

## How reliable are data on alien species in Flora Europaea?

Petr Pyšek

Institute of Botany, Academy of Sciences of the Czech Republic, CZ-252 43 Průhonice, Czech Republic

Submitted: Apr 29, 2003 · Accepted: Jul 7, 2003

### Summary

Flora Europaea represents a basic source of information on the flora of European countries. Since it contains detailed treatment of naturalized species, it is used as a data source in comparative analyses of alien floras. By using the Czech Republic as a model country, for which solid information on alien species is available, the present paper assesses the reliability of data on alien species contained in Flora Europaea and critically evaluates their potential for utilization in comparative analyses. Of the 332 naturalized species reported in Flora Europaea for the territory of the former Czechoslovakia, some species are relevant only to the territory of Slovakia and some are planted species and never reported escaping from cultivation in the Czech Republic. By excluding these species, there are 312 species relevant to the Czech Republic and supposedly naturalized in this country. Among these, there are 7 species now considered native and 15 are erroneous records of plants which never occurred in the country. In total, there are 290 species (92.9% of the 312 reported) correctly identified by Flora Europaea as aliens to the Czech flora. Of these species, considered by Flora Europaea as naturalized, only 118 in fact do have this status. The remaining 172 species are casuals. After excluding 11 species casual in the Czech Republic but naturalized in Slovakia, there are 161 species, i. e. 55.5% of the 290 reported, with incorrect status given in Flora Europaea. Another 111 naturalized species (48.5% of those currently known) are missing from the account on alien species in Flora Europaea. It is argued that while Flora Europaea can be, with careful interpretation, used for identifying robust patterns based on species numbers, it cannot be used for in-depth analyses of invasion pattern across Europe, namely for studies on the naturalization success in different parts of the continent, since the data it contains are highly unreliable in terms of evaluating species invasion status. These results indicate that there is an urgent need to include the issue of alien species in integrated European projects.

Key words: Alien species, Flora Europaea, data quality, naturalization, casual species

### Introduction

The comparative analysis of alien floras is an important approach for describing the extent of invasion of different taxa in different parts of the world. Such studies are a critical first step in the search for the explanation of invasion patterns, and for characterizing invasive taxa and invaded ecosystems (Crawley et al. 1996; Goodwin et al. 1999; Rejmánek et al. 2004). In addition, conclusions drawn from such studies can be used to formulate hypotheses which can be tested by other approaches (Daehler 2001). This is reflected by increas-

ing number of comparative studies (Rejmánek 1996; Daehler 1998; Pyšek 1998; Lonsdale 1999). Such analyses, using information previously published in floras and checklists, crucially depend on the quality of assessment of particular species with respect to their taxonomic identity, time of immigration and invasion status. Most of this work relies on specialized checklists of alien species. Most ambitious studies cover global (Lonsdale 1999) and continental scales and some of them (Weber 1997; Rejmánek 2003) rely on synthetic continental data sources (Tutin et al. 1964–1980; Kartesz & Meacham 1999).

---

\* **Corresponding author:** Petr Pyšek, Institute of Botany, Academy of Sciences of the Czech Republic, CZ-252 43 Průhonice, Czech Republic, e-mail: pysek@ibot.cas.cz

For the European continent, Flora Europaea (Tutin et al. 1964–1980; FE) represents a basic source of information on flora of particular countries, including alien species. This source was used for comparative analyses on continental level in the work of Weber (1997) who asked which families provide most alien species, how is the number of alien species in European countries related to their geography, and what is the origin of these alien species. There are surely many possible types of error that could creep in when the analysis is based on previously published data, e.g. species are listed as naturalized that are only casual; species listed as alien that are native; species absent from the list that are in fact naturalized/invasive, etc. These categories of error pose different types of problems to workers that rely on such data sources. A problem when considering the accuracy of classification of alien species in a work such as FE is the scarcity of “reference systems” with which to calibrate the classification. For all the regions covered in FE, only few have received sufficiently detailed treatment (application of objective criteria) to warrant a cross-validation of the categorization of alien species (Clement & Foster 1994; Ryves et al. 1996). The recently completed alien flora of the Czech Republic (Pyšek et al. 2002) presents such an opportunity to explore the extent to which data on alien species in FE can be accepted as objective.

## The data

### Flora Europaea

Two groups of non-native plants are included in Flora Europaea (FE): (i) Aliens which are effectively naturalized, including garden plants which have escaped to situations not immediately adjacent to those in which they are cultivated and weeds and other plants which have been accidentally introduced; provided in both cases that the plant has been established in a single station for at least 25 years, or is reported as naturalized in a number of widely separated locations. (ii) Trees or crop plants cultivated in continuous stands on a fairly extensive scale. Casual aliens (*sensu* Richardson et al. 2000) are not included unless often mistaken for native or established species, or for any other reason of special interest (Tutin et al. 1964–1980). The information on species occurrence is structured according to political boundaries, i.e. reported for particular countries. It is explicitly stated that in assessing the status of a species in any part of Europe, the authors have been dependent entirely on the information contained in national floras.

### Czech alien flora

The Czech Republic (CR) covers an area of 78, 864 square kilometres and has 10.3 million inhabitants, creating a human population density of 131 inhabitants per km<sup>2</sup>. The network of

roads (0.71 km per km<sup>2</sup>) and railways (0.11 km per km<sup>2</sup>) is rather dense. These features contribute to the richness of alien flora (Pyšek & Prach 2003). Compared to similar regions of Central and Western Europe, the landscape mosaic is diverse and remarkably heterogeneous in the Czech Republic. The dynamics of plant migrations are similar to those in other Central and Western European regions; there has been a continuous stream of plant invasions since the Neolithic agricultural colonization which started in about 5300 B. C. The landscape was gradually colonized between the Neolithic period and the Medieval, but until the Late Medieval, there were still large portions of closed forests and these acted as barriers to migrations (Pyšek et al. 2002). The geographical position of the country has made it crossroad in Europe for plant invasion between east and west and north and south since early times. Intensive movement of people and goods have contributed to the introduction of many species (Pyšek & Prach 2003). Many plant species of Asian and southeast-European origin entered the central part of the continent via one of the largest European railway stations in Čierna nad Tisou in the Slovak part of the former Czechoslovakia (Jehlík & Hejný 1974; Jehlík 1998). Besides railways and roads, river traffic on the Elbe river, the Danube river and their tributaries significantly contributed to the richness of present alien flora (Jehlík 1998).

There is a remarkable floristic tradition in CR. Floristic research dates back to the beginning of the 18th century (Pohl 1809–1814; Presl & Presl 1819; Opiz 1823) and since then, the country was covered by several fairly reliable and solid floras (Opiz 1852; Čelakovský 1867–1881; Polívka 1900–1904). This information provided a solid background for compilation of the catalogue of alien species of the country with relevant historical information (Pyšek et al. 2002) and allowed detailed analyses of the dynamics of alien flora (Pyšek et al. 2003a, b).

The recent catalogue of alien plants of CR (Pyšek et al. 2002) includes all species ever reported as occurring outside cultivation and indicates the invasion status of each taxon included following the criteria of Richardson et al. (2000). Those applied to distinguish between casual and naturalized species, i.e. the successful reproduction and persistence in the nature without direct assistance from humans, correspond well to those adopted by FE, so that the status of species as indicated in both sources is directly comparable.

## Methods

The list of species reported as naturalized for CR was extracted from Flora Europaea and the status of each species was checked with reference to the new alien flora of the Czech Republic (Pyšek et al. 2002). Taxa for which taxonomic research in recent years has improved our knowledge of their identity and can be therefore synonymized with those on the FE list were considered as correctly included (Appendix 1). Since FE covers not only the territory of the current Czech Republic but of the whole former Czechoslovakia (including Slovakia), species had to be screened to ascertain which species occurred only in the current Slovakia – this to achieve

comparability with the data from Pyšek et al. (2002). Those species known to occur only in Slovakia (Marhold & Hindák, 1998; Gojdičová et al. 2002), but not in the Czech Republic (Hejný & Slavík 1988–1992; Slavík 1995–2000; Kubát et al. 2002) were excluded.

When evaluating invasion status, i.e. whether the species is casual or naturalized according to objective criteria (see Richardson et al. 2000), species that are casual in the CR but naturalized in Slovakia (Appendix 1) were considered as correctly classified by FE and excluded from the comparison.

## Results

There are 332 naturalized species reported in FE for the territory of the former Czechoslovakia (Appendix 1). Of these, 8 species occur only in the territory of Slovakia, and 11 planted species have never been reported as escaping from cultivation in the CR. One species (*Che-nopodium suecicum*) is considered native in the CR but alien in Slovakia. This leaves us with 312 species relevant to the CR and supposedly naturalized in this country. Of these, 7 species are now considered native, and there are 15 records that are obviously erroneous (never reported from the CR; cf. Hejný & Slavík 1988–1992; Slavík 1995–2000; Kubát et al. 2002). In total, there are 290 species (92.9% of the 312 reported) correctly identified as aliens in the Czech flora, i. e. corresponding with the list compiled by Pyšek et al. (2002). Of these species, considered by FE as naturalized, only 118 have this status. The remaining 172 species are considered casuals by Pyšek et al. (2002). Of the latter number, 11 species that are casual in CR but naturalized in Slovakia (Gojdičová et al. 2002) must be subtracted. Hence there are 161 species (55.5% of the total 290) with incorrect status reported in FE.

Since the recent checklist of alien flora of CR gives 229 naturalized neophytes (Pyšek et al. 2002), there are 111 naturalized species (48.5% of those currently known) missing from FE (Table 1).

## Discussion

The concept of alien species adopted in FE can clearly be faulted with the benefit of hindsight. When FE was prepared (starting in the 1960s), concepts relating to biological invasions were very poorly developed, and the need for clear, objective categories of alien plant taxa had not been articulated. Over the last four decades, the field of invasion ecology has emerged and much attention has been given to developing sound concepts (Webb 1985; Richardson et al. 2000; Rejmánek et al. 2004). With this in mind, it is clearly harsh to apply current concepts to FE. Nevertheless, even when taking into account that the number of alien species in the territory of the current Czech Republic has been increasing (Pyšek et al. 2003a), this fact alone cannot explain that half of the species naturalized in CR are missing from the list in FE. At the time of preparation of FE, the flora and key of Dostál (1948–1950, 1958) was available for CR which served as the most comprehensive source of the data from the country until the new flora started to be published in the late 1980s (Hejný & Slavík 1988–1992; Slavík 1995–2000). However, as shown by Pyšek et al. (2002), the floristic similarity between the present list of neophytes and that given by Dostál (1958) expressed by Jaccard coefficient is only 0.47.

Flora Europaea claims to consider only naturalized species and obviously does not include archaeophytes (though this is not explicitly stated). Of the total number

Table 1. Comparison of data on naturalized species given by Flora Europaea (Tutin et al. 1964–1980) for the territory of former Czechoslovakia with their present status (based on data in Pyšek et al. 2002 and Gojdičová et al. 2002).

Group	Number of species
Total reported in Flora Europaea for the Czech Republic	<b>332</b>
Not relevant for the Czech Republic (occurring only in Slovakia)	8
Planted, not escaping from cultivation	11
Not relevant for the Czech Republic (native, alien only in Slovakia)	1
Relevant for the Czech Republic	<b>312</b>
Considered native	7
Erroneous records (not occurring in the Czech Republic)	15
Correctly reported as aliens	<b>290</b>
Naturalized in the Czech Republic (status correct in FE)	118
Casual in the Czech Republic but naturalized in Slovakia (status correct in FE)	11
Casuals in the Czech Republic (status incorrect in FE)	161

of species reported as naturalized for the territory of the CR, 34 are currently considered as archaeophytes. This imprecision can be hardly criticised because it is often difficult to decide about the residence status of an alien species, i.e. whether it is an archaeophyte or neophyte, and opinion on this matter changes as the knowledge has been improving (Pyšek et al. 2002; Preston et al. 2002).

The major bias in data contained in FE is associated with the assessment of invasion status. Although Flora Europaea claims to include only “aliens which are effectively naturalized”, 55.5% of species reported are in fact not naturalized, either in CR or in Slovakia. Only 37.8% species claimed as naturalized in the CR in FE really deserve this status (to calculate this proportion, the 118 species correctly identified as naturalized in FE must be related to the total of 312 reported for CR, i.e. including those incorrectly reported as aliens).

The undoubtedly useful system of regional contributors from national botanical institutions which was adopted in FE lead, in the case of alien species in particular, to the reflection of different levels of floristic and taxonomic knowledge in European countries.

Some species reported as naturalized by FE are very rare in CR indeed; there are species that even have only a single locality (*Prunus virginiana*, *Lycium chinense*) and nine species had only few localities and now are considered extinct (e.g. *Axyris amaranthoides*, *Cirsium tuberosum*, *Alyssum rostratum*, *Vicia melanops*, *Trifolium lappaceum*). There does not seem to be any obvious clue as to which casual species are included. Comparison of casual species that are included in FE with those that are not reveals that there is a trend towards listing more abundant casual species (Fig. 1) but still, for as many as 32.7% of included casual species, more than four localities were never reported, and additional 38.3% species only have 5–14 localities (Pyšek et al. 2002). Since there are obviously no consistent rules, and the statement in FE that “casual species are not included unless often mistaken for native or established species or for any other reason of special interest” does not apply here, it is legitimate to compare the proportion of alien species recorded by FE with the total number of neophytes in the Czech flora, i.e. including casuals. The 290 species reported constitute 27.7% of the total 1046 species given by Pyšek et al. (2002) for the country; the ratio is slightly higher if extinct casuals (231 species) are excluded from calculation but still it is as low as 35.5%.

The estimation of the error associated with evaluation of invasion status is conservative. The reversed order of the invasion process, i.e. from a species once naturalized to casual is a rare event in plant invasions. Rather the opposite is true, as the number of naturalized species should be increasing over time even if no new introduc-

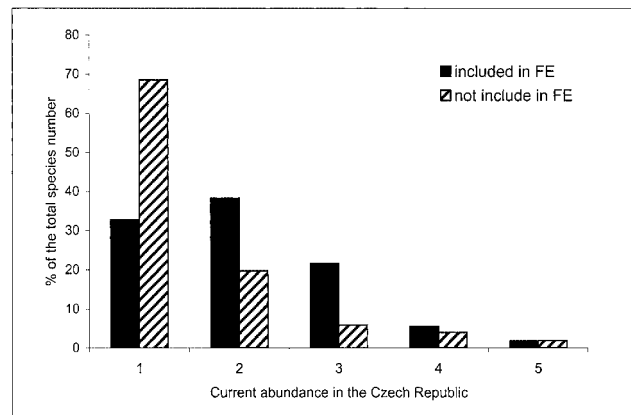


Fig. 1. Comparison of abundance of casual aliens included on the FE list with those that were omitted. Abundance is based on a quantitative estimate of the number of localities using the scale of Clement & Foster (1994): 1 = 1–4 localities; 2 = 5–14; 3 = 15–49; 4 = 50–499; 5 = over 500 localities. Abundance values between both lists were significantly different (Kruskal-Wallis  $\chi^2 = 69.24$ ,  $df = 1$ ,  $p < 0.0001$ ).

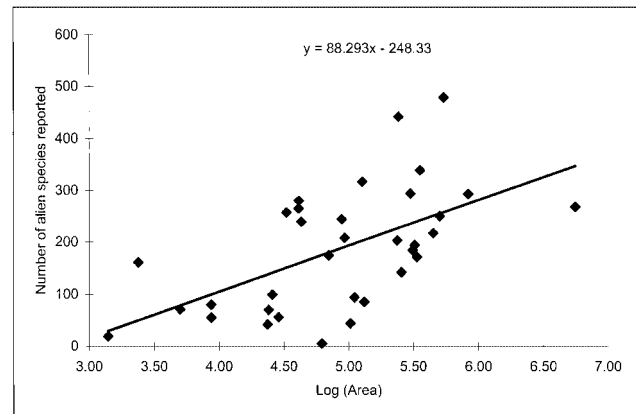


Fig. 2. Species area relationship for the total number of alien species reported in Flora Europaea as naturalized in European countries (based on data from Weber 1997, Table 4).  $F = 15.51$ ,  $df = 1, 32$ ,  $P < 0.001$ .

tions are realized (Kowarik 1995). It can be therefore supposed (and the knowledge of the history of invasion of these species in the country substantiates this notion) that species that now occur as casuals were not naturalized at the time of data collation for FE.

What do these rather bleak conclusions mean for the results of Weber (1997) who focused on taxonomic structure of the alien flora of Europe and concluded that (i) 113 families are represented, (ii) most aliens came from Americas and Asia, (iii) species with origin outside Europe are more widespread than those with origin in other parts of the European continent, and (iv) richness of alien flora decreases from the North to the South?

Despite the bias in data given in FE documented in the present paper, I believe that the conclusions of Weber (1997) are rather robust. Obvious imprecisions in compiling national species lists do not seem to prevent the numbers of naturalized species given for particular countries from reflecting reasonably well the extent of invasion. Indeed, highest numbers of naturalized species are reported by Weber (1997) for countries with the heaviest invasion load, i.e. France (479), United Kingdom (442) and Germany (332). This, and the highly significant species-area relationship (Fig. 2) indicate that the use of species numbers in FE for a robust analysis on continental level might be justified. This is supported by the fact that the conclusions made by Weber (1997) on taxonomic structure and the pattern of naturalized species origin are fairly similar to the results obtained by similar analyses of global data sets (Daehler 1998; Pyšek 1998). Similarly, the total list of species naturalized for all of Europe (1568 – Weber 1997) probably reasonably well reflects the diversity of naturalized species which were present in Europe at the time of the preparation of the work. There is a good reason to believe that only species effectively naturalized in at least some countries appeared on this list. This total list can be therefore used for, e.g., comparison of European aliens with those from other continents.

Unfortunately, the situation is much more problematic at the level of particular countries. The analysis reported here has revealed a major bias for one region in the FE. There is no reason to believe that the situation is different for other countries. This suggests that data in FE cannot be used for in-depth analyses of invasion patterns across Europe. For example, studies evaluating naturalization success in different parts of the continent would be based on rather unreliable data, in terms of distinguishing naturalized species from casuals (*sensu* Richardson et al. 2000). Conclusions based on this biased data would lead to spurious results.

The focus of the present paper is not to criticise the quality of data in FE. This extremely valuable work reflected the level of knowledge relating to alien species at the time of collation. Rather, this analysis serves to warn that in some aspects, the data do not correspond well to the real situation and their utilization in comparative studies is therefore seriously limited.

There is an urgent need to give more careful attention to categorizing alien species in ongoing integrated European projects such as Euro+Med Plant Base (<http://www.euromed.org.uk>). Such efforts could start with collating existing floristic information, completing it where missing (by using standardized approach across countries) and should lead to a detailed checklist of the alien flora of Europe. The 6th framework programme of the European Union provides a convenient platform for such an effort since alien species have been included

among the topics (<http://fp6.cordis.lu>). As a next step, building a database with attributes of European aliens should follow. Despite rather pessimistic view that the best way to join two databases is to create a new one, I believe that some of the existing databases (Klotz et al. 2003) could be used as a convenient background and extended beyond the national level.

## Acknowledgements

I thank Ewald Weber for providing me with an electronic version of the list of aliens of the former Czechoslovakia reported in Flora Europaea, and Alžběta Cvachová for providing me with unpublished version of the list of Slovakian alien plants. Dave Richardson commented on the manuscript and kindly improved my English. The work was supported by grant no. 206/03/1216 from the Grant Agency of the Czech Republic, and grant no. AV0Z6005908 from the Academy of Sciences of the Czech Republic.

## References

- Čelakovský, L. (1867–1881): Prodrómus der Flora von Böhmen, enthaltend die wildwachsenden und allgemein kultivierten Gefäßpflanzen der Königreiches ... I. Gefäßkryptogamen, Gymnospermen und Monocotylen, p. 1–112 (1867); II. Apetale und Sympetale Dicotylen, 113–388 (1871–1872); III. Eleutheropetale Dicotylen, p. 389–691 (1874); IV. Die Nachträge bis 1880 nebst Schlusswort, Verzeichnissen und Register, p. 693–955 (1881). – Commisions-Verlag von Fr. Řivnáč, Praha.
- Clement, E. J. & Foster, M. C. (1994): Alien plants of the British Isles. A provisional catalogue of vascular plants (excluding grasses). – Botanical Society of the British Isles, London.
- Crawley, M. J.; Harvey, P. H. & Purvis, A. (1996): Comparative ecology of the native and alien floras of the British Isles. – Biol. Trans. R. Soc. B, **351**: 1251–1259.
- Daehler, C. C. (1998): The taxonomic distribution of invasive angiosperm plants: ecological insights and comparison to agricultural weeds. – Biol. Conserv. **84**: 167–180.
- Daehler, C. C. (2001): Darwin's naturalization hypothesis revisited. – Amer. Natur. **158**: 324–330.
- Dostál, J. (1948–1950): Květena ČSR. – Přírodovědecké nakladatelství, Praha.
- Dostál, J. (1958): Klíč kúplné květeně ČSR. – Praha.
- Gojdičová, E.; Cvachová, A. & Karasová, E. (2002): Zoznam nepôvodných, invázných a expanzívnych cievnatých rastlín Slovenska 2. – Ochrana Prírody **21**: 39–58.
- Goodwin, B. J.; McAllister, A. J. & Fahrig, J. (1999): Predicting invasiveness of plant species based on biological information. – Conserv. Biol. **13**: 422–426.
- Hejný, S. & Slavík, B. (eds.) (1988–1992): Květena České republiky. Vol. 1 (1988), 2 (1990), 3 (1992). – Academia, Praha.
- Holub, J. (1997): 106. *Oxalidaceae* – štavelovité. – In: Slavík B. (ed.), Květena České republiky **5**: 179–191, Academia, Praha.

- Jehlik, V. (ed.) (1998): Cizí expanzivní plevele České republiky a Slovenské republiky. – Academia, Praha.
- Jehlik, V. & Hejný, S. (1974): Main migration routes of adventitious plants in Czechoslovakia. – *Folia Geobot. Phytotax.* **9**: 241–248.
- Kartesz, J. T. & Meacham, C. A. (1999): Synthesis of the North American Flora. Version 1.0. – North Carolina Botanical Garden, Chapel Hill.
- Klotz, S.; Kühn, I. & Durka, W. (2003): BIOLFLOR – Eine Datenbank zu biologisch-ökologischen Merkmalen der Gefäßpflanzen in Deutschland. – Bundesamt für Naturschutz, Bonn.
- Kowarik, I. (1995): Time lags in biological invasions with regard to the success and failure of alien species. In: Pyšek, P., Prach, K., Rejmánek, M. & Wade, M. (eds.), Plant invasions: General aspects and special problems, 15–38. – SPB Academic Publishing, Amsterdam.
- Kubát, K.; Hrouda, L.; Chrtek, J. jun.; Kaplan, Z.; Kirschner, J.; Štěpánek, J. & Zázvorka, J. (eds.) (2002): Klíč ke květeně České republiky. – Academia, Praha.
- Lonsdale, M. (1999): Global patterns of plant invasions and the concept of invasibility. – *Ecology* **80**: 1522–1536.
- Marhold, K. & Hindák, F. (eds.) (1998): Checklist of non-vascular and vascular plants of Slovakia. – Veda, Bratislava.
- Opiz, F. M. (1852): Seznam rostlin květeny České. – Spis. Mus. XLIV, V kommissi u Fr. Řivnáče, Praha.
- Opiz, P. M. (1823): Böheims phänerogamische und cryptogamische Gewächse. – C. W. Enders, Prag.
- Pohl, J. E. (1809–1814): Tentamen florae bohemiae. Vol. 1 (1809), 2 (1814). – E. M. Enders und Compagnie, Prag.
- Polívka, F. (1900–1904): Názorná květena zemí Koruny České. – P. Promberger, Olomouc.
- Presl, J. S. & Presl, C. B. (1819): Flora Čechica. – In comissis apud J. G. Calve, Pragae.
- Preston, C. D.; Pearman, D. A. & Dines, T. D. (2002): New atlas of the British and Irish flora. – Oxford Univ. Pr., Oxford.
- Pyšek, P. (1998): Is there a taxonomic pattern to plant invasions? – *Oikos* **82**: 282–294.
- Pyšek, P. & Prach, K. (2003): Research into plant invasions in a cross-roads region: history and focus. – *Biol. Invas.* **5** (in press).
- Pyšek, P.; Sádlo, J. & Mandák, B. (2002): Catalogue of alien plants of the Czech Republic. – *Preslia* **74**: 97–186.
- Pyšek, P.; Sádlo, J., Mandák, B. & Jarošík, V. (2003 a): Czech alien flora and a historical pattern of its formation: what came first to Central Europe? – *Oecologia* **135**: 122–130.
- Pyšek, P.; Sádlo, J. & Mandák, B. (2003 b): Alien flora of the Czech Republic, its composition, structure and history. In: Child, L. E., Brock, J. H., Brundu, G., Prach, K., Pyšek, P., Wade, M. & Williamson, M. (eds.), Plant invasions: Ecological threats and management solutions, 113–130. – Backhuys Publ. (in press).
- Rejmánek, M. (1996): Species richness and resistance to invasions. In: Orians, G. H., Dirzo, R. & Cushman, J. H. (eds.), Diversity and processes in tropical forest ecosystems, 153–172. – Springer, Berlin.
- Rejmánek, M. (2003): Patterns of non-native plant species richness in the United States: a comment. – *Frontiers in Ecology and Environment* **1**: 122–123.
- Rejmánek, M.; Richardson, D. M.; Higgins, S. I.; Pitcairn, M. & Grotkopp, E. (2004): Plant invasion ecology: state of the art. In: Mooney, H. A., McNeel, J. A., Neville, L., Schei, P. J. & Waage, J. (eds.), Invasive alien species: searching for solutions. – Island Press, Washington, D. C.
- Richardson, D. M.; Pyšek, P.; Rejmánek, M.; Barbour, M. G.; Panetta, F. D. & West, C. J. (2000): Naturalization and invasion of alien plants: concepts and definitions. – *Diversity & Distributions* **6**: 93–107.
- Ryves, T. B.; Clement, E. J. & Foster, M. C. (1996): Alien grasses of the British Isles. – Botanical Society of the British Isles, London.
- Slavík, B. (ed.) (1995–2000): Květena České republiky. Vol. 4 (1995), 5 (1997), 6 (2000). – Academia, Praha.
- Tutin, T. G.; Heywood, V. H.; Burges, N. A.; Moore, D. M.; Valentin, D. H.; Walters, S. M. & Webb, D. A. (eds.) (1964–1980): Flora Europaea. Vols. 1–5. – Cambridge Univ. Pr., Cambridge.
- Webb, D. A. (1985): What are the criteria for presuming native status – *Watsonia* **15**: 231–236.
- Weber, E. F. (1997): The alien flora of Europe: a taxonomic and biogeographic overview. – *J. Veget. Sci.* **8**: 565–572.

Appendix. List of species reported as naturalized aliens for the former Czechoslovakia by Flora Europaea (Tutin et al. 1964–1980) and revision of their status based on current knowledge. See Pyšek et al. (2002) for more details on particular species present in the country. Evaluation of invasion status at the territory of Slovakia was based on Gojdičová et al. (2002). For taxa in which research resulted in the precision of taxonomic knowledge and their current taxonomic status is different, but they can be synonymized with those on the FE list, the name under which they are given in Pyšek et al. (2002) is shown in parentheses. Status = present occurrence in the Czech Republic: cas = casual alien; cas-SK = casual in CR, naturalized in Slovakia; err = erroneous record; ind = indigenous (native); indSK = native in CR, alien in Slovakia; nat = naturalized alien; plt = planted, not escaping from cultivation; SK = occurring only in Slovakia.

Genus	Species	Status
<i>Abutilon</i>	<i>theophrasti</i>	cas
<i>Acer</i>	<i>negundo</i>	nat
<i>Acorus</i>	<i>calamus</i>	nat
<i>Adonis</i>	<i>annua</i>	cas
<i>Aesculus</i>	<i>hippocastanum</i>	cas
<i>Agrimonia</i>	<i>pilosa</i>	SK
<i>Agrimonia</i>	<i>repens</i>	ind
<i>Achillea</i>	<i>macrophylla</i>	SK
<i>Achillea</i>	<i>tomentosa</i>	plt
<i>Ailanthus</i>	<i>altissima</i>	nat
<i>Alcea</i>	<i>rosea</i>	nat
<i>Allium</i>	<i>ampeloprasum</i>	cas
	(= <i>porrum</i> )	
<i>Allium</i>	<i>paradoxum</i>	nat

Genus	Species	Status	Genus	Species	Status
<i>Alnus</i>	<i>rugosa</i>	nat	<i>Centaurea</i>	<i>diffusa</i>	cas
<i>Alopecurus</i>	<i>myosuroides</i>	nat	<i>Centaurea</i>	<i>nigra</i>	cas
<i>Alyssum</i>	<i>repens</i> (= <i>rostratum</i> )	cas	<i>Centaurea</i>	<i>solstitialis</i>	cas
<i>Ambrosia</i>	<i>artemisiifolia</i>	nat	<i>Chamomilla</i>	<i>suaveolens</i>	nat
<i>Ambrosia</i>	<i>trifida</i>	cas	<i>Cheiranthus</i>	<i>cheiri</i>	cas
<i>Amorpha</i>	<i>fruticosa</i>	nat	<i>Chenopodium</i>	<i>ambrosioides</i>	cas-SK
<i>Anaphalis</i>	<i>margaritacea</i>	cas	<i>Chenopodium</i>	<i>foliosum</i>	cas
<i>Anemone</i>	<i>trifolia</i>	SK	<i>Chenopodium</i>	<i>suecicum</i>	indSK
<i>Anethum</i>	<i>graveolens</i>	cas	<i>Chrysanthemum</i>	<i>coronarium</i>	cas
<i>Anchusa</i>	<i>azurea</i>	cas	(= <i>Xanthophthalmum</i> )		
<i>Antirrhinum</i>	<i>majus</i>	nat	<i>Cicerbita</i>	<i>macrophylla</i>	cas
<i>Apium</i>	<i>graveolens</i>	cas	<i>Cirsium</i>	<i>tuberosum</i>	cas
<i>Armoracia</i>	<i>rusticana</i>	nat	<i>Clematis</i>	<i>flammula</i>	cas
<i>Artemisia</i>	<i>abrotanum</i>	cas	<i>Clematis</i>	<i>orientalis</i> (= <i>tangutica</i> )	cas
<i>Artemisia</i>	<i>annua</i>	nat	<i>Clematis</i>	<i>viticella</i>	cas
<i>Artemisia</i>	<i>dracunculus</i>	cas	<i>Cnicus</i>	<i>benedictus</i>	cas
<i>Artemisia</i>	<i>verlotiorum</i>	nat	<i>Cnidium</i>	<i>silifolium</i>	nat
<i>Asclepias</i>	<i>syriaca</i>	nat	<i>Collomia</i>	<i>grandiflora</i>	nat
<i>Asperula</i>	<i>arvensis</i>	nat	<i>Commelina</i>	<i>communis</i>	cas-SK
<i>Aster</i>	<i>laevis</i>	cas	<i>Conringia</i>	<i>orientalis</i>	nat
<i>Aster</i>	<i>lanceolatus</i>	nat	<i>Consolida</i>	<i>ambigua</i> (= <i>ajacis</i> )	cas
<i>Aster</i>	<i>novae-angliae</i>	cas	<i>Consolida</i>	<i>orientalis</i>	nat
<i>Aster</i>	<i>novi-belgii</i>	nat	<i>Conyza</i>	<i>canadensis</i>	nat
<i>Aster</i>	× <i>salignus</i>	nat	<i>Coriandrum</i>	<i>sativum</i>	cas
<i>Aster</i>	× <i>versicolor</i>	nat	<i>Coronopus</i>	<i>didymus</i>	cas
<i>Astrodaucus</i>	<i>orientalis</i>	nat	<i>Corydalis</i>	<i>lutea</i>	nat
<i>Avena</i>	<i>sterilis</i>	cas	<i>Corylus</i>	<i>maxima</i>	cas
<i>Axyris</i>	<i>amaranthoides</i>	cas	<i>Crambe</i>	<i>maritima</i>	cas
<i>Azolla</i>	<i>caroliniana</i> <sup>1</sup>	cas	<i>Crataegus</i>	<i>crus-galli</i>	cas
<i>Azolla</i>	<i>filiculoides</i>	cas-SK	<i>Crepis</i>	<i>nicaeensis</i>	cas
<i>Balsamita</i>	<i>major</i>	cas	<i>Crocus</i>	<i>chrysanthus</i>	cas
<i>Beta</i>	<i>trigyna</i>	cas	<i>Cuscuta</i>	<i>australis</i>	err
<i>Bidens</i>	<i>connata</i>	cas	<i>Cuscuta</i>	<i>campestris</i>	nat
<i>Bidens</i>	<i>frondosa</i>	nat	<i>Cuscuta</i>	<i>gronovii</i>	err
<i>Bidens</i>	<i>pilosa</i>	cas	<i>Cuscuta</i>	<i>suaveolens</i>	err
<i>Bilderdykia</i> (= <i>Fallopia</i> )	<i>aubertii</i>	nat	<i>Cycloloma</i>	<i>atriplicifolia</i>	SK
<i>Borago</i>	<i>officinalis</i>	cas	<i>Cydonia</i>	<i>oblonga</i>	cas
<i>Bromus</i>	<i>arvensis</i>	nat	<i>Cymbalaria</i>	<i>muralis</i>	nat
<i>Bromus</i>	<i>lepidus</i>	cas	<i>Cymbalaria</i>	<i>pallida</i>	cas
<i>Bromus</i>	<i>rigidus</i>	cas	<i>Cynosurus</i>	<i>echinatus</i>	cas
<i>Bromus</i>	<i>secalinus</i>	nat	<i>Datura</i>	<i>stramonium</i>	nat
<i>Bryonia</i>	<i>alba</i>	nat	<i>Dicentra</i>	<i>spectabilis</i>	plt
<i>Bunias</i>	<i>erucago</i>	cas	<i>Digitalis</i>	<i>lutea</i>	cas
<i>Bunias</i>	<i>orientalis</i>	nat	<i>Digitalaria</i>	<i>ischaemum</i>	nat
<i>Bunium</i>	<i>bulbocastanum</i>	cas	<i>Digitalaria</i>	<i>sanguinalis</i>	nat
<i>Cakile</i>	<i>maritima</i> (= <i>baltica</i> ?)	cas	<i>Dipsacus</i>	<i>sativus</i>	cas-SK
<i>Calepina</i>	<i>irregularis</i>	err	<i>Dipsacus</i>	<i>strigosus</i>	nat
<i>Calystegia</i>	<i>pulchra</i>	nat	<i>Doronicum</i>	<i>pardalianches</i>	nat
<i>Campanula</i>	<i>rhomboidalis</i>	nat	<i>Ecballium</i>	<i>elaterium</i>	cas
<i>Cannabis</i>	<i>sativa</i>	cas	<i>Echinocystis</i>	<i>lobata</i>	nat
<i>Cardaria</i>	<i>draba</i>	nat	<i>Echinochloa</i>	<i>crus-galli</i>	nat
<i>Carex</i>	<i>vulpinoidea</i>	SK	<i>Elaeagnus</i>	<i>angustifolia</i>	cas
<i>Carthamus</i>	<i>tinctorius</i>	cas	<i>Elatine</i>	<i>ambigua</i>	SK
<i>Castanea</i>	<i>sativa</i>	cas	<i>Elodea</i>	<i>canadensis</i>	nat
<i>Centaurea</i>	<i>cyanus</i>	nat	<i>Elsholtzia</i>	<i>ciliata</i>	cas
<i>Centaurea</i>	<i>dealbata</i>	cas	<i>Epilobium</i>	<i>adenocaulon</i> (= <i>ciliatum</i> )	nat
<i>Centaurea</i>	<i>debeauxii</i>	err	<i>Epimedium</i>	<i>alpinum</i>	cas
			<i>Eranthis</i>	<i>hyemalis</i>	cas

Genus	Species	Status	Genus	Species	Status
<i>Erechtites</i>	<i>hieracifolia</i>	nat	<i>Lupinus</i>	<i>polyphyllus</i>	nat
<i>Erica</i>	<i>tetralix</i>	ind	<i>Lycium</i>	<i>barbarum</i>	nat
<i>Erigeron</i>	<i>annuus</i>	nat	<i>Lycium</i>	<i>chinense</i>	cas
<i>Erodium</i>	<i>moschatum</i>	cas	<i>Lychnis</i>	<i>flos-jovis</i>	plt
<i>Eruca</i>	<i>vesicaria (= sativa)</i>	cas	<i>Mahonia</i>	<i>aquifolium</i>	nat
<i>Erucastrum</i>	<i>nasturtiifolium</i>	nat	<i>Malope</i>	<i>trifida</i>	cas
<i>Eschscholzia</i>	<i>californica</i>	cas	<i>Malva</i>	<i>verticillata</i>	cas
<i>Euphorbia</i>	<i>lathyris</i>	cas	<i>Medicago</i>	<i>arabica</i>	cas
<i>Euphorbia</i>	<i>myrsinites</i>	err	<i>Medicago</i>	<i>polymorpha</i>	cas
<i>Euphorbia</i>	<i>segetalis</i>	SK	<i>Medicago</i>	<i>rigidula</i>	cas
<i>Fagopyrum</i>	<i>esculentum</i>	cas	<i>Melilotus</i>	<i>indica</i>	cas
<i>Ficus</i>	<i>carica</i>	cas	<i>Melissa</i>	<i>officinalis</i>	cas
<i>Foeniculum</i>	<i>vulgare</i>	cas	<i>Mentha</i>	<i>spicata</i>	nat
<i>Fraxinus</i>	<i>pennsylvanica</i>	nat	<i>Mentha</i>	<i>suaveolens</i>	nat
<i>Galeopsis</i>	<i>segetum</i>	cas		<i>(= × rotundifolia)</i>	
<i>Galinsoga</i>	<i>ciliata</i>	nat	<i>Mentha</i>	<i>× smithiana</i>	err
<i>Galinsoga</i>	<i>parviflora</i>	nat	<i>Mespilus</i>	<i>germanica</i>	cas
<i>Galium</i>	<i>verrucosum</i>	cas	<i>Mimulus</i>	<i>guttatus</i>	nat
<i>Gentiana</i>	<i>lutea</i>	nat	<i>Mimulus</i>	<i>moschatus</i>	nat
<i>Geranium</i>	<i>pyrenaicum</i>	nat	<i>Mirabilis</i>	<i>longiflora</i>	err
<i>Geranium</i>	<i>sibiricum</i>	nat	<i>Misopates</i>	<i>orontium</i>	nat
<i>Geum</i>	<i>macrophyllum</i>	cas	<i>Moenchia</i>	<i>mantica</i>	SK
<i>Glaucium</i>	<i>corniculatum</i>	nat	<i>Myagrum</i>	<i>perfoliatum</i>	cas-SK
<i>Glaucium</i>	<i>flavum</i>	cas	<i>Myrrhis</i>	<i>odorata</i>	nat
<i>Gleditsia</i>	<i>triacanthos</i>	plt	<i>Narcissus</i>	<i>poeticus</i>	cas
<i>Glycyrrhiza</i>	<i>glabra</i>	nat	<i>Narcissus</i>	<i>pseudonarcissus</i>	cas
<i>Guizotia</i>	<i>abyssinica</i>	cas	<i>Nepeta</i>	<i>cataria</i>	nat
<i>Gypsophila</i>	<i>elegans</i>	cas	<i>Nicotiana</i>	<i>alata</i>	cas
<i>Helianthus</i>	<i>annuus</i>	cas	<i>Nicotiana</i>	<i>rustica</i>	cas
<i>Helianthus</i>	<i>tuberosus</i>	nat	<i>Nicotiana</i>	<i>tabacum</i>	cas
<i>Helleborus</i>	<i>viridis</i>	nat	<i>Nigella</i>	<i>damascena</i>	cas
<i>Hemerocallis</i>	<i>fulva</i>	cas	<i>Nigella</i>	<i>sativa</i>	cas
<i>Hemerocallis</i>	<i>lilioasphodelus</i>	cas	<i>Oenothera</i>	<i>parviflora</i>	cas
<i>Heracleum</i>	<i>mantegazzianum</i>	nat	<i>Oenothera</i>	<i>strigosa</i>	nat
<i>Iberis</i>	<i>pinnata</i>	err		<i>(= canovirens et depressa)</i>	
<i>Iberis</i>	<i>umbellata</i>	cas	<i>Omphalodes</i>	<i>verna</i>	cas
<i>Impatiens</i>	<i>balsamina</i>	cas	<i>Ornithogalum</i>	<i>nutans</i>	nat
<i>Impatiens</i>	<i>glandulifera</i>	nat	<i>Ornithogalum</i>	<i>umbellatum</i>	ind
<i>Impatiens</i>	<i>parviflora</i>	nat	<i>Ornithopus</i>	<i>perpusillus</i>	ind
<i>Inula</i>	<i>helenium</i>	nat	<i>Orobanche</i>	<i>ramosa</i>	nat
<i>Iris</i>	<i>germanica</i>	nat	<i>Oxalis</i>	<i>corniculata</i>	nat
<i>Iva</i>	<i>xanthifolia</i>	nat	<i>Oxalis</i>	<i>europaea</i>	nat
<i>Juncus</i>	<i>tenuis</i>	nat		<i>(= Xanthoxalis fontana)</i>	
<i>Kochia</i>	<i>scoparia</i>	nat	<i>Oxalis</i>	<i>stricta</i> <sup>2</sup>	err
<i>Lactuca</i>	<i>tatarica</i>	cas	<i>Oxybaphus</i>	<i>nyctagineus</i>	nat
<i>Lens</i>	<i>culinaris</i>	cas	<i>Paeonia</i>	<i>officinalis</i>	cas
<i>Lepidium</i>	<i>densiflorum</i>	nat	<i>Panicum</i>	<i>miliaceum</i>	nat
<i>Lepidium</i>	<i>neglectum</i>	cas-SK	<i>Papaver</i>	<i>orientale</i>	err
<i>Lepidium</i>	<i>sativum</i>	cas	<i>Parthenocissus</i>	<i>inserta</i>	nat
<i>Lepidium</i>	<i>virginicum</i>	cas	<i>Petasites</i>	<i>japonicus</i>	cas
<i>Linaria</i>	<i>repens</i>	cas	<i>Petroselinum</i>	<i>crispum</i>	cas
<i>Lobularia</i>	<i>maritima</i>	cas	<i>Phacelia</i>	<i>tanacetifolia</i>	cas
<i>Lolium</i>	<i>multiflorum</i>	nat	<i>Phalaris</i>	<i>canariensis</i>	cas
<i>Lonicera</i>	<i>periclymenum</i>	ind	<i>Philadelphus</i>	<i>coronarius</i>	cas
<i>Lonicera</i>	<i>tatarica</i>	cas-SK	<i>Physalis</i>	<i>peruviana</i>	cas
<i>Lupinus</i>	<i>angustifolius</i>	cas	<i>Physocarpus</i>	<i>opulifolius</i>	nat
<i>Lupinus</i>	<i>luteus</i>	cas	<i>Phytolacca</i>	<i>americana</i>	cas-SK
<i>Lupinus</i>	<i>perennis</i>	err	<i>Picris</i>	<i>echioides</i>	cas



Genus	Species	Status	Genus	Species	Status
<i>Pimpinella</i>	<i>anisum</i>	cas	<i>Sisyrinchium</i>	<i>montanum</i>	nat
<i>Plumbago</i>	<i>europaea</i>	plt		(= <i>angustifolium</i> )	
<i>Polygonum</i>	<i>orientale</i>	cas	<i>Solidago</i>	<i>canadensis</i>	nat
<i>Polypogon</i>	<i>monspeliensis</i>	cas	<i>Solidago</i>	<i>gigantea</i>	nat
<i>Potentilla</i>	<i>intermedia</i>	nat	<i>Solidago</i>	<i>graminifolia</i>	cas
<i>Prunus</i>	<i>armeniaca</i>	cas	<i>Sophora</i>	<i>japonica</i>	plt
<i>Prunus</i>	<i>cerasus</i>	nat	<i>Sorbus</i>	<i>domestica</i>	cas
<i>Prunus</i>	<i>dulcis</i>	plt	<i>Sorbus</i>	<i>intermedia</i>	ind
<i>Prunus</i>	<i>serotina</i>	cas	<i>Sorghum</i>	<i>halepense</i>	cas
<i>Prunus</i>	<i>virginiana</i>	cas	<i>Spiraea</i>	<i>alba</i>	cas
<i>Rapistrum</i>	<i>rugosum</i>	cas-SK	<i>Spiraea</i>	<i>corymbosa</i>	plt
<i>Reseda</i>	<i>alba</i>	cas	<i>Spiraea</i>	<i>douglasii</i>	cas
<i>Reseda</i>	<i>odorata</i>	cas	<i>Spiraea</i>	<i>japonica</i>	plt
<i>Reseda</i>	<i>phyteuma</i>	nat	<i>Spiraea</i>	<i>tomentosa</i>	plt
<i>Reynoutria</i>	<i>japonica</i>	nat	<i>Spiraea</i>	× <i>vauhouttei</i>	plt
<i>Reynoutria</i>	<i>sachalinensis</i>	nat	<i>Symphoricarpos</i>	<i>albus</i>	nat
<i>Rhus</i>	<i>typhina</i> (= <i>hirta</i> )	nat	<i>Syringa</i>	<i>vulgaris</i>	nat
<i>Ribes</i>	<i>spicatum</i>	cas	<i>Tanacetum</i>	<i>parthenium</i>	nat
<i>Robinia</i>	<i>pseudacacia</i>	nat	<i>Tanacetum</i>	<i>macrophyllum</i>	cas
<i>Rosa</i>	<i>foetida</i>	cas	(= <i>Pyrethrum</i> )		
<i>Rosa</i>	<i>villosa</i>	cas	<i>Taraxacum</i>	<i>glaucanthum</i>	err
<i>Rubia</i>	<i>tinctorum</i>	cas	<i>Tetragonolobus</i>	<i>purpureus</i>	err
<i>Rubus</i>	<i>laciniatus</i>	nat	<i>Thladiantha</i>	<i>dubia</i>	cas
<i>Rubus</i>	<i>odoratus</i>	nat	<i>Torilis</i>	<i>leptophylla</i>	err
<i>Rubus</i>	<i>phoenicolasius</i>	cas	<i>Torilis</i>	<i>nodosa</i>	cas
<i>Rudbeckia</i>	<i>hirta</i>	nat	<i>Tragopogon</i>	<i>porrifolius</i>	cas
<i>Rudbeckia</i>	<i>laciniata</i>	nat	<i>Trifolium</i>	<i>lappaceum</i>	cas
<i>Rumex</i>	<i>longifolius</i>	nat	<i>Trifolium</i>	<i>pallidum</i>	cas
<i>Rumex</i>	<i>triangulivalvis</i>	nat	<i>Trifolium</i>	<i>resupinatum</i>	cas
<i>Ruta</i>	<i>graveolens</i>	cas	<i>Trigonella</i>	<i>foenum-graecum</i>	cas
<i>Sagittaria</i>	<i>latifolia</i>	cas	<i>Tulipa</i>	<i>silvestris</i>	cas
<i>Salvia</i>	<i>officinalis</i>	cas	<i>Typha</i>	<i>laxmannii</i>	cas-SK
<i>Salvia</i>	<i>sclarea</i>	cas	<i>Ulex</i>	<i>europaeus</i>	cas
<i>Saponaria</i>	<i>ocymoides</i>	cas	<i>Urtica</i>	<i>pilulifera</i>	cas
<i>Scilla</i>	<i>amoena</i>	cas	<i>Vaccaria</i>	<i>pyramidata</i> (= <i>hispanica</i> )	cas
<i>Scilla</i>	<i>sibirica</i>	nat	<i>Veronica</i>	<i>filiformis</i>	nat
<i>Sedum</i>	<i>aizoon</i>	cas	<i>Veronica</i>	<i>peregrina</i>	cas-SK
<i>Sedum</i>	<i>hybridum</i>	nat	<i>Veronica</i>	<i>persica</i>	nat
<i>Sedum</i>	<i>spurium</i>	nat	<i>Vicia</i>	<i>articulata</i>	cas
<i>Senecio</i>	<i>vernalis</i>	nat	<i>Vicia</i>	<i>ervilia</i>	cas
<i>Setaria</i>	<i>italica</i>	cas	<i>Vicia</i>	<i>lutea</i>	cas
<i>Setaria</i>	<i>verticillata</i>	nat	<i>Vicia</i>	<i>melanops</i>	cas
<i>Sicyos</i>	<i>angulatus</i>	cas	<i>Vicia</i>	<i>narbonensis</i>	cas
<i>Silene</i>	<i>pendula</i>	cas	<i>Viola</i>	<i>cornuta</i>	cas
<i>Silphium</i>	<i>perfoliatum</i>	cas	<i>Xanthium</i>	<i>spinosum</i>	nat
<i>Silybum</i>	<i>marianum</i>	cas			
<i>Sisymbrium</i>	<i>irio</i>	cas			
<i>Sisymbrium</i>	<i>orientale</i>	ind			

<sup>1</sup> Two species, *A. caroliniana* and *A. filiculoides*, are given which are synonyms according to Kubát et al. (2002).

<sup>2</sup> Probably the same species as *O. europaea*, i.e. *Xanthoxalis fontana* (Holub 1997).