Flora 226 (2017) 10–16

Contents lists available at ScienceDirect

Flora

journal homepage: www.elsevier.com/locate/flora

Invasive *Impatiens parviflora* has negative impact on native vegetation in oak-hornbeam forests

Anna Florianová[a,b,*], Zuzana Münzbergová[a,b]

[a] *Department of Botany, Faculty of Science, Charles University in Prague, Benátská 2, 128 01 Praha 2, Czechia*
[b] *Institute of Botany, Czech Academy of Sciences, Zámek 1, 252 43 Průhonice, Czechia*

ARTICLE INFO

Article history:
Received 25 July 2016
Received in revised form 2 November 2016
Accepted 7 November 2016
Edited by Fei-Hai Yu.
Available online 9 November 2016

Keywords:
Forest understory herb
Deciduous forest
Plant functional trait
Removal experiment
Small balsam
Vegetation recovery

ABSTRACT

Impatiens parviflora (Balsaminaceae) is one of the most widespread invasive plant species in Central Europe. Nevertheless, both mechanisms and consequences of its invasion are still poorly understood. In this study we attempt to understand the impact of this species on native vegetation.

The impact of *I. parviflora* on native vegetation was studied using removal experiment on permanent plots in oak-hornbeam forests in central Bohemia, Czech Republic. Nine pairs of plots were established in invaded vegetation, one plot in each pair stayed invaded and the other served as removal plot and all *I. parviflora* individuals were repeatedly removed from the plot. Species composition in 4 subsequent years was recorded in the plots. Species response to *I. parviflora* removal was correlated to plant traits to reveal trait characteristics of species suppressed by the invasion.

Significant increase in both numbers and cover of native species was observed in removal plots in comparison with invaded plots during the experiment, with the greatest change in first two years after invader removal. Species composition also significantly differed between invaded and removal plots. Species with high affinity to removal plots, i.e. species that are most restricted by *I. parviflora* invasion, were mostly species with small releasing height and early start of flowering.

Our results indicate that *I. parviflora* has negative impact on native vegetation but that the vegetation can recover within few years after the invader removal. Due to its extensive distribution and high turnover, removal of the species from larger plots is, however, not realistic in practice.

1. Introduction

Biological invasions are a key topic of ecological research in the last decades (Sol et al., 2012). The reason is obvious – invasive plants affect natural communities, displacing native species and changing vegetation structure, causing reduction in diversity in the affected areas (Hejda et al., 2009; Powell et al., 2013; Worz and Thiv, 2015), undermine functioning of whole ecosystems (Richardson and Pyšek, 2012) and cause significant economic losses (Zavaleta, 2000). While the increasing number and expanding ranges of non-native species in the world flora are very well documented (Lonsdale, 1999; Pyšek and Hulme, 2005), their impacts remain unquantified for most alien plants (Barney et al., 2013; Pyšek et al., 2012b).Moreover, ecological impacts of most invasive plants have not been studied experimentally (Barney et al., 2015) and our knowledge of their impact comes from observational studies that have compared invaded and non-invaded habitats (Levine et al., 2003). However, as species composition and diversity may themselves influence the likelihood of invasion, separating cause and effect using such correlative approach is nearly impossible (Levine and D'Antonio, 1999). Alternative approaches include either experimental introduction (e.g. Flory and Clay, 2010; Maron and Marler, 2008) or removal of the invasive species (Guido and Pillar, 2015; Kumschick et al., 2015). As experimental introductions of invasive species into natural or semi-natural habitats are understandably not encouraged, removal experiments seem to be the best way to study the impact of invasive species on native vegetation (Zavaleta et al., 2001).

Several removal experiments have already been performed to assess the impact of invasive species such as *Impatiens glandulifera* (Hejda and Pyšek, 2006; Hulme and Bremner, 2006), *Alliaria petiolata* (Stinson et al., 2007) or *Mimulus guttatus* (Truscott et al., 2008) on native vegetation. For most species, comparative studies still remain the main source of information (for complete list of invasive species for which removal experiments were done see

* Corresponding author at: Department of Botany, Faculty of Science, Charles University in Prague, Benátská 2, 128 01 Praha 2, Czech Republic.
E-mail address: ancaflorianova@centrum.cz (A. Florianová).

http://dx.doi.org/10.1016/j.flora.2016.11.006
0367-2530/

Guido and Pillar (2015)). One of the species that lacks good data from removal experiments is *Impatiens parviflora,* an invasive plant of Central and East Asiatic origin, that belongs to most widespread invasive plants in Europe. (Lambdon et al., 2008).

As this alien is often seen dominating herbal layer of invaded forests, including sites with relatively low hemeroby, it can potentially impact rare native species (Godefroid and Koedam, 2010). However, its interaction with native species of invaded communities is surprisingly poorly documented (Godefroid and Koedam, 2010). Negative impact of *I. parviflora* has been reported by a few studies (Chmura and Sierka, 2006; Dobravolskaitė, 2012; Łysik, 2008; Obidzinski and Symonides, 2000). However, because of the comparative approach of the studies, it is not clear, whether the changes in the vegetation of herbal layers are caused by the invasion of *I. parviflora* or if *I. parviflora* just profits from changes caused by another factors. Hejda (2012), who as the only one aimed to disentangle these two options by using removal experiment, reported only minuscule, if any, impact of the species on native vegetation. Specifically, he observed no significant changes in cover of native species and only minor differences in species composition in removal and invaded plots. However, Hejda (2012) in his study compared large set of very variable removal and invaded plots, instead of performing more precise pair-wise experiment. Also the impact of the species could be weakened due to rather late removal of the invader. As seedlings of *I. parviflora* grow fast, they can possibly suppress other species already in the first few weeks after germination. Therefore, it seems more appropriate to set up the plots before the season and start removing *I. parviflora* seedlings immediately after germination to avoid any possible impact on native vegetation. Lastly, Hejda's (2012) study took only two years which might not be enough for all changes to take place. For the above mentioned reasons, another removal experiment for *I. parviflora* should be done, with following differences: i) perform pair-wise comparisons of plots, ii) remove *I. parviflora* seedlings immediately after germination, iii) run the experiment for longer than two seasons only.

It has been suggested that *I. parviflora* cannot have strong impact on native vegetation as it is competitively rather weak (Čuda et al., 2015). As an annual species with modest root system (Slavík, 1997), it is unlikely that it will compete with native plants via belowground competition. Aboveground competition is much more likely, given that *I. parviflora* is locally very abundant and often creates dense stands on small spatial scales (Dostál et al., 2012) and therefore changes the light conditions for understory species (Uherčíková and Eliáš, 1987). However, *I. parviflora* usually competes with forest herbs and tree seedlings which are well adapted to low light condition (Hejda, 2012). Therefore, we think that intensive competition during the early phases of the season might be the only mechanism how *I. parviflora* impacts native vegetation. To test this hypothesis, we correlated selected species traits with the level of their suppression by *I. parviflora* invasion. If mostly early spring, heliophilous or small plants get suppressed by the invasion, it will indicate competition for light. If the level of suppression is correlated with other plant traits, such as nutrient or water supply requirements, below-ground competition will be more likely.

In this paper we aim to assess the impact of *I. parviflora* on native vegetation by comparing heavily invaded vegetation with dominant *I. parviflora* and heavily invaded plots from which *I. parviflora* had been removed. If the vegetation on removal plots develops in a different way compared to the invaded plots (i.e. interaction of treatment and year will significantly affect the species composition, number or cover of native species), it will suggest that *I. parviflora* affects native diversity or composition of the invaded communities. In this case, *I. parviflora* would be the driver of the changes associated with the invasion. However, if the vegetation on removal and invaded plots is the same at the end of the experiment, it will show that *I. parviflora* itself does not affect the vegetation and more likely acts as a passenger of the environmental changes associated with the invasion. The overall aim of this study is to answer the following questions: i) What is the effect of invader removal on species composition, number and cover of native species? ii) What are the traits of plants most suppressed by *I. parviflora* invasion?

2. Material and methods

2.1. Study species and area

Impatiens parviflora is an annual representative of Balsaminaceae family, native in Eastern and Central Asia. The species was first introduced to Europe in 1831 as an ornamental plant (Coombe, 1956). Since then it spread through whole Europe, except for the very south and north of the continent (Trepl, 1984). It has been reported from 34 European countries in total (Lambdon et al., 2008), with Central Europe being one of the most widely invaded area. In the Czech Republic, it was first introduced in 1844, it became naturalized already in 1870s (Slavík, 1997). The species is common over the whole area of the Czech Republic except for very dry and mountain areas (Pyšek et al., 2012a). Specific characters of *I. parviflora* such as short life cycle, presence of cleistogamic and chasmogamic flowers, high production of seeds, long duration of flowering, fast growth of seedlings and high tolerance to light conditions (Coombe, 1956; Eliáš, 1999; Perrins et al., 1993,) make it one of the most ideal weeds (Noble, 1989) able to colonize high number of habitats. In the Czech Republic, it has been reported from 45 habitat types and it is considered a dominant species in number of them, including perennial nitrophilous herbaceous vegetation of mesic sites, herb layers of alluvial forest, oak-hornbeam forests, ravine forests and *Robinia pseudoacacia* plantations (Pyšek et al., 2012a; Sádlo et al., 2007).

The study was carried out in oak-hornbeam forests near nature reserve Zvolská Homole, central Bohemia, Czech Republic (49°56′24″N, 14°24′09″E). Oak-hornbeam forests are one of the most typical stands for *I. parviflora*. The particular area was chosen because it is massively invaded, which made it suitable for removal experiments. Also it is easily accessible, and could thus be visited weekly during the whole vegetation season.

2.2. Experimental design

Nine pairs of 1×1 m permanent plots were established in August 2011 in homogenous part of the forest invaded by *I. parviflora*. The two plots of one pair were established in the same distance from a path (representing the intensity of trampling by tourists and dogs), on the same inclination, they had the same canopy openness, level of *I. parviflora* invasion (approximately 50% coverage) and as similar vegetation as possible. One plot in each pair stayed invaded (hereafter referred to as invaded plot). All *I. parviflora* plants were removed from the other one, hereafter referred to as removal plot, in August 2011. Subsequently, *I. parviflora* seedlings were removed from the removal plots every week in vegetation season in years 2012–2015.

Small scale plots (1×1 m) were chosen, as it would not have been possible to eradicate *I. parviflora* from larger plots without inducing severe disturbance to the removal plots. Given the low density of the understory, most plots harbored just 3–7 species with some of the plots actually being empty in summer and not harboring any native species (these two plots remained empty during the whole experiment, even after *I. parviflora* removal, indicating very unfavourable conditions). Vegetation on such small scale plots is prone to be influenced by edge effects. Removal plots could have been impacted by the surrounding stands of *I. parviflora*. Con-