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Original scientific paper

OVERVIEW OF BRYOPHYTE FLORA OF THE ULCINJ SALINE (MONTENEGRO)

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Bryological investigations conducted in 2023 at the Ulcinj Saline and its surroundings revealed significant bryophyte biodiversity, with six liverwort species and 33 moss species recorded. Notably, the discovery of the genus *Riella* and three new species for the flora of Montenegro (*Riella macrocarpa*, *Riccia canaliculata*, and *Tortula pallida*) is particularly significant. As this was the first time these studies were conducted, the recorded number of species cannot be considered final. Further research is needed for a more accurate assessment of biodiversity and the identification of potential threats. The data obtained will be crucial for planning conservation measures for this ecosystem.

Key words: Ulcinj Saline; bryophyte biodiversity; new species; conservation measures; Montenegro

INTRODUCTION

The Ulcinj Saline, located in the Ulcinj Municipality of Montenegro, is one of the largest saline areas in the Mediterranean region, including its immediate surroundings. In the 19th century, it was known as Zoganjsko Blato—a vast, impassable marshland of about 25 km² characterized by brackish water (Sovinc et al. [1]). To combat malaria, drainage works connected the area to the sea via the Port Milena canal and enclosed it from the Bojana River with embankments. The Ulcinj Saline was established in 1920 and constructed between 1927 and 1934, resulting in the first salt harvest in 1935. Notable for its salt production and rich biodiversity—comprising a total of 201 recorded plant species, about 250 bird species, 18 fish species, 1 amphibian species, and 7 reptile species—it was designated as a protected bird area in 1989. Over the years, it has become a crucial site for ornithological research, confirming its significance as the most important bird habitat along the eastern Adriatic coast. This area serves as a nesting site, wintering ground, and stopover for migratory birds traveling to and from Africa. In 2005, privatization halted salt production, altering the ecosystem; however, the area's biodiversity has been preserved. As a result, in 2019, it was designated a Nature Park and listed on the Ramsar List (Sovinc et al. [1]).

Despite the fact that the first data on Montenegrin bryophytes were obtained in the second half of the 19th century, and numerous foreign researchers have been involved, the bryophyte flora of Montenegro remains insufficiently studied, with some areas lacking data. According to the most recent European bryophyte checklist (Hodgetts & Lockhart [2]), Montenegrin bryophyte flora consists of over 700 taxa. The earliest data on the bryophyte flora of Ulcinj pertain to the hinterland of Ulcinj's Long Beach (Velika plaža), which has proven particularly interesting, as 54 bryophyte species (6 liverworts and 48 mosses) were recorded in that area. Among them were the second recorded findings of the liverworts Riccia cavernosa Hoffm. and R. trabutiana Steph. (Dragićević, [3, 4]). These findings suggest that the area is promising for further research. However, the Ulcinj Sa-

line was considered potentially uninteresting due to its saline and predominantly anthropogenic habitats, except for the expected presence of species that prefer wetland habitats, which has not yet been confirmed. There is only one published record regarding the presence of the moss Entosthodon hungaricus (Boros) Loeske, which was recorded along a path that separates the water basins from the area protected for birds (Ellis et al. [5]).

MATERIAL AND METHODS

The methodology for fieldwork was established following a preliminary reconnaissance of the target area. The point-sampling method was chosen, which involves collecting material from selected locations to cover all available and accessible natural, semi-natural, and anthropogenic habitats, as well as various substrates. Fieldwork was conducted between April and May 2023, and each site was geopositioned (see Table 1). The collected bryophyte samples were placed in bryological paper envelopes, with each sample containing information such as location, collection date, habitat, substrate, and collector's name. The bryophytes were air-dried without pressure. Species identification was performed using a microscope and hand lens, consulting contemporary bryological literature (Smith [6, 7]; Paton [8]; Frahm & Frey [9]; Frey et al. [10]; Atherton et al. [11]; Erzberger & Schröder [12]; Preston [13]; Hedenäs [14]; Lüth [15]). Nomenclature followed Hodgetts et al. [16] (2020), and the international status of species was based on Hodgetts et al. [17]. The collected bryophytes are preserved in the collector's private collections and in the herbarium of the Natural History Museum of Montenegro (NHMM).

Site details

Table 1. GPS coordinates of the locations where the material was sampled

Location	Coordinates, short description of locations, substrate
1	41.917184 N, 19.253827 E, degraded area, outside the pools that were filled with sea water, poor with grassy vegetation, gravel and sand soil
2	41.916815 N, 19.255880 E, embankment along the path between the canal and the pools, densely covered with herbaceous types of vegetation, soil
3	41.917096 N, 19.257812 E, embankment along the path between the canal and the pools, densely covered with herbaceous plants, soil
4	41.918415 N, 19.261633 E, pool for salt crystallization, sandy substrate with rare halophyte species, dominated by the invasive species *Cynodon dactylon*
5	41.918416 N, 19.271174 E, the surroundings of the engine building, canal without water, from soil and the concrete wall above
6	41.921855 N, 19.274982 E, footpath between the pools, gravel and sand soil
7	41.926411 N, 19.286792 E, difficult to pass footpath between the pools, with *Tamarix dalmatica, Rubus ulmifolius, Juncus* sp., gravel and sand soil
8	41.927308 N, 19.274971 E, drying stripe-like temporary pond with slightly concave bottom in the abandoned salt crystallization pond
9	41.927399 N, 19.274524 E, dirt footpath between the pools and channel along the edge of Saline, soil
10	41.927312 N, 19.273431 E, slope bank of the channel, soil
11	41.929655 N, 19.273433 E, a temporary stream in an unshaded drainage channel between fields, soil
12	41.926598 N, 19.270432 E, slope bank of the channel, soil
13	41.923565 N, 19.271397 E, pool for salt crystallization, occasionally under water, sand soil
14	41.918730 N, 19.252710 E, temporary inundated wetland in abandoned salt crystallization pond overgrown with sparse and irregularly spaced *Bolboschoenus maritimus*
15	41.919590 N, 19.253351 E, storage pool
16	41.920370 N, 19.255989 E, embankment along with storage pools, gravel and sand soil
17	41.921493 N, 19.259227 E, embankment along with storage pools, gravel and sand soil
18	41.921756 N, 19.260493 E, fenced area around an abandoned building, shade, moist, gravel and sandy soil
19	41.921251 N, 19.262237 E, pool for salt crystallization, body with water, sand soil
20	41.935469 N, 19.293316 E, slope bank of the channel, soil
21	41.9145 N, 19.2979 E, abandoned salt evaporation pond
22	41.9127 N, 19.3198 E, temporary pond in the abandoned salt evaporation pond
23	41.9233 N, 19.3240 E, abandoned salt evaporation pond

RESULTS AND DISCUSSION

Bryological research conducted at the Ulcinj Saline and its immediate surroundings across 23 locations has identified the area as highly significant (Figure 1), with 6 liverwort species and 33 true moss species recorded (Table 2). This number cannot be considered final, as the research did not encompass a critical period for this part of Montenegro—the end of winter and early spring. The significance of this area is underscored by the presence of certain taxa that were first recorded in the national moss flora, including the genus *Riella* and three species: *Riella macrocarpa* (Dragićević [18]), *Riccia canaliculata* Hoffm. (Ellis et al. [20]), and *Tortula pallida* (Lindb.) R. H. Zander. Additionally, some species with only one or two previously known occurrences in Montenegro were also observed. A list of recorded species, along with the importance of their records at the national level, is provided in Table 2.

Figure 1. Protected area Ulcinj Saline, positions of sites (1–23) where bryophytes were sampled (map source: Google Earth)

Table 2. List of species recorded at the Ulcinj Saline and its surroundings in 2023 with importance of species records at the national level

Liverworts (Marchantiophyta)			
Family	Species	Sites	Significance of the area for the species
Fossombroniaceae Hazsl.	*Fossombronia caespitiformis* (Raddi) De Not. ex Rabenh. subsp. *multispira* (Schiffn.) J. R. Bray & Cargill	9, 10, 12, 20	Second data for the national moss flora
Lunulariaceae H. Klinggr.	*Lunularia cruciata* (L.) Dumort. ex Lindb.	10, 20	—
Ricciaceae Rchb.	*Riccia canaliculata* Hoffm.	11	New species for Montenegro
	Riccia sorocarpa Bisch.	11	—
	Riccia crozalsii Levier	11	—

Table 2. Continues

Riellaceae Engl.	***Riella*** *macrocarpa* (P. Allorge) Puche, Segarra, Sabovlj., M. Infante & Heras	8, 13, 14, 15, 19, 21, 22, 23	New genus and new species for Montenegro
Mosses (Bryophyta)			
Family	Species	Sites	Significance of the area for the species
Brachytheciaceae Schimp.	*Homalothecium lutescens* (Hedw.) H. Rob.	5	—
	Homalothecium sericeum (Hedw.) Schimp.	5	—
	Rhynchostegium confertum (Dicks.) Schimp.	5	—
	Rhynchostegium megapolitanum (Blandow ex F.Weber & D.Mohr) Schimp.	2, 5, 11	Found at the Montenegrin coast after 90 years
	Rhynchostegiella litorea (De Not.) Limpr.	6	Found at the Montenegrin coast after 90 years
	Scorpiurium circinatum (Bruch) M.Fleisch. & Loeske	5, 7	—
	Scleropodium touretii (Brid.) L.F.Koch	5	Second recent finding
Bryaceae Schwägr.	*Bryum argenteum* Hedw.	1, 2, 3, 4, 5, 6, 7, 16, 17, 18	—
	Bryum canariense Brid.	2	First recent finding after more than 40 years
	Bryum sp. (without sporophyte)	4, 18	—
	Ptychostomum capillare (Hedw.) Holyoak & N.Pedersen	1, 2, 5, 6	—
	Ptychostomum compactum Hornsch.	6, 7	Second record in Montenegro
	Ptychostomum pseudotriquetrum (Hedw.) J.R.Spence & H.P.Ramsay ex D.T.Holyoak & N.Pederson	11	—
Dicranellaceae M.Stech	*Dicranella howei* Renauld & Cardot	1, 5, 6	—
Fissidentaceae Schimp.	*Fissidens incurvus* Starke ex Röhl.	5	Found at the Montenegrin coast after 90 years.
	Fissidens taxifolius Hedw.	10, 20	—
	Fissidens viridulus (Sw.) Wahlenb.	5	—
Funariaceae Schwägr.	*Funaria hygrometrica* Hedw.	1, 6, 7, 18	—
Grimmiaceae Arn.	*Grimmia pulvinata* (Hedw.) Sm.	4	—
Orthotrichaceae Arn.	*Orthotrichum diaphanum* Brid. ()	12	—
Pottiaceae Schimp.	*Aloina aloides* (Koch ex Schultz) Kindb.	6	The first finding after 2007
	Barbula unguiculata Hedw.	1, 2, 3, 6, 7, 18	—
	Didymodon acutus (Brid.) K.Saito	5, 6, 7, 17	—

Table 2. Continues

Didymodon luridus Hornsch.	5, 17	—
Syntrichia princeps (De Not.) Mitt.	2	First record in Montenegro after 40 years
Syntrichia ruralis (Hedw.) F.Weber & D.Mohr	1, 2, 3, 4, 5, 6, 7, 16, 17, 18	—
Tortella nitida (Lindb.) Broth.	1, 2, 4, 5	—
Tortella squarrosa (Brid.) Limpr.	1, 2, 3, 5, 6, 7, 16, 17, 18	—
Tortella tortuosa (Hedw.) Limpr.	1	—
Tortula muralis Hedw.	3, 4, 5, 7, 18	
Tortula pallida (Lindb.) R. H. Zander	6	New species for Montenegro
Trichostomum brachydontium Bruch	11	—
Weissia sp. (without sporophyte)	2	—

NOTABLE GENUS AND SPECIES, NEW FOR BRYOPHYTE FLORA OF MONTENEGRO

Riella Mont.

Riella macrocarpa (P. Allorge) Puche, Segarra, Sabovlj., M. Infante & Heras.

Location: Ulcinj Saline, temporary pools with stagnant and brackish water, and damp meadows with small inundated depressions, April – May 2023.

Collectors: R. Romanov, S. Dragićević, and V. Biberdžić.

Determination: R. Romanov, S. Dragićević.

Note: More details will be available in the upcoming article (Dragićević [18]).

Riella is a distinctive genus of thallose liverworts typically found in seasonally flooded ponds with fresh and brackish water in Mediterranean climates (Segarra-Moragues et al. [21]). With approximately 28 species globally, it is primarily distributed in arid and semi-arid regions. The highest diversity is observed in the Mediterranean, with 10 species reported (Hodgetts et al. [16]). Spain has the greatest representation in Europe, hosting seven known species. According to IUCN criteria, the status of *Riella* is assessed as endangered (EN) at the global level (Segarra-Moragues et al. [21]).

Riccia canaliculata **Hoffm.**

Location: Ulcinjsko field, north of the Ulcinj Saline, a temporary stream in an unshaded drainage channel, almost dry, on muddy ground, 17th April 2023.

Collector: R. Romanov.

Determination: S. Dragićević

Riccia canaliculata is a circumpolar species found in Atlantic-subatlantic Europe and Southeastern Europe, including Slovenia, Serbia, Greece, and Romania (Hodgetts & Lockhart [2]). This rare species typically inhabits damp mud on the margins of water bodies in subhumid Mediterranean climates. Although it is expected in high mountain lakes in Montenegro, our finding is at a low elevation, similar to occurrences in Britain, Ireland, and Romania, contrasting with its presence in subalpine regions in Serbia and Turkey. *Riccia canaliculata* is recognizable by its terrestrial, bright or yellowish-green thalli, which are 0.2–2 cm long, with trap-like or rosette shapes, dichotomous branching, and faint surface lines. It may be confused with *R. fluitans*, *R. rhenana*, or *R. hueberiana*, but *R. canaliculata* has longer branches (Ellis et al. [20]).

Tortula pallida **(Lindb.) R. H. Zander**

Location: Ulcinj Saline, on soil in an open area near a gravel road (Figure 2A), 2nd April 2023.

Collector/Determination: S. Dragićević, confirmed by J. G. Montes

Tortula pallida is a southern European species that is not common in Europe and is rare in the Balkans, where it has only been documented in Greece (including Crete) and Croatia (Hodgetts & Lockhart [2]; Šegota et al. [22]). The species represents the Mediterranean-Atlantic floral element, typically found in coastal habitats influenced by

salinity, although populations have recently been discovered in inland salt marshes in eastern Germany (Müller [23]; Bosanquet [24]).

Tortula pallida forms small tufts up to 0.5 cm tall, characterized by the shape of its leaf tips and the color of its setae, which distinguish it from the very similar *T. caucasica* found in similar habitats. The leaves of *T. pallida* are usually lingulate or spathulate (Figure 2B), with an obtuse apex, while *T. caucasica* has lanceolate or ovate-lanceolate leaves, rarely lingulate, with an acute apex. Additionally, the capsules of *T. pallida*, which lack a peristome (Figure 2C), typically have brighter yellow setae compared to the reddish setae of *T. caucasica* (Bosanquet [24]).

The species is adapted to the Mediterranean climate with a specific life strategy as a sporadic annual species. It develops its gametophyte and sporophyte during very short, favorable wet periods, surviving drought and heat in the form of spores. At the European level, it has been assigned the IUCN category of Least Concern (LC) (Rimac et al. [25]). At the Ulcinj Saline, a small population was found at only one location, which does not necessarily indicate it is the only one in the area. This moss grows on a gravel saline substrate alongside *Aloina aloides* (Koch ex Schultz) Kindb., *Didymodon acutus* (Brid.) K. Saito, *Tortella squarrosa* (Brid.) Limpr., *Funaria hygrometrica* Hedw., *Bryum argenteum* Hedw., *Syntrichia ruralis* (Hedw.) F. Weber & D. Mohr, and other moss species.

Figure 2. *Tortula pallida*, habitat (A), leaves (B), capsule (C) (photo: S. Dragićević)

CONCLUSION

Our initial research conducted in the Ulcinj Saline and its vicinity has revealed significant gaps in our knowledge of the bryophytes of the Ulcinj area. This region encompasses a large variety of habitats, many of which are important for bryophytes. Therefore, more detailed research is needed, particularly given the increasing pressure from urbanization, which negatively impacts these habitats and leads to their degradation, damage, or permanent loss. Some of the studied habitats are unique and rare in Montenegro, yet they have not been the subject of extensive research, making them relatively unknown (e.g., temporary inundated basins).

For years, there has been a lack of basic data on these habitats and their bryophyte diversity, especially since the conditions during salt extraction and production remain poorly understood. Consequently, the data presented should be regarded as a "baseline" for bryophyte diversity, which will need to be expanded over the next three years to provide a more accurate picture of ecological conditions, existing species, and potential future discoveries. Ongoing research will be crucial for gaining a clearer understanding of this diversity and identifying potential threats to these plants in the area.

Based on this information, conservation activities and measures can be defined for significant species and their habitats, as well as for overall biodiversity. Monitoring of significant species should be integrated into regular monitoring programs, with a focus on developing action plans for their conservation to protect biodiversity in the area.

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ПРЕГЛЕД НА БРИОФЛОРАТА НА УЛЦИЊСКАТА СОЛАНА (ЦРНА ГОРА)

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Биолошките истражувања спроведени во 2023 година на Улцињската солана и нејзината околина откриј значителен биодиверзитет на бриофити, при што се евидентирани шест видови талусни мовови и 33 видови листостеблесни мовови. Имено, откривањето на родот *Riella* и три нови видови за флората на Црна Гора (*Riella macrocarpa, Riccia canaliculata* и *Tortula pallida*) е особено значајно. Со оглед на тоа што овие истражувања првпат беа спроведени на овој простор, регистрираниот број видови не може да се смета за конечен. Потребни се дополнителни истражувања за попрецизна процена на биолошката разновидност и идентификација на потенцијалните закани. Добиените податоци ќе бидат клучни за планирање мерки за зачувување на овој екосистем.

Клучни зборови: Улцињска солана; биодиверзитет на бриофити; нови видови; мерки за зачувување; Црна Гора