First Record of Water Chestnut (*Trapa natans* L., Trapaceae, Myrtales) in Central Serbia

Prvi nalaz vodenog oraška (*Trapa natans* L., Trapaceae, Myrtales) u Centralnoj Srbiji

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Abstract

Water chestnut (*Trapa natans* L.) is a floating macrophyte that generates differing views on its role and importance in aquatic ecosystems. It is protected as a rare species in a number of European countries and is an invasive species in some regions of the world. *T. natans* inhabits stagnant and slow flowing waters that exhibit large fluctuations in water level. Occurrence records are frequently reported from the north of the Republic of Serbia (Vojvodina Province), while there are no relevant data about its habitats in southern parts of the country. The first record of *T. natans* in Central Serbia was from the Međuvršje Reservoir on the Zapadna Morava River (the Danube River Basin) in 2011. A marked increase in species abundance in certain sections of the reservoir was observed in 2012. High water temperatures and continuous inflow of nutrients reported in recent years will most likely induce further propagation of this species, potentially leading to further eutrophication of the system and upsetting the ecological balance of the new habitat.

Keywords: Central Serbia, first record, invasive plant, *Trapa natans*

Rezime

Vodeni orašak (*Trapa natans L.*) predstavlja flotantnu makrofitu koju karakteriše različita procena uloge i značaja u akvatičnim ekosistemima. Zaštićena kao prirodna retkost u većem broju evropskih zemalja, ima status invazivne vrste u pojedinim regionima sveta. *T. natans* je vrsta kojoj pogoduju stajaće i sporotekuće vode sa velikim variranjima vodostaja. Česti su nalazi u severnom delu Republike Srbije

(Vojvodina), dok nema relevantnih podataka o staništima u južnijim delovima. Tokom 2011. godine registrovan je prvi nalaz *T. natans* na području Centralne Srbije u akumulaciji Međuvršje na reci Zapadnoj Moravi (Dunavski sliv). Izrazito omasovljenje vrste u pojedinim sektorima akumulacije je evidentirano u 2012. godini. Visoke temperature vode i stalan dotok nutrijenta koje se registruju zadnjih godina verovatno će usloviti dalju propagaciju vrste. To može doprineti daljoj eutrofikaciji ekosistema I narušiti postojeće ekološke ravnoteže u novom staništu.

Ključne reči: Centralna Srbija, invazivna biljka, prvi nalaz, *Trapa natans*

Detailed abstract

Termin *Trapa natans L.* 1753, (Trapaceae, Myrtales) se koristi kao zbirni naziv za kompleks sličnih vrsta vodenih makrofita koje se prvenstveno razlikuju po broju i veličini trnolikih (rogolikih) izraštaja na plodu. Obuhvata vodene jednogodišnje zeljaste flotantne biljke koje najčešće naseljavaju stajaće ili sporotekuće vode sa izraženom fluktuacijom vodostaja. Biljke imaju 3 vrste listova – podvodni su uski linearni i lancetasti, dok su na površini vode flotantni (plivajući), nazubljeni listovi rombičnog oblika. Plod je jednosemena koštunica, na preseku trouglastog oblika sa 2-4 karakteristična rogolika izraštaja. Seme vodenog oraha (Janković, 1973) sadrži velike količine skroba (52%), vode (22.5%), i proteina (15%). Zbog visokog sadržaja hranljivih materija vodeni orah je bio značajna komponenta u ishrani ljudi (posebno u neolitu) i nekih domaćih životinja, prvenstveno svinja. I danas se u nekim zemljama Jugostočne Azije gaji u akvakulturi. U SAD-u ima status invazivne korovske vrste – zasenčuje i ometa razvoj drugih makrofita, u gustom sklopu otežava plovidbu na jezerima i kanalima. Intenzivno truljenje plodova povećava eutrofikaciju, pogoršava kvalitet vode i smanjuje njenu upotrebnu vrednost za vodosnabdevanje (Borojević, 2009).

Prisustvo vrste je zabeleženo u većem broju stajaćih i sporotekućih vodotokova severnog regiona Srbije - Vojvodini (Stojanović, 2006; Panjković, 2008; Radulović et al. 2010; Stanković, 2011; Džigurski et al., 2013). Ne postoje relevantni podaci o prisustvu vrste na području Centralne Srbije. *T. natans* je prvi put registrovana u ovom regionu 2011. u akumulaciji Međuvršje na reci Zapadnoj Moravi.

Monitoringom hidrofilne vegetacije u periodu 2011-2012. godina registrovano je prisustvo 19 vrsta makrofita iz 13 porodica. Među konstatovanim vrstama, 11 su emerzne, 5 submerzne i 3 flotantne uz dominaciju predstavnika familija Poaceae i Potamogetonaceae. Prisustvo vodenog oraška (*T.natans*) u akumulaciji Međuvršje je prvi put evidentirano tokom 2011. godine. To je prvi nalaz vrste u vodotocima Centralne Srbije. Nepoznat je način introdukcije *T.natans* u akumulaciju Međuvršje. Vrsta je konstatovana u većem broju lokaliteta sa najvećom frekvencijom u sektoru Pejicina krivina (43°55’05’’N 20°13’04’’ E / 43°55’38’’N 20°13’56’’E). Tokom 2012. godine *T. natans* se omasovila širom akvatorije akumulacije tako da uz vrste *Typha latifolia, Ceratophyllum demersum, Myriophyllum spicatum* i *Potamogeton fluitans* dominira u zajednici makrofita. Pojava vrste je zabeležena 2012. i u akumulaciji Gruža, takođe lociranoj u slivnom području Zapadne Morave (neobjavljeni podaci).

Tokom 2011. godine registrovan je prvi nalaz *T.natans* na području Centralne Srbije, u akumulaciji Međuvršje na reci Zapadnoj Moravi (Dunavski sliv). Tokom 2012. uočeno je izrazito omasovljenje vrste u pojedinim sektorima akumulacije. Visoke temperature vode i stalan dotok nutrijenta koje se registruju zadnjih godina pogoduju propagaciji vrste, što može narušiti postojeće ekološke ravnoteže u novom staništu. Potrebno je nastaviti monitoring i pratiti potencijalnu ekspanziju i njen uticaj na analizirani ekosistem.

Introduction

The term *Trapa natans* L. 1753 (Trapaceae, Myrtales) is a collective name for a complex of similar species of aquatic macrophytes that primarily differ in the number and size of thorn-like (horn-like) projections on the fruit. It includes annual aquatic floating rooted herbs generally found in stagnant or slow flowing waters that exhibit major fluctuations in water levels. The plant has three types of leaves – narrow submerged leaves and rhombic floating leaves with toothed margins. Fruit is a singleseeded drupe, triangular in cross-section, with 2-4 distinctive horns. Seed contains a large amount of starch (52%), water (22.5%) and protein (15%) (Janković, 1973). Due to its high nutrient content, water chestnut was an important source of food for both humans (in the Neolithic Age in particular) and some types of livestock, primarily pigs. Water chestnut aquaculture is still practiced in some Southeast Asian countries today. The plant is an invasive weed species in the USA – it shades out and impedes the development of other macrophytes, its dense stands hinder navigation on lakes and canals. Intensive decay of its fruit increases eutrophication, deteriorates water quality and reduces the supply of usable water (Borojević, 2009).

T. natans has a wide native range extending from Western Europe and Africa to Eastern and Southeastern Asia. The species has been introduced into North America and Australia. *T. natans* is on the Red List of Threatened Species in many European countries and is included in the Bern Convention - Convention on the Conservation of European Wildlife and Natural Habitats (Džigurski et al., 2013). In Serbia, it is protected as a tertiary relict of the Balkan Peninsula (Stanković, 2011). The fossil records of *T. natans* in Serbia territory dates back in Neolithic Period and detected at several sites in Vojvodina province (Borojević, 1998; van Zeist, 2001).

The presence of the species at the beagining of XXI century has been recorded in a number of stagnant and sluggish water bodies in Vojvodina, the northern Serbian region (Stojanović, 2006; Panjković, 2008; Radulović et al. 2010; Stanković, 2011; Džigurski et al., 2013). There are no relevant data on its presence in Central Serbia. *T. natans* was first recorded in Central Serbia in 2011, in the Međuvršje Reservoir on the Zapadna Morava River.

Material and methods

Study area

The Međuvršje reservoir was created in 1953 by constructing a 31 m high concrete dam at 182 km downstream (Figure 1.).

Figure 1. Location of the Međuvršje reservoir (Serbia)

In 1955, the Međuvršje Hydroelectric Plant with a power capacity of 6.9 MW was built. The reservoir is 9.312 km in length, 1.5 km^2 in surface area, 292 m in maximum width and 12 m in depth (Markovic et al., 2003). The reservoir has a muddy and gravelly bottom and steep banks covered with forests. The initial reservoir volume was 15.4 x 106 m^3. However, 70% of its original reservoir capacity has lost due to intensive sedimentation (Lenhardt et al., 2009). The aquatic biota of this ecosystem (plankton, macrophytes, macrozoobenthos and fish communities) are very diverse (Markovic, 2011).

Sampling

In 2011 and 2012, the qualitative and quantitative composition of the macrophyte vegetation of the Međuvršje reservoir was monitored. On-site and laboratory identification of the plant material was performed using standard procedures (Janković, 1973; Jávorka and Csapody, 1975).

Results and discussion

Monitoring the hydrophilic vegetation in 2011-2012 revealed the presence of 19 macrophyte species belonging to 13 families. Among the species identified, 11 are emersed, 5 submerged and 3 floating, with Poaceae and Potamogetonaceae representatives dominating (Table 1.). Emersed vegetation is dominant in terms of species diversity, whereas submerged vegetation dominates in terms of the number of individuals. Apart from the numerous meanders, fen meadows formed by sediment deposition and covered with reed sweetgrass (*Glyceria maxima*) contribute to the specificity of the reservoir. As compared to the previous inventory conducted in 2001

(Đelić and Vićentijević - Marković, 2002), a significant increase in the coverage of common reed (*Phragmites australis*) was observed in the littoral zone of the reservoir.

Table 1. Macrophyte vegetation of the Međuvršje Reservoir

Family	Species	Ecological group
Alismataceae	*Alisma plantago-aquatica*	emersed
Butomaceae	*Butomus umbellatus*	
Lamiaceae	*Mentha aquatica*	
Cyperaceae	*Carex vulpina*	
Juncaceae	*Juncus effusus*	
Lythraceae	*Lythrum salicaria*	
Typhaceae	*Typha latifolia*	
Poaceae	*Phragmites australis*	
	Arundo donax	
	Calamagrostis arundinacea	
	Glyceria maxima	
Ceratophyllaceae	*Ceratophyllum demersum*	submerged
Halorrhagidaceae	*Myriophyllum spicatum*	
	Myriophyllum verticilatum	
Potamogetonaceae	*Potamogeton crispus*	
	Potamogeton natans	
	Potamogeton fluitans	floating
Lemnaceae	*Lemna minor*	
Trapaceae	*Trapa natans*	

Positive effects of macrophytes include phytofiltration, adsorption and absorption of some potentially harmful substances, and organic matter mineralization (Borišev et al., 2008). However, macrophyte abundance causes benthic eutrophication, particularly during the summer months. The buildup of deposits rich in cellulose and other polysaccharides can cause anaerobic mud formation and river bed depth reduction. Plant material deposition favors the production of toxic substances (nitrite, ammonia, hydrogen sulfides, etc.) at the bottom of the watercourse, thus affecting the living conditions for benthophagous fish species and bottom-fauna organisms (Simović et al., 2001).

The presence of water chestnut (*T. natans*) in the Međuvršje Reservoir was first recorded in 2011. This was the first record of this species in Central Serbian water bodies. The mode of introduction of *T.natans* into the Međuvršje Reservoir is unknown. The species was recorded at a number of locations, its incidence rate being the highest at the Pejičina Krivina site (43°55’05’’N 20°13’04’’E / 43°55’38’’N 20°13’56’’E). During 2012, *T. natans* massively increased in abundance throughout

the reservoir aquatoria, becoming the dominant species in the macrophyte community along with *Typha latifolia, Ceratophyllum demersum, Myriophyllum spicatum* and *Potamogeton fluitans*. Another record of the species in 2012 was from the Gruža Reservoir, also located in the Zapadna Morava catchment area (authors' personal record).

There are many contrasting views on the ecology of *T. natans* and its importance in aquatic ecosystems. The decline in population size in some regions is attributed to intense water pollution due to rapid urbanization and human activity (Hummel and Kiviat, 2004). There are published accounts of the profusion of this species in eutrophic waters with fluctuating water levels (Naylor, 2003). Based on main indicators of organic matter production, the Međuvršje Reservoir is classified as an eutrophic ecosystem (Spasojević et al., 2005). This is a possible factor favoring acclimatization of *T. natans* in the new habitat. The study conducted on the Hudson River (Canada) suggests the dominant role of *T. natans* in denitrifying and removing dissolved N from water. During the summer months, *T.natans* beds removed 70-100% the total N from the water although they accounted for only 2.7% of the total area of the tidal river (Tall et al., 2011). The extent of the effect of this species on the chemistry and further eutrophication of the Međuvršje Reservoir will be the focus of further monitoring work.

Regardless of its wide range, *T. natans* is generally a thermophilic macrophyte. The northern limit of the range is in waters whose temperature reaches 22°C at least 63 times throughout the year (Hegi, 1965, cited after Borojević, 2009). The large expansion of *T. natans* in 2012 was favored by high water temperatures of the Međuvršje Reservoir– the temperature of the water was ≥ 22°C for 80 days (Figure 2.). Based on realistic predictions of increases in temperature over the next years, further expansion of this species is expected to occur in the ecosystem analyzed.

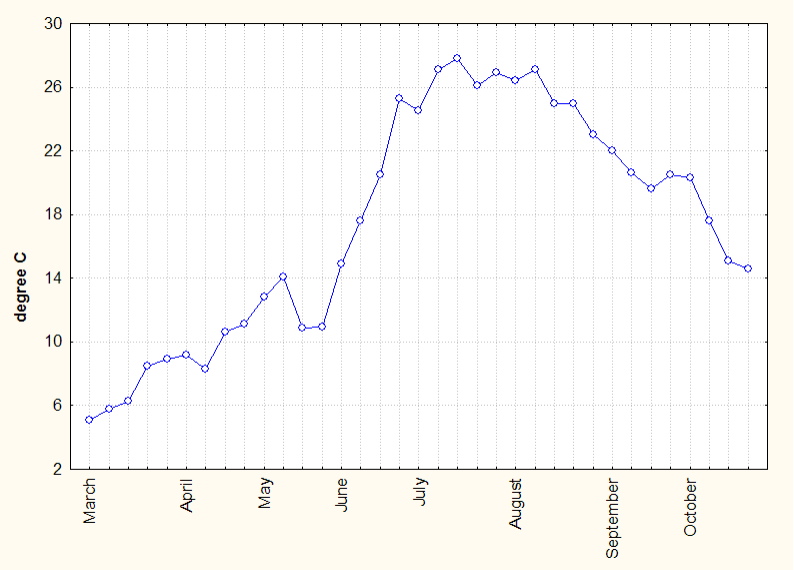

Figure 2. Average water temperatures of the Međuvršje Reservoir in 2012 (March-October)

Figure 3. *Trapa natans* in the study area

T. natans is an invasive and highly expansive species within the biotope analyzed. The drastic increase in *T. natans* populations may result in root competition between this species and other macrophytes. The dense rosette of its floating leaves (Figure 3.) can shade out photosynthetic surfaces of indigenous macrophytes and, hence, reduce the rate of primary production of competing species. Although the effects of further propagation of the species on overall hydroecologic characteristics of the ecosystem are difficult to predict, certain preventive measures should be taken to limit its expansion. Mechanical removal of *T. natans* from parts of the lake most abundant in its populations is a realistically practicable operation. Potential expansion and effects of *T. natans* on the chemistry of the ecosystem and qualitative and quantitative structure of macrophyte communities of this ecosystem should be monitored, similarly to monitoring activities conducted in Bulgaria (Yocheva et al., 2013) or Croatia (Vukojević and Vitasović-Kosić, 2012)

Conclusions

Water chesnut (*T. natans)* is an endangered and protected species in a number of European countries. In some regions of the world it is grown in aquaculture, while in some others it is an invasive species. In Serbia, frequent records of the species are reported from the north (Vojvodina province). In 2011, *T. natans* was first recorded in Central Serbia, in the Međuvršje Reservoir on the Zapadna Morava River (the Danube River Basin). In 2012, a marked increase in abundance of the species was observed in some sections of the reservoir. High water temperatures and the continuous inflow of nutrients reported in recent years will favor the propagation of this species, thus potentially upsetting the ecological balance of the new habitat. Further monitoring should focus on the potential expansion of the species and its effect on the ecosystem analyzed.

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