	0.006	0.003	<i>Poa annua</i>	0.198	0.103	0.002
88	<i>Veronica persica</i>	0.236	0.040	0.008	<i>Apera spica-venti</i>	0.000	0.000	0.000
89	<i>Veronica persica</i>	0.134	0.026	0.003	<i>Polygonum aviculare</i> agg.	0.000	0.000	0.000
51	<i>Virga strigosa</i>	0.249	0.043	0.005	<i>Elymus cf. caninus</i>	0.036	0.020	0.004
93	<i>Virga strigosa</i>	0.511	0.140	0.013	<i>Urtica dioica</i>	0.000	0.000	0.000

On Thu, 13 Nov 2008, 14:33, Petr Smilauer wrote:

Ahoj, nahodne jsem se zadival na vytistenou prvni stranku prilohy, kterou tu Majka nechala, a zaujal mne tam termin "dwarf wall" coby "habitat type". Chapu spravne, ze jde o ohradu, branici nekontrolované expanzi trpasliku do zahrady? Jinak - obavam se - to asi nebude spravny termin, pokud to ovsem neni zed vystavena z mrtvych tel trpasliku 😊...

On Thu, 13 Nov 2008, 15:00, Marie Smilauerova wrote:

Cau, ale ono to asi opravdu brani proniknuti trpajzliku do objektu. Je to proste nizka zidka na zahrade, bud ohranicujici sklenik, zimni zahradu apod. a nahore pokracujici sklem, nebo asi i normalni zidka kolem zahonu. Treba to nebrani trpajzlikum pronikat do zahrady, ale naopak jim to brani v uteku ze zahrady (aspon tady ve stredni Evrope jsem videla vic trpasliku na zahradach a skalkach nez venku v terenu 😊).

On Thu, 13 Nov 2008, 20:09, Katerina Stajerova wrote:

Teda pratele, jak to sleduju, tak ta ma diplomka zacina smerovat uplne jinam 😊.

On Thu, 14 Nov 2008, 07:23, Petr Smilauer wrote:

Ale kdepak, trpaslici jsou urcite take invazivni druhy, ted jde jen o to zjistit, zda spolupracuji s houbami (nebo maji alespon plisen na nozickach), ci ne ...

On Thu, 14 Nov 2008, 20:21, Katerina Stajerova wrote:

Ahoj M+P, podle nejnovějších článků, které jsem našla na web of science, se v případě trpaslíku skutečně jedná o invazivní druhy! Navíc jsou uvedeni společně s např. hasivkou orlicí na seznamu pěti nejnebezpečnějších invazivních druhů v historii celé planety Země vůbec. Co se týče jejich vlivu na AMF, tak o tom se zatím moc neví. Našla jsem pouze jednu studii zabývající se okrajově tímto tématem (autory této studie jsou shodou okolností Česi společně s Němci), která vyšla letos v lednu v časopisu Nature...

V této práci autoři využili molekulárních metod a zjišťovali genofond veskerých hub odebraných na trpaslicích umístěných v zahradách pěti zemí Evropy (jednalo se o ČR, SR, Německo, Francii a Belgie). Největší práci přý dalo určit správné primery, ale když se to podařilo, dostali nevidané výsledky! Ukázalo se, že sekvence hub odebraných z evropských populací trpaslíku mají napadnou shodu s populacemi "trpaslicích" hub v ČR, což vedce inspirovalo k dalšímu výzkumu. Začali hloubkově patřit po zdroji všech studovaných evropských trpaslíku, tedy po místě, kde je jejich dnešní majitele koupili. Závěr byl jednoznačný - všichni trpaslici pocházeli z česko-německého pohraničí.

Jejich původním areálem je tedy oblast západních Čech, odkud se nekontrolovatelně šíří dál do celého světa. Biokoridory jejich šíření jsou zejména dálnice, silnice, silničky i polní cesty, které protínají křížem křížem celou pevninu, proto je jejich invaze tak zákeřná a nebezpečná! Navíc společně s trpaslíky cestují do nových oblastí i další nepůvodní organismy jako např. plíseň (které mohou ulpět na nozickách trpaslíku, když ještě leží ve skladech v ČR), ale i jiné houby (např. spory AMF).

No, jak je vidět, vztah trpaslíku a AMF je bližší než by se nám mohlo zdát 😊. Taky mám pár vzorků ze západních a severních Čech, tak bychom je mohli porovnat 😊...

Appendix 5. E-mail conversation (in native language) among my supervisor, her husband and me, from November 2008.