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THE FIRST RECORD OF THE INVASIVE *Impatiens Glandulifera* Royle (HIMALAYAN BALSAM) IN THE REPUBLIC OF MACEDONIA

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Abstract

A population of *Impatiens glandulifera* Royle, an invasive plant species native to the Western Himalayas, was recorded in 2013 near the village Gorno Sedlarce in the north-western mountainous region of the Republic of Macedonia. *I. glandulifera* is a new alien species to the Macedonian flora. The surveys revealed an intensive growth and low to medium dense population of *I. glandulifera*. The population's density was not quantified, but several stands of different sizes were found. A rapid ecological risk assessment, mainly based on knowledge about invasion histories in North-Western and Central European countries, showed that this species which is on the EPPO List of Invasive Alien Plants is a serious threat to Macedonian biodiversity. Biological invasions of *I. glandulifera* affect biodiversity worldwide, and, consequently, the invaded ecosystems may suffer from significant losses in economic and cultural values. In accordance with nature conservation efforts, there is a clear need to develop a strategy for its control, which will deliver the greatest potential benefits to biodiversity, as a whole.

Key words: *Impatiens glandulifera, alien species, Republic of Macedonia, control, forecast*

Introduction

Impatiens glandulifera Royle (Balsaminaceae), known also as the Himalayan balsam, is a herbaceous summer-annual, widespread invasive plant species native to the Western Himalayas (Gupta 1989; Tanner 2007), which was established in North-Western and Central Europe (Beerling, 1993; Beerling & Perrins, 1993; Pyšek & Prach, 1995; Dawson & Holland, 1999; Weber, 2000; Peltre *et al*., 2002), temperate North America (Toney *et al*., 1998; Clements *et al.,* 2008) and New Zealand (Weber 2003). In Europe, *I. glandulifera* escaped from cultivation in the mid-19th century as a garden ornamental and nectar-producing plant (Pyšek & Prach, 1995) in the United Kingdom and is now a problematic invasive in many regions between the latitudes of 30 and 64^{o}N (Beerling & Perrins, 1993; Wadsworth *et al*., 2000; Lid & Lid, 1994, Prots & Klotz, 2004). It is identified as a significant invasive plant in at least 18 European countries (CABI, 2004; Sheppard *et al*., 2006) and has been on the EPPO List of Invasive Alien Plants since 2004. In the countries of Central and Western Europe *I. glandulifera* is a problematic weed in moist and semi-open habitats (Kollmann *et al*., 2007). Due to its large size (it is the tallest annual plant in Europe) (Perrins *et al*., 1990; Stace, 1991; Pyšek & Prach, 1995; Willis & Hulme, 2004) rapid growth, high reproductive output and its ability to outcompete native species (Andrews *et al*., 2005), *I. glandulifera* is able to quickly dominate local vegetation and diminish conservation value at some sites (Roblin, 1994). It is ranked in the top 20 invasive plants in the UK (Crawley, 1987), is on the Swiss 'black list' of harmful invasive species (Anonymous, 2002) and is one of the invasive species in Germany against which specific control measures are directed (Kowarik, 2003). In Poland it is regarded as one of the top 20 invasive alien plant species (Tokarska-Guzik, 2003). In Sweden Himalayan balsam has been classified as one of the five most aggressive

invasive plant species. It is found in all parts of Sweden except inner parts of Lappland. Its stands have been reported to persist for at least 70 years (Larsson & Martinsson, 1998). In Norway the species is rapidly expanding, and it is now found in natural and semi-natural habitats such as moist forests, moist meadows, flooded ground, in ditches and on seashores as well as along watercourses, in addition to various types of moist ruderal sites (Alm, 2002). Dominance of *I. glandulifera* along riverbanks has been reported to cause problems in stream management in the Czech Republic, Germany, Finland, Slovakia and the United Kingdom (Beerling, 1993; Pyšek & Prach 1995). In Lithuania (Gudžinskas & Sinkevičienė, 1995) and Latvia (Helmisaari, 2010) *I. glandulifera* has spread rapidly, since its introduction to invade riverbanks of major rivers and their tributaries. In Russia *I. glandulifera* is one of the widespread alien species and occurs from northern regions (Murmansk, Karelia) to Caucasus in the south. It occurs in floodplains, along river banks, wetlands and roads and in different human-made habitats (Markov *et al*., 1997).

First record in Republic of Macedonia

In this record, the authors of this paper are the first to document the presence of *Impatiens glandulifera* Royle in Republic of Macedonia. On 25 July 2013, a visit to maize field trials with herbicides near the village Gorno Sedlarce (41° 56' 12" N and 20° 56' 38" E) located in the North-Western mountainous part of the Republic of Macedonia, revealed an intensive growth of *Impatiens glandulifera* Royle (Himalayan balsam), a new alien species to the Macedonian flora (Fig. 1).

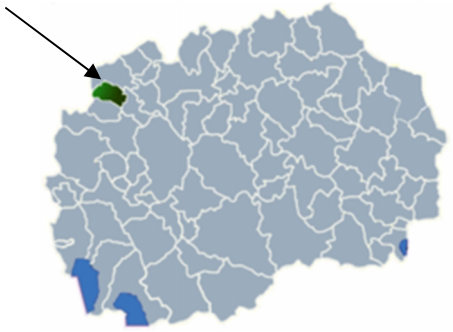

Figure 1. Map of the Republic of Macedonia showing where the invasive *Impatiens glandulifera* Royle (Himalayan balsam) was found. The green area is the area in the top left of the country is where the village Gorno Sedlarce is situated and where the plants were observed. The blue areas are lakes

The places where *I. glandulifera* was found are damp woodlands near streams which spring from the Sharr Mountains, the biggest mountains in the Republic of Macedonia. On the 9th of August 2013 and the 3rd of September 2013, the site was surveyed to estimate the extent of the invasion. These surveys revealed an intensive growth (flowering - development of fruit stages) and a low to medium dense population of *I. glandulifera*. The population's density was not quantified, but several stands of different sizes were found. The largest stands were approximately 10-12 metres at their widest point During the second survey, the authors extended the area of observation, and the plant was found mainly in human influenced and man-made habitats such as shrubbery, ditches, roadsides, hedges, alongside canals and nearby arable lands. Research by Garkāje (2006) has shown that the biotopes that are most suitable for *I. glandulifera* are those that have been affected by humans. The studies of species dynamics in Latvia suggest that in the initial phases of invasion the species prefers human-affected, weedy sites and dump sites, while on later invasion stages it appears to be successful and a frequent invader in riparian habitats (Priede, 2008).

In habitats where *I. glandulifera* was detected, it most commonly grows together with nitrophilous plant species such as, *Urtica dioica* L.*, Calystegia sepium* (L.) R. Br.*, Tanacetum vulgare* L. and *Rubus caesius* L. Similar finding are reported by Kurtto (1992) and Kowarik

(2003). Clements *et al.,* (2008) gave detailed list of species growing near *I. glandulifera* in Canada: *Alnus rubra* Bong., *Athyrium filix-femina* (L.) Roth., *Barbarea orthoceras* Ledeb., *Cirsium vulgare* (Savi) Ten., *Convolvulus arvensis* L., *Corylus cornuta* var. *californica* (A.DC.) Sharp, *Epilobium angustifolium* L., *Hypochaeris radicata* L., *Leucanthemun vulgare* Lam., *Myrica gale* L., *Plantago lanceolata* L., *Prunella vulgaris* L., *Ranunculus repens* L., *Symphoricarpos albus* (L.) Blake, *Tanacetum vulgare* L., *Vicia cracca* L.,and *Impatiens noli-tangere* L. In other Canadian regions, *I. glandulifera* is likewise associated with plants of riparian areas, but because of the tendency of *I. glandulifera* to form monotypic stands the diversity of plants within these stands is probably fairly low. In Europe, *Impatiens glandulifera* is associated also with riparian communities (Wadsworth *et al.* 2000; Hejda & Pyšek, 2006; Hulme & Bremner, 2006). In river valleys *I. glandulifera* forms dense vegetation patches of its own community classified phytosociologically as association *Impatienti-Calystegium* (Moor 1958, Soó 1971)(cit. by Helmisaari, 2010).

In all study areas, the highest densities of plants, and the tallest ones, were recorded in the places close to the water streams with sufficiently high soil moisture. Out of these areas, several single plants could be observed as smaller forms, even in the edges of neighbouring maize crop fields.

Because of its preference for moist areas, rainfall might seem to be a key predictor of *I. glandulifera* distribution. In that context, the region where the village Gorno Sedlarce is situated is the most humid region in the Republic of Macedonia with annual precipitation of 795 mm (Kostov, 2003). However, Kollmann & Bañuelos (2004) noted that *I. glandulifera* occurred in European locations with moderate (e.g., Halle-Leipzig, Germany with 519 mm annual precipitation) to heavier precipitation (e.g., Zurich, Switzerland with 1137 mm annual precipitation). Thus, soil moisture is a more stringent requirement than the annual precipitation level (Beerling & Perrins, 1993).

Taking into consideration that, *I. glandulifera* was found in human influenced and man-made habitats, probably the introduced pathway may have been human activity. The starting point of the invasion was in the North-Western mountainous region of the Republic of Macedonia, where, because of very difficult economic situation, the majority of the population lives and works in western European countries (Belgium, Denmark, France, Germany, Switzerland, etc.). Thus, it is very likely that the occurrence there could be attributed to a person who illegally introduced *I. glandulifera* plant material from these countries in the Republic of Macedonia. It is well-known that small seed quantities of *I. glandulifera* are sufficient for establishing a new plant population in favourable environmental conditions. Hejda & Pyšek (2006) concluded that high rates of seed production, explosive dispersal from capsules and spread via water enable *I. glandulifera* to spread rapidly, particularly in riparian areas.

Ecological impacts

The discovery of a well-established population of *I. glandulifera*, as a new alien species in the Macedonian flora, is a significant concern. Biological invasions of *I. glandulifera* affect biodiversity worldwide, and, consequently, the invaded ecosystems may suffer from significant losses in economic and cultural values (Marton, 2011). The threat to biodiversity from *I. glandulifera* is particularly high in vulnerable habitats, including national parks, as the plant is able to successfully compete directly with native species for space, light and nutrients (Tanner, 2011). For example, in damp woodlands *I. glandulifera* forms dense monotypic stands which choke out all other plants (Perrins *et al.,* 1993; Prots & Klotz, 2004). Hulme & Bremner (2006) found that dense stands of *I. glandulifera* forms monocultures, and reduce species diversity by as much as 25% in sites in the United Kingdom whereas Hejda & Pyšek (2006) found only a negligible effect of *I. glandulifera* in the species diversity in the Czech Republic. The same authors suggested that invasion of *I. glandulifera* did not reduce species diversity so much as it changes the dominance hierarchy, with *I. glandulifera* reducing populations of other nitrophilous annual species. However, Maule *et al.,* (2000) showed that

in the UK *I. glandulifera* could successfully compete with native plants, including tree seedlings with the potential to inhibit the regeneration cycle of woodlands. This was not the case, in Germany, Ammer *et al.,* (2011), found no impact of *I. glandulifera* on established tree seedlings.

In a study of indirect competition, Chittka & Schürkens (2001) showed that *I. glandulifera* is capable of reducing the fitness of native plant species through reduced seed-set, by luring pollinators away from native species due to its higher rate of sugar nectar production. According to the same authors, in Central Europe the recorded rate of sugar production by *I. glandulifera* of 0.479±0.12 mg per flower per hour, was substantially higher than other common species visited by bumblebees. As a result of this, they recorded a 50% reduction in pollinator visits to the native species *Stachys palustris* L. when *I. glandulifera* plants were introduced to areas where native plants of *Stachys palustris* L. occurred. Prowse & Goodridge (2000) showed a similar preference for *I. glandulifera* by bees from the genus *Bombus* in a study of pollinator visitations to *I. glandulifera* and other plant species. Over time, such competition between plant species for pollinators could leave native species, which are unsuccessful at attracting pollinators genetically depauperate (Prowse & Goodridge, 2000). Apart from experimental evidence that *I. glandulifera* may compete successfully with native plants for pollinators (Chittka & Schürkens, 2001), observational studies indicate impacts may largely consist of a local change in cover and/or dominance of native species (Larsson & Martinsson, 1998; Maule *et al.,* 2000). At high densities, *I. glandulifera* can alter water flow, increase erosion, and cause flooding (King County, 2004). When thick patches of *I. glandulifera* die off in the fall, the stalks quickly rot exposing large areas of river banks and making them increasingly susceptible to erosion from high winter flows (Roblin, 1994; Graham 2003; Sheppard *et al.,* 2006; Martin & Pyšek, 2006). Even during the growing season, the plants offer little protection against soil erosion due to their extremely shallow root systems.

The success of *I. glandulifera* as an invasive annual species could be due to the intraindividual variation in seed mass that helps the utilization of heterogenous environments (Rees & Westoby, 1997). The ability of *I. glandulifera* to outcompete native flora and its predicted expansion along water courses indicates that it could become a more serious threat to nature conservation in the future (Prach, 1994; Pysek & Prach, 1995). *I. glandulifera* is known to prevent forests regeneration in moist and half shaded habitats (Lhotska & Kopecky, 1966). Since *I. glandulifera* seems to react positively to an increase in CO_2 and temperature it is potentially a still more aggressive invader in a changing climate (NeoFlora 2006)(cit. by Helmisaari, 2010).

Control management strategies

Because of the fact that *I. glandulifera* is a quite new alien species in the Republic of Macedonia, and there is still a lot of missing information regarding its invasion, there is a clear need to develop a strategy for identifying priority for its control. According to Dawson & Holland (1999), the first step after identifying a new invasive colony is to initiate an immediate control, because it is easier and cheapest to control invasions at an early stage of the process. Removal of invasive alien species should start as early as possible, before the species is too widespread. The prevention actions should be well organized. The success of actions needs to have public acceptance and hence the public needs to be informed about the negative effects of the plant and its effective spread along waterways (in particular beekeepers and growers of ornamental plants should be targeted with information on the species). Since *I. glandulifera* is an annual species, the best way to manage its dispersal is to prevent flowering and the formation and spread of its seeds. Care has to be taken to hinder spread of its seeds by transport of plant parts or soil containing viable seeds (Wadsworth *et al*., 2000; Shaw, 2003).

In areas of a high conservation interest, mechanical eradication efforts are often used. This method consists of removing the whole plant, as this is quite easy due to the modest root

system of *I. glandulifera*. However, the effect of using this method is rather questionable due to the effective transportation of seeds through the river corridors. Cutting should sever the plant below the lowest node, preventing future seed set (Howell, 2002). According Prach, (1994) it must be carefully timed, in June, respectively. Since *I. glandulifera* is sensitive to grazing and grazing animals eat it, grazing is a good method to manage the species (Larsson and Martinsson, 1998). Sheep and cattle may also be used to graze the plant.
Chemical treatment is the most shared control method and it is very important that the plant is treated twice in a season, once before flowering and again later on (Wadsworth *et al.,* 2000). Glyphosate application is effective against *I. glandulifera* (Stensones & Garnett, 1994) but will also kill other plants in the near vicinity. Nevertheless, Wadsworth *et al.,* (2000) found that 99% control was almost as ineffective as no control at all due to prolific seed production. Control has also been achieved by spraying 2,4-D amine at rates of 6-9 L/ha early on in the season at the rosette stage (Environment Agency, 2003) and before flowering to prevent the development of seeds (Beerling & Perrins, 1993). But, the use of herbicides should be avoided and are often not permitted especially along waterways.
Biological control agents offer a sustainable, ecological and economically viable tool to support and sometimes to replace chemical and manual control methods. In 2006, a biocontrol programme was initiated, and it included three surveys conducted across the native range of *I. glandulifera* in Pakistan and India to collect and record its natural enemies (Shaw & Tanner, 2008). The studies have revealed the fact that in its native range, the plant is attacked by an array of invertebrate species and plant pathogens, which cause considerable damage for the plant. Beerling & Dawah (1993) recorded relatively few phytophagous insects on the foliage of *I. glandulifera* in Cardiff, United Kingdom. *Hymenoscyphus vitellinus* (Rehm) Kuntze was recorded as occurring on I. *glandulifera* in the United Kingdom (Dennis 1986). Glushakova & Chernov (2005) recorded that epiphytic yeasts occurred on *I. glandulifera*. In Germany, *Phyllosticta impatientis* (L. A. Kirchn.) Fautrey and *Ascochyta weissiana* Allesch. were found on the leaves of *I. glandulifera*. A rust tentatively identified as *Puccinnia argentata* (C. F. Schulz) Wint. was found on *I. glandulifera* in its native Pakistan in 2006 (Tanner, 2007). Tanner (2007) evaluated this pathogen as having good potential for biocontrol use in Europe. The CABI scientists also identified leafspot damage in Pakistan due to three *Coelomycetes* species (*Phomopsis* sp., *Phoma* sp. and *Ascochyta* sp.), a downy mildew (*Peronosporaceae*) and a powdery mildew (*Erysiphaceae*) (Tanner, 2007).
Focusing management where *Impatiens* populations are most extensive may not only improve the effectiveness of control (Wadsworth *et al.,* 2000) but, also deliver the greatest potential benefits to biodiversity. Invasive alien species are a major problem for habitat management, because of the associated economic costs and concerns about losses in biodiversity. Invasive alien plants lead to devaluation of agricultural land, interfere with forest management, increase costs for maintenance of road margins, railways and waterways, and they can cause extinction of native species.

Conclusions for the Republic of Macedonia

Impatiens glandulifera Royle has been found in the Republic of Macedonia. However, in some areas, particularly in North-Western and Central Europe, it has spread fairly widely and is established and has become the target of large scale removal campaigns. Within 16 years of its introduction into the United Kingdom (1839-1855), it was able to spread from gardens and become established (Beerling & Perrins 1993). Now it is a widespread problem almost in the whole of Europe. The climate and topography of the many European regions are favourable for its growth and expansion. In other Macedonian locations with similar climates to the north-western part where *I. glandulifera* was found, it is important to detect where new plants of this species are present. *I. glandulifera* is able to outgrow its competitors as it reaches great heights in a short period of time and thereby shades other plants that are living in the close vicinity. The prolific seed production and explosive seed dehiscence contribute to

its invasive potential. Spread is also facilitated by waterways and human transportation. Although glyphosate can be used to control *I. glandulifera*, its use is limited as the plants are often near water ways where herbicide use is not recommended. The other control methods, however, are time consuming, and could be quite costly. The recent efforts to develop biological control in North-Western and Central Europe (Tanner, 2007) could eventually provide additional measures to be used against *I. glandulfera* in Republic of Macedonia, as well. It appears that curbing the spread of *I. glandulifera* in Republic of Macedonia will be extremely difficult. The authors expect that in the very close future, it will rapidly establish itself along waterways in many other Macedonian regions, following the pattern seen over the past two centuries in North-Western and Central Europe.

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