Ornamental horticultural trade as pathway for invasions

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ABSTRACT

We compare 403 ornamental species known to have started an invasion process in the UK with a sample of 394 ornamental species not occurring outside cultivation. The results show that the percentage of species on sale in the last century and the frequency with which they have occurred in the market has been always higher in the invading sample than in the non-invading sample. Furthermore, the invading species more often than the non-invading species, originate in Europe and Asia, and belong to a genus native in Britain.

INTRODUCTION

Deliberate introductions of plant species are recognised to be the main source of non-indigenous species in many countries (Groves 1998; Mack 2003; Reichard & White 2001). Horticulture promotes invasions in many different ways, of which the introduction of plants is the most obvious. For instance, gardening fashions lead to the rapid distribution of species across a country. Plant characteristics that make a plant interesting for gardeners, such as climatic suitability or quick propagation, may also promote a successful invasion. As a result, the rate of naturalisation is higher in deliberately introduced plants as compared to accidental introductions (Kowarik 2003).

In this paper, we are interested in understanding the extent to which horticultural trade may contribute to the invasion of non-native species in natural ecosystems. Studies of the trade in pet animals like parrots (Cassey et al. 2004) and aquarium fish (Duggan et al. in press; Semmens et al. 2004) have shown a relationship of the availability and frequency of species in the international and national trade with its invasion success. Mulvaney (2001) analyse nursery catalogue records in the middle of the 19th century in south-eastern Australia to explore the links between availability of woody plants and their invasion. In this study we extend this work by focusing on the horticultural trade in Britain over the last 120 years, and we compare samples of ornamental non-native species which have and have not become invasive. Studies comparing invasive species with non-invasive species have been shown to be a good method to describe traits of invasive species (e. g. Frappier & Eckert 2003). Here, we use it to include socio-economic factors as well as plant characteristics in the analysis.

DATA COLLECTION AND ANALYSIS

For the purposes of this analysis, we compare two groups of non-native ornamental plant species: invading and non-invading species. The invading group includes all species listed in

the catalogue of alien plants of the British Isles (Clement & Foster 1994; Ryves et al. 1996) as garden escapes and as having at least 15 localities in the area. This group comprised 403 established and casual species (following the nomenclature in Richardson et al. 2000). For the non-invading group, a sample of 600 non-invading species was randomly drawn from eight nursery catalogues printed in the middle of the 19th century, between 1854 and 1869. We choose eight nurseries known to be among the leading companies at that time (Hadfield 1960) that were located in different parts of Britain. Native species, species found outside cultivation anywhere in the British Isles and species twice in the list due to synonyms were excluded resulting in a final data set of 394 non-invading species.

Information on the availability of these samples of non-native plants in the horticultural market were collected using nursery and seed catalogues over the last 120 years. Thus, starting from 1885, the occurrence of these 797 species in five nursery catalogues was checked every 20 years. The Plant Finder 2004 (Royal Horticultural Society 2004) provides the opportunity to compare our results from the nursery catalogues with a data source including the whole range of ornamental species available in the market today. Further variables included in the dataset were the plant family, whether or not a species belongs to a genus native in Britain, and the native range. This data were mostly taken from Klotz et al. (2002), Preston et al. (2002), and Brickell (1996).

Frequency analysis is used to examine whether the two groups have statistically significant differences in the attributes examined in this paper. Dichotomous variables were coded as 1 (present or yes) and 0 (absent or no). For the analysis of the native range of the species each species was dummy coded into separate dichotomous variables for the following regions: Africa, America, Asia, Australia and Europe. Species originating in cultivation were included in an additional category. The total number of scores is higher than the number of species included in the analysis because many species are considered native to more than one continent. The frequency in the market for each ornamental non-native plant is defined as the number of nursery and seed catalogues in which that plant was present at each time period. We assume that the higher the frequency the more accessible is the plant and the more likely it is that the species has been bought and planted. To analyse the relationship between invading and non-invading species with their frequency in the market in the whole period studied, the species were grouped into 6 categories of 75 based on their frequency order. Category 7 contains the remaining 113 species (all with the same frequency). Species order was randomised within frequencies in those cases where there were overlapping

RESULTS

Native range of the species

Compared to the non-invading sample invading species are more frequently native in Europe, Asia and Africa or originate in cultivation. Species of American origin are the biggest group (33%) in the non-invading group. They contribute only half this percentage to the invading sample. Species originating in cultivation (hybrids) occur more frequently in the invading sample. The difference between the two samples is highly significant (Chi-sq = 49.00, d.f. = 5, $P < 0.001$).

Taxonomic description

The sample included species from 122 plant families with 21 families contributing more than 10 species. The frequency with which species of both samples occur in these families are significantly different (Chi-sq = 100.52, d.f. = 20, P < 0.001). Invading species are particularly dominant in the Asteracea, Rosaceae and Liliaceae families and the non-invading species in the Fabaceae and Ranunculaceae families.

Table 1: Number of species of the non-invading and invading sample in the 21 plant families contributing more than 10 species to the total sample.

Family	Non-invading	Invading	Family	Non-invading	Invading
Asteraceae	24	55	Saxifragaceae	12	5
Fabaceae	55	13	Campanulaceae	7	8
Rosaceae	9	45	Onagraceae	7	8
Scrophulariaceae	14	21	Boraginaceae	3	10
Liliaceae	10	24	Ericaceae	7	6
Ranunculaceae	22	7	Crassulaceae	7	5
Lamiaceae	10	16	Caprifoliaceae	3	9
Brassicaceae	8	13	Malvaceae	5	7
Caryophyllaceae	13	8	Poaceae	10	2
Iridaceae	9	11	Solanaceae	6	5
Primulaceae	13	4			

Four hundred of the species belong to a genus native in Britain, with 235 species of the invading and 165 of the non-invading sample. The difference between the two groups is highly significant (Chi-Sq = 20.87, d.f. = 1, P < 0.001).

Availability in the horticultural market

To test if the availability in the market is related to the ability of the species to become an invader, we compared the proportion of species found in nurseries catalogues in each group. The data show that the percentage of species which have been available in the market in the different periods studied is always higher in the invading groups than in the non-invading species. The difference in the proportion of species on sale between the groups is small for the first period studied, but this difference increases with time during the first half of the period studied and stabilises in the second half. Statistical highly significant differences were found in the frequencies of species on sale in the periods studied, with the exception of the year 1885 (in 1885: Chi-sq = 1.88, d.f. =1, P > 0.1; in 1905: Chi-sq = 58.94, P < 0.001; in 1925: Chi-sq = 83.12, P < 0.001; in 1945: Chi-sq = 145.95, P < 0.001; in 1965: Chi-sq = 143.10, P < 0.001; in 1985: Chi-sq = 148.20, P < 0.001; in 2005: Chi-sq = 174.41, P < 0.001). Similarly, the proportion of invading species on sale according to the Plant Finder 2004 is higher than that of non-invading species. The difference between the two groups is highly significant (Chi-sq = 166.52, d.f. = 1, P < 0.001).

Occurrence frequency in the horticultural market

In order to explore the relationship between the frequency in the market and the invasion success, we first compare the proportion of species in the two groups that appear at least in two of the five catalogues examined every twenty years. We focus thus on the species most frequently on sale given that the average of the third quartiles for the series examined is two nurseries. For all the periods, the invading species group contains a higher percentage of species that are on sale at least in two nurseries. On average this percentage is 29% for the invading group and 7% for the non-invading sample. The χ^2 test shows that these groups are statistically significantly different in their popularity in the horticultural market in all years examined (in 1885: Chi-sq = 5.40, d.f. =1, $P < 0.05$; in 1905: Chi-sq = 36.35, $P < 0.001$; in 1925: Chi-sq = 70.35, $P < 0.001$; in 1945: Chi-sq = 87.37, $P < 0.001$; in 1965: Chi-sq = 89.14, $P < 0.001$; in 1985: Chi-sq = 60.54 $P < 0.001$; in 2005: Chi-sq = 106.58, $P < 0.001$). We also examine the frequency of the non-native ornamental species in the nursery catalogues for the whole period. In this analysis only those plants that appear at least in one catalogue are included. This reduces our sample size to 219 in the non-invading group, and 344 in the invading group. Figure 1 shows that only a small percentage of the non-invading species are among the most commonly frequent ornamental plants in the total sample (rank 1). This percentage increases as we move along the ranks towards those with the least frequent species. The percentage of the species from the invading group in the different ranks seems to be less variable, although it is declining towards ranks presenting species less frequently on sale.

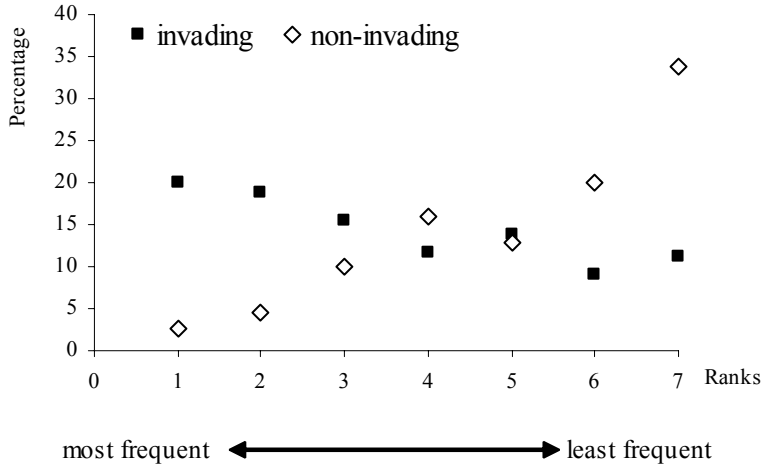

Figure 1: Percentage of invading and non-invading ornamental plants available in the horticultural market at least in one of the following periods: 1885, 1905, 1925, 1945, 1965, 1985, and 2005. Invading plants were ranked based on the frequency which they occur in the nursery catalogues in these periods.

DISCUSSION

Our comparisons of invading and non-invading ornamental species show significant differences in their ecological as well as trade related characteristics. The analysis of the areas of origin is in line with descriptions of alien floras in Europe where species of

European and Eurasian origin have been shown to be the most frequent invaders (Kühn & Klotz 2003; Pyšek et al. 2002). The high percentage of American species in the non-invading sample compared to the low percentage in the invading sample suggests that species of American origin might be less likely to start an invasion process. This may, however, also be caused by lower resident times of these species. The taxonomic description of the species shows that plant families like the Asteraceae or Brassicaceae which are over-represented in alien floras worldwide (Pyšek 1998) are also more frequently represented in our invading species sample. Pyšek (1998) also found families contributing to the alien species pool which were supported by deliberate introductions (for example the Liliaceae or Rosaceae) that are also over-represented in the invading species group of our analysis. In contrast to Pyšek's results, however, we found the Fabaceae under-represented.

The results show a clear relationship between availability and frequency in the market of non-native plants in the last 120 years and the current status of the plants as invading or non-invading. In the invading group there is a higher percentage of species that have been on sale (i.e. available in the market) than in the non-invading one. Furthermore, species in the invading group are also sold by more nurseries. Therefore, invading species have had a higher probability of being found in the market in the last century. This may have increased their chances to be planted and thus increased their risk from escaping from the garden by an increased propagule pressure. Mulvaney (2001) also concluded that species appearing with higher frequencies in mid 19th century nursery catalogues contributed a higher percentage to the naturalised species pool in south-eastern Australia than species appearing less frequently. However, to our knowledge these results are the first to document these relationships based on historical time series data of nursery catalogues (1885-2005). "Popularity" seems thus to be a relevant factor to explain the ability of an ornamental non-native plant species to start an invasion process. Policies to increase general awareness of plant invasions such as education and codes of conduct, as well as screening process for non-native ornamental plants are therefore an important step to prevent further invasions (Bell et al. 2003; Reichard & White 2001).

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