

# NEW RECORDS OF ALIEN PLANTS – *LUDWIGIA PEPLOIDES* (KUNTH) P. H. RAVEN, *REYNOUTRIA SACHALINENSIS* (F. SCHMIDT) NAKAI AND *NICOTIANA GLAUCA* GRAHAM IN CROATIA

NINA VUKOVIĆ\*, VEDRAN ŠEGOTA<sup>1</sup>, ANJA RIMAC<sup>2</sup>,  
NIKOLA KOLETIĆ<sup>2</sup> & ANTUN ALEGRO<sup>2</sup>

<sup>1</sup>ZA and ZAHO, Faculty of Science, University of Zagreb,  
Marulićev trg 20/II, HR-10000, Zagreb, Croatia

<sup>2</sup>Division of Botany, Department of Biology, Faculty of Science,  
University of Zagreb, Marulićev trg 20/II, HR-10000, Zagreb, Croatia

Vuković, N., Šegota, V., Rimac, A., Koletić, N. & Alegro, A.: New records of alien plants – *Ludwigia peploides* (Kunth) P. H. Raven, *Reynoutria sachalinensis* (F. Schmidt) Nakai and *Nicotiana glauca* Graham in Croatia. *Nat. Croat.*, Vol. 30, No. 1, 27-35, 2021, Zagreb.

Invasive alien species *Ludwigia peploides*, *Reynoutria sachalinensis* and *Nicotiana glauca*, currently registered in Croatia with small number of records, were found during fieldwork undertaken mostly through the national monitoring of waters from 2018 to 2020. *Ludwigia peploides* was previously recorded only once in the River Ilova, the existing data for *R. sachalinensis* indicate only three confirmed findings, in Čabar, Karlovac and Donja Stubica, while the previous data for *N. glauca* include several localities in Central and Southern Dalmatia. The new records are as follows: two findings of *L. peploides* refer to the River Česma (Obedišće and Sišćani); three records of *R. sachalinensis* refer to Gorski Kotar (Gerovo and Čabar), while *N. glauca* is newly recorded in the Neretva River Valley (Krvavac) and the island of Krk. Despite their potential invasiveness, all three are still locally naturalized and currently their spread is very slow and limited in Croatia.

**Keywords:** Invasive species, new records, distribution

Vuković, N., Šegota, V., Rimac, A., Koletić, N. & Alegro, A.: Novi nalazi stranih vrsta – *Ludwigia peploides* (Kunth) P. H. Raven, *Reynoutria sachalinensis* (F. Schmidt) Nakai i *Nicotiana glauca* Graham u Hrvatskoj. *Nat. Croat.*, Vol. 30, No. 1, 27-35, 2021, Zagreb.

Invazivne strane vrste *Ludwigia peploides*, *Reynoutria sachalinensis* i *Nicotiana glauca*, trenutno zabilježene u Hrvatskoj s malim brojem nalaza, nađene su tijekom terenskih istraživanja obavljanih većinom u sklopu nacionalnog monitoringa voda u razdoblju 2018.–2020. *Ludwigia peploides* je dosad bila zabilježena samo jednom, u rijeci Ilovi, postojeći podaci za *R. sachalinensis* ukazuju na samo tri potvrđena nalaza, u Čabru, Karlovcu i Donjoj Stubici, a postojeći podaci za *N. glauca* odnose se na nekoliko lokaliteta u srednjoj i južnoj Dalmaciji. Novi nalazi su sljedeći: dva nalaza *L. peploides* za rijeku Česmu (Obedišće i Sišćani); tri nalaza *R. sachalinensis* za Gorski kotar (Gerovo i Čabar), a *N. glauca* je novozabilježena za dolinu rijeke Neretve (Krvavac) i otok Krk. Usprkos potencijalnoj invazivnosti, sve tri vrste su zasad tek lokalno naturalizirane i trenutno je njihovo širenje u Hrvatskoj vrlo sporo i ograničeno.

**Ključne riječi:** invazivne vrste, novi nalazi, rasprostranjenost

\* Corresponding author: nina.vukovic@biol.pmf.hr

## INTRODUCTION

The spread of invasive alien species (IAS) is globally a large problem in nature conservation; IAS are even recognized as the second major cause of biodiversity loss (GENOVESI & SHINE, 2011). Apart from threatening local biodiversity, IAS represent a serious problem to economies and human health worldwide. Invasive weeds, pests or pathogens often cause significant yield losses (PAINI *et al.*, 2016), while some IAS may cause health issues such as allergies or skin irritations (e.g. RASMUSSEN *et al.*, 2017; HASHIMOTO & YOKOZEKI, 2019; SCHAFFNER *et al.*, 2020). In the attempt to reduce the numerous negative impacts of IAS, the European Union produced a regulation that tackles the most troublesome IAS in the EU territory (ANONYMOUS, 2014). This regulation applies to the list of species of Union concern, which is regularly updated and at the moment includes 66 species (ANONYMOUS, 2016; 2017; 2019).

*Ludwigia peploides* (Kunth) P. H. Raven (Onagraceae) is a creeping (semi)aquatic plant originating from the Americas and possibly Australia, frequently used as an ornamental and therefore deliberately introduced into other parts of the world (CABI, 2020). Its prolific vegetative growth together with reproduction from fragments and seeds make this plant a very successful colonizer. *Ludwigia peploides* is recognized as troublesome in the European Union, and has been listed as a species of European concern since 2016 (ANONYMOUS, 2016). Its detrimental effects are best observable in France, where *L. peploides* was introduced in 1830 and subsequently became one of the most dangerous aquatic invasive plants, spreading rapidly and forming dense mats consequently blocking waterways and causing major biodiversity loss (CABI, 2020). The species was firstly recorded in Croatia in 2018, in the river Ilova (BUZJAK & SEDLAR, 2018). This record has been so far the only reported locality in Croatia. There it was recorded in dense mats, occurring in many micro-localities scattered along a 2 km of the river course.

*Reynoutria sachalinensis* (F. Schmidt) Nakai (Polygonaceae) is a large, perennial herb originating from Southeast Asia, introduced elsewhere as an ornamental plant (BAILEY & CONOLLY, 2000). Like its relative *R. japonica* Houtt. and their stabilized hybrid *R. × bohemica* Chrtek et Chrtková, the plant exhibits significant vegetative growth through branched underground woody rhizomes, and may spread via stem fragments and seeds. It mostly invades riparian habitats, outcompeting and displacing native vegetation. Although not as invasive as its congeners, *R. sachalinensis* provides pollen to male-sterile *R. japonica* resulting in the creation of *R. × bohemica*, and current data suggest that the hybrid is the most pernicious invader among the three. The first records of *R. sachalinensis* in Croatia were erroneous due to the confusion with *R. × bohemica*, while the revised data suggest that the species has been scattered in three geographically distinct localities: the river Čabranka near Čabar, Donja Stubica and Karlovac (VUKOVIĆ *et al.*, 2019). The populations in Stubica and Karlovac were rather small and localized, while the plants near Čabar were more numerous, growing between the road and the river Čabranka, covering approximately 200 m<sup>2</sup>. *Reynoutria sachalinensis* is currently not listed in the Union list, but is being considered for inclusion and a risk assessment is currently being carried out (BORŠIĆ, pers. comm.)

*Nicotiana glauca* Graham (Solanaceae) is an evergreen, branched perennial of South-American origin, introduced into other parts of the world as a garden and landscape ornamental (CABI, 2020a). Unlike the previous two aliens, this species does not readily reproduce by vegetative means but can produce huge numbers of

extremely small seeds, easily distributed by wind or water. It mostly occupies semi-natural, disturbed, warm and dry habitats, where it can form dense stands and outcompete native vegetation. The first Croatian record refers to the herbarium material collected in 1977 on the island of Lokrum in the southern Adriatic (BOGDANOVIĆ *et al.*, 2006). This record was, however, "lost" in the ZA collection until BOGDANOVIĆ *et al.* (2006) found the species in 2002 on the island of Vis in Central Dalmatia, and subsequently searched the ZA collection for any historical data. In 2004, the same authors recorded other populations in Central and Southern Dalmatia (the island of Lokrum and cities of Split and Dubrovnik). The only subsequent record was the one from JERIČEVIĆ *et al.* (2014) who found *N. glauca* on the island of Korčula.

All three species are recognized as invasive in the Flora Croatica Database (NIKOLIĆ, 2005-onwards), while *L. peploides* and *R. sachalinensis* are also listed by EPPO, as recommended for regulation as quarantine pest (EPPO, 2019) and invasive alien plant (EPPO, 2020), respectively. Furthermore, *L. peploides* is listed on the list of species of Union concern (ANONYMOUS, 2016).

## MATERIAL & METHODS

The fieldwork was undertaken in 2018, 2019 and 2020 mostly within the framework of a national inland waters monitoring scheme, carried out according to the Water Framework Directive (EUROPEAN COMMUNITY, 2000). The scheme covers several hundred of freshwater localities monitored at intervals of 2–3 years, with 150–200 localities inspected yearly. These localities are scattered across the whole Croatia, while the inspection of the localities includes the assessment of the abundance and cover of macrophytes. However, due to the large number of localities studied through many long-distance journeys over a large territory, other interesting plants apart from macrophytes are often recorded. The exception is *Nicotiana glauca*, which was found during a project of mapping invasive alien plants in the Neretva River Valley in 2019, and by sporadic visits to the island of Krk in 2020.

The coordinates of the localities were recorded using a Garmin eTrex 20× GPS device. The species were identified using the following literature: JACONO (2017), BOGDANOVIĆ *et al.* (2006), and BAILEY & WISSKIRCHEN (2006) for *L. peploides*, *N. glauca* and *R. sachalinensis*, respectively. Several specimens of *L. peploides* were collected and herbarized, and deposited in ZA and ZAGR collections.

## RESULTS

*Ludwigia peploides* was detected in two localities related to the river Česma (Tab.1, Appendix 1). At the first locality (Obedišće) the alien was first spotted at the confluence of a side-channel into the river. The river was subsequently inspected 100 m downstream of the confluence, and other infestations were found, although rather small, the largest covering approximately 1 m<sup>2</sup>. The plants were recorded in the stage of early growth, with only floating leaves developed on the water surface and no emergent stems or flowers.

The other site was at Sišćani fishponds, where a channel encompassing the western border of the fishpond connects to the river. Here, a large population of fully developed, flowering plants was found in the channel, while the banks of the channel

were fully overgrown (Fig. 1). The plants were vigorous, with floating leaves stretching into the channel and emergent stems occupying its banks, producing flowers and fruits (Fig. 1). Similarly, the river Česma was inspected near the confluence of the channel and other populations were found. So far, the infestations of the river were very small and patchy, recorded in the stage of early growth, with no emergent stems (Fig. 1).



**Fig. 1.** *Ludwigia peploides*. Floating shoots in the stage of early growth in Obedišće (above, left), emergent, flowering shoots in Sišćani (above, right), large population of *Ludwigia peploides* invading a channel in Sišćani (below).

Three new populations of *Reynoutria sachalinensis* were recorded in Gorski Kotar, one in the settlement of Čabar, and two in the settlement of Gerovo (Tab. 1, Appendix 1). The population in Čabar was recorded on the right bank of the river Čabranka (Fig. 2), 2 km upstream from the previous literature record. Here, young shoots were observed emerging from the recently mowed area along the river (Fig. 2). Populations in Gerovo can be described as follows: 1) an approximately 50 × 10 m large stand stretching by the road, and 2) a few square meters next to an old house occupied by *R. sachalinensis*, on the left bank of the (channelized) river Gerovčica (Fig. 2).

*Nicotiana glauca* was found in two geographically distant areas on the eastern Adriatic coast: the Neretva River Valley (southern Dalmatia, southern Adriatic) and the island of Krk (Quarnero bay, northern Adriatic) (Tab. 1, Appendix 1). In the Neretva River Valley, two sites with *N. glauca* were recorded in the settlement Krvavac, both composed of only a few plants, flowering at the time (Fig. 3). The finding on Krk relates to a single flowering plant growing from a crevice of an old wall (Fig. 3).



Fig. 2. Emerging shoots of *Reynoutria sachalinensis* along Čabranka in Čabar (above), a dense stand of *R. sachalinensis* along river Gerovčica in Gerovo (below).



Fig. 3. *Nicotiana glauca* in Krvavac (left), and Krk (right).

Tab. 1. New records of *Ludwigia peploides*, *Reynoutria sachalinensis* and *Nicotiana glauca* in Croatia with GPS coordinates in WGS84 coordinate system.

Species	WGS84 X	WGS84 Y	Locality	Date
<i>L. peploides</i>	16,558352	45,626532	Obedišće (River Česma)	10.07.2020.
<i>L. peploides</i>	16,640288	45,826632	Siščani (River Česma)	10.07.2020.
<i>R. sachalinensis</i>	14,645000	45,597770	Čabar	29.06.2018.
<i>R. sachalinensis</i>	14,635590	45,516163	Gerovo (River Gerovčica)	17.07.2020.
<i>R. sachalinensis</i>	14,632072	45,506805	Gerovo	29.06.2018.
<i>N. glauca</i>	17,590302	43,026044	Krvavac (Neretva River Valley)	28.06.2019.
<i>N. glauca</i>	17,591168	43,027067	Krvavac (Neretva River Valley)	28.06.2019.
<i>N. glauca</i>	14,574530	45,027499	Island Krk	04.08.2020.

## DISCUSSION

Once established and widespread, IAS are almost impossible to eradicate. For this reason, preventing new introductions and disabling further spread (early detection and rapid response) of newly established IAS is a priority aim of national strategies against biological invasions. New records of “rare” invasive plants should be taken as a serious alarm, and actions should be taken to prevent their massive distribution across large areas.

The newly found populations of *Ludwigia peploides* are located on the same river, which means they almost certainly originate from the same source. The absolute distance between these localities is 23 km, and most probably other infestations exist in between. A previous record on the river Ilova (BUZJAK & SEDLAR, 2018) is relatively close to the new localities (30 km from Obedišće and 40 km from Siščani); however, these two watercourses are not connected so this population might originate from elsewhere or the plants might have been transferred through a vector (fishing equipment, boats, birds etc.). Most importantly, both rivers flow into the river Lonja, the core river of Lonjsko Polje Nature Park, a significant wetland area especially important for birds and internationally recognized as a Ramsar site (RAMSAR SITES INFORMATION SERVICE, 2020). The finding of *L. peploides* in these particular localities and its

potential spread into a valuable and protected area is obviously a serious problem. This is especially valid in view of the same Nature Park already having a significant problem with the invasion of *Amorpha fruticosa* L., a N American shrub that spreads quickly in regularly flooded areas. Eradication is perhaps still possible in Česma, where minor infestations in the early growth stage were mainly found. However, study of the whole course is necessary to reveal the extent of its current distribution, and monitoring of the downstream areas is recommended, to detect the possible spread towards other watercourses and tributaries as soon as possible. The same localities on the Česma were previously inspected in 2016 through the monitoring of inland waters, and *L. peploides* was not recorded, therefore most probably the arrival of the species is indeed very recent. On the other hand, the locality on Ilova was not inspected before 2018.

According to the current data, *Reynoutria sachalinensis* does not display invasive behaviour in Croatia. A comprehensive field study of all three *Reynoutria* taxa in Croatia confirmed only three localities in the field (VUKOVIĆ *et al.*, 2019). This may mean that the spread of the species is rather slow, but it could also be that the arrival of the species was more recent than previously thought. Records previously confirmed in the field refer to 2016, while older literature records were identified either as erroneous, or could not be confirmed. Noteworthy, the oldest records from the 1970s were identified as erroneous based on the revision of the herbarium material (VUKOVIĆ *et al.*, 2019). One of the newly found localities is in the settlement of Čabar, approximately 2 km upstream from the previous literature record (VUKOVIĆ *et al.*, 2019). The other two populations in Gorski Kotar are in Gerovo, located 1 km apart and approximately 10 km south of Čabar. Most probably the populations of this area originate from the same source, possibly introduced from the neighbouring Slovenia, where the species has been confirmed since the late '80s (STRGULC KRAJŠEK & JOGAN, 2011). *Reynoutria* taxa are frequently found growing along roads or watercourses (VUKOVIĆ *et al.*, 2019), which are often maintained through periodic mowing. Due to their capacity for vegetative spread via stem fragments, mowing might cause the dispersion of plants into new areas through stowaways on machinery or equipment.

Known records of *Nicotiana glauca* imply that its behaviour in Croatia is currently non-invasive. During a detailed, comprehensive mapping of a large area, only two small populations were found in the Neretva River Valley, probably originating from the same source. This record in southern Dalmatia fits into the previously registered extent of occurrence of this plant in Croatia (BOGDANOVIĆ *et al.*, 2006). More interestingly, the finding on Krk is geographically isolated, 200 km northwest of Split, currently the northernmost reported finding (BOGDANOVIĆ *et al.*, 2006). Given that the plant is used as an ornamental, the long-distance spread most probably occurs through sharing among gardeners, a common practice for obtaining garden plants in Croatia. Escapes from gardens occur through the prolific production of tiny seeds; although seemingly, no significant release to nature has been detected so far.

Although these alien species are seemingly not problematic in Croatia so far, monitoring of their populations is a reasonable measure to undertake. Prevention of introduction and spread before a species becomes a noxious weed is the best management practice for invasive species. It is true that the occurrences are still localized, with rather small populations, but control measures are advisable in the early stage of invasion (i.e. before the species are widespread) to prevent further spread.

## ACKNOWLEDGMENTS

The authors would like to thank the State Institution for Water Management “Hrvatske vode” and Public Institution for the Management of Protected Areas in Dubrovnik-Neretva County for the financial support of corresponding projects.

Received September 24, 2020

## REFERENCES

- ANONYMOUS, 2014: Regulation (EU) No 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species. Official Journal of the European Union **317**, 35–55.
- ANONYMOUS, 2016: Commission Implementing Regulation (EU) 2016/1141 adopting a list of invasive alien species of Union concern pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council. Official Journal of the European Union **189**, 4–8.
- ANONYMOUS, 2017: Commission Implementing Regulation (EU) 2017/1263 updating the list of invasive alien species of Union concern established by Implementing Regulation (EU) 2016/1141 pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council. Official Journal of the European Union **182**, 37–39.
- ANONYMOUS, 2019: Commission Implementing Regulation (EU) 2019/1262 amending Implementing Regulation (EU) 2016/1141 to update the list of invasive alien species of Union concern. Official Journal of the European Union **199**, 1–4.
- BOGDANOVIĆ, S., MITIĆ B., RUŠIĆIĆ, M. & DOLINA, K., 2006: *Nicotiana glauca* Graham (Solanaceae), a new invasive plant in Croatia. Acta Botanica Croatica **65**(2), 203–209.
- BAILEY, J. P. & CONOLLY, A. P., 2000: Prize-winners to pariahs – A history of Japanese Knotweed *s.l.* (Polygonaceae) in the British Isles. Watsonia **23**, 93–110.
- BUZJAK, S. & SEDLAR, Z., 2018: *Ludwigia peploides* (Kunth) P.H. Raven – floating water primrose, a new species in Croatian flora from the list of invasive alien species of Union concern. Natura Croatica **27**(2), 351–356.
- EPPO, 2019: EPPO Standards PM 1/2(28). A1 and A2 lists of pests recommended for regulation as quarantine pests.
- EPPO, 2020: *Fallopia sachalinensis*. URL: <https://gd.eppo.int/taxon/REYSA/categorization>.
- EUROPEAN COMMUNITY, 2000: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal of the European Communities L327: 1–72.
- GENOVESI, P. & SHINE, C., 2011: European Strategy on Invasive Alien Species. Convention on the Conservation of European Wildlife and Habitats (Bern Convention). Nature and environment, No. 161. Council of Europe Publishing, Strasbourg.
- HASHIMOTO, T. & YOKOZEKI, H., 2019: Occupational contact dermatitis caused by *Eucalyptus* species and *Tanacetum parthenium*. Contact Dermatitis **80**(5), 333–334.
- JACONO, C., 2017: Identification of common aquatic water-primrose species in Florida. University of Florida, Center for Aquatic & Invasive Plants and The University of Florida Herbarium, Florida Museum Gainesville, Florida. Available at: <https://plants.ifas.ufl.edu/site/assets/files/2615/ludwigiaidguide.pdf>
- JERIČEVIĆ, M., JERIČEVIĆ, N. & JASPRICA, N., 2014: Floristic novelties from the island of Korčula and peninsula of Pelješac (south Croatia). Natura Croatica **23**(2), 241–253.
- CABI, 2020: *Ludwigia peploides* [original text by Alison Mikulyuk] In: Invasive Species Compendium. Wallingford, UK. CAB International. URL: [www.cabi.org/isc](http://www.cabi.org/isc).
- CABI, 2020a: *Nicotiana glauca* [original text by Isabel Jones]. In: Invasive Species Compendium. Wallingford, UK: CAB International. URL: [www.cabi.org/isc](http://www.cabi.org/isc).
- NIKOLIĆ, T. (ed.), 2005-onwards: Flora Croatica Database. Faculty of Science, University of Zagreb. URL: <http://hirc.botanic.hr/fcd>.
- PAINI, D. R., SHEPPARD, A. W., COOK D. C., DE BARRO, P. J., WORNER, S. P. & THOMAS, M. B., 2016: Global threat to agriculture from invasive species. PNAS **113**(27), 7575–7579.



RAMSAR SITES INFORMATION SERVICE, 2020: Lonjsko Polje Nature Park. URL: <https://rsis.ramsar.org/ris/584>.

RASMUSSEN, K., THYRRING, J., MUSCARELLA, L. & BORCHSENIUS, F., 2017: Climate-change-induced range shifts of three allergenic ragweeds (*Ambrosia* L.) in Europe and their potential impact on human health. *PeerJ* **5**:e3104.

SCHAFFNER, U., STEINBACH, S., SUN, Y., SKJØTH, C. A., DE WEGER, L. A., LOMMEN, S. T., AUGUSTINUS, B. A., BONINI, M., KARRER, G., ŠIKOPARIJA, B., THIBAUDON, M. & MÜLLER-SCHÄRER, H., 2020: Biological weed control to relieve millions from *Ambrosia* allergies in Europe. *Nature Communications* **11**(1), 1745.

STRGULC KRAJŠEK, S. & JOGAN, N., 2011: The genus *Fallopia* Adans. in Slovenia. *Hladnikia* **28**, 17–40.

VUKOVIĆ, N., ŠEGOTA, V., ALEGRO, A., KOLETIĆ, N., RIMAC, A. & DEKANIĆ, S., 2019: "Flying under the radar" – how misleading distributional data led to wrong appreciation of knotweeds invasion (*Reynoutria* spp.) in Croatia. *BioInvasions Records* **8**(1), 175–189.

## APPENDIX 1.

Distribution maps of *Ludwigia peploides*, *Reynoutria sachalinensis* and *Nicotiana glauca* with previously recorded localities (Old records) and localities newly found in this study (New records).

