Plant species of the Central European flora as aliens in Australia

Středoevropské rostlinné druhy zavlečené do Austrálie

Megan L. Phillips[1], Brad R. Murray[1], Petr Pyšek[2,3], Jan Pergl[2,4], Vojtěch Jarošík[3,2], Milan Chytrý[5] & Ingolf Kühn[6]

[1]*Plant Functional Biology and Climate Change Cluster, Department of Environmental Sciences, University of Technology Sydney, PO Box 123, Broadway NSW 2007, Australia, e-mail: Megan.Phillips@uts.edu.au, Brad.Murray@uts.edu.au*; [2]*Institute of Botany, Academy of Sciences of the Czech Republic, CZ-252 43 Průhonice, Czech Republic, e-mail: pysek@ibot.cas.cz; pergl@ibot.cas.cz;* [3]*Department of Ecology, Faculty of Science, Charles University Prague, Viničná 7, CZ-128 01 Prague, Czech Republic, e-mail: jarosik@cesnet.cz;* [4]*Institute of Ecology and Evolution, University of Bern, CH-3012 Bern, Switzerland;* [5]*Department of Botany and Zoology, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic, e-mail: chytry@sci.muni.cz;* [6]*UFZ, Helmholtz Centre for Environmental Research – UFZ, Department of Community Ecology, Theodor-Lieser-Strasse 4, D-06120 Halle, Germany; ingolf.kuehn@ufz.de*

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The Central European flora is an important source pool of plant species introduced to many regions throughout the world. In this study, we identified a total of 759 plant species of the Central European flora that are currently recognized as alien species in Australia. We explored temporal patterns of introduction of these species to Australia in relation to method of introduction, growth form, naturalization status and taxonomy. Across all species, substantially larger numbers of species were introduced between 1840 and 1880 as well as between 1980 and the present, with a small peak of introductions within the 1930s. These patterns reflect early immigration patterns to Australia, recent improvements in fast and efficient transportation around the globe, and emigration away from difficult conditions brought about by the lead up to the Second World War respectively. We found that the majority of species had deliberate (69%) rather than accidental (31%) introductions and most species have not naturalized (66% casual species, 34% naturalized species). A total of 86 plant families comprising 31 tree species, 91 shrub species, 533 herbaceous species and 61 grass species present in Central Europe have been introduced to Australia. Differential patterns of temporal introduction of species were found as a function of both plant family and growth form and these patterns appear linked to variation in human migration numbers to Australia.

K e y w o r d s: alien plants, Australia, Central Europe, growth form, introduction history, naturalization, residence time, source-pool approach

Introduction

Alien species are nowadays widespread and there is virtually no region of the world free of invasive plants (Pyšek et al. 2008). Alien plant species invade a wide range of habitats (Stohlgren et al. 1999, 2006, Chytrý et al. 2005, 2008a, b, 2009a, b, Lambdon et al. 2008, Pyšek et al. 2010a, b), exert serious ecological impacts on invaded ecosystems (Parker et al. 1999, Mack et al. 2000, McGeoch et al. 2010, Vilà et al. 2010), incur huge costs to economies (Perrings et al. 2000, Pimentel et al. 2005, Binimelis et al. 2007, Kettunen et al.

2009, Vilà et al. 2010) and are subject of management efforts (see Pyšek & Richardson 2010 for a review). The distribution of invasive species on continents (Weber 2003), which shapes current global patterns of plant invasions (Lonsdale 1999, Pyšek et al. 2008), is a result of historical factors (di Castri 1989), differences in vulnerability of regions to invasion (Lonsdale 1999), opportunistic human-induced dispersal via various introduction pathways (Hulme et al. 2008, Hulme 2009) and interactions with native biota in regions of introduction (e.g. Richardson et al. 2000a, Sax & Gaines 2008, Vilà et al. 2009, Walther et al. 2009, Winter et al. 2009, Schweiger et al. 2010).

Historically, the exchange of alien biota between continents has not been random, reflecting factors such as cultural background, intensity of trade and movement of human populations (di Castri 1989, Thuiller et al. 2005). Successful translocation of plant and animal species from one continent to another also reflects the climatic match between the target and source region (Panetta & Mitchell 1991, Rouget et al. 2004, Thuiller et al. 2005, Bomford et al. 2009). As such, the geographic origin of an alien species is an important trait that has been shown to play a role in the temporal sequence of arrivals into target regions (Kowarik 1995, Pyšek et al. 2003) and in predicting a species ability to naturalize (Pyšek et al. 2009b).

In contrast to most studies that focus on alien floras of target regions (the 'target-area' approach, see Pyšek & Richardson 2007 for a review), a 'source-area' approach has been developed (Prinzing et al. 2002, Pyšek et al. 2004b, 2009a), which means that the invasiveness of species in the introduced range can be explored by considering the complete species pool of a specific source region. This partly minimizes some of the biases associated with propagule pressure (e.g. distance to source areas) and evolutionary predispositions acquired in various regions of origin. It is based on the assumption that members of the flora of a single biogeographical region have comparable chances to be transported by humans from their native region to other parts of the world. Thus, the structure of an alien flora that they form can be more unequivocally attributed to their traits, because biases related to different chances of species being translocated from the source pool are reduced (Pyšek et al. 2009a). For example, it may be easier for species to be translocated to the introduced range from a closer source region than from one that is more distant. The advantages of the source-area approach remain valid even though many species were not introduced from the source region directly to the target region, but may have reached it via another region on the donor continent to which they were introduced at an earlier time (LaSorte & Pyšek 2009). In the present paper, we use such an approach to explore the source pool of Central European plant species as aliens in Australia, thus linking a region on a continent that historically acted as a major donor of alien species to other parts of the world (di Castri 1989, Pyšek 1998) with the one that is among the most seriously affected by invasions globally (Randall 2007). The Old World, Europe and Western Asia have served as an important donor area of alien species to other regions of the globe (di Castri 1989) and European species in particular have experienced many centuries of testing their invasion potential in a wide range of conditions.

European colonists permanently settled in Australia in 1788. The continent, located in the Southern Hemisphere, was originally established by the British as a penal colony. Since colonial establishment at the end of the 18th century, a total of 26,242 plant species have been introduced to Australia and 2,739 of these introduced species have become naturalized (Randall 2007). A comparatively small number of these introduced species may have arrived in Australia, predominantly in the remote northern regions of the continent, several years before as a result of trading by native Aborigines with peoples of south-east Asia (Groves et al. 2005). Over all this time, many different regions of the world have donated alien plant species to Australia including Asia, South America, North America, Africa and Europe (Groves & Hosking 1998, Cook & Dias 2006, Harris et al. 2007, Phillips et al. 2010).

Unlike in Europe, where the patterns and history of plant invasions have been the focus of enormous research effort, enabled by a detailed knowledge of regional and continental alien floras (e.g. Kühn & Klotz 2003, Pyšek et al. 2003, 2005, Křivánek & Pyšek 2006, Chytrý et al. 2008b, 2009a, Lambdon et al. 2008, Hulme et al. 2009, Štajerová et al. 2009, Knapp et al. 2010, Kubešová et al. 2010, Pyšek et al. 2010a, c), there is a comparative paucity of information concerning such patterns and processes for Australia. While a growing body of disparate work over the last 20 years is beginning to raise the profile of the importance of understanding patterns and processes in alien plant introductions for Australian ecosystems (Lonsdale 1994, Groves & Hosking 1998, Lake & Leishman 2004, Hamilton et al. 2005, Leishman et al. 2007, Murray & Phillips 2010, Phillips et al. 2010), we are far from possessing as comprehensive an understanding of alien plant introductions to Australia as has been developed for some other regions of the world.

Exploration of temporal patterns of introduction of alien plant species to different regions of the world can provide important baseline information in the study of large-scale patterns of introduction and naturalization (e.g. Fuentes et al. 2008). For instance, if it can be determined that there were influxes of alien plant species, families or life histories during particular periods of human population growth and expansion, it becomes possible to understand more fully the introduction to naturalization transition in alien plants in relation to patterns of human exploration (e.g. colonization of new continents), technological advances (e.g. more rapid movement of humans around the globe via air travel), agricultural development (e.g. introduction of pasture species) and societal events (e.g. world wars or economic cycles). If these temporal patterns of introduction can also be considered in regard to the current status of aliens in new regions (e.g. whether the species have become naturalized or not), then we can start to understand the role of shifting patterns of human activity through time in facilitating the introduction to naturalization pathway and subsequent plant invasion.

Here, we explore historical patterns of introduction of alien plant species to Australia. Specifically, we focus on alien plant species in Australia in relation to the large source pool of species of Central Europe. We examine temporal patterns of introduction to Australia across the Central European species source pool and explore relationships between introduction time and (i) method of introduction (deliberate or accidental), (ii) current status of species (casual or naturalized), (iii) plant taxonomy (family) and (iv) plant growth form. This study is the first component of a larger investigation into the introduction-history, life-history and ecological factors underpinning naturalization and invasion success among Central European plant species in Australia. Importantly, it is through our deepening comprehension of patterns of historical introductions to Australia that we may better understand why some species are more successful than others at becoming naturalized and why other plant species are unable to sustain established populations within Australia.

Materials and methods

Source species pool

The flora of the Czech Republic (Kubát et al. 2002) and Germany (Klotz et al. 2002) was taken as a source species pool to obtain a sample of plant species that are native to Central Europe and belong to the Central European floristic element (Oberdorfer 2001). This approach is justified by the geographical location of these countries in the centre of the continent and by both having one of the strongest floristic traditions among European countries. The earliest accounts of the complete flora of the territory of the Czech Republic date from the beginning of the 19th century (see Pyšek et al. 2002 for an overview), and there is a recently compiled modern national flora (Hejný & Slavík 1988–1992, Slavík 1995–2000, Slavík & Štěpánková 2004) and identification key (Kubát et al. 2002). Scientific floristic inventories in Germany date back to 1687 (Knauth 1687, see Knapp et al. 2010 for details) with the first floras of large parts of the current German territory dating back to the early 19th century (Röhling et al. 1823–1839, Garcke 1849, 1871). Modern distribution atlases (Haeupler & Schönfelder 1989, Benkert et al. 1998) were compiled into databases and are regularly updated (www.floraweb.de). The most recent complete checklists are from Wisskirchen & Haeupler (1998) and Buttler & Hand (2008). In addition, there is very good knowledge on the traits of species occurring in these two regions (Kühn et al. 2003, 2004, 2006, Klimešová & Klimeš 2008, Küster et al. 2008, 2010), their distribution across different habitats (Sádlo et al. 2007) and affiliation to vegetation units inferred from large databases (e.g. Douda 2008, Schaminée et al. 2009, Dúbravková et al. 2010)

For the Czech Republic, the compilation of the dataset followed the procedure described in Pyšek et al. (2009a), using the working database CzechFlor held at the Institute of Botany, Průhonice, and the same criteria were applied to compiling data from Germany, using the BIOLFLOR database (Klotz et al. 2002). This screening yielded 1845 vascular plant species of Central European distribution occurring in the Czech Republic and/or Germany. These species are a highly representative sample as illustrated by comparison of their commonness/rarity in the region compared with pan-European patterns. Species frequencies in the Czech Republic and Germany, expressed as the number of ca 11 × 12 km grid cells from which a species has been reported, are highly correlated in frequency ($r = 0.85$, $df = 1154$, $P < 0.001$) and very well reflect species frequency in the digitized Atlas Florae Europaeae (see www.fmnh.helsinki.fi/english/botany/afe and references therein; $r = 0.89$, $df = 313$, $P < 0.0001$, for Czech and German species from our data set combined for which European distribution data are available). Atlas Florae Europaeae is currently only available for ca 20% of European species, however, it is a highly representative sample showing that the frequencies in the Czech Republic and Germany are well able to serve as proxies for the size of a species' native European range. For that reason we term the species identified as using the above criteria as the "Central European source species pool". Since the native range has been shown to affect the probability that a species will be introduced to other regions of the world (Pyšek et al. 2009a), this correlation allows the assumption that the chances of species in our Central European source species pool being introduced elsewhere also reflect their chances of being introduced from Europe as a whole.

Target region data

We compared the Central European source species pool list with a recent comprehensive database of all known plant introductions to Australia (Randall 2007) to extract the set of Central European species that have been recorded in Australia. We identified 759 plant species found in Central Europe that have been recorded as introduced to Australia (our nomenclature follows Randall 2007). We are careful to note that in the present study we are not inferring that Central European plant species in Australia were transported directly between the two regions. Indeed, it is likely that many of the species arrived namely via Britain, given its historical association with Australia, and also other parts of the world. Nevertheless, this does not invalidate our investigation, as (i) our focus in this study is specifically on providing an analysis of the contemporary source pool of Central European plant species in Australia in relation to general patterns of introduction history, and (ii) there is a close correlation between the distribution of our source pool species in Central Europe and in Europe as a whole, including the UK (see above).

We accessed the Australian Census of Cultivated Plants 2009 database from the Department of Agriculture, Fisheries and Forestry (DAFF) and obtained data on both the earliest year of introduction of the species to Australia as well as the means by which the species arrived in Australia. For the purposes of this research, earliest year of introduction refers to the earliest known record of a species being imported to, or reported within, the country. Method of introduction was divided into two categories, deliberate (e.g. species known to be brought in as ornamental or garden plants) or accidental (no known purposeful reason for introduction), as this was the most detailed information available for the species in the dataset. Public domain sources including over 600 plant nursery catalogues spanning 200 years, botanical and major garden plant species lists, Australian Quarantine and Inspection Service (AQIS) permitted import list, State department vegetation surveys and Commonwealth lists of imported species have been meticulously sourced for the DAFF database (R. Ingram, personal communication).

Information on taxonomic membership, at the level of family, and the current status of each species in Australia (casual or naturalized, corresponding to definitions in Richardson et al. 2000b, Pyšek et al. 2004a) was obtained from Randall (2007). In the present study, cultivated species that may have escaped from cultivation and that have not become naturalized are considered casual species. The data available do not allow us to discriminate consistently between cultivated and non-cultivated species that occur as casuals in the Australia flora, hence they are pooled into one meaningful category. Each species in our database was classified according to its growth form as (i) tree, (ii) shrub, (iii) herb or (iv) grass with data on growth forms sourced from CzechFlor, a working database of national flora held at the Institute of Botany, Průhonice, which was compiled using the monographs of national flora (Hejný & Slavík 1988–1992, Slavík 1995–2000, Kubát et al. 2002, Slavík & Štěpánková 2004) and other sources. Herbs included all herbaceous species with the exception of grasses. Species in the *Cyperaceae* and *Juncaceae* were considered as herbs.

Statistical analysis

We used χ^2 contingency table analysis (i.e. analysis of independence in a two-way table, Quinn & Keough 2002) to test for differences in the number of species among categories that included naturalized accidental, naturalized deliberate, casual accidental and casual deliberate introductions. In addition, standardized residuals (differences between the observed and expected values) from the analysis were determined to illustrate the direction of patterns emerging from contingency analysis. To compare frequency distributions of introduction times between different categories (e.g. accidental vs. deliberate introductions) we used non-parametric Kolmogorov-Smirnov tests.

Results

Central European species in Australia: a summary

Across all species, substantially larger numbers of species were introduced between 1840 and 1880 as well as between 1980 and the present, with a small peak of introductions within the 1930s (Fig. 1). The majority of species had deliberate (69%) rather than accidental (31%) introductions and most species have not become naturalized (66% casual species, 34% naturalized species). Interestingly, significantly more naturalized (but fewer casual) species than expected were introduced accidentally rather than deliberately ($\chi^2_{df=1}$ = 551.96, $P < 0.0001$, standardized residuals: accidental naturalized = 15.92, deliberate naturalized = –10.57, accidental casual = –11.33, deliberate casual = 7.60). The earliest record of an accidental introduction was in 1802 for *Daucus carota* which is now a naturalized species, while the earliest record of a deliberately introduced species was in 1803 for the casual species *Corylus avellana*. In total, 86 different plant families comprising 31 tree species, 91 shrub species, 533 herbaceous species and 61 grass species present in Central Europe have been introduced to Australia.

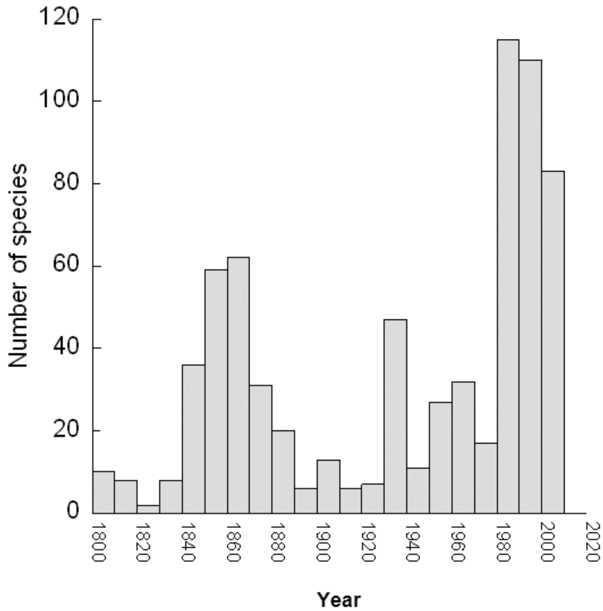

Fig. 1. – Frequency distribution of introduction times for all Central European plant species that have been introduced to Australia.

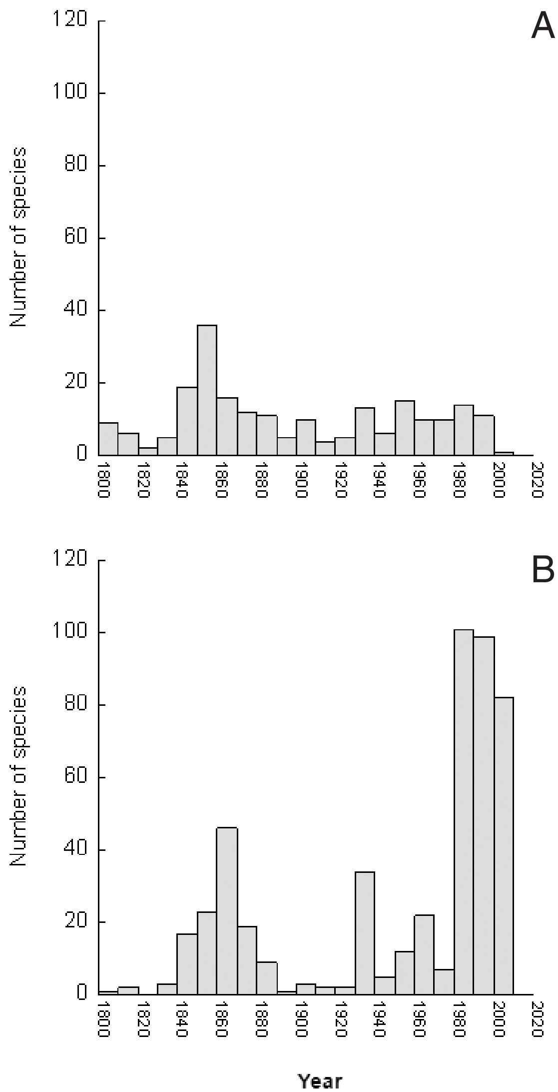

Fig. 2 – Frequency distributions of introduction times for species that were introduced (A) accidentally or (B) deliberately.

Accidental and deliberate introductions over time

Examination of temporal patterns of introduction as a function of method of introduction (accidental or deliberate) revealed that the high peak of recent introductions was largely due to a substantial increase in deliberate introductions since the early 1980s (Fig. 2). There was a significant difference in frequency distributions of introduction times between species arriving accidentally and deliberately (Kolmogorov-Smirnov test: $Z = 11.33$, $P < 0.0001$). The spike in introductions observed during the 1930s was a product of

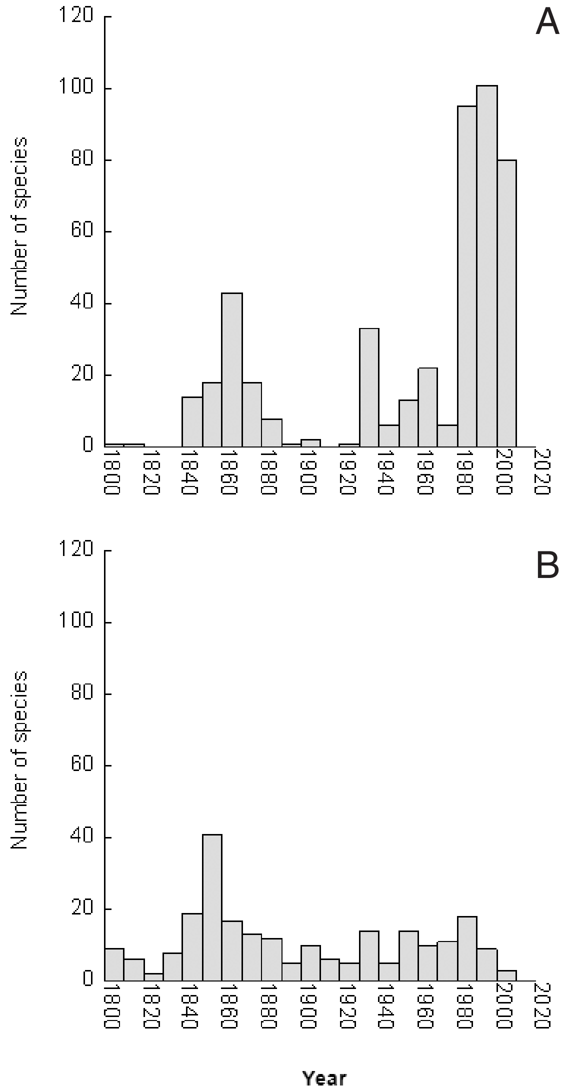

Fig. 3 – Frequency distributions of introduction times for species that are currently classed as (A) casual or (B) naturalized.

considerably more deliberate introductions compared with accidental introductions, while the second highest peak in introductions, from 1840 to 1880, appears to have been generated by similarly large numbers of accidental and deliberate introductions during this time.

Current status of Central European plants in Australia in relation to introduction periods

Consideration of temporal patterns of introduction as a function of the current status of species (casual and naturalized species, Fig. 3) showed that the peak of recent introductions (i.e. since the 1980s) can be linked to larger numbers of casual than naturalized species. Indeed, there was a significant difference in frequency distributions of introductions between casual and naturalized species (Kolmogorov-Smirnov test: $Z = 6.12$, $P < 0.0001$). It is worth noting, however, that the large number of species with introductions between 1840 and 1880 appears to be made up of equivalent numbers of casual and naturalized species.

Introductions of plant families over time

Three major groups of plant introduction emerged by examining temporal patterns of introduction as a function of plant family (Fig. 4 illustrates patterns of introduction times for the 13 most speciose families, represented by more than 15 species). First, most species from several of the larger plant families (*Apiaceae*, *Brassicaceae*, *Campanulaceae*, *Cyperaceae*, *Lamiaceae* and *Scrophulariaceae*) were introduced quite recently (since the 1960s). Second, most species from two families (*Poaceae* and *Fabaceae*) were introduced in the more distant past (between the late 1800s and the late 1920s). Third, other families (*Asteraceae*, *Caryophyllaceae*, *Ranunculaceae*, *Rosaceae* and *Salicaceae*) reveal a long and consistent pattern of species' introductions to Australia.

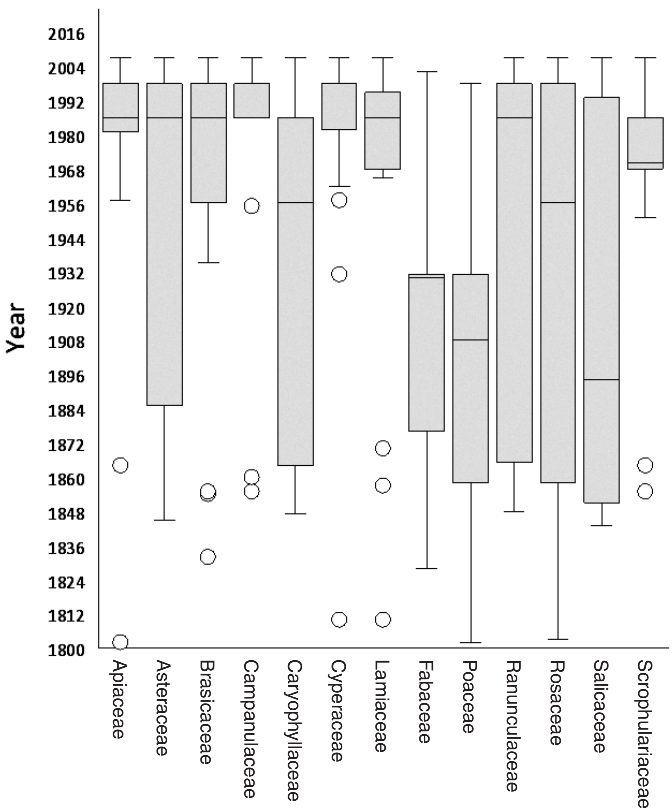

Fig. 4. – Distribution of earliest years of introduction for families with more than 15 species. The median, upper and lower quartile, smallest and largest non-outlier observations and outliers are presented. Outliers are those further away than 1.5 times the interquartile range (box).

Introductions of plant growth forms over time

The temporal breakdown of species' introductions as a function of growth form revealed intriguing patterns of variation (Fig. 5). Tree species were introduced mostly in the mid-1800s with many fewer trees arriving since then. Grass species similarly appear to have been restricted in their introductions, mostly to earlier periods in Australia's history of colonization, while herbs and shrubs have had a long and consistent pattern of species' introductions to Australia since the mid to late 1800s.

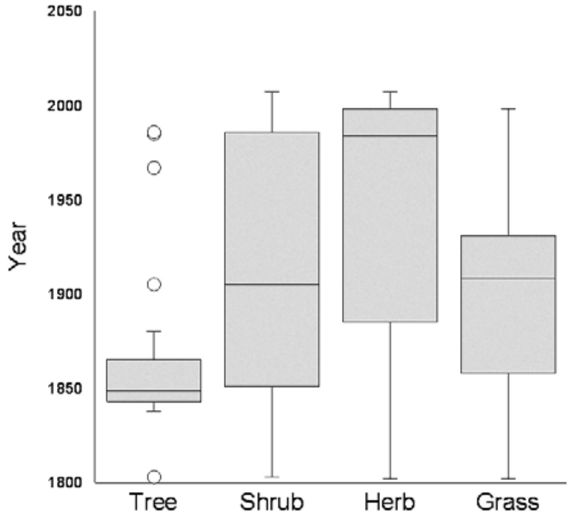

Fig. 5. – Distribution of earliest years of introduction for species in each of the four plant growth forms. The median, upper and lower quartile, smallest and largest non-outlier observations and outliers are presented. Outliers are those further away than 1.5 times the interquartile range (box).

Discussion

Our results reveal two peak periods of introduction among the source pool of Central European plant species in Australia. The first peak occurred between 1840 and 1880 and the second peak between 1980 and 2000. There was also a smaller rise in introductions during the 1930s. The first major influx of species coincides with convict transportation to Australia during the first half of the 19th century. During this time, transportation became the preferred punishment for crime over the death penalty in Britain and Ireland, and over 100,000 convicts were sent to Australia before 1840 (Sherrington 1980). An additional 58,000 free colonial settlers emigrated from the United Kingdom to Australia between 1815 and 1840, as the promotion of affordable settlement and lifestyle became a new driving force behind migration to Australia (Sherrington 1980). These social changes were then followed by the 'Gold Rush', beginning in 1851 with the discovery of gold near the township of Bathurst in New South Wales. The Gold Rush stimulated a large increase in foreign immigration to Australia as migrant families, primarily from the United Kingdom, continental Europe and Asia, sought wealth through gold prospecting and the establishment of businesses to support the new gold mining industry (Bligh 1973, Sherrington 1980). Census data from 1851 report the Australian colonial population was approximately 437,655, but by the end of the decade it had increased over two-fold to 1,151,947 (Sherrington 1980).

As human migration to Australia became more frequent, so followed the movement of commodities and possessions, including seeds and plants that were introduced both intentionally (e.g. orchard species) and unintentionally (i.e. through contamination of grain) (Groves et al. 2005). Migrant families that travelled to Australia to establish a new lifestyle often sought to make their properties and gardens reflect the aesthetics of their countries in order to preserve their unique cultural identities (Sherrington 1980). In 1848, the first retail botanical nursery was opened in Sydney, after which the nursery and horticulture trades developed continuously within Australia (Bligh 1973). Alien plants became a common feature of new gardens, in the first instance with many gardening societies being formed along with botanical gardens that often displayed ornamental specimen plants from many parts of the world, including popular tree species like European ash (*Fraxinus excelsior*) and beech (*Fagus sylvatica*), both introduced from Central Europe and both grown and sold commercially in Australia during the 1850s (Shepherd 1851, Macarthur 1857, Pembroke 2009).

The second significant peak period of plant introductions (occurring during the 1980s to 2000s) follows the rapid development of communications and transport networks in Australia. In addition, there appears to have been a rise in the popularity of gardening culture in Australia through the medium of television. Following this, alien ornamental species have become valuable aesthetic commodities to Australian gardeners, with many publications and websites promoting the use of ornamental alien plants as desirable features within garden settings. The number of new plant species, including species already invasive in Australia, that are able to be legally imported into States and Territories of Australia is extremely large (Glanznig 2005). Some 162,000 plant species are able to be legally imported into all States and Territories (except Western Australia) with no risk assessment, which is about 60% of all vascular plant species on Earth (Whitton & Rajakaruna 2001). Interestingly, this trend of recent increase in plant introductions to Australia contrasts with findings for New Zealand, where rates of plant introductions and naturalizations are in decline (Williamson et al. 2010).

Despite carefully elaborated protocols of Australian weed risk-assessment and intensive research in this field (Pheloung et al. 1999, Gordon et al. 2008, 2010, Weber et al. 2009) plant introductions continue to increase. The ease with which an alien ornamental species may be ordered and brought into Australia through the postal system is often noted as highly problematic for their control, despite Australian Quarantine's rigorous screening systems to detect and prevent the entry of unauthorized alien plant species (Ernst & Young 2007). It has been recently reported that the collaborative efforts of Australian Quarantine and Australia Post have had considerable difficulty meeting targets and effectiveness benchmarks for screening international mail and large container cargo (i.e. to detect biological material such as seeds), especially in Western Australia, and have consistently failed to meet mail screening targets during the Christmas holiday period when the volume of international mail and importation to Australia peaks annually (Ernst & Young 2007). These failures in the biological screening protocol present open opportunities for alien species to be imported to Australia without permit (Australian Biosecurity Group 2005, Ernst & Young 2007).

The third peak of plant introductions that occurred during the 1930s was of smaller magnitude and appears to be isolated within a smaller period of time, in contrast to the longer duration of the two main plant introduction peaks. This may be accounted for by the pre-war immigration of Central European citizens to Australia during the 1930s. Prior to World War II, there was a large expatriation of European families as a result of the rising political tensions and outbursts of violence in European countries, with Australia receiving approximately 170,529 British immigrants in the 1920s and into the 1930s (Sherrington 1980). This would also coincide with a large number of immigrants coming to Australia because of economical difficulties during the Great Depression of 1929–1933.

The majority of species had deliberate rather than accidental introductions. One possible explanation for this pattern is that there has been a botanical recording bias. In other words, it is perhaps far easier to keep records of species' introductions if species have been brought in purposefully, than to record accidental introductions across a large area such as Australia. However, there is some evidence that deliberate introductions do perhaps comprise the majority of introduction events. The gardening industry is by far the largest importer of introduced plant species, being the source for the introduction of 25,360 or 94% of new plant species into Australia and garden plant introductions are also the dominant source of new naturalized plants and weeds in Australia; in fact, of the 2779 introduced plant species that have naturalized in the Australian environment, 1831 (or 66%) are escaped garden plant species (Groves et al. 2005). This is comparable to the situation in Europe where the majority of species have been introduced deliberately for ornamental or horticultural reasons (Lambdon et al. 2008, Pyšek et al. 2009c) and the more widespread a species is, the higher its frequency in botanic gardens (Hanspach et al. 2008).

This is probably also reflected in the pattern of introduction of different growth forms over time (Pyšek et al. 2003). Tree species to provide building material, shelter, shadow and some sort of "home feeling" in the new settlements were brought to Australia rather early, as many European migrant families desired familiar plant species that reflected their traditional cultures (Bligh 1973). Grasses followed soon after, mainly for agricultural reasons (pastures), although some grasses are also prone to accidental introduction, for example, due to their awns sticking to clothes (Groves et al. 2005). More recently, gardening and ornamentation were responsible for the vast numbers of shrubs and herbs introduced to Australia (Groves & Hosking 1998, Groves 2005).

Several European plant species have become commonplace within Australia since their early introductions. The earliest known intentional introduction is the common hazel (*Corylus avellana*) brought in to Australia as a nursery plant in 1803. Common hazel is a tall, deciduous shrub or small tree with multiple human uses, the most notable use being the production of edible nuts; it is also able to grow as a hedgerow species and its timber can be harvested for fence posts. Norway maple (*Acer platanoides*) was introduced from Europe in 1843. Landscape designers frequently use Norway maple as an avenue tree to line city streets for a more "traditional" street aesthetic. Heal-all (*Prunella vulgaris*), introduced in 1810, is both an edible and medicinal herb used for its antibacterial properties. All parts of the plant are used for a variety of alternative medicinal treatments, including teas, soups and salads.

We found that the peak of recent (i.e. after 1980) introductions to Australia is made up largely of species currently classed as casual species. This is probably a reflection of their short residence time in their new range. An invasion ecology generality is that long residence time is correlated with a wide distribution and invasiveness (Rejmánek 2000, Castro et al. 2005, Pyšek & Jarošík 2005, Harris et al. 2007, Wilson et al. 2007, Williamson et al. 2009, Gassó et al. 2010, Phillips et al. 2010). Although much less studied, residence time is also most likely correlated with a species likelihood of becoming naturalized (Pyšek & Jarošík 2005, Křivánek et al. 2006). It is quite a daunting prospect then, that with so many casual species entering the continent, there is a strong likelihood that we shall see many more alien plants becoming naturalized and potentially becoming serious invaders to rival Australia's current worst invaders, due to their still running lag times (Kowarik 1995).

Acknowledgements

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Souhrn

Středoevropská flóra je významným zdrojem zavlečených druhů v mnoha oblastech celého světa. Tento článek ukazuje, že 759 druhů pocházejících ze střední Evropy bylo zavlečeno do Austrálie, a popisuje časový průběh zavlékání těchto druhů s ohledem na způsob zavlečení, růstovou formu, úspěšnost naturalizace a taxonomické složení. Ve dvou obdobích byl zaznamenán zvýšený počet zavlékaných druhů, a to v letech 1840–1880 a od roku 1980 do současnosti; mírně vyšší intenzita byla pozorována také ve 30. letech 20. století. V prvním případě to odráží časné imigrační vlny, ve druhém pak současnou globalizaci dopravy a lepší příležitosti k zavlékání; poslední období vyšší intenzity zavlékání rostlinných druhů je důsledkem meziválečné imigrace. Většina druhů ze studovaného souboru byla introdukována úmyslně (69 % ve srovnání s 31 % zavlečenými neúmyslně). Naturalizované druhy tvoří menší část (34%) než druhy, které jsou zatím hodnoceny jako přechodně zavlečné (66 %). Pokud jde o taxonomické složení, obsahuje nepůvodní flóra Austrálie středoevropské druhy z celkem 86 čeledí. Z celkového počtu tvoří 31 druhů stromy, 91 keře, 533 byliny a 61 druhů trávy. Rozdíly v časovém průběhu zavlékání středoevropských druhů do Austrálie jsou tedy dány zejména taxonomickou příslušností a růstovou formou a odrážejí průběh imigrace lidí na tento kontinent.

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