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Distribution and threat status of the liverwort
Mannia triandra (Scop.) Grolle (Aytoniaceae,
Marchantiophyta) in Montenegro

Snežana DRAGIĆEVIĆ & Christian BERG

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Distribution and threat status of the liverwort *Mannia triandra* (Scop.) Grolle (Aytoniaceae, Marchantiophyta) in Montenegro

Snežana DRAGIČEVIĆ

Natural History Museum of Montenegro,
Square Vojvode Bećir bega Osmanagića 16, 81000 Podgorica (Montenegro)
snezanadragicevic@canu.ac.me (corresponding author)

Christian BERG

Institute of Biology, University of Graz, 8010 Graz (Austria)

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ABSTRACT

We summarise all known data on the liverwort *Mannia triandra* (Scop.) Grolle in Montenegro. This species was previously only known from literature. During our fieldwork between 2016 and 2022, we were able to detect it in seven parts of the country at 18 localities. It occurs mainly in the south-western part of the country, at altitudes between 40 and 1720 m above sea level, mainly in small caves or crevices in north, north-east and east exposure. These are mostly small populations with only a few individuals. Due to this increase in recent occurrences, Montenegro has a great responsibility for the conservation of this rare species, which is protected and endangered throughout Europe. However, following the IUCN criteria, we estimate that *Mannia triandra* should be considered endangered (VU) in Montenegro, too.

KEY WORDS

Montenegro,
liverwort,
Mannia,
ecology,
conservation status.

RÉSUMÉ

Distribution et statut de menace de l'hépatique Mannia triandra (Scop.) Grolle (Aytoniaceae, Marchantiophyta) au Monténégro.

Nous résumons toutes les données connues sur l'hépatique *Mannia triandra* (Scop.) Grolle au Monténégro. Cette espèce n'était auparavant connue que par la littérature. Au cours de notre travail de terrain entre 2016 et 2022, nous avons pu la détecter dans sept parties du pays correspondant à 18 localités distinctes. Elle se rencontre principalement dans le sud-ouest du pays, à des altitudes comprises entre 40 et 1720 m au-dessus du niveau de la mer, principalement dans de petites grottes ou crevasses exposées au nord, au nord-est et à l'est. Il s'agit le plus souvent de petites populations ne comptant que quelques individus. En raison de l'augmentation des occurrences récentes, le Monténégro a une grande responsabilité dans la conservation de cette espèce rare, qui est protégée et menacée dans toute l'Europe. Cependant, selon les critères de l'IUCN, nous estimons que *Mannia triandra* devrait également être considérée comme en danger (VU) au Monténégro.

MOTS CLÉS

Monténégro,
hépatique,
Mannia,
écologie,
statut de conservation.

INTRODUCTION

Mannia triandra (Scop.) Grolle is a small liverwort forming greyish blue-green, green or somewhat reddish thalli. The thalli, dichotomously branched (branches broadening towards the apex), when moist with reticulate surface, punctate of the simple, slightly elevated pore, in older parts becoming brown and lacunose (Fig. 1). The most complete description was provided by Schill (2006). Lobes are (2)3.2-13.5(16.7) mm long and (0.3)0.9-2.8(4.9) mm wide, with margins sometimes weakly crispate and hyaline with age, purple or green. Ventral scales in two rows, sometimes only sparse or absent, overlapping each other and midline of thallus, purple with sometimes paler margins, semicircular to oblong semicircular, small slime papillae present on margin, abundant. Rhizoids smooth and pegged, hyaline and often purplish or brownish towards base. Gemmae lacking. Autoicous, antheridia located on lateral thallus lobes in a small diffuse group of *c.* 1 mm diameter, or, rarely, paroicous directly behind the archegoniophore. Capsule spherical, dehiscing with a lid, wall-cells thin, spores 50-65 µm, yellowish, granular, exine irregularly alveolate, elaters 8-14 µm wide, yellowish, bi- or trispiral (Damsholt 2002; Schill 2006). The closest species with which *Mannia triandra* could be confused is *Mannia pilosa* (Hornem.) Frye & L. Clark. This is also autoicous, but the antheridia of this species are located on small, ventral branches.

It seems to be an ephemeral, short lived species (Schill 2006), usually disappearing during the dry summer period after spore dispersal in early spring (Németh & Papp 2011). *Mannia triandra* prefers more shady and sheltered habitats, damp ledges, rock crevices, slopes in forests and ravines, often in north or east exposition, on young soil accumulations or on limestone, sandstone, schist, or dolomite rock (Schill 2006; Németh & Papp 2011), or even on moist tree roots (Strgulc Krajšek & Martinčič 2017). It has a holarctic distribution, but is primarily found in Eastern North America and in Europe, and rare in Eastern Asia (Borovichev & Bakalin 2016). It grows from sea level to the subalpine altitudinal zone, from 40-2200 (3450) m a.s.l. (Schill 2006). It occurs mainly in montane-subalpine regions in the European Alps, although it is also found in the lower regions of central and southern Europe (Németh & Papp 2011). According to Hodgetts & Lockhart (2020), it is present in all countries around the Alps, Scandinavia, Central and Eastern Europe and the western and northern Balkan peninsula. It is also known from China, Japan and Russia (Németh & Papp 2011).

In Europe, *Mannia triandra* is considered rare (ECCB 1995). In the latest Red List of European bryophytes, it is listed as vulnerable (VU) by criteria D1 (Hodgetts *et al.* 2019). It is a species of Annex II of the Habitat Directive (plant species of community interest whose conservation requires the designation of special areas of conservation) and of Appendix I of the Bern Convention (species of special protection). It has been protected in Montenegro by national legislation since 2006 (Official Gazette of Republic of Montenegro, no 76/06, 12 December 2006).

Comparatively little is known about this rare species in Europe, and even less in Montenegro. We would like to contribute to the knowledge of the European situation and the threats to the species with new results from Montenegro.

MATERIAL AND METHODS

Field work was carried out from 2016 to 2022 visiting several published localities. Based on this knowledge, we tried to find new locations in potentially suitable situations. For each *Mannia triandra* record, we noted the habitat situation, the exposition, the GPS-coordinates and the altitude with a Garming GPS device using the WGS84 system, subsequently projected to D96TM system. Additionally, we identified any negative impacts (habitats risk factors) at each site to assess endangerment status. Finally, the criteria (A-D) of the IUCN Red List categories were checked (IUCN 2012) for the Montenegrin populations.

As most populations were very small (the surface area of the microhabitat was in most cases well under 1 m²), material was only collected from larger populations around Lake Skadar.

As this work focuses on the current situation of *Mannia triandra*, the analysis of herbarium material from inside and outside Montenegro was not studied.

RESULTS

LITERATURE DATA

According to Pavletić (1955), the first data about *Mannia triandra* in Montenegro were provided by Dörfler-Schiffner in Klemen, *c.* 160 m a.s.l. near the Montenegrin-Albanian border. We did not consider this data because to our knowledge, this locality is outside Montenegro. The first information about the existence of *Mannia triandra* in Montenegro was given by Josef Duda. He reported an occurrence at Rijeka Crnojevića based on the bryophyte collections of Günther Beck-Mannagetta, which are kept in the Herbarium of the Botanical Department of the Faculty of Science of Charles University in Prague (Duda 1965). Further data were provided by Bischler & Jovet-Ast (1974) for a few places in the southern and continental part of Montenegro: Orjen, Knežlaz; Boka Kotorska, above Risan, Rvaši; Lovćen, Njeguši, Krstac; Rumija, Dobovici. More recently, Papp *et al.* (2019) found *Mannia triandra* in the Prokletije Mts near Gusinje, Dolina Grebaja and from Treća livada to Kotlovi. Summarizing this literature data, seven sites of *Mannia triandra* are known in Montenegro.

Except for recently published data from the Prokletije Mts area (Papp *et al.* 2019), the literature did not provide detailed information on habitats and population status, nor did it address threat status.

HABITATS AND ECOLOGY OF MONTENEGRIN POPULATIONS

We found *Mannia triandra* in areas from near the coast to higher mountains (altitudinal range from 40 to 1720 m a.s.l.).

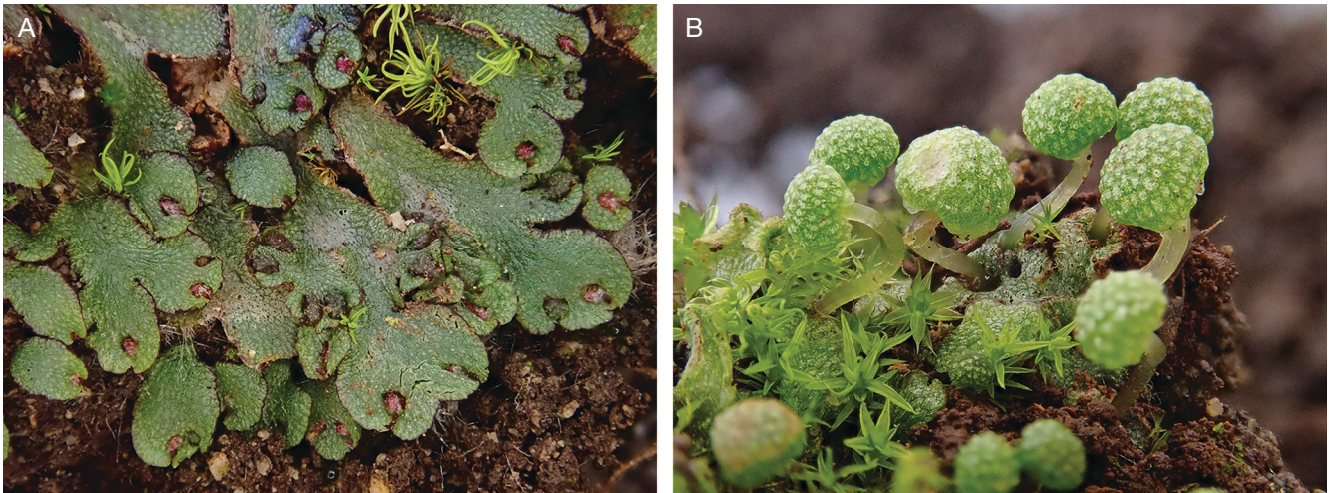


Fig. 1. — *Mannia triandra* (Scop.) Grolle in Montenegro (A), with carpocephala (B).

It grows in rock crevices, sheltered hollows or small caves with sparse vegetation along roadside embankments, included or at the base of carbonate rocks, in pastures, dry grassland and other non-forest habitats, as well as on very old *Pinus heldreichii* Christ pine forests with beech (Orjen Mt, Maganik Mt). The macrohabitat is mostly in full light, but the microhabitat is often sheltered or north exposed, providing more moist and cooler conditions. Our impression is that species has a preference for shaded and relatively mesic sites. Microhabitats are rather small, and mostly covering only several square decimetres. It occurs on the soil, or on thin soil layers over limestone rock, where *Mannia triandra* is often the only species.

FIELD DATA

During our research conducted in 2016 and 2019–2022 (mapping of Natura 2000 habitats and species), we registered *Mannia triandra* in the following localities:

Lovćen Mt

Cetinje, from Dubovik to Njeguši, open rocky slopes near road, 42°25'50.5"N, 18°51'43.2"E, small cave under a limestone rock, north exposure, 990 m a.s.l., 24.II.2020, leg./det. C. Berg & S. Dragičević).

Njeguši, open rocky slopes near road, 42°25'56.7"N, 18°48'34.2"E, under a limestone rock, north exposure, 910 m a.s.l., 24.II.2020, leg./det. C. Berg & S. Dragičević.

Between Štirovnik and Jezerski vrh, open rocky slopes, small cave in a limestone rock, south-west exposure, 42°24'14.9"N, 18°49'28.1"E, 1335 m a.s.l., 30.VI.2020, leg./det. S. Dragičević.

Skadar Lake

Old road from Virpazar to Rijeka Crnojevića, Komarno, very open forests of Mediterranean thermophilic vegetation, 42°18'36.0"N, 19°02'59.9"E, under a limestone rock on soil, east exposure, 100 m a.s.l., 30.VII.2016, leg./det. S. Dragičević.

From Virpazar to Ostros, thermophilic rock vegetation, small caves with sparse vegetation at the base of carbonate

rocks, 42°14'09.5"N, 19°06'13.5"E, north-east exposure, 100 m a.s.l., 25.II.2020, leg./det. C. Berg & S. Dragičević.

Godinje, rocky slopes near road, 42°13'15.9"N, 19°06'51.4"E, on thin soil in north exposure, 40 m a.s.l., 25.II.2020, leg./det. C. Berg & S. Dragičević.

Above Seoca, *Carpinus orientalis* Mill. shrubland, 42°12'37.7"N, 19°08'59.1"E, deep carbonate rock fissure, in south exposure, 300 m a.s.l., 25.II.2020, leg./det. C. Berg & S. Dragičević.

Turning towards Vučedabići, open rocky slopes, 42°12'03.5"N, 19°09'35.9"E, carbonate rock fissure in north-east exposure, 430 m a.s.l., 25.II.2020, leg./det. C. Berg & S. Dragičević.

Above Karanikići, open rocky slopes, 42°11'12.2"N, 19°10'14.3"E, carbonate rock fissure, in north exposure, 430 m a.s.l., 25.II.2020, leg./det. C. Berg & S. Dragičević.

Above Murići, dry calcareous grassland, 42°09'30.9"N, 19°12'33.4"E, small hollow in north-east exposure, 250 m a.s.l., 25.II.2020, leg./det. C. Berg & S. Dragičević.

Above Murići, 42°09'19.3"N, 19°12'33.2"E, under a calcareous block in an erosion gorge in north exposure, 270 m a.s.l., 25.II.2020, leg./det. C. Berg & S. Dragičević.

Rumija Mt

Along the road from Ulcinj to Vladimir, open rocky slopes near road, 41°59'01.0"N, 19°15'55.4"E, under a limestone rock, west exposure, 110 m a.s.l., 26.II.2020, leg./det. C. Berg & S. Dragičević.

Katunska nahija

Above village Štitari, along the hiking trail, open rocky habitats, around the thermophilic forest with *Quercus cerris* L., *Q. pubescens* Willd., *Ostrya carpinifolia* Scop., *Carpinus orientalis*, *Juniperus oxycedrus* L., *Petteria ramentacea* (Sieber) C.Presl, 530 m a.s.l., southwest exposure, 42°25'54.0"N, 19°00'35.7"E, 20.V.2019 and 14.III.2020, leg./det. S. Dragičević.

Above village Štitari, thermophilic forest, 42°25'54.7"N, 19°00'46.2"E, under a crevices in limestone rocks, on open soil, east exposure, 475 m a.s.l., 20.V.2019 and 14.III.2020, leg./det. S. Dragičević.



FIG. 2. — Microhabitat of *Mannia triandra* (Scop.) Grolle in a west exposed limestone rock crevice in Tuzy municipally (red arrow).

Maganik Mt

Very old *Pinus heldreichii*-forest, but largely degraded by fire (Natura 2000: 95A0 High oro-Mediterranean pine forests), hiking trail to Kurozeb, 42°44'45.2"N, 19°13'27.8"E, under a limestone rock, on soil, south exposure, 1720 m a.s.l., 7.XI.2020, leg./det. S. Dragičević.

Orjen Mt

Sedlo, small pasture rockery in the beech (*Fagus sylvatica* L.) and munika forest (*Pinus heldreichii*) (Natura 2000: 95A0 High oro-Mediterranean pine forests), 42°33'25.4"N, 18°33'19.3"E, under a limestone rock, on soil, east exposure, 1575 m a.s.l., 12.IX.2021, leg./det. S. Dragičević.

Tuzi municipality

Degradated Mediterranean thermophilic forest vegetation (*Colutea arborescens* L., *Ficus carica* L., *Paliurus spina-christi* Mill., *Phillyrea latifolia* L., *Ostrya carpinifolia*, *Carpinus orientalis*, *Rosa sempervirens* L., *Juniperus oxycedrus*, *Smilax aspera* L., *Phlomis fruticosa* L., etc.), under a limestone rock, 42°21'55.2"N, 19°24'20.6"E, north exposure, 520 m a.s.l., 24-25.IV.2022, leg./det. S. Dragičević & D. Saveljić (Fig. 2).

Degradated Mediterranean thermophilic forest vegetation, in a limestone rock crevice, 42°22'11.7"N, 19°25'14.5"E, west exposure, 670 m a.s.l., 24-25.IV.2022, leg./det. S. Dragičević & D. Saveljić.

Degradated Mediterranean thermophilic forest vegetation, 42°19'36.6"N, 19°23'39.9"E, in a limestone rock crevice, north exposure, 140 m a.s.l., 24-25.IV.2022, leg./det. S. Dragičević & D. Saveljić.

OCCURRENCE AND ECOLOGY

We found *Mannia triandra* predominantly in shady, sheltered microhabitats on open ground, mostly without any other accompanying species, or with some short-living pioneer mosses. Such situations can be found particularly in small caves up to approximately 50 cm deep under rocks, stones or overhangs, but also in deep rock crevices. We found it in altitudes between 40 and 1720 m a.s.l. In conjunction with a north or northeast exposure (50% of all samplings) or east exposure (another 25% of all samplings), a comparatively cool microclimate is created. The species covers his water requirement mainly from soil moisture, air humidity and fog, because the places are usually not directly reached by

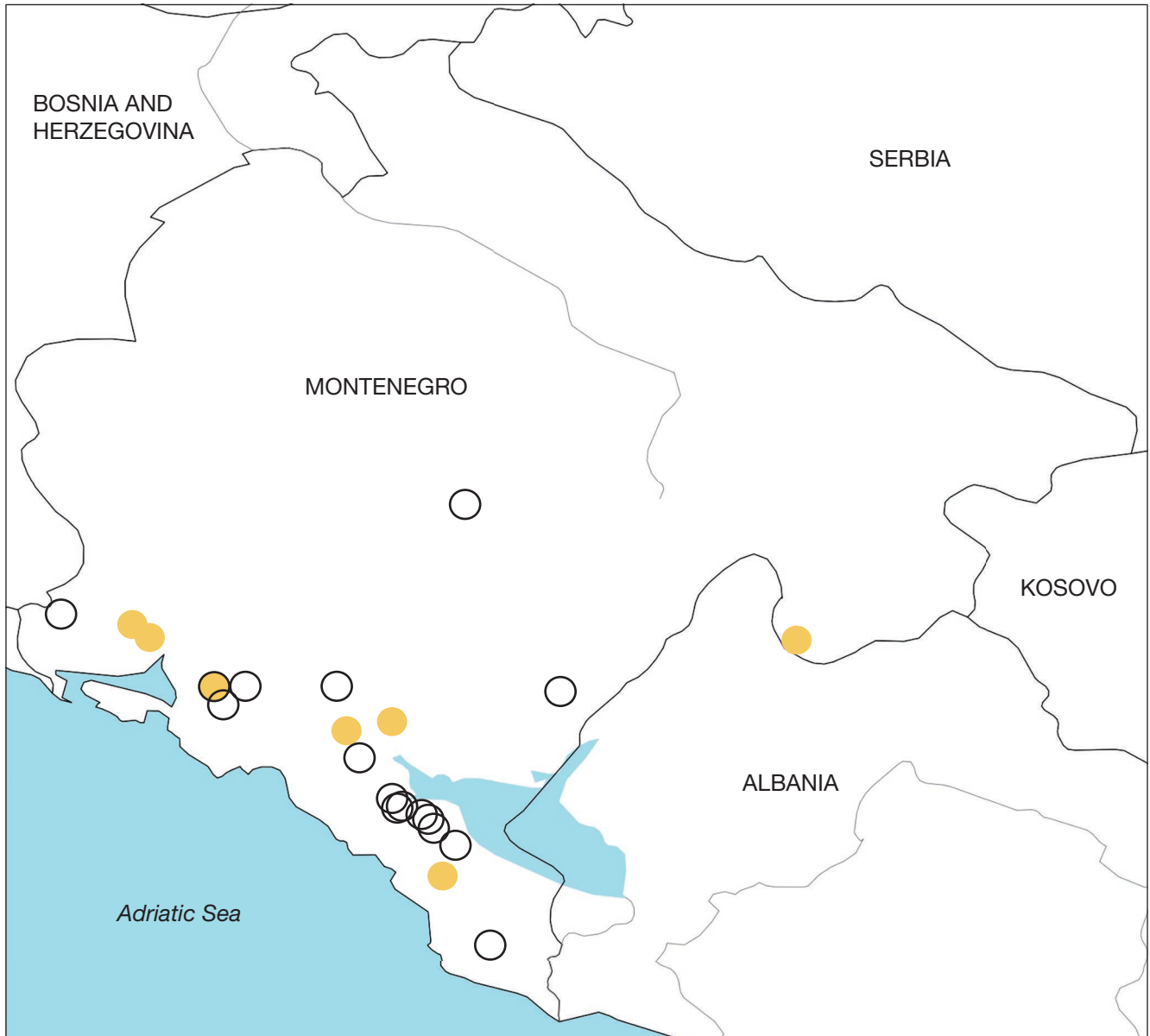


FIG. 3. — Distribution map of *Mannia triandra* (Scop.) Grolle in Montenegro. **Orange dots** are literature data (1965-2019), and **black rings** are new field data (2016-2022) given in the text.

rain, and dew rarely falls in such places. Southern exposures are rare, but can be found at higher altitudes.

THREATS

Threats to bryophytes are complex and often difficult to categorise because of synergistic effects (e.g. climate change and increased fire frequency), and it is hard to determine which threat is the key driver impacting a bryophyte (Hodgetts *et al.* 2019). According to Schill (2006), *Mannia triandra* sometimes disappears in some habitats from one year to the next depending on climatic conditions. Because historical data are lacking, it is not possible to assess population trends in Montenegro. Also, the estimation of the Red List criteria is difficult. Consequently, some general threats can only be confirmed in the field, depending on the habitat situation.

The species highly depends on the microclimate of the habitat. This particular situation can quickly disappear in the course of climate change if summers in the Mediterranean become hotter and drier. Populations growing along mountain trails are in same way endangered by trampling and littering. The same applies for the occurrences along embankments of old and small country roads around Skadar Lake, where we found the most important populations (Fig. 3). If these roads are reconstructed and widened as part of Montenegro's economic development, this could destroy large parts of the *Mannia triandra* populations.

Therefore, we can definitely assume at least a potential endangerment of the species in Montenegro. Applying the IUCN criteria for threat status, we note that the low extent of occurrence (criterion B1), the area of occupancy and number

of sites (criterion B2), the extremely small population size of <250 individuals (criterion D), as well as the uncertainties in analyzing the criteria, argue in favor of a classification as endangered (VU) in Montenegro.

DISCUSSION

We were able to substantially increase the knowledge on *Mannia triandra* in Montenegro. After our fieldwork, more records of this species are known in Montenegro than ever before. Montenegro therefore has a great responsibility for this rare species, which is protected throughout most of Europe.

The altitudinal amplitude from sea level to the subalpine belt is remarkable, as the species is generally considered to be quite stenocous and, like most thallose liverworts, prefers consistently cool, moist conditions. The species compensates for this by choosing its microhabitat, preferring small caves or deep crevices, and in warm locations, it occurs predominantly in north and east exposures. At higher altitudes it can also be found facing south.

Despite the large increase in new locations, we are still far from having an accurate picture of its distribution and endangerment in Montenegro. A monitoring program in accordance with the criteria of the habitat directive for the species should be established in the long term, and bryologists should always be consulted on major road construction projects. *Mannia triandra* and other bryophyte species should also be considered in the management plans of the National parks Skadar Lake, Prokletije, and Lovćen. In this context it is important to note that *Mannia triandra* has a certain pioneer character and only occurs in practically unvegetated areas. This also means that its habitat has to be created again and again, and gives *Mannia triandra* the character of a short-lived shuttle species (Kürschner & Frey 2012). This should be considered in management plans, as management that only targets known occurrences is not effective enough.

Knowledge about the distribution of the species has also improved significantly in other European countries, where the species has recently been found at higher frequency, or even for the first time, e.g. Harz Mountains (Müller *et al.* 2014), Transdanubian Mountain Range (Németh & Papp 2011), northern Calcareous Alps in Austria (Zechmeister & Kropik 2021) or South-East France (Hugonnot & Offerhaus 2005). We do not want to interpret this as a recent spread of the species, but rather attribute these increased findings to a higher interest of bryologists Europe-wide after this species was included in Annex 2 of the Habitats Directive as a species of community interest. The many new observations, also in Montenegro, in the absence of old records, make an objective assessment of the endangerment situation difficult. According to our analysis, *Mannia triandra* is vulnerable (VU) in Montenegro because the populations are small and fragmented, and its habitats are at least potentially and partly under pressure. Climate change could be a serious threat in the future, also due to the increases of forest fires, which can threaten the moss layer in Mediterranean habitats (Kaufmann & Berg 2014).

If we compare Montenegro with the generally low occurrences of the species elsewhere, we must consider Montenegro as an area with a key distribution of *Mannia triandra* in Europe. The situation in Montenegro is probably one of the better in Europe; some of the Montenegrin populations are located in protected areas (e.g. NP Skadar Lake, NP Prokletije, NP Lovćen). In this way, Montenegro has an important role to play in the conservation of this rare bryophyte species that is endangered and protected throughout Europe.

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