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Competitive advantages of *Najas marina* L. in a process of littoral colonization in the lake Velenjsko jezero (Slovenija)

Tekmovalne prednosti vrste *Najas marina* L. pri kolonizaciji litorala Velenjskega jezera (Slovenia)

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Abstract. *Najas marina* is the dominant macrophyte species in Velenjsko jezero. It appeared in the lake in 1997 and soon prevailed over the species *Myriophyllum spicatum* L. and *Potamogeton crispus* L., which used to be the two most abundant species in the lake in the past. The physico-chemical and geomorphological characteristics of the lake are discussed in relation to the attributes of *Najas marina*, presenting competitive advantages in this environment. Conditions in the lake such as warm water and unstable sediment enabled successful growth and life strategy of *Najas marina*, which is a summer-annual plant with short life cycle, quick propagation from seeds and a very extensive root system.

Key words: artificial lake, physico-chemical and geomorphological characteristics of the lake, plant invasion, aquatic macrophytes, *Najas marina* L.

Izvleček. *Najas marina* je prevladujoča makrofitska vrsta v Velenjskem jezeru. V jezeru se je pojavila leta 1997 in kmalu prevladala nad vrstama *Myriophyllum spicatum* L. in *Potamogeton crispus* L., ki sta do takrat prevladovali v jezeru. V članku so izpostavljene fizikalno kemijske in geomorfološke značilnosti jezera, ki so ene izmed pomembnih dejavnikov, ki vplivajo na kompeticijske lastnosti določene vrste. Razmere v jezeru, kot so topla voda in nestabilen sediment, omogočajo uspešen razvoj in rast vrste *Najas marina*, ki je toploljubna enoletnica s kratkim življenjskim ciklom, hitrim načinom razmnoževanja iz semen in z zelo ekstenzivnim koreninskim sistemom.

Ključne besede: umetno jezero, fizikalno kemijske in geomorfološke značilnosti jezera, invazivnost rastlin, vodni makrofiti, *Najas marina* L.

Introduction

The ability of a plant species to invade a region depends not only on the attributes of the plant, but also on the physico-chemical characteristics of the lake habitat invaded (Ali & Soltan 2006). Besides penetration of radiation and temperature, the key factor determining the composition and vertical distribution of submersed macrophyte communities is substrate composition (average grain size, sorting level, silt fraction, organic matter). Sediments influence vegetation in two ways, i.e. by serving as an anchor for roots and rhizoids (Handley & Davy 2002) and as potential nutrient reservoir

(Peralta & al. 2003). Sculthorpe (1967) pointed out that the principal influence of the substrate on the distribution of rooted aquatic plants is due to its physical texture rather than chemical composition. The sediment texture is a very important characteristic, which has very great influence on the physical, chemical and, indirectly, on the biological properties of the sediment. The mechanical properties and instability of the substrate in aquatic habitats might prevent seedling establishment and increase the chances of dislodgement (Titus & Hoover 1991) in many species. In contrast seedlings of *Najas marina* L. can not colonize on firm sediments (Handley & Davy 2002). Authors who have investigated the interaction between vegetation and sediment (Lindner 1978, Selig & al. 2007) clearly distinguished between plant communities' characteristic for mineral sediments with low nutrient content and plant communities' characteristic for muddy sediments with high nutrient content.

Najas marina is a rare species in Slovenia, registered in only six locations (Vreš & Kaligarič 1999, Germ & al. 2008) beside Velenjsko jezero, where *Najas marina* is the dominant species. It appeared in the lake in 1997 (Mazej 1998) and outcompeted both *Myriophyllum spicatum* L. and *Potamogeton crispus* L., which used to be abundant in previous years. However, they had never occurred in the lake to such an extent as *Najas marina*. *Myriophyllum spicatum* and *Potamogeton crispus* are known as very competitive species, which establish large monospecific weed beds in many lakes (Nichols & Show 1986; Bolduan & al. 1994), including some Slovenian meso-eutrophic lakes (Mazej 1998; Mazej & Gaberščik 1999).

We hypothesize that physico-chemical and geomorphological characteristics of the lake are the main factors, which allow the broad expansion of *Najas marina*. Species composition was related to environmental characteristics in order to point out the reasons for the successful growth of *Najas marina*, which prevailed over other macrophytes. Some of the attributes of *Najas marina* were also stressed.

Materials and methods

Study Area

Velenjsko jezero is situated in the Šalek valley, in the Sub-alpine part of Slovenia near the Austrian border at an altitude of 366 m, with a surface area of 135000 m^2 and a maximum depth of 54 m. Huge lignite-coal reserves, which are dug in Velenje Colliery are the crucial factor of human caused changes and pollution of the Šalek valley. The most remarkable consequences of coal mining are three subsidence lakes, Škalsko, Velenjsko and Družmirsko jezero. Velenjsko jezero came into existence after the World War II. At the beginning of its existence it was used as a reservoir for ash transport water from the Šoštanj thermal plant. The pH of transport water is around 12. The pH of lake was the same so any sorts of organism could not survive in such an alkaline environment. Up to early eighties ash slurry had run into lake, but afterwards the building of the ash landfill was begun. Ash reminded on the landfill and only transport water ran to lake. The pH remained 12 because the only reason for high alkinity was transport water. The closed loop system for the ash was built in 1994 and this has an impact on the lake quality. In only three years the lake pH has almost been normalized and biota appeared in the lake again (Šterbenk, 1999). It was recolonized by phyto- and zooplankton, fish, macrophytes and other organisms. The pH-value of the lake is now around 8.

Sampling

Three sampling locations (L1, L2, L3) with highest species richness and similar morphometric characteristics of littoral on the south-eastern part of the lake, were chosen. Samples of water and sediment were taken adjacent to vegetation from three sampling locations monthly from June to September 2004. Samples of water were taken at 0.5 m depth in plastic bottles, while sediment was sampled by a handled plastic scoop. Water transparency was measured in the middle of the lake with a Secchi disk. Temperature at 30 cm and pH at all three locations were measured with a MultiLine P4.

Presence and abundance of macrophytes

At the same time the distribution of macrophyte species at the three sampling locations was assessed using a boat, a depth meter, a viewing box and a sampling rake. Species abundance was evaluated according to Kohler (1978) on a five level descriptor scale (1 – very rare, 2 – infrequent, 3 – common, 4 – frequent, 5 – abundant, predominant).

Water and sediment analysis

The samples of water and sediment were brought to the laboratory and stored at 4 °C. The contents of total nitrogen (TN), total phosphorus (TP) and soluble reactive phosphate (SRP) in sediment were analysed by the standard methods: ISO 11261:1995, ISO 11263:1995 and ÖNORM L 1088:2005, while TN and TP in the water were determined according to the standard methods ISO 10304-2:1995 and ISO 6878:2004.

Soil texture, sorting level and the content of organic matter were also determined in the sediment. Soil texture was determined by mechanical analysis – the sedimentation stactometer method with American classification according to Hodnik (1988). The percentages of four fractions were determined: sand (grain size > 0.2 mm), coarse silt (grain size 0.05<x<0.2 mm), fine silt (grain size 0.02<x<0.05 mm) and loam (grain size < 0.02 mm). The sorting level was calculated according to Nausch & Schlungbaum (1984). The organic matter was determined according to the method described in international standard ISO 14235.

Results

The littoral of Velenjsko jezero is relatively steep (Table 1). The geomorphology of the chosen transects was quite homogenous, as the areas of the littoral at different depth zones were similar.

Table 1: Average distance and area of the littoral from the shore to a defined depth of the lake basin measured at three sections each 200±2 m in length.
Tabela 1: Povprečna razdalja od obale do določene globine jezera in površina enometerskih globinskih pasov v treh izbranih transektih (širina enega 200±2 m).

Depth of lake basin (m)	Distance from the shore (m)	Depth zone (m)	Area of the littoral of the three sections (m^2) L1	L2	L3
1	6.1±2.30	0 – 1	710	1396	1572
2	11.6±2.09	1 – 2	644	1177	1473
3	16.9±1.40	2 – 3	784	1047	1357
4	22.2±1.43	3 – 4	808	948	1368
5	27.4±1.15	4 – 5	874	959	1307
6	32.7±1.00	5 – 6	971	933	1298
7	38.1±1.00	6 – 7	1013	921	1308

We detected large seasonal changes in the presence and abundance of macrophyte species in the three chosen locations of the lake (Table 2). *Potamogeton pectinatus* L. prevailed in June and July, while in August *Najas marina* became the most abundant and colonized almost all littoral. *Potamogeton crispus* was abundantly present mainly in June, while its abundance drastically decreased during

July. *Chara* sp., *Potamogeton lucens* L., *Najas minor* All. and *Myriophyllum spicatum* were present in low abundance over the whole season.

Table 2: Average relative abundance of different macrophyte species in Velenjsko jezero in the year 2004 at the three chosen transects 200±2 m in length. Abundance: a five level descriptor scale (0 – absent, 1 – very rare, 2 – infrequent, 3 – common, 4 frequent, 5 – abundant, predominant) (Kohler 1978).
Tabela 2: Prisotnost in pogostost makrofitov v Velenjskem jezeru v treh izbranih transektih od junija do septembra 2004. Abundanca temelji na petstopenjski skali: 0 – odsotna, 1 – zelo redka, 2 – posamična, 3 – pogosta, 4 – množična, 5 – prevladujoča) (Kohler 1978).

	L1				L2				L3			
	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep
Chara sp.	1	1	0	0	1	0	0	0	0	0	0	0
Myriophyllum spicatum	0	1	1	2	1	1	0	0	1	1	0	0
Najas marina	0	1	5	4	0	2	5	3	0	2	5	3
Potamogeton crispus	0	2	0	0	2	1	0	0	2	1	0	0
Potamogeton pectinatus	3	3	3	2	0	0	0	0	3	3	2	2
Potamogeton lucens	0	0	0	0	1	2	2	1	1	2	2	1
Najas minor	0	0	0	0	0	0	2	2	0	1	2	2

The mean values of physical characteristics of water observed in Velenjsko jezero throughout the season 2004 are shown in Table 3. The temperature of the water was the highest in August (23.9 ^{o}C), when the transparency of the lake was the lowest (3.1 m). In September lake water was still relatively warm (22.5 ^{o}C), but the transparency had increased (8 m). pH value was stable and the water was well aerated throughout the whole season.

Table 3: Physical characteristics of water over the period from June to September 2004 at three chosen locations (average±SD; n=3).
Tabela 3: Rezultati fizikalnih meritev in kemijskih analiz vode opravljenih enkrat mesečno od junija do septembra 2004 na izbranih transektih (povprečna vrednost ±SD; n=3).

Date 2004	Temperature (^{o}C)	Oxygen (mg/L)	Oxygen saturation (%)	pH	Transparency (m)
08.06.	19.0±0.5	10.0±0.3	111.0±1.1	8.2±0.1	4.5
14.07.	21.0±0.1	11.7±0.5	127.4±0.9	8.1±0.1	3.7
18.08.	23.9±0.2	7.8±0.2	100.0±1.2	8.1±0.1	3.1
08.09.	22.5±0.2	7.5±0.3	93.9±0.9	8.2±0.1	8.0

The contents of TN and TP in water and sediment and SRP in sediment varied throughout the season (Table 4), at a rather high level.

Sediment parameters were variable, when comparing different sampling sites, but on average sand (83.6%) was the prevailing fraction. The sorting level (S=1.6) reflects the fact that one-grain size fractions clearly dominated (more than 50%), which is often the case in exposed areas. The level of organic matter varied from 2.5 to 13 % (Table 5).

Table 4: The contents of nutrients in sediment and water measured every month from June to September at three chosen locations (average±SD; n=3).
Table 4: Povprečna vsebnost hranil v sedimentu in vodi, merjena enkrat mesečno od junija do septembra (povprečna vrednost ±SD; n=3).

	SEDIMENT			WATER	
Date	Total N (%DW)	Total P (mg/kg)	SRP (mg/kg)	Total N (mg/l)	Total P (mg/l)
08.06.	0.067±0.05	302±169	7.14±1.51	1.23±0.01	0.06±0.02
14.07.	0.102±0.04	456±140	6.40±2.32	1.20±0.00	0.14±0.05
18.08.	0.098±0.01	456±93.2	6.75±1.89	1.83±0.58	0.17±0.02
08.09.	0.098±0.008	505±54.6	6.51±1.31	1.10±0.00	0.08±0.01

Table 5: Results of the analysis of sediment texture, sorting level and organic matter content at three chosen locations (povprečna vrednost ±SD; n=3).
Tabela 5: Tekstura in sortirna stopnja sedimenta ter vsebnost organskih snovi v sedimentu iz treh izbranih transektov (average±SD; n=3).

loam (%)	fine silt (%)	coarse silt (%)	sand (%)	sorting level	organic matter (%)
5.42±5.80	7.06±5.42	3.88±1.58	83.6±11.5	1.62±0.29	5.8±4.7

Discussion

Many authors reported *Myriophyllum spicatum* as outcompeting *Najas marina* in different lake ecosystems (Agami & Waisel 1986, Simons & al. 1994, Bootsma & al. 1999, Ali & Soltan 2006). In Velenjsko jezero the situation is the opposite (Tab. 2). Prior to 1997, when *Najas marina* appeared in the lake, *Myriophyllum spicatum* and *Potamogeton crispus* were the most abundant species (Mazej 1998, Mazej & Gaberščik 1999, Mazej & Epšek 2005). After 1997 *Najas marina* had spread rapidly within a few years, forming weed beds that covered larger areas. Abundance of *Myriophyllum spicatum* and *Potamogeton crispus* declined even in spring (Mazej & Epšek 2005), when *Najas marina* is not competitive, since it is a summer-annual plant, starting its life cycle in July. *Potamogeton crispus* and *Myriophyllum spicatum* show different life cycles in comparison to *Najas marina*. They overwinter, and then grow rapidly in the spring. By early summer the plants undergo senescence processes and then remain dormant until autumn (Bolduan & al. 1994). The biomass production of *Potamogeton crispus* often reaches its maximum in early summer, avoiding competition with other species (e.g. with *Najas marina*) in the same habitat, which begins their growth later in the season (Tobiessen & Snow 1984). In contrast to the other species in the lake, *Najas marina* propagates from seeds (Agami & Weisel 1986) that enable quick colonization of new habitats.

Optimum germination temperatures of *Najas marina* are between 20 and 25 ^{o}C (Proctor 1967). That might be a reason why the species is rare throughout Europe (Handley & al. 2002). It begins its growth in July, when nutrients in lakes are usually impoverished and the littoral is fully overgrown with other macrophytes. This is not the case in Velenjsko jezero. In July soft sediment littoral is still not colonized and the amounts of nutrients in the water and sediment do not decrease before September (Tabs. 2, 4). Velenjsko jezero could be classified as eutrophic according to the level of total phosphorus (0.11 mg/L) and total nitrogen (1.34 mg/L) in the water (OECD 1982). *Najas marina* is reported to thrive in oligotrophic and mesotrophic shallow freshwater habitats (TP in sediment <50 μg g^{-1} dw) and was considered to be nearly extinct due to hypereutrophication (Selig & al. 2007). For example, Simons & al. (1994) beside the decline of charophytes, described the decline of *Najas marina* stands in a shallow peat lake (Botshol, The Netherlands) due to nutrient input. The same effect was observed in the research of Bootsma & al. (1999) in the shallow lakes of Naardemeer nature reserve (The Netherlands). *Najas marina* disappeared from the lakes when the concentration of total P in the water was 0.1 mg/l and it reappeared when the concentration of total phosphorus had dropped to 0.05 mg/l. Our results cannot confirm these findings as the sediment (mean TP in sediment is 329 $\mu g\ g^{-1}$ dw) and water (mean TP in water is 0.11 mg/l) of Velenjsko jezero are very rich in phosphorus. However, Velenjsko jezero, in contrast to Botshol and the lakes in Naardemeer, is a deep lake (max depth is 54.6 m) with steep slopes along greater parts of the lakeshore (Tab. 1). Its transparency (mean Secchi depth was 4.8 m) is much better than the transparency in the lakes of Naardmeer (from 0.3 to 1.05 m). Stelzer & al. (2005) claim, that *Najas marina* is a taxon with a high preference for good ecological status in a case of German lakes. Selig & al. (2007) found *Najas marina* stands in eutrophic waters, even though TP was comparatively low.

The littoral of Velenjsko jezero is decisive for low sediment stability. Therefore species, which develop extensive root systems, were expected to be more successful. Unstable sediment that prevails in Velenjsko jezero prevented spreading of *Myriophyllum spicatum* and *Potamogeton crispus*. *Myriophyllum spicatum* is reported to have difficulty in becoming rooted in a soft and moving bottom (Nichols & Shaw 1986). *Najas marina* with a branching growth form (Handley & Davy 2000) forms dense beds and develops very extensive root systems (Handley & Davy 2002). Roots can account for more than 30% of plant biomass compared to the values of 10% or less for the majority of submersed aquatic plants (Agami &Weisel 1986). The sorting level and sediment fraction type reflected other abiotic parameters such as wave exposure and water current. Selig & al. (2007) found that *Najas marina* stands prefer sediment with a higher sorting level in the range similar to the sediment of Velenjsko jezero (S =1.6) (Tab. 5). This level describes open sandy areas with little sedimentation. *Myriophyllum spicatum* and *Potamogeton pectinatus* can be found in sediments with a wide range of sorting level but with the lower median (1.3) (Selig & al. 2007). It is known from literature that *Myriophyllum spicatum* (and also *Potamogeton crispus*) grow best on fine sediment with a relatively high organic matter concentration, e.g. 10-25% (Nichols & Shaw 1986) and 9-13% (Van Wijck & al. 1994), which is higher than the concentration in the sediment of Velenjsko jezero.

Conclusion

This investigation revealed that species composition in a particular lake depends on plant strategy and on the physico-chemical and geomorphological characteristics of the lake. The same species cannot be equally successful in habitats with differing physico-chemical and geomorphological characteristics. Favourable circumstances in the lake Velenjsko jezero like warm water, unstable sediment and life strategy of *Najas marina* as a summer-annual plant with short life cycle, rapid propagation by seed and a very extensive root system, enable this species to grow successfully and dominate over other macrophytes in the lake.

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References

Agami M. & Waisel Y. 1986: The ecophysiology of roots of submerged vascular plants. – Physiologie Végétale **24**: 607–624.

Ali M. M. & Soltan M. A. 2006: Expansion of *Myriophyllum spicatum* (Eurasian water milfoil) into Lake Nasser, Egypt: Invasive capacity and habitat stability. Aquat. Bot. **84**: 239–244.

Bolduan B. R., Van Eeckhout G. C., Quade H. W. & Gannon J. E. 1994: *Potamogeton crispus* – The Other Invader. – Lake and Reserv. Manage. **10**: 113–125.

Bootsma M. C., Barendregt A. & van Alphen J. C. A. 1999: Effectiveness of reducing external nutrient load entering a eutrophicated shallow lake ecosystem in the Naardemeer nature reserve. – The Netherlands. Biol. Conserv. **90**: 193–201.

Germ M., Urbanc-Berčič O., Janauer, G. A., Filzmoser P., Exler N. & Gaberščik A. 2008: Macrophyte distribution pattern in the Krka River – the role of habitat quality. Arch. Hydrobiol., Large rivers **18**: 145–155.

Handley R. J. & Davy A. J. 2000: Discovery of male plants of *Najas marina* L. (Hydrocharitaceae) in Britain. – Watsonia **23**: 331–334.

Handley R. J. & Davy A. J. 2002: Seedling root establishment may limit *Najas marina* L. to sediment of low cohesive strength. Aquat. Bot. **73**: 129–136.

Hodnik A. 1988. Kemične analize talnih vzorcev, rastlinskih vzorcev in odcednih vod (Chemical analyses of soil and plant samples and leachate), Biotechnical Faculty, Ljubljana.

International standard ISO 11261:1995: Soil quality – Determination of total nitrogen – Modified Kjeldahl method. Brussels, Belgium.

International standard ISO 11263:1995: Soil quality – Determination of phosphorus – Spectrometric determination of phosphorus soluble in sodium hydrogen carbonate solution. Brussels, Belgium.

International standard ISO 10304–2: 1995: Water quality – Determination of dissolved anions by liquid chromatography of ions – Part 2: Determination of bromide, chloride, nitrate, nitrite, orthophosphate and sulfate in waste water. Brussels, Belgium.

International standard SIST ISO 14235: 1999: Soil quality – Determination of organic carbon by sulfochromic oxidation. Brussels, Belgium.

International standard ISO 6878:2004. Water quality – Determination of phosphorus – Ammonium molybdate spectrometric method. Brussels, Belgium.

Kohler A. 1978: Methoden der Kartierung von Flora und Vegetation von Süßwasserbiotopen. – Landschaft und Land **10** (2): 78–85.

Lindner A. 1978: Soziologisch-ökologische Untersuchungen an der submersen Vegetation in der Boddenkette südlich des Darß und Zingst. – Limnologica **11**: 299–305.

Mazej Z. 1998: Macrophytes in the different types of lakes: Species composition and species vitality: Master of Science thesis. University of Ljubljana, p 104.

Mazej Z. & Gaberščik A. 1999: Species composition and vitality of macrophytes in different types of lakes. Acta biologica Slovenica **42** (3): 43–52.

Mazej Z. & Epšek, M. 2005: The macrophytes of Lake Velenjsko Jezero, Slovenia – the succession of macrophytes after restoration of the lake. – Acta Biologica Slovenica **48** (1): 21–31.

Nausch G. & Schlungbaum G. 1984: Sediment-chemical investigations in the coastal waters of the GDR. 17. Special investigations on the dynamics of the surface sediments of shallow boden water (Barther Bodden). – Acta Hydrochim Hydrobiol **12** (1–2): 61–72.

Nichols S. A. & Shaw B. H. 1986: Ecological life histories of the three aquatic nuisance plants, *Myriophyllum spicatum*, *Potamogeton crispus* and *Elodea canadensis*. – Hydrobiol **131**: 3–21.

Oecd 1982: Eutrophication of waters monitoring, assessment and management, Paris.

Önorm L 1088: 2005: Chemische Bodenuntersuchungen. Bestimmung von pflanzenverfügbarem Phosphat und Kalium nach der Doppel-Lactat (DL)-Methode. Wien, Austria.

Peralta G., Bouma T. J., van Soelen J., Perez-Lorens J. L.& Hernandez I. 2003: On the use of sediment fertilization for seagrass restoration: a mesocosm study on *Zostera marina* L. Aquat Bot **75**: 95–110.

Proctor V. W. 1967: Storage and germination of *Chara* oospores. J Phycol 3: 40–92.

Sculthorpe C. D. 1967: The Biology of Aquatic Vascular Plants. Edward Arnold, London.

Selig U., Schubert M., Aggert A., Steinhardt T., Sagert S. & Schubert H., 2007: The influence of sediment on soft bottom vegetation in inner coastal waters of Mecklenburg-Vorpommern (Germany). Estuarine, Coastal and Shelf Science **71** (1–2): 241–249.

Simons J., Ohm M., Daalder R., Boers P. & Rip W. 1994: Restoration of Botshol (the Netherlands) by reduction of external nutrient load – recovery of a characean community, dominated by *Chara connivens*. -Hydrobiologia **276**: 243–253.

Stelzer D., Schneider S. & Melzer A. 2005: Macrophyte-based assessment of lakes – a contribution to the implementation of the European Water Framework Directive in Germany. International Review of Hydrobiol **90** (2): 223–237.

Šterbenk E., 1999: Šalek Lakes. Pozoj, Velenje.

Titus J. E. & Hoover D. T. 1991: Towards predicting reproductive success in submersed angiosperms. Aquat Bot **41**: 111–136.

Tobiessen P. & Snow P. D. 1984: Temperature and light effects on the growth of *Potamogeton crispus* in Collins Lake, New York State. Can J Bot **62**: 2822–2826.

Van Wijck C., Grillas P., Degroot C. J., Ham L. T. 1994: A comparison between the biomass production of *Potamogeton pectinatus* L. and *Myriophyllum spicatum* L. in the Camargue (southern France) in relation to salinity and sediment characteristics. – Vegetatio **113**: 171–180.

Vreš B. & M. Kaligarič 1999: Rastlinski svet. – In: Vogrin M. & Vogrin N. (eds.): Krajinski park Rački ribniki – Požeg: vodnik. (Nature park Rački ribniki – Požeg: guidebook). Association for bird study and nature conservation, Rače.