

Short communication

New records of *Salicornia* s.l. in Montenegro and Bosnia and Herzegovina

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Abstract – Floristic investigations on the eastern part of Adriatic coast in Montenegro and Bosnia and Herzegovina led to the discovery of three glasswort taxa new for the area: *Arthrocaulon macrostachyum* (Moric.) Piirainen et G. Kadereit and *Salicornia procumbens* Sm. subsp. *procumbens* and *S. perennis* Mill. All three taxa were recorded in the abandoned basins of Tivat Saline in Montenegro, while *S. perennis* was also found in the Klek Peninsula in Bosnia and Herzegovina. According to the IUCN criteria, the status of the newly reported taxa was classified as “critically endangered” (CR) in both countries.

Keywords: *Arthrocaulon macrostachyum*, new records, *Salicornia perennis*, *Salicornia procumbens*

Introduction

Due to coexistence in similar ecological environments, representatives of glassworts (*Salicornia* s.l. (incl. *Sarcocornia* A.J. Scott) and *Arthrocnemum* Moq.) have developed characteristic morphological traits, such as succulent, articulated and apparently leafless stems. Although they are easy to recognize, sometimes it is difficult to distinguish between species or even between the related genera. According to the literature sources (Kutleša and Lakušić 1964, Kaligarič and Škornik 2007, Kaligarič et al. 2008, Stešević and Caković 2013, Barina et al. 2018, Nikolić 2020), the following glasswort species/aggregates have been reported along the eastern Adriatic coast (SVN – Slovenia, HRV – Croatia, BIH – Bosnia and Herzegovina, MNE – Montenegro, ALB – Albania): *Arthrocaulon macrostachyum* (SVN, HRV, BIH, ALB), *Salicornia fruticosa* (SVN, HRV, BIH, MNE, ALB), *S. perennis* (HRV, ALB), *Salicornia europaea* aggr. (SVN, HRV, MNE, ALB) and *S. procumbens* aggr. (SVN, HRV, ALB). To date, *Arthrocaulon macrostachyum*, *Salicornia perennis* and *S. procumbens* have not been included in the Checklist of Vascular Plants in Montenegro (Stešević and Caković 2013), while *Salicornia perennis* has not been recorded from BIH (Kutleša and Lakušić 1964), so

the current results represent the first records in this part of the Adriatic coast.

The aim of this paper is to present new records of the glassworts *A. macrostachyum*, *S. perennis* and *S. procumbens* on the eastern Adriatic coast and to highlight their importance for nature conservation.

Material and methods

Field investigation was conducted along the eastern Adriatic coast in Montenegro and Bosnia and Herzegovina. The collected plant material was deposited in the Herbarium Collection of the University of Montenegro (TGU) and in the Herbarium of the Faculty of Forestry University of Banja Luka under the following voucher numbers: TGU 1570521 (*Arthrocaulon macrostachyum*), TGU 1570524 (*Salicornia perennis*), SFUNIBL 753/2017 (*Salicornia perennis*) and TGU 1644085 (*Salicornia procumbens* subsp. *procumbens*). Specimens were identified according to Kaligarič et al. (2008), Kadereit et al. (2012) and Piirainen et al. (2017). Phytosociological relevés were recorded according to the Braun-Blanquet method (1964) and included in the Vegeta-

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tion Database of Montenegro (EU-ME-001, <http://www.givd.info/ID/EU-ME-001>). The nomenclature of the taxa given in Tab. 1, and in the text follows Euro+Med (2006), except for the *Arthrocaulon* and *Salicornia* (Piiirainen et al. 2017).

Results and discussion

***Arthrocaulon macrostachyum* (Moric.) Piiirainen & G. Kadereit** (syn. *Salicornia macrostachya* Moric., *Arthrocnemum macrostachyum* (Moric.) K. Koch, *Salicornia virginica* Forssk., *Salicornia glauca* Delile). The species is reported at several sites within Tivat Saline in Montenegro, at the edge of the front basin and on one of its islets. At all its micro-localities *A. macrostachyum* grows in association with *Salicornia fruticosa* L., but the cover of its individuals changes with the inundation period by the sea. Table 1 shows the four ecological microsites with *A. macrostachyum* from the slightly elevated site, which has the shortest exposure to direct seawater impact, to the rapid alternation of dry and wet phases, where it grows in a monodominant community (Tab. 1, rel. 1) to the longest flooded site, where it grows in the association *Puccinellia festucaeformis*-*Sarcocornietum fruticosae* (Braun-Blanquet 1928) Géhu 1976 (Tab. 1, rel. 4).

According to the IUCN (2012) criteria *A. macrostachyum* is considered Critically Endangered (CR) in Montenegro (Tab. 2).

***Salicornia perennis* Mill.** (syn. *Sarcocornia perennis* (Mill.) A. J. Scott, *Arthrocnemum perenne* (Mill.) Moss). The species is found in Tivat Saline in Montenegro and in the Klek Peninsula in Bosnia and Herzegovina.

Salicornia perennis is more widespread in Tivat Saline than *A. macrostachyum*; it occurs not only in the slightly elevated and drier parts of the front basin, but also in the back basins, which are not exposed to the direct influence

of seawater and are outside the tidal framework. Table 1 shows the phytosociological relevés with *S. perennis* recorded at different sites in Tivat Saline, starting with the wettest site, where *S. fruticosa* dominates, while *S. perennis* occurs only sporadically (rel. 5), through the transitional and less humid and flooded variants (rels. 6, 7), to the monodominant stands of *S. perennis* in the back basins, which are completely dry and out of the tidal range from May onwards (rels. 8, 9).

In Bosnia and Herzegovina, *S. perennis* is an extremely rare species that is found in a narrow zone of salt-sprayed rocky cliffs. It grows in flattened and sheltered parts of *Plantagini-Limonietum cancellati* Horvatić (1934) 1939, together with *Limbarda crithmoides* (L.) Dumort., *Crithmum maritimum* L., *Limonium cancellatum* (Bernh. ex Bertol.) Kuntze, *Juncus acutus* L., *Sonchus maritimus* L., *Reichardia picroides* (L.) Roth, etc.

According to the IUCN (2012) criteria, *S. perennis* is classified as Critically Endangered (CR) in both Montenegro and Bosnia and Herzegovina (Tab. 2).

Salicornia procumbens* Sm. subsp. *procumbens (syn. *S. emericii* Duval-Jouve, *S. herbacea* var. *stricta* G. Mey., *S. procumbens* var. *stricta* (G. Mey.) J. Duvign. & Lambinon in Lambinon & al., *S. oliveri* Moss, *S. dolichostachya* Moss, *S. strictissima* Gram, *S. fragilis* P.W. Ball & Tutin, *S. lutescens* P.W. Ball & Tutin, *S. ramosissima* var. *vicensis* J. Duvign., *S. vicensis* (J. Duvign.) J. Duvign., *S. emericii* var. *peltii* Géhu, Géhu-Franck & Caron, *S. veneta* Pignatti & Lausi, *S. borys-thenica* Tzvelev) was found in Tivat Saline, both in the front and in the back basins as well as along the channels of the seawater drainage system on mudflats exposed to a regular tidal regime and nutrient flux, forming mostly immersed pioneer communities that are monospecific (Tab. 1, rel. 10) or of low species richness (Tab. 1, rels. 11-13). All relevés

Tab. 1. Phytosociological table of the vegetation with *Arthrocaulon macrostachyum* (rels. 1-4), *Salicornia perennis* (rels. 5-9) and *Salicornia procumbens* subsp. *procumbens* (rels. 10-13) in the Tivat Saline, Montenegro.

Relevé no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Plot size (m ²)	25	25	25	25	25	25	25	25	25	25	25	4	25
Vegetation cover (%)	60	40	70	90	100	80	40	80	95	30	70	80	60
<i>Arthrocaulon macrostachyum</i> (Moric.) Piiirainen & G. Kadereit	4	3	3	1	.	.	.	.	.	.	.	.	.
<i>Salicornia perennis</i> Mill.	.	.	.	.	+	3	3	3	2	.	.	.	+
<i>Salicornia fruticosa</i> (L.) L.	1	2	3	5	5	3	2	.	.	.	.	1	+
<i>Salicornia procumbens</i> Sm. subsp. <i>procumbens</i>	.	.	.	.	.	.	.	.	.	3	4	4	4
<i>Limonium narbonense</i> Mill.	.	.	.	1	1	2	.	2	3	.	+	1	1
<i>Puccinellia festuciformis</i> (Host) Parl.	.	.	.	1	1	2	.	2	2	.	+	1	.
<i>Atriplex portulacoides</i> L.	.	.	.	.	.	.	+	3	4	.	.	1	.
<i>Hordeum marinum</i> Huds.	.	.	.	.	.	.	.	1	+	.	.	.	.
<i>Plantago coronopus</i> L.	.	.	.	.	.	.	.	+	.	.	.	.	.
<i>Parapholis incurva</i> (L.) C.E.Hubb.	.	.	.	.	.	.	.	+	.	.	.	+	.
<i>Spergularia marina</i> (L.) Besser	.	.	.	.	.	.	.	+	.	.	.	.	.
<i>Triglochin maritima</i> L.	.	.	.	.	.	.	.	.	.	.	.	1	.

Tab. 2. Assessment of the status of the *Arthrocaulon macrostachyum*, *Salicornia perennis* and *Salicornia procumbens* subsp. *procumbens* in Montenegro (MNE) and Bosnia and Herzegovina (BIH) according to the IUCN criteria.

Taxon	<i>Arthrocaulon macrostachyum</i>	<i>Salicornia perennis</i>	<i>Salicornia procumbens</i> subsp. <i>procumbens</i>	
Country	MNE	MNE	BIH	MNE
Category	Critically Endangered (CR)	Critically Endangered (CR)	Critically Endangered (CR)	Critically Endangered (CR)
Assessment criteria	B2; B2a; B2biii	B2; B2a; B2biii	D	B2; B2a; B2biii
Date of assessment	September 2019	September 2019	October 2018	September 2019
Population size	ca. 500 mature individuals	Very large	Less than 30 individuals	Very large
Habitat and ecology	Coastal salt marshes in intertidal area with varying degrees of inundation. Frequently occurs in saline sandy to clayey soils, mostly accompanied by <i>Salicornia fruticosa</i>	Coastal salt marshes, on mudflats exposed to regular tide regime and rich nutrient flow	Sheltered salt-sprayed rocky cliffs	Coastal salt marshes, on mudflats exposed to regular tide regime and rich nutrient flow
Threats	Ecosystem modification, changes in shoreline morphology, changes in the tidal regime, accelerated sea-level rise due to climate changes	Ecosystem modification, changes in shoreline morphology, changes in the tidal regime, accelerated sea-level rise due to climate changes	Urbanization, water pollution, waste deposition	Ecosystem modification, changes in shoreline morphology, changes in the tidal regime, accelerated sea-level rise due to climate changes
Estimated by	D. Stešević	D. Stešević	Đ. Milanović	D. Stešević

could be assigned to *Salicornietum emerici* O. Bolós ex Brullo et Furnari 1976.

According to the IUCN (2012) criteria, *S. procumbens* Sm. subsp. *procumbens* is classified as Critically Endangered (CR) in Montenegro (Tab. 2).

The morphological similarity of genera and species of certain halophytic succulents from the subfamily *Salicornioideae*, compounded by the lack of studies dealing with the diversity of this group, could be considered the main reasons why it took so long to identify and report *A. macrostachyum*, *S. perennis* and *S. procumbens* subsp. *procumbens* in the studied parts of the eastern Adriatic coast. Based on the experience gained in recent surveys at two studied sites in Montenegro and Bosnia and Herzegovina, further work on glasswort chorology all along the eastern Adriatic coast is recommended. Indeed, *S. perennis* is confirmed at both localities where only *S. fruticosa* is previously reported (Kutleša and Lakušić 1964, Janković and Stevanović 1983), while *S. procumbens* subsp. *procumbens* is reported at Tivat Saline where this annual glasswort has been treated as *S. herbacea* s.l. (Janković and Stevanović 1983). Inspection of a small number of existing digitised herbarium specimens from Croatia (using the platform of the Flora Croatica Database, Nikolić 2020), shows that the glasswort is still frequently confused and misidentified by many botanists (e.g. *Arthrocaulon macrostachyum* is frequently confused with *Salicornia fruticosa*).

Recent studies of annual glassworts (Kadereit et al. 2012, Kaligarić et al. 2008, Šajna et al. 2013) have shown that two annual species occur on the Adriatic coast: the tetraploid *S. procumbens* and the diploid *S. perennans* Willd. Along the inundation gradient, tetraploid species usually alternate

with diploid. The vegetation belts containing these species are clearly distinguishable in late autumn when *S. procumbens* turns red and *S. perennans* remains dully green (Fanelli et al. 2015). During our field surveys we did not find *S. perennans* individuals, but since our transects did not cover the entire area of the saline, as well as the late autumn aspect, the reports of *S. procumbens* do not exclude the possibility that diploid *S. perennans* species also grow in the back basin of the saline. Thus, further investigation is required.

Based on the IUCN category assessment, we propose the newly reported glasswort species as candidates for the national list of protected plant species: *Arthrocaulon macrostachyum*, *Salicornia procumbens* subsp. *procumbens* and *S. perennis* in Montenegro and *S. perennis* in Bosnia and Herzegovina.

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Appendix

Data and coordinates (WGS84) of the relevés (Tab. 1). All relevés were collected at 0 m.a.s.l., except relevés 8 and 9, collected at 1 m.a.s.l. Rel. 1 – 2019/09/20, 42.39742N 18.71352E; Rel. 2 – 2019/09/20, 42.3973N 18.71381E; Rel. 3 – 2019/09/20, 42.375N 18.7303E; Rel. 4 – 2019/09/20, 42.39553N 18.71223E; Rel. 5 – 2019/08/15, 42.39092N 18.7185E; Rel. 6 – 2019/09/20, 42.39156N 18.71871E; Rel. 7 – 2019/09/20, 42.39203N 18.71695E; Rel. 8 – 2019/07/06, 42.39829N 18.71825E; Rel. 9 – 2019/08/15, 42.39791N 18.71889E; Rel. 10 – 2019/09/02, 42.39525N 18.71759E; Rel. 11 – 2019/09/02, 42.39376N 18.71843E; Rel. 12 – 2019/05/03, 42.39226N 18.71006E; Rel. 13 – 2019/09/20, 42.39488N 18.71912E.