



# Contribution to knowledge of the charophytes (Charales) of Vojvodina (Serbia) – 20 years after the first review

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**ABSTRACT:** This paper summarises known data regarding floristic richness, distribution and habitat preferences of the charophyte algae (Charales) in the region of Vojvodina (Serbia). The historical records were collected from all available literature and herbarium data on charophytes in Vojvodina from the beginning of charophyte research in the 19<sup>th</sup> century to the present day. Moreover, detailed field investigations were carried out in the period from 2012 to 2014. The last study summarising knowledge about the distribution and ecology of charophytes (Charales) in Vojvodina was done in 1995, and nine species were listed therein. At the present time, 20 years later, 11 more species are known. Altogether, charophytes are represented in the flora of Vojvodina with 20 species, belonging to four genera: *Chara*, *Nitellopsis*, *Nitella* and *Tolypella*. All data were georeferenced and species distribution maps are given. Concerning habitat preferences, charophytes of Vojvodina are mainly found in three types of habitats, namely puddles and ruts in river floodplains, different kinds of excavation pits and periodically dredged canals. Most of the known localities are in the protected areas of Vojvodina.

**KEYWORDS:** charophytes, richness, distribution, habitat

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## INTRODUCTION

The charophyte algae (Charales) are a group of mainly freshwater algae inhabiting different kinds of standing and slow running aquatic habitats that can have a “key factor” role in the ecosystems they inhabit and provide many important ecosystem services. However, even though this group of algae affects many aspects of ecosystem functioning, at the same time they are often underexplored and their ecology is not well known, especially when it comes to the rarest and most threatened species. Given that some species have the capacity to colonise newly created habitats (SIMONS & NAT 1996; BELTMAN & ALEGRINI 1997; URBANIAK & GĄBKA 2014; MOURONVAL *et al.* 2015), they are important as pioneer vegetation both in new habitats and in habitats that are in recovery after biomanipulation or reduction of

negative influences (LAURIDSEN *et al.* 2003; HILT *et al.* 2006; AZZELLA *et al.* 2014). Some species are considered sensitive to habitat eutrophication and pollution, while others are very tolerant and widespread (KRAUSE 1997; MELZER 1999; AUDERSET-JOYE *et al.* 2002; LACOUL & FREEDMAN 2006; PENNING *et al.* 2008; URBANIAK *et al.* 2011).

Vojvodina is the region occupying the northern part of Serbia, and it represents one third of the country's territory. Most of Vojvodina's territory is lowland, situated in the southern part of the Pannonian Plain. The climate is temperate continental, with mean annual precipitation of around 600 mm (KATIĆ *et al.* 1979). Regarding its hydrological characteristics, Vojvodina is the richest area of Serbia, with numerous streams and rivers, a large number of standing water bodies and an almost 15 000 km long network of artificial channels. Rivers and streams in

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Vojvodina are naturally characterised by low inclination and slow flow, forming wide flood plains, with many meanders and oxbow lakes. Due to intensive regulation work in the last two centuries, many river branches are now separated from the main channel and the water level in the floodplain is controlled and regulated (ŽIVKOVIĆ *et al.* 1972; GAVRILOVIĆ & DUKIĆ 2002). In addition, Vojvodina has more than a thousand small ponds formed in abandoned excavation pits (gravel, sand or other kinds) (MESAROŠ & DOŽAI 2011). Natural lakes are a type of water body lacking in Serbia generally, and in Vojvodina in particular. Even artificial lakes are rare in this region. A few of those that exist are called “lakes”, but they do not have real lake ecological characteristics.

The first known record of charophytes in Vojvodina dates back to 1855 (KOŠANIN 1907) and is related to research done by the famous Serbian botanist Josif Pančić, who noted charophytes in “Sava ponds”. Although the data are rather imprecise, it can be asserted that those findings were probably in the floodplain of the Sava River, today located in the region of Vojvodina. Almost a quarter of a century later, FILARSZKY (1931) reported several more species, found, interestingly, in the same region of the Sava floodplain. Up to the 1980s, data regarding charophyte algae were to be found only in papers treating the flora and vegetation of vascular aquatic plants (PROTIĆ 1933; JANKOVIĆ 1953; MARINOVIĆ 1955; SLAVNIĆ 1956; BABIĆ 1971; GUELMINO 1973; VUKOJE 1979). Those records were very scarce and often determined only to the genus level. Thanks to the efforts of Blaženčić and associates (BLAŽENČIĆ 1980; BLAŽENČIĆ *et al.* 1995), more systematic investigations were carried out from the 1980s to the middle of the 1990s. Unfortunately, frequent explorations were not continued thereafter. Hence, only rare data can be found (STEVANOVIĆ *et al.* 2003; BLAŽENČIĆ & STANKOVIĆ 2008). In the last decade, charophytes were brought back into focus (VEŠIĆ *et al.* 2011; BLAŽENČIĆ 2014) and new explorations were started.

The paper of BLAŽENČIĆ *et al.* (1995) was the first and last study summarising knowledge about the distribution and ecology of charophytes (Charales) in Vojvodina. In the present study, 20 years later, we aim to give an up-to-date summary of knowledge about the floristic richness, distribution and habitat preferences of charophytes on the territory of Vojvodina.

## MATERIALS AND METHODS

Historical records on the distribution and ecology of the analysed species were collected from all available literature and herbarium sources of data on charophytes in Vojvodina from the beginning of charophyte research up to the present day. Herbarium data were acquired by reviewing several collections containing charophyte algae: BEOU, BEO, BUNS, ZA, BU (THIERS 2016). The majority

of references related to charophyte findings from the last few decades. All the collected data on distribution and ecology of charophytes in Vojvodina were incorporated into a single database.

In addition to this, detailed field investigations were carried out in the period from 2012 to 2014. Almost 250 localities were visited and the waterbodies checked for the presence of charophytes. In order to achieve balanced geographical and ecological coverage of the study area, localities were selected in accordance with the habitat diversity of Vojvodina. To be specific, the investigated water bodies were diverse in regard to their origin, water quality, manner of utilisation, status of protection, duration (temporary / permanent) and type (standing / slow-running). Charophytes were collected from the shore or by boat, using a special kind of rake.

Charophyte species were identified using the keys proposed by CORILLION (1957, 1975), WOOD & IMAHORI (1964, 1965), GOLLERBAH & KRASAVINA (1983), KRAUSE (1997), SCHUBERT & BLINDOW (2003) and BAILLY & SCHAEFER (2010). The samples are deposited in the collection of wet specimens of the herbarium of the Institute of Botany and Botanical Garden “Jevremovac” (BEOU), University of Belgrade. They were fixed in an alcohol solution (50% ethanol: glycerin, 1:1).

Data on the distribution of historical findings were georeferenced in the OziExplorer 3.95 4s program (D & L Software Pty. Ltd., Brisbane, Australia), while the new findings were mapped with the aid of a GPS positioning method using the eTrex Vista C GPS receiver (Garmin). The vector distribution maps of charophyte species were created from the collected data using the Manifold System 5.50 Professional Edition software (Manifold System, CDA International Ltd.).

To be specific, the distribution of charophyte species is mapped on a 10 × 10-km grid square using the Military Grid Reference System (MGRS) (LAMPINEN 2001). New records included findings that have not been previously registered for individual 100-km<sup>2</sup> squares. Imprecise records refer to wider localities, which included two or more 100-km<sup>2</sup> squares. The MGRS coordinates of all mapped localities are listed in Appendix 1 (available online).

## RESULTS

Nine species of charophyte algae were listed for the territory of Vojvodina in the last inventory (BLAŽENČIĆ *et al.* 1995), four of them for the first time [*C. tenuispina* A. Braun, *C. virgata* A. Braun ex Kütz (subnom. *C. delicatula*), *Nitella opaca* (Bruzelius) C. Agardh and *N. capillaris* (Krock.) J.Groves & Bull.-Webst.], while the other five (*Chara braunii* C. C. Gmel., *C. canescens* Desv. & Loisel., *C. contraria* A. Braun ex Kütz, *C. globularis* Thuill. and *C. vulgaris* L.), had already been mentioned in the literature (KOŠANIN 1907; FILARSZKY 1931; PROTIĆ 1933; JANKOVIĆ 1953; MARINOVIĆ 1955; BABIĆ

1971; VUKOJE 1979; BLAŽENČIĆ 1980; STOJANOVIĆ *et al.* 1994). In the period between 1995 and 2015, 11 more species were discovered. Ten out of these 11 species were reported in previous papers (GUELMINO 1973; STEVANOVIĆ *et al.* 2003; BLAŽENČIĆ & STANKOVIĆ 2008; VESIĆ *et al.* 2011; BLAŽENČIĆ 2014). In the present paper, we report findings of the species *Chara intermedia* A. Braun for the first time. We also indicate new findings of the other species at several new localities. Unfortunately, the species *Chara virgata* Kütz. and *Chara canescens* Desv. & Loisel have not been found again after 1995. A comparison of the number of localities recorded in 1995 and the number known today is provided in Appendix 2 (available online).

BLAŽENČIĆ *et al.* (1995) reported one locality for *Chara braunii* C. C. Gmel. 1826, the fishpond “Južna Jezera”, near Ečka, and summarised data (subnom. *C. coronata* Ziz.) previously published by FILARSZKY (1931). FILARSZKY (1931) reported four localities, three near Kupinovo (the marsh Tikvar, across from Skela and a marsh in Kupinski Kut) and one near Jakovo, “the great marsh by the causeway”.

Since 1995, several new localities have been reported: a pond in the marsh Petrovaradinski Rit; a puddle in Štrbac, Gornje Podunavlje; puddles on the left bank of the Danube across from the Lido Beach (Belgrade-Zemun); and puddles on the Danube River's bank near the bridge Pančevački Most, Belgrade (BLAŽENČIĆ 2014). Moreover, there is one unpublished historical record of a *C. braunii* finding in a pond near Grabovci (*leg. Gjurašin, 08.09.1913*, subnom. *Chara coronata* Ziz., collection ZA), as well as three new findings, namely in a puddle near Sečanj (*leg. Šinžar-Sekulić, J., Sekulić, N., 13.07.2013*) and in a shallow ditch and in a puddle (*leg. Vesić, A., 20.06.2013*) in the Obreške Širine, SNR (Special Nature Reserve) „Obedska Bara“.

*Chara canescens* Desv. & Loisel. in Loisel. 1810 was reported by STOJANOVIĆ *et al.* (1994) in the Vrbas-Bezdan Canal, near Mali Stapar.

For *Chara contraria* A. Braun ex Kütz. 1845, BLAŽENČIĆ *et al.* (1995) reported three localities, namely a fishpond near Čenta, the fishpond “Južna Jezera” near Ečka and a drainage canal in “Tresetište” near Subotica, in addition to which they summarised data previously published by Filarszky. FILARSZKY (1931) reported *C. contraria*, subnom. *Chara pseudogymnophylla* F. f. *aspera* F. (syn. *Chara contraria* var. *gymnophylla* A. Br.), in one locality near Kupinovo, across from Skela.

Since 1995, several more localities have been listed: canals in Ostrovac, Turske livade and Jovača and puddles in Valjevac, Široka Bara and Bara Ribnjača in SNR “Zasavica” (VESIĆ *et al.* 2011); and in the sandpit “Majdan” near Subotica, a rut near “Franjina Skela” (Monoštorski Rit, Gornje Podunavlje), puddles on the left bank of the Danube across from the Lido Beach (Belgrade-Zemun) and puddles on the Danube River's bank near the bridge Pančevački Most (BLAŽENČIĆ 2014), Belgrade.

In the present paper, we report four new findings: a rut in the marsh Apatinski Rit in SNR “Gornje Podunavlje” (*leg. Vesić, A., Šinžar-Sekulić, J., 21.05.2013*); a puddle in the marsh Monoštorski Rit in the same SNR (*leg. Vesić, A., Šinžar-Sekulić, J., 22.05.2013*); a pond in a tilery near Crepaja (*leg. Vesić, A., Radivojević, L., 15.07.2012*); and the pond „Makova Sedmica“ near Subotica (*leg. Đurović, S., 11.06.2015*).

BLAŽENČIĆ *et al.* (1995) did not find *Chara globularis* Thuill. 1799 during their own research. The authors summarised data previously published by FILARSZKY (1931). Filarszky reported two localities for this species, subnom. *Chara fragilis* Desv.: Kupinovo (in the Tikvar Marsh) and Jakovo.

Rather imprecise literature data published before 1995 include *C. globularis* findings in the “King Petar and King Aleksandar” Canal (PROTIĆ 1933, subnom. *Chara fragilis*); the Petrec Canal, Belgrade (MARINOVIĆ 1955, subnom. *Chara fragilis*); and the ephemeral pond Dugaja in the marsh Koviljski Rit (BABIĆ 1971, subnom. “*Hara fragilis*”).

After 1995, VESIĆ *et al.* (2011) reported several localities in SNR “Zasavica”: canals in Ostrovac, Turske Livade, Prekopac and Jovača; a beaver pond in the stream Batar; and puddles in Preseka, Valjevac, Šumareva Čuprija, Pačja Bara and Zovik. BLAŽENČIĆ (2014) reported the following localities: the sandpit “Selevenj”; a pond in a tilery in Stanišić, near Sombor; puddles on the Danube River's bank near the bridge Pančevački Most, Belgrade; a pond in Deliblatska Peščara; and several localities near Banatska Palanka, namely the Stari Karaš river bed, ponds in a willow forest near the Danube River, ponds by Dolnice and ponds on Stevan's Plain and the Jaruga River.

Our new findings include: a rut in the marsh Apatinski Rit (*leg. Vesić, A., Šinžar-Sekulić, J., 21.05.2013*) and a puddle in the marsh Monoštorski Rit (*leg. Vesić, A., Šinžar-Sekulić, J., 22.05.2013*), both in the SNR “Gornje Podunavlje”; the ephemeral pond Kozarnica (*leg. Vesić, A., 14.08.2013*); a rut near the causeway in the marsh Koviljski Rit, SNR “Koviljsko-Petrovaradinski Rit” (*leg. Vesić, A., 15.08.2013*); an oxbow of the Tamiš River in Sefkerin (*leg. Vesić, A., Šinžar-Sekulić, J., 03.07.2012*); a pond in a tilery near Crepaja (*leg. Vesić, A., Radivojević, L., 15.07.2012*); a sandpit near the Nera River, Bela Crkva (*leg. Vesić, A., 15.09.2012*); a waterhole between Boka and Sečanj (*leg. Perić, R., 22.05.2013*); a puddle near Sečanj (*leg. Šinžar-Sekulić, J., Sekulić, N., 13.07.2013*); six localities in the SNR “Obedska Bara”: on the edge of the “Krstonošića Okno” (*leg. Vesić, A., 29.05.2013*), a shallow ditch, three puddles and a canal in the Obreške Širine (*leg. Vesić, A., 20.06.2013*), and the pond “Makova Sedmica”, near Subotica (*leg. Đurović, S., 11.06.2015*). *Chara globularis* was confirmed once more for the “Selevenj” sandpit locality (*leg. Vesić, A., 27.08.2013*).

*Chara hispida* (L.) Hartm. 1820 was reported in the literature for the first time by BLAŽENČIĆ (2014), for three sandpits, at localities near Subotica: “Makova Sedmica”, “Majdan” and “Selevenj”. For the last of them, this species was confirmed in the latest explorations (leg. Vesić, A., 27.08.2013), but it wasn't found again at the first two. We herewith report two new localities: a sandpit close to “Majdan” (so-called “Majdan 2”) and the sandpit “At Lofej's”, both near Subotica (leg. Vesić, A., 27.08.2013).

*Chara intermedia* A. Braun in A. Braun, Rabenh. & Stizenb. 1859 is reported in the present paper for the first time for the territory of Vojvodina. It was found at two localities: the sandpits “Majdan” and “Selevenj”, near Subotica (leg. Vesić, A., 27.08.2013). This species was not found at these localities during previous field surveys.

*Chara tenuispina* A. Braun 1835 was reported for the first time in the paper of BLAŽENČIĆ *et al.* (1995), in a pond near Kelebija, in the neighbourhood of Subotica. BLAŽENČIĆ (2014) reported a new finding in the Čik River, near Bačko Petrovo Selo. We here report one new finding in the sandpit “At Lofej's”, near Subotica (leg. Vesić, A., 08.09.2012).

*Chara virgata* Kütz. 1834 was reported for the first time by BLAŽENČIĆ *et al.* (1995), for the fishpond “Južna Jezera”, near Ečka (subnom. *Chara delicatula* Ag.). It hasn't ever been found again since then.

BLAŽENČIĆ *et al.* (1995) summarised results previously published in the literature and reported several new findings of *Chara vulgaris* L. 1753. Most of them were located near Subotica: Lake Palić, the pond “Makova sedmica”, a drainage canal and a pond at the “Tresetište” locality and the Kereš River, near Hajdukovo. The finding in “Makova Sedmica” was confirmed again in 2015 (leg. Đurović, S., 11.06.2015). One finding was located in the Danube-Tisza-Danube Canal, near Stara Palanka.

In the literature prior to 1995, *C. vulgaris* was reported in: imprecisely designated Sava River ponds (KOŠANIN 1907, subnom. *Chara foetida* A.Br.); Jakovo, “the great marsh by the causeway”, and Kupinovo, across from Skela (FILARSZKY 1931, subnom. *Chara foetida* A. Br.); the pond Veliko Blato, Belgrade (JANKOVIĆ 1953, subnom. *Chara foetida*); the Petrec Canal and Dudovske Mlake puddles, Belgrade (MARINOVIĆ 1955, subnom. *Chara foetida*); the oxbow Mrtva Tisa, near Senta (GUELMINO 1973, *Chara foetida* A.Br.); the Carinova Pond and “Pond 10”, both in the marsh Petrovaradinski Rit (VUKOJE 1979); and the Danube River near Banatska Palanka (BLAŽENČIĆ 1980).

After 1995, VESIĆ *et al.* (2011) reported several localities for this species in SNR “Zasavica”: ruts and puddles in Valjevac and Batve, as well as puddles in Široka Bara and Bara Ribnjača. BLAŽENČIĆ (2014) reported findings in Lake Palić, near Subotica; in the Dolnice Bay of the Danube River and in the Jaruga River (both near Banatska Palanka); and in puddles on the Danube River bank near the bridge Pančevački Most, Belgrade.

We report findings at six new localities in SNR “Gornje Podunavlje”: three ruts and one puddle in the marsh Apatinski Rit (leg. Vesić, A., Šinžar-Sekulić, J., 21.05.2013); and one puddle and the Sirota Canal (leg. Vesić, A., Šinžar-Sekulić, J., 22.05.2013). Also, we here report for the first time unpublished herbarium data for the following localities: Vršac (leg. Bernátsky, J., 05.1902, subnom. *Chara foetida* A.Br. f. *reflexa* Mig., collection BU); and a pond near Grabovci (leg. Gjurašin, 08.09.1913, det. Tortić, M., 1951, subnom. *Chara foetida* A.Br., collection ZA).

*Nitellopsis obtusa* (Desv. in Loisel.) J.Groves 1919 was reported for the first time for the territory of Vojvodina by STEVANOVIĆ *et al.* (2003) for the Dolnice Bay of the Danube River, near Banatska Palanka. It has been found several times since 1998 and was confirmed again in 2012 (leg. Stevanović, V., 29.07.2012). BLAŽENČIĆ (2014) reported one new locality, a sandpit near the Nera River, Bela Crkva.

*Nitella brachyteles* A.Braun 1864 was reported for the first time by BLAŽENČIĆ (2014) in a canal by Padinska Skela, Belgrade. This species hasn't been found since 1998, either in Vojvodina or in Serbia.

*Nitella capillaris* (Krock.) J. Groves & Bull.-Webst. 1920 was reported for the first time in BLAŽENČIĆ *et al.* (1995), for the pond “Makova Sedmica”, near Subotica. VESIĆ *et al.* (2011) reported a new locality for this species in SNR “Zasavica”, namely puddles in Valjevac.

*Nitella confervacea* (Bréb.) A. Braun ex Leonh. 1863 was reported for the first time by VESIĆ *et al.* (2011) for one locality, Valjevac, in SNR “Zasavica”. It was found in a rut and in a puddle.

STEVANOVIĆ *et al.* (2003) reported *Nitella gracilis* (Sm.) C. Agardh 1824 for the first time, in the Danube River. In the present paper, we report four new findings, i.e., at the following localities: in a rut in the marsh Apatinski Rit in SNR “Gornje Podunavlje” (leg. Vesić, A., Šinžar-Sekulić, J., 21.05.2013); and in a puddle near the causeway (leg. Vesić, A., 13.08.2013) and in the ephemeral pond Kozarnica (leg. Vesić, A., 14.08.2013), both in the marsh Koviljski Rit (SNR “Koviljsko-Petrovaradinski Rit”). The fourth finding was in an oxbow of the Tamiš River in Sefkerin (leg. Šinžar-Sekulić, J., Sekulić, N., 13.07.2013).

VESIĆ *et al.* (2011) reported *Nitella mucronata* (A. Braun) Miq. in H. C. Hall 1840 emend. Wallman 1853 for the first time in Vojvodina, at a great number of localities on territory of SNR “Zasavica”: in puddles in Ostrovac, Lug, Sadžak, Preseka, Gradina, Valjevac, Šumareva Čuprija, Pačja Bara, Bostanište, Trebljevine and Panjevine. BLAŽENČIĆ (2014) reported its finding at one more locality, namely a fishpond near Čenta.

During the newest investigations, *N. mucronata* has been found the most frequently of all *Nitella* species, with findings at many new localities: two ruts (leg. Vesić, A., 15.08.2013) and a puddle (leg. Vesić, A., 13.08.2013) near the causeway in the marsh Koviljski Rit in SNR “Koviljsko-Petrovaradinski Rit”; an oxbow of the Tamiš River in

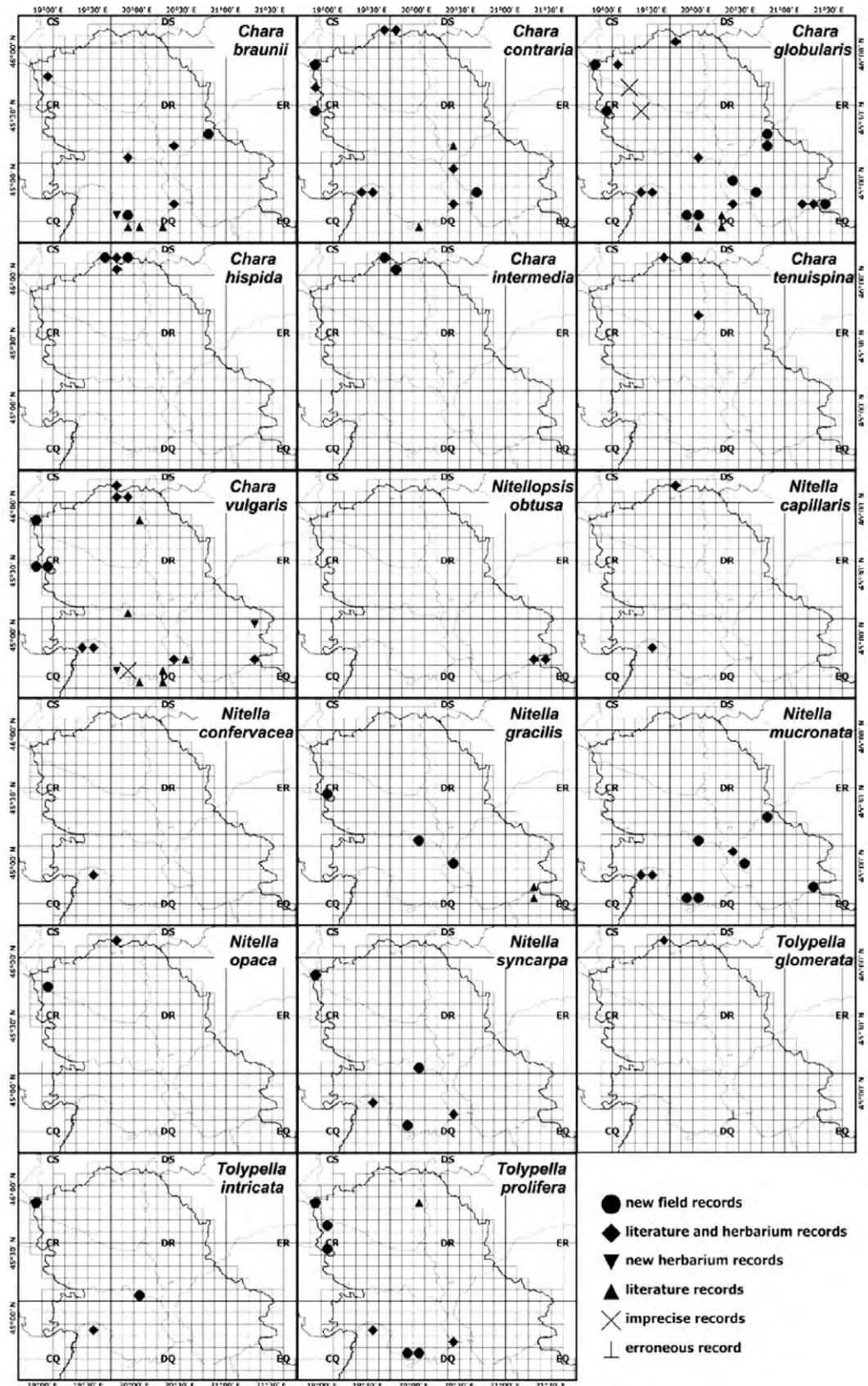


Figure 1. Distribution of charophyte species in Vojvodina.

Glogonj (*leg. Vesić, A., Šinžar-Sekulić, J., 03.07.2012*); and a puddle near Sečanj (*leg. Šinžar-Sekulić, J., Sekulić, N., 13.07.2013*). Four localities are in SNR "Obedska Bara": two in Kupinske Grede, one of which is on the edge of the „Krstonošića Okno“ (*leg. Vesić, A., 29.05.2013*) and the second on the edge of the Velika Rogozita ephemeral pond (*leg. Vesić, A., 06.06.2013*), while two are in the Obreške Širine, namely a shallow ditch and a puddle (*leg. Vesić, A., 20.06.2013*). It was also found at a new locality in SNR "Zasavica", viz., in a puddle in Jovača (*leg. Stanković, M., 09.08.2013*). *Nitella mucronata* was also found in the Jaruga River, near Banatska Palanka (*leg. Stevanović, V., 15.10.2002*), but this finding has not yet been reported in the literature.

*Nitella opaca* (Bruzelius) C. Agardh 1824 was reported for the first time in BLAŽENČIĆ *et al.* (1995), for a drainage canal at the "Tresetište" locality, near Subotica. In the present paper, we report one new locality, a puddle in the reserve of Štrbac in the marsh Monoštorski Rit (SNR "Gornje Podunavlje").

*Nitella syncarpa* (Thuill.) Chevall. 1827 was found for the first time in SNR "Zasavica", in puddles in Sadžak and Valjevac (VESIĆ *et al.* 2011). BLAŽENČIĆ (2014) reported one new finding in a puddle on the left bank of the Danube River across from the Lido Beach (Belgrade-Zemun).

In the present paper, we report five new localities for *N. syncarpa*: a puddle and the Sirota Canal in the marsh Monoštorski Rit, SNR "Gornje Podunavlje" (*leg. Vesić, A., Šinžar-Sekulić, J., 22.05.2013*); a rut near the causeway in the marsh Koviljski Rit, SNR "Koviljsko-Petrovaradinski Rit" (*leg. Vesić, A., 15.08.2013*); and a puddle and a canal in the Obreške Širine, SNR "Obedska Bara" (*leg. Vesić, A., 20.06.2013*).

*Tolypella glomerata* (Desv.) Leonh. 1863 was reported by BLAŽENČIĆ (2014) for two localities: the sandpit "Majdan" near Subotica and ponds by the Danube River near Borča, Belgrade. However, as a result of a later revision of samples by the author, it was established that this species was not found in ponds by the Danube River (an erroneous record), the samples in question belonging to the species *T. prolifera* instead. The sandpit "Majdan" therefore remains the only locality of this species in Vojvodina and Serbia.

BLAŽENČIĆ & STANKOVIĆ (2008) reported *Tolypella intricata* (Trentep. ex Roth) Leonh. 1863 for the first time in SNR "Zasavica", in puddles at the localities of Valjevac and Pačja Bara.

In the present paper, we report two new localities for this species: the Sirota Canal in the marsh Monoštorski Rit, SNR "Gornje Podunavlje" (*leg. Vesić, A., Šinžar-Sekulić, J., 22.05.2013*); and a rut near the causeway in the marsh Koviljski Rit, SNR "Koviljsko-Petrovaradinski Rit" (*leg. Vesić, A., 15.08.2013*).

*Tolypella prolifera* (Ziz ex A. Braun) Leonh. 1863 was reported for the first time by GUELMINO (1973), for the Mrtva Tisa locality, near Senta. Almost 40 years later,

VESIĆ *et al.* (2011) reported a new locality, a puddle in Valjevac, SNR "Zasavica". BLAŽENČIĆ (2014) reported one new finding in a puddle on the left bank of the Danube River, across from the Lido Beach (Belgrade-Zemun).

Here we report seven new findings, i.e., at the following localities: a sandpit near Apatin (*leg. Vesić, A., Šinžar-Sekulić, J., 21.05.2013*); a rut in the marsh Apatinski Rit, SNR "Gornje Podunavlje" (*leg. Vesić, A., Šinžar-Sekulić, J., 21.05.2013*); a puddle and the Sirota Canal in the marsh Monoštorski Rit, SNR "Gornje Podunavlje" (*leg. Vesić, A., Šinžar-Sekulić, J., 22.05.2013*); the Velika Rogozita ephemeral pond on the the edge of the Obreške Širine in SNR "Obedska Bara" (*leg. Vesić, A., 06.06.2013*); and a shallow ditch and a puddle in the aforementioned Obreške Širine (*leg. Vesić, A., 20.06.2013*).

Maps of their distribution are given for most species (Fig. 1). A list of localities with MGRS coordinates is given in Appendix 1. Such maps are not given for only three species, viz., *Chara canescens*, *C. virgata* and *Nitella brachytelea*, since they are known solely on the basis of historical data from the last century.

## DISCUSSION

Floristic diversity of the charophyte algae in the region of Vojvodina, numbering 20 species, represents 86,95% of the charophyte flora of Serbia (BLAŽENČIĆ 2014). By the same token, it represents 45,45 % of the Balkan charophyte flora (BLAŽENČIĆ *et al.* 2006) and between 37,03 and 40,81% of the European flora, given that the number of charophyte species in Europe is estimated to be between 49 and 54 (KRAUSE 1997). Furthermore, it is very high in comparison with the overall charophyte species richness in other regions and countries of Europe (AUDERSET-JOYE *et al.* 2002; BLAŽENČIĆ *et al.* 2006; URBANIAK 2007; AZZELLA 2014; BORYSOVA 2014a; TORN *et al.* 2015).

The explanation for such a high diversity lies in the richness of specific habitats in Vojvodina suitable for charophyte algae development, habitats such as wide areas of river floodplains and the existence of numerous small ponds formed in abandoned excavation pits. The climate of Vojvodina is characterised by unequally distributed precipitation that varies greatly over time and space. For this reason, dry periods are frequent during summer (KATIĆ *et al.* 1979), and that affects the hydrological regime of water bodies. Hence, charophyte habitats in river floodplains are small, shallow and temporary puddles and ruts, which usually dry up during summer. River floodplains are nevertheless known to be centers of diversity for charophytes (BORYSOVA 2014a). Both temporary puddles and excavation pits, as well as canals that are for the most part periodically dredged, are favourable for charophytes because of their ability to colonise newly created habitats (SIMONS & NAT 1996; BELTMAN & ALEGRINI 1997; BAILLY & SCHAEFER 2010; URBANIAK & GĄBKĄ 2014; GALLEGÓ *et al.* 2015;

MOURONVAL *et al.* 2015). This ability is a result of specific features of their resistant oospores, which can stay viable for a long period of time and then germinate when suitable conditions are met (CORILLION 1975; CASANOVA & BROCK 1990, 1999; KRAUSE 1997; BONIS & GRILLAS 2002).

Besides the total number of species, particularly interesting is the ratio of the number of species of the genus *Chara* to the number of species of the genus *Nitella*. In different regions of the world, this ratio varies between 2:1 and 6:1 (BORYSOVA 2014a), but in Vojvodina it is almost 1:1. The value of the given ratio is related to ecological preferences of *Nitella* species for certain types of habitats, such as temporary puddles in river floodplains, as opposed to *Chara* species, which dominate in lakes (BORYSOVA 2014b). As previously mentioned, Vojvodina is very rich in different kinds of river floodplain habitats, but lacks habitats such as lakes. The ecological preferences of *Nitella* species are confirmed by the fact that they were not found in excavation pits, which is in accordance with the results of other research (LAMBERT-SERVIEN *et al.* 2006).

Particularly interesting and important are the findings of species of the genus *Tolypella*. In Serbia, the species *Tolypella glomerata*, *T. intricata* and *T. prolifera* were found only on the territory of Vojvodina. Moreover, the findings of *T. intricata* and *T. prolifera* are the only reliable data indicating the presence of these species in the entire region of the Western and Central Balkans. Besides *Tolypella* species, *Nitellopsis obtusa* and *Nitella confervacea* were also found only on the territory of Vojvodina, while *Chara hispida*, *C. intermedia*, *C. tenuispina* and *Nitella capillaris* (Krock.) J. Groves & Bull.-Webst. were found in Serbia more than 100 years ago, making the findings in Vojvodina the only reliable data for the entire territory of Serbia. *Chara intermedia* is a new species for the flora of Vojvodina. All charophyte species that are found in Vojvodina are rare and threatened in Serbia (BLAŽENČIĆ 2014), the Balkans (BLAŽENČIĆ *et al.* 2006) and most European countries (PALMER 2008; CAISOVA & GĄBKA 2009; AUDERSET-JOYE & SCHWARCER 2012; KORSCH *et al.* 2013; AZZELLA 2014). *Tolypella* species are among the rarest representatives of the order Charales, making their finding very interesting and valuable.

Species of the genus *Tolypella*, together with the species *Nitella capillaris*, have very specific ecological characteristics and are considered typical spring species (CORILLION 1975; GOLLERBAH & KRASAVINA 1983; COMELLES 1984; BAILLY & SCHAEFER 2010; AUDERSET-JOYE & SCHWARCER 2012; CIRUJANO BRACAMONTE *et al.* 2013; MOURONVAL *et al.* 2015), meaning that they develop very early during the spring and have the ability to finish their life cycle quickly, before their habitat dries up during summer droughts. Other *Nitella* species, such as *N. opaca*, *N. gracilis* and even *N. syncarpa*, are generally found in different types of habitats, ones that are permanent and often deep. However, in the specific conditions of their habitats in Vojvodina, which are small, shallow and liable

to dry up quickly, these species also behave as spring species (AUDERSET-JOYE & SCHWARCER 2012; MOURONVAL *et al.* 2015). Studies have shown that desiccation and high temperatures can be stimulating factors for early development of charophytes (BONIS & GRILLAS 2002; DE WINTON *et al.* 2004; GĄBKA & OWSIANNY 2005; CALERO *et al.* 2015). We therefore consider it very important to conduct field explorations during the springtime.

*Chara braunii* is also a species found in shallow ephemeral water bodies, often eutrophic, which is in accordance with the literature data (URBANIĄK 2007; BAILLY & SCHAEFER 2010; MOURONVAL *et al.* 2015).

Contrary to the species found in temporary puddles and ruts, *Chara hispida* and *C. intermedia* are found exclusively in sandpits, which are deeper, more durable and with a sandy substrate. Both species are characterised by wide ecological tolerance and plasticity (LACOUL & FREEDMAN 2006; GĄBKA *et al.* 2007; BAILLY & SCHAEFER 2010; URBANIĄK *et al.* 2011). However, they prefer habitats that are permanent, deeper, with clear and alkaline water and a sandy or silty-sandy substrate (CORILLION 1957, 1975; SIMONS & NAT 1996; AUDERSET-JOYE & SCHWARCER 2012; BARINOVA *et al.* 2014; URBANIĄK & GĄBKA 2014; REY-BOISSEZON & AUDERSET-JOYE 2015), which is in accordance with their findings in Vojvodina. The basic geological substrate in Vojvodina is loess, a soil that is very rich in calcium-carbonate (ŽIVKOVIĆ *et al.* 1972). We expect these species to be even more frequent, but to demonstrate that, it is necessary to explore these kinds of water bodies more thoroughly. Findings of *Chara tenuispina*, as one of the rarest and most threatened of European charophytes (GĄBKA 2007; AUDERSET-JOYE & SCHWARCER, 2012; KORSCH *et al.* 2013), are also very important and ecologically interesting.

*Nitellopsis obtusa*, found only at several localities in the vicinity of Banatska Palanka, is also a very rare species in Serbia, but the population in the Danube bay of Dolnice can be considered stable, since it has been confirmed several times during the last 15 years or so. The habitats of *N. obtusa* are specific and, in contrast to other charophyte habitats, are characterised by relatively deep, clear and mesotrophic water, allowing it to form vast underwater meadows. This species was also confirmed by other authors (COOPS *et al.* 1999; CRISTIFOR *et al.* 2003) for the Danube River and lakes in the Danube's floodplain.

*Chara globularis*, *C. vulgaris*, *C. contraria* and *Nitella mucronata* are the most frequently found charophytes in Vojvodina. These species are known to be ecologically eurytolerant and widely distributed (SIMONS & NAT 1996; KRAUSE 1997; AUDERSET-JOYE *et al.* 2002; LACOUL & FREEDMAN 2006; CAISOVA & GĄBKA 2009; BAILLY & SCHAEFER 2010; URBANIĄK *et al.* 2011; BORYSOVA 2014a; VESIĆ *et al.* 2014). *Nitella mucronata* is estimated to be critically endangered in Serbia (BLAŽENČIĆ 2014), but the status of this species is likely to be changed in the future in accordance with the latest discoveries. Although

BLAŽENČIĆ *et al.* (1995) did not find *C. globularis* in their research, they assumed that this species occurs in Vojvodina because there are suitable habitats in this area. The most recent explorations confirmed their viewpoint. On the other hand, opposite to the assumption given by BLAŽENČIĆ *et al.* (1995), *Chara vulgaris* and *C. contraria*, species „famous“ as colonisers, were found less frequently than expected in the latest explorations. They were found more often compared to other, very rare, species, but not as often as one might expect. Still, we consider that more frequent field studies will show this posture to be true. The authors also expressed their doubts about the findings of *C. canescens*, saying that this species could not be found in the kind of habitat mentioned in the literature (STOJANOVIĆ *et al.* 1994). The given species has never since been found, supporting this contention.

In view of the fact that 11 more species have been discovered since the previous review (BLAŽENČIĆ *et al.* 1995), an important conclusion which can be drawn is that more frequent explorations are needed and should be extended to cover the whole year, with particular attention paid to the early spring period. Charophyte findings in SNR „Zasavica“ (VESIĆ *et al.* 2011) and SNR „Gornje Podunavlje“, the richest areas in Serbia with nine species of charophyte algae found, support this view. It is also important to intensify research and expand it to include the whole territory of Serbia. Most of the charophyte algae in Serbia are rare and critically endangered species (BLAŽENČIĆ 2014) which we consider to be underexplored in the first place.

Since most of the charophyte findings in the latest investigations were located in protected areas of Vojvodina, we can suspect that the rest of its territory for some reason is not suitable for charophytes. Given that more than 80% of the territory of Vojvodina is used for agriculture (SEKULIĆ *et al.* 2011), we can assume that the „reasons“ for the aforementioned situation can be sought in this anthropogenic pressure. Although human influence can sometimes be beneficial for charophytes as a dispersal vector (BONIS & GRILLAS 2002), we are of the opinion that this agent should not be used as a „protective“ measure, as suggested by some authors (AUDERSET-JOYE & SCHWARZER 2012). Instead, more comprehensive measures should be enforced aiming to protect not only charophytes, but entire habitats and ecosystems, with all the species supported by them.

## CONCLUSION

The charophyte flora of Vojvodina includes 20 species, belonging to four genera. Nine species belong to the genus *Chara*: *C. braunii*, *C. canescens*, *C. contraria*, *C. globularis*, *C. hispida*, *C. intermedia*, *C. tenuispina*, *C. virgata* and *C. vulgaris*. The genus *Nitellopsis* is represented with one species, *N. obtusa*. Seven species belong to the genus *Nitella*: *N. brachytelea*, *N. capillaris*, *N. confervacea*, *N. gracilis*, *N.*

*mucronata*, *N. opaca* and *N. syncarpa*. The genus *Tolypella* is represented with three species: *T. glomerata*, *T. intricata* and *T. prolifera*. Compared to the last summary, given in 1995, when nine species were reported, eleven more species are known today. Concerning habitat preferences, charophytes of Vojvodina are mainly found in three types of habitats, namely puddles and ruts in river floodplains, different kinds of excavation pits and periodically dredged canals. Most of the known localities are in the protected areas of Vojvodina.

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## Botanica SERBICA



## REZIME

## Prilog poznavanju harofita (Charales) Vojvodine – 20 godina posle prvog prikaza

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Ovaj rad sumira podatke o florističkom bogatstvu, distribuciji i stanišnim preferencama algi reda Charales (harofita, pršljančica) na teritoriji Vojvodine (Srbija). Istorijski podaci su prikupljeni pregledom dostupne literature i herbarijumskog materijala o harofitama Vojvodine, od početka njihovog istraživanja, u XIX veku, do danas. Povrh toga, detaljna terenska istraživanja sprovedena su u periodu od 2012. do 2014. godine. U poslednjoj studiji u kojoj je dat prikaz distribucije i ekologije harofita Vojvodine, iz 1995. godine, navodi se devet vrsta. U ovom trenutku, 20 godina kasnije, poznato je još 11 vrsta harofita. Sveukupno, flora harofita Vojvodine predstavljena je sa 20 vrsta, koje su svrstane u četiri roda: *Chara*, *Nitellopsis*, *Nitella* i *Tolypella*. Svi prostorni podaci su georeferencirani i date su mape distribucije vrsta. Kada je reč o stanišnim preferencama, harofite su u najvećem broju slučajeva nađene na tri tipa staništa, lokvama i kolotrazima u plavnim područjima reka, barama nastalim u različitim vrstama površinskih kopova, kao i u kanalima u kojima se periodično vrši izmuljavanje. Većina lokaliteta na kojima su harofite nađene nalazi se u zaštićenim područjima Vojvodine.

**KLJUČNE REČI:** harofite, bogatstvo vrsta, distribucija, stanište

