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Original paper

Sigesbeckia orientalis L. – new allochthonous species in the Serbian flora

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Summary. In Serbia, *Sigesbeckia orientalis* L. was discovered for the first time in 2015 on the territory of the Special nature reserve "Obedska bara". Thus, much of what is known about this species relies on earlier studies in the surrounding regions. Its most important morphological characteristic is its ability to blend in with its surroundings, rendering it almost indistinguishable from other species in its habitat. Extensive field research conducted every year since 2015 until 2022 confirms that *Sigesbeckia orientalis* is widespread at the two locations in the SNR "Obedska bara". The first is located along tarmac roads leading through cultivated poplar forests, while the second is located along tarmac roads and in natural mixed forests. The populations were already established at the investigated sites at the time of the first discovery. Based on the results of the study, measures to prevent, eradicate and control this invasive species are recommended to the managers of protected areas.

Keywords: alien, conservation, invasive, plant, Sticky weed.

INTRODUCTION

Recognising the threat to biodiversity posed by invasive alien species (IAS), the ninth Aichi Target under Strategic Goal B: Reduce the direct pressure on biodiversity and promote sustainable use in the Strategic Plan for Biodiversity 2011–2020, was dedicated exclusively to mitigating their foreseeable negative impacts (CBD 2011). This target underlines the importance of identifying and prioritising invasive alien species and their pathways of introduction, followed by the introduction of management measures (control, eradication) for priority species. Although numerous studies have been carried out and appropriate measures have been introduced on the basis of legislation adopted in the European Union, it has been concluded that these targets are too ambitious. However, when defining the global framework for biodiversity for the post-2020 period, the existing measures were maintained, with the proposal to expand and complement them (CBD 2022). Specifically, the aim is to significantly reduce the impact of invasive species on terrestrial and aquatic ecosystems by 2030, including the prevention of their introduction and the control or eradication of priority species (CBD 2020). As part of further measures in Europe, the EU Regulation on Invasive Alien Species 1142/2014 was adopted, which contains binding targets for all Member States (IAS 2014). The main objectives of this legislation include the identification of invasive alien species and their distribution pathways, as well as joint management measures in neighbouring regions (including Serbia).

According to the available data, more than 160 alien plant species are recorded in the Serbian flora (Anačkov et al. 2011, 2013; Lazarević et al. 2012). Most of these species (with

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the exception of freshwater plants) have been found along roads and in urban/rural areas (i.e. anthropogenic habitats), and some have established substantial populations in man-made and disturbed natural habitats. In contrast, the number of invasive alien plants in protected natural and semi-natural habitats is lower. In wetlands, however, there are several invasive alien plant species that can form a dense population (Stanković et al. 2020). Most alien species that form established populations were accidentally introduced to Serbia, or the nature of their introduction is unknown (Anačkov et al. 2013).

With the aim of studying the main distribution routes of alien plants in Serbia in detail and clarifying their dispersal patterns, a survey of alien plant species was conducted as part of the ESENIAS-TOOLS project activities, focusing on the main transport routes (including roads, railway lines), riverbanks near urban areas and large industrial facilities, and in selected nature reserves. This survey had two main objectives, namely (a) to record new alien taxa and (b) to describe the main distribution routes for alien plants in Serbia.

One of the protected areas in this project was the Special Nature Reserve "Obedska bara" (SNR "Obedska bara"). SNR "Obedska bara" was recognised as an important nature reserve in the 19th century when it was protected as an imperial hunting ground in the Austro-Hungarian monarchy. In 1951, it was placed under national legal protection as a nature reserve. After an amendment to the law in 1994, an area of 9,820 hectares of this area was declared the Special Nature Reserve "Obedska bara", with an amendment in 2008 (enlargement of the protected area) (Official Gazette 56/94 and 81/08). SNR "Obedska bara" was declared a Ramsar site in 1977, an IBA site in 1989 and an IPA site in 2002. In addition, the SNR "Obedska bara" is an EMERALD site, part of the Sava Parks network and an ecologically important area in Serbia.

SNR "Obedska bara" is in the south-eastern part of Srem, on the southern edge of the Pannonian Plain (Vojvodina, Serbia). It is 40 km from Belgrade and 65 km from Novi Sad. It is bordered by the settlements of Kupinovo, Obrež and Grabovac and the river Sava, which forms the southern border. The closest tributary of the Sava to the west is the Drina, while its confluence with the Danube is in Belgrade. This protected area is the largest floodplain in the country and represents a cut-off meander of the Sava River (Puzović and Panjković 2015). The area harbours diverse natural habitats and biotopes where a variety of plants and animals thrive (Letić et al. 2008). These habitats are under the constant influence of the Sava River and its tributaries, while also being influenced by the SNR "Obedska bara" waterlogging, as its water seeps through the alluvial soil when the water level of the Sava River decreases, thus increasing the groundwater table (Krajić 2011).

The focus of this article is on the species *S. orientalis* L., which was found within the boundaries of the SNR "Obedska bara". It is followed by a detailed description, biological and ecological characterisation and an assessment of the invasiveness of the species in the country, with a commentary on its distribution in neighbouring regions.

MATERIAL AND METHODS

The plant material for this study was collected in October 2015 as part of a survey at two sites within the SNR "Obedska bara". The location data were recorded together with data on population status, density and distribution for each site (Fig. 1, Table 1). The herbarium specimens are deposited in the herbarium collection BUNS at the University of Novi Sad, Faculty of Sciences, Department of Biology and Ecology. The species was identified from relevant literature sources (Nyárádi 1964; Zoku 1965; Brummit 1976), and its morphological description is based on both collected specimens and published data. Information on population status and habitat description is based on personal observations.

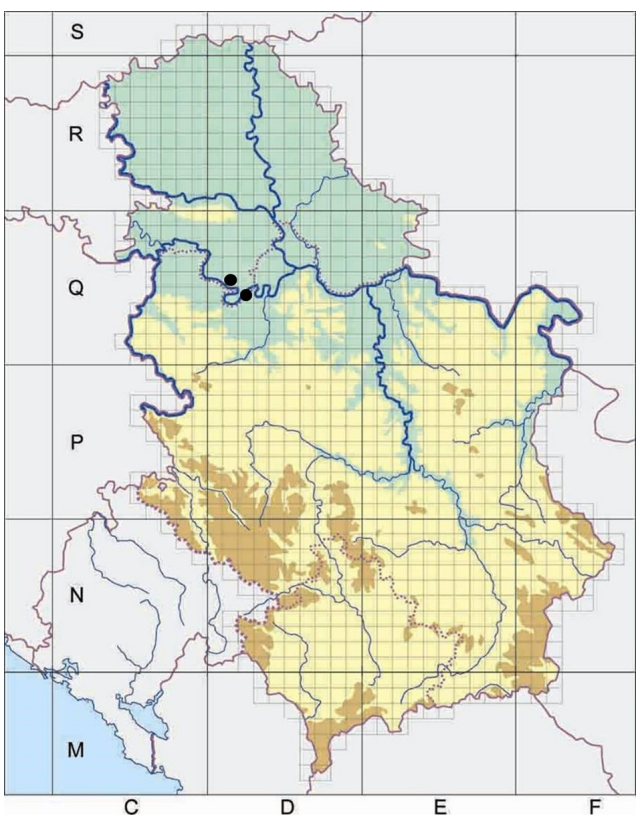

Fig. 1. *Sigesbeckia orientalis* locations in the Special Nature Reserve "Obedska bara", Srem, Republic of Serbia.

Table 1. *Sigesbeckia orientalis* locations in the Special Nature Reserve "Obedska bara".

Site name	GPS coordinates, elevation	Site description	Herbarium number
Kupinovo	Lat: 44.691200 Long: 20.040504 59 m asl	along road, forest edge	BUNS 24581
Grabovci	Lat: 44.752180 Long: 19.836193 77 m asl	along road, forest edge, forest clearing, ditch	BUNS 24582

The following rules were used to assess the degree of invasiveness: number of individuals per square metre, number and abundance of mature, fertile individuals and abundance of fruiting plants. These data were collected during field studies carried out in the period 2015–2022. Consequently, the preventive measures proposed in this document are compatible with the relevant biological characteristics of the species and in dialogue with the managers of the nature reserve.

RESULTS AND DISCUSSION

***Sigesbeckia orientalis* L., Sp. Pl. 2: 900 (1753)**

Annual herb (Fig. 2). Stem erect, usually dichotomously extensively branched, reaching up to 120 (–190) cm in height, lower part glabrous, upper pubescent. Leaves opposite, the lower ones large, triangular-hastate, attenuated in petiole, irregularly dentate or lobed, acute at apex, cuneate at base, the petiole tapering from above and ±unwinged in its lower part, not amplexicaul, pubescent with short hairs; the upper leaves simple, narrower, rhombic, hard teeth attenuated. Capitula small, 6–10 mm in diameter (excluding outer involucral bracts), in lax panicles or rarely solitary, numerous, outer involucral bracts 7–15 mm, linear to linear-spathulate, patent, usually much longer than the inner, with stipitate glands. Stalked glands present on outer and inner involucral bracts and often on peduncle. Outer florets with short 3-toothed rudimentary ligules, female, yellow; inner florets tubular, hermaphrodite, with the ovary wrapped in blades and longer than corolla, subtended by receptacle scales. Cypsela black, 4-angular, curved arch, 4 mm long, closed in blades. Pappus absent (Nyárádi 1964; Brummitt 1976). Flowering time July–October, fruiting time August–November (for Serbia).

Dispersion. Epizoochory. The diaspores of *Sigesbeckia* consist of bracts and cypsela, which are torn, as well as the capitulum (Heinrich et al. 2002). All *Sigesbeckia* species produce sticky, adhesive exudates with which the fruits can adhere to animal fur. According to Wagenitz (1979), this method of epizoic fruit dispersal is unusual within the Asteraceae family. However, thanks to the sticky, lipophilic exudates produced by the glandular hairs, the carpels of *S. jorullensis* can easily adhere to fur, skin or other materials even in the absence of water (which the seeds need to adhere via mucilaginous glandular trichomes).

Native distribution. In Europe, *Sigesbeckia orientalis* is native to the Asian part of Turkey and the Transcaucasus region (Greuter 2006+), but it is also widespread in the warm temperate and tropical regions of Asia, Africa and Australia (Brummitt 1976).

Distribution and habitats in Europe. Several species have been cultivated as medicinal plants (Heinrich et al. 2002). The first reports on the distribution of *Sigesbeckia orientalis* in Europe come from Romania (Nyárádi 1964; Brummitt 1976). According to Malý (1948), this species was first recorded in Romania in 1864 and identified as *S. iberica* species. The occurrence of *S. orientalis* was confirmed in 1898 in the region of the Subcarpathian forests (Grecescu 1898). Brummitt (1976) suggested that this species was naturalised in southern Romania on fallow land along railway lines and occasionally occurs in other parts of Romania. According to Malý (1948), it was first observed in Bosnia and Herzegovina in 1926 near the confluence of the Dilka and Neretva rivers (but only on sterile shoots). Since the plants were cultivated in a botanical garden of the National Museum of Bosnia and Herzegovina (Bjelčić 1983), the discovery of a new location near the village of Brđani (SE of Konjic) in 1947 was of great significance. In 2009, *S. orientalis* was recognised as a potential IAS in Slovenia due to its current distribution as an ornamental plant and as a weed in Italy, without naming the location (Lešnik 2009).

In Europe, according to the CABI's IAS database (CABI 2022), *S. orientalis* is common in Belgium, Denmark, Great Britain, Sweden, Poland, Romania and Ukraine. However, Greutter (2006+) considers this species as a naturalised plant in Romania, Italy and France, and as a casual species in Belgium, Bosnia and Herzegovina, Germany, and Ukraine, while its degree of naturalisation is uncertain in Great Britain. These inconsistencies can be attributed to its scattered distribution, and insufficient knowledge of the species in Europe.

Fig. 2. *Sigesbeckia orientalis* florets, Special Nature Reserve "Obedska bara", October 2016.

Distribution range and invaded habitats in Serbia. In Serbia, to date, *Sigesbeckia orientalis* has been found at two sites only, both of which are located within the borders of the SNR "Obedska bara".

One of these sites is located near the settlement of Grabovci, where a large and dense population of *S. orientalis* was already established in the ground floor of the mixed forest of ash (*Fraxinus angustifolia* Vahl.) and black locust (*Robinia pseudoacacia* L.). At this site, a smaller part of the *Sigesbeckia* population (the section between the road and the forest) is regularly mowed, while the rest of the population is largely undisturbed as it is located deeper in the forest. The other site is located in the region of the cultivated poplar forest near Kupinovo. This population is distributed

only along the road and forms a regular (transverse) shape between the road and the cultivated poplars. This section is regularly mowed and is under water when the Sava River floods the area.

According to the rangers, pigs and wild boars are widespread and numerous in Grabovci. Thus, on their migrations, they cross the dense population of *Sigesbeckia orientalis* growing above their heads. Therefore, during the fruiting season, their fur is covered with textured, long, sticky bracts and numerous fruits, allowing the cypsela to spread along different routes (Fig. 3). At the site near Kupinovo, where the species was found along the road, *S. orientalis* was probably spread by fruits sticking to the tyres of mowing machines or accidentally by workers, as they can easily detach from tools, shoes and clothing (Fig. 4).

Introduction mode and pathway. It is not known how and when *Sigesbeckia orientalis* was introduced to Serbia, as it is currently only recorded within the boundaries of the SNR "Obedska bara". Although both sites are close to settlements, it is unlikely that horticulture has contributed to the spread of *S. orientalis* into the natural habitat, as *S. orientalis* does not occur in these areas as an ornamental or ruderal plant. Similarly, there are no cereal fields in the vicinity of the two sites, which rules out the possibility that the species was accidentally introduced with the seeds. It can therefore be surmised that the cypsela with bracts was brought to this area during the great Sava flood in 2014 or earlier. During the flood season, most of the SNR "Obedska bara" area is flooded, with the water coming from the direction of Bosnia and Herzegovina, Croatia and Slovenia. However, this assumption is only tentative, as there is currently no data on the distribution of *S. orientalis* along the Sava in Bosnia and Herzegovina or Croatia, and the exact locations in Slovenia are not known.

Invasiveness. According to the proposed definition of invasive species in the EU IAS Regulation, the term 'invasive alien species' refers to an alien species whose introduction or spread has been shown to threaten or adversely affect biodiversity and associated ecosystem services. Therefore, we can conclude that *Sigesbeckia orientalis* is an alien species with invasive character in Serbia due to its spread in the protected area and its negative impact on various ecosystem services (e.g. forestry and livestock).

In addition, *S. orientalis* has an exceptionally high reproductive potential due to its abundant seed production and highly efficient dispersal model. At the site where the population was established in a mixed forest of ash and black locust, more than 100 specimens per 1 m^2 were counted and the total area covered by this species was more than 10 × 100 m, with additional smaller patches along the road. At this site, *S. orientalis* was the predominant species on the ground, with a vegetation cover of almost 100% in some parts. As

Fig. 3. The wild boar in Grabovci, Special Nature Reserve "Obedska bara", sited on a location populated by *Sigesbeckia orientalis*.

both sites are located in the Sava floodplain and the flowers are surrounded by glandular hairs that make them highly buoyant (allowing easy dispersal by water to remote areas), it can be assumed that the species will expand its range in Serbia in future large floods. This is an extremely important finding for planning initiatives to monitor the spread of the species, considering its invasiveness and the sensitivity of all ecosystems in the Danube catchment that are potential targets. The planning of these initiatives should also consider the absence of major floods in the studied area since 2014, as well as a decreasing trend in precipitation and groundwater since 2018, leading to a drought in 2022 (I. Lozjanin, JP "Vojvodinašume", pers. comm.). As a result, most of SNR "Obedska bara" remained without water for most of the year, which probably contributed to the stagnation of the population of this species.

From an agricultural point of view, *S. orientalis* is recognised as one of the field-verified host plants for *Bemisia tabaci* (Gennadius, 1889) in Europe (EFSA 2013). *Bemisia tabaci* (silverleaf whitefly) is one of the major threats to crop production worldwide, mainly due to the large number of viruses it transmits. It has been detected in three locations in AP Vojvodina (Konjević et al 2018), but all detections are far from the location of *S. orientalis*.

Preventive measures. Considering that *S. orientalis* has been recorded for the first time within the boundaries of the protected area and its population has remained stable since 2015, it is necessary to take measures that can effectively prevent its further spread both within the boundaries of the protected area and beyond, as this could prevent its further spread on the territory of the Republic of Serbia. In order to ensure that these objectives are achieved, it is necessary to mechanically remove the existing plants (by mowing and collecting the plant remains) due to the known characteristics of this species, especially the stickiness of the bracts and seeds. After mowing, the machines must be thoroughly cleaned to remove all remaining particles and the waste water must be collected to prevent the seeds from contaminating the soil. In addition, all collected plant residues must be disposed of as hazardous waste or incinerated in a suitable facility in accordance with legal requirements. Mowing should take place during early vegetative development (before flowering), i.e. in July or August. In particular, mowing at the end of autumn, when the plants are fruiting, should be avoided as this is likely to facilitate seed dispersal.

Related species in Europe. *Sigesbeckia serrata* DC. (misapplied name *S. jorullensis* Kunth in Humb.) is a naturalised plant species in the Great Britain, Germany and France (Brummitt 1976; Greuter 2006+). It originates from tropical America (Brummitt 1976) and thrives in the undergrowth of shrubs, in gardens and on riverbanks (Heinrich et al. 2002). *Sigesbeckia microcephala* DC. is native to Australia and occurs as an alien species in the Great Britain and Germany (Brummitt 1976; Greuter 2006+). On the other hand, *S. pubescens* (Makino) Makino, native to East Asia, is presently distributed in the Asian part of Turkey only.

Fig. 4. Sticky bracts with fruits that remained attached to the researchers' clothes and shoes after a field survey.

Historical notes. *Sigesbeckia orientalis* was already known in the Istanbul region (Turkey) before Linne's time. Upon finding it in a village near Istanbul (Turkey) in July, Buxbaum described it as "*Bidenti similis, foliis latissimis serratis*" (Buxbaum 1729), which is justified because the species is morphologically and visually similar to the species of the genus *Bidens*. Linnaeus (1753) later added China as its distribution area. The genus was named after Linnaeus contemporary Johann Georg Sigesbeck, who was the director of the botanical garden in St. Petersburg at the time (Nyárádi 1964). Needham (1976) opined that Linne named the genus *Sigesbeckia* in response to his negative comments by Sigesbeck about Linne's sexual approach to systematics.

Medicinal use. The aerial part of the plant is used in

traditional Chinese medicine for treating allergies and rheumatoid arthritis, among other ailments. Several bioactive compounds have been isolated from *S. orientalis*, including substances with allelopathic effects and medicinal agents, which increases its invasiveness (Wagenitz 1979; Aquilera et al. 2004). *Sigesbeckia orientalis* has a bitter taste and is considered a panacea in Madagascar, while *S. pubescens* is commonly used as a remedy for arthritis (Heinrich et al. 2002).

CONCLUSION

Sigesbeckia orientalis is a new invasive alien species in the Serbian flora. Its invasiveness is reflected in the fact that it has been recorded for the first time in two locations within the Special Nature Reserve "Obedska bara". Since the first records in 2015, it has been repeatedly reported in the same locations. Its detrimental effects are also attributed to its strong and efficient dispersal mode and high cypsela production rate. In addition, the species is a host for IAS insects that transmit viruses and harmful plant pathogens in agriculture. It therefore poses a significant threat to natural biodiversity in this region, particularly to flooded forests and their ground vegetation. Continuous field surveys and research on the biology and ecology of the species in Serbia are therefore warranted and should be complemented by effective monitoring programmes to prevent the spread of this species beyond its current limits.

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