



Distribution of rare *Cystoseira* species along the Montenegro coast (South-Eastern Adriatic Sea)

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Abstract

Background and purpose: Multiple studies have shown that *Cystoseira* species are sensitive to anthropogenic impact, and a decrease in their populations was observed, especially close to urban areas. To better understand status of such endangered and protected species, we studied the distribution of six rare *Cystoseira* species along the Montenegro coast: *C. compressa* subsp. *pustulata*, *C. crinita*, *C. crinitophylla*, *C. sauvageauana*, *C. squarrosa* and *C. tamariscifolia*.

Materials and methods: The study is based on field researches conducted through snorkelling and scuba diving along the Montenegrin coast during the period 1998–2009. In addition to the field work, we examined the published data for these species and the unpublished data from prof. Boris Antolić's field diary.

Results: Based on our 12-year-long investigations, we concluded that *C. compressa* subsp. *pustulata*, *C. crinita*, *C. crinitophylla* and *C. squarrosa* are rare and endangered species along the Montenegro coast.

Conclusions: The published data for *C. sauvageauana* is likely mistaken due to incomplete and poorly conserved algal material, while regarding the reference for *C. tamariscifolia* should be checked if the collected sample was preserved. Furthermore, we noted that the habitat destruction and the proliferation of sea urchin populations have the most dramatic negative impact on the biocenosis formed by such rare and endangered *Cystoseira* species.

INTRODUCTION

The genus *Cystoseira* was identified in 1820 by the Swedish phycologist Carl Adolph Agardh; it originally included 37 species, but most taxonomists currently accept approximately 50 *Cystoseira* species (1, 2). Most of them are registered in the Mediterranean Sea; few species were observed in the Atlantic (primarily Europe), and certain species were observed in the Pacific and Indian Oceans (3, 4, 5). Although certain *Cystoseira* species were described using samples from the Adriatic Sea and though an important and detailed work by Ercegović (6) refers to the east Adriatic coast, the *Cystoseira* vegetation in the South-East Adriatic Sea is not well understood, and data for such algae are few and incomplete. Furthermore, published data for the genus *Cystoseira* includes different numbers of taxa, even over a short period of time for both the Adriatic and Mediterranean Seas. For example, Ribera et al. (7) listed 47 taxa in the Mediterranean Sea and 29 in the Adriatic Sea, while Cormaci et al. (8) listed 29 taxa in the whole Mediterranean Sea. The differences are even more evident for

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data from the west and east Adriatic Sea coasts, which were reported as having 18 and 30 taxa, respectively (9, 10). However, for the moment, the 35 *Cystoseira* taxa found in the Adriatic Sea likely represent an accurate indication of the *Cystoseira* diversity for this area (9, 10), while further taxonomy and molecular analyses of this genera will give more light to the relationships between the species, varieties and forms (10, 11).

The genus *Cystoseira* is characteristic of the Mediterranean flora (2). These algae are often the dominant species on the rocky bottom and provide a suitable habitat for many additional species; thus, it is important to understand these algae's distribution and biocenosis. Moreover, a UNEP/RAC-SPA report (12) proposed protection for these species, and countries that are party to the Barcelona Convention are obliged to protect them. According to many published data, the *Cystoseira* species are sensitive to the anthropogenic impact, and a decrease in their populations was observed, especially in urban areas (13, 14, 15, 16, 17). The studied species *C. crinita*, *C. crinitophylla*, *C. sauvageauana* and *C. squarrosa* are endemic, while *C. tamariscifolia* and *C. compressa* subsp. *pustulata* are rare in the Mediterranean Sea. Therefore, the aim of this study was to present their distribution along the Montenegrin coast and provide useful information for future conservation.

MATERIALS AND METHODS

The study included 6 *Cystoseira* species and was based on field researches conducted through snorkelling and scuba diving along the Montenegrin coast (South-East Adriatic Sea) during the period 1998-2009.

The Montenegrin coast is located between Albania and Croatia and stretches over about 90km in straight line, but the entire length of the coast, including small islands is about 300km (18). Along the coast of Montenegro 86 locations were surveyed by scuba diving and 18 by snorkeling. Seasonal field researches were conducted on 10 locations through 2005-2007, while other locations were surveyed randomly through different months of the year, and many of them several times in different periods of the same year, as well as several times during the period 1998-2009. Scuba diving was performed randomly down to the 40m depth (if possible) and usually during 1h of diving. All together 39 samples were collected for species *C. compressa* subsp. *pustulata*, *Cystoseira crinita*, *C. crinitophylla* and *C. squarrosa*. For each of these species one sample were deposited (under labels: 2-2058, 2-2059, 2-2061 and 2-2063) in herbarium collection of Faculty of biology, University Novi Sad (Serbia) -BUNS, (19). Three samples for each of these species were preserved in 4% formalin seawater, while others were preserved in 70% alcohol and deposited in the collection of the Institute of marine biology, Kotor (Montenegro). During this research samples of *C. tamariscifolia* and *C. sauvageauana* were not found.

In addition to the field work, we examined the published data for these species and the data from prof. Boris Antolić's field diary. The Antolić field diaries are unpublished data, held in the laboratory for benthos of the Institute of oceanography and fisheries in Split (Croatia). With all available data (taxonomy, data of collection, depth and bibliographic reference) a cartography and data base for six *Cystoseira* species was performed with Quantum GIS software Ver. 2.2.0. (20).

RESULTS AND DISCUSSION

Cystoseira compressa subsp. *pustulata* (Ercegović) Verlaque

In our research, *C. compressa* subsp. *pustulata* was only observed twice, at Perast (6 m) and at cape Kočište (5 m) (Fig. 1, 2A and Table 1). For locations on the open coast of Montenegro (cape Kočište), we should consider the negative impact from illegal date shell (*Lithophaga lithophaga*) collection and proliferating sea urchins populations that degrade habitats and reduce the *Cystoseira* and *C. compressa* subsp. *pustulata* populations (17, 21). Thus, it might be interesting to monitor barren areas and sea urchin populations because they are likely one of the dominant factors in *Cystoseira* biocenosis degradation.

Ercegović (6) reported this taxon mostly in the middle Adriatic Sea as *C. abrotanifolia* subsp. *pustulata* Ercegović. But we should have in mind that the taxonomy of *Cystoseira compressa* subsp. *pustulata* is quite confused. Giaccone and Bruni (1973) reduced this taxon to a heterotypic synonym of *C. myriophylloides* Sauvageau (= *C. humilis* Schousboe ex Kützing), a species described from Atlantic France (11, 23). According to Thibaut *et al.* (11) *C. compressa* subsp. *pustulata* axes are frequently compressed at the basis, the branches are more or less distichously inserted in one plane and the cryptostomata are large and prominent (whence the name '*pustulata*'). On the basis of a same authors study of genuine Atlantic specimens of *C. humilis* from Canary Islands, Spain and Morocco there is a distinction between the two taxa. In *C. humilis* the axes are always cylindrical, the branches are never distichously inserted (thallus with pyramidal outline) and the cryptostomata are inconspicuous (branches smooth) (11). Because of all this, our samples were described as *C. compressa* subsp. *pustulata*. Furthermore, we urge to pay attention and check reports for *C. humilis* for the possible future analyses of *C. compressa* subsp. *pustulata* distribution in Adriatic Sea (10) and beyond.

Cystoseira crinita Duby

The distribution of *C. crinita* along the Montenegrin coast is shown in Fig. 1, 2B and Tab. 1, with 6 locations from published data and 13 total observations. We only observed *C. crinita* on the open sea, primarily on the highly exposed coast, as it was also observed by Špan and

Tab. 1. Details on rare *Cystoseira* species observations along the Montenegro coast

Species	location	depth (m)	sampling date	source of data	location no. on the map
<i>C. compressa</i> subsp. <i>pustulata</i>	Perast	6	23.08.2006.	this study	5
	rt Kociste	5	12.05.2007.	this study	16
	Platamuni		1984-1985	Lovric, Rac, 2006	20
<i>C. crinita</i>	rt Kočište	5	12. 05. 2007.	this study	16
	Ponta Veslo	4	03. 09. 2006.	this study	15
	Kamenovo	1,5	25. 08. 2006.	this study	21
	Ponta Veslo	1	18. 06. 2006.	this study	15
	rt Dobreč	5	01. 09. 2006.	this study	13
	rt Žukovac	3	14. 08. 2007.	this study	19
	rt Kočište	5	25. 10. 2006.	this study	16
	Platamuni		1984-1985	Lovric, Rac, 2006.	20
	Bigova		1984-1985	Lovric, Rac, 2006.	18
	Radimiri		1970	Solazzi, 1971.	2
	Prčanj	5	1970	Solazzi, 1971.	1
<i>C. crinitophylla</i>	Ulcinj	0	26. 06. 1950.	Ercegović, 1952.	24
	u. Trašte		1986-1987	Špan, Antolić, 1987.	17
	iza Perasta ponte	2,5	24.08.1997.	this study	7
	iza Orahovca	3	09.07.1997.	this study	4
	Krasici	0.5	05.09.2006.	this study	11
	rt Dobrec		01.09.2006.	this study	13
	Perast	3	23.08.2006.	this study	6
	Kamenovo		25.08.2006.	this study	21
	Orahovac	3	23.08.2006.	this study	3
	o. Gospa od Škrpjela	1	1986	Špan, Antolić, 1992	8
	Krašići	0.7	1986	Špan, Antolić, 1992	10
Rt Kobilja	0,5-2,5	19.08.1989.	Antolić's field diary	12	
Uvala Trašte (istok)	0-3	19.09.1986.	Antolić's field diary	17	
<i>C. sauvageauana</i>	Perast	10-15	1970	Solazzi, 1971	6
<i>C. squarrosa</i>	Posejdonov grad	1,5	22.07.2008.	this study	14
	Ponta Veslo	1	10.05.2009.	this study	15
	Platamuni		1984-1985	Lovric, Rac, 2006	20
	Bigova		1984-1985	Lovric, Rac, 2006	18
	rt Voluica		1979-1981	Span, Antolic, 1983	22
	rt Mendra		1979-1981	Span, Antolic, 1983	23
<i>C. tamariscifolia</i>	Solila		1984-1985	Lovric, Rac, 2006	9

Antolić (24). However, this species was observed in this area at depths ranging from the one to 5 m; thus, this alga likely prefers locations with moderate water movement, which has been reported for additional locations in the Mediterranean (6, 25, 26, 27). Overgrazing by sea urchins and habitat destruction by illegal date shell (*Lithophaga lithophaga*) collection has likely had the greatest negative impact on this alga (17, 21, 28).

***Cystoseira crinitophylla* Ercegovic**

C. crinitophylla populations along the Montenegrin coast are presented with two literature data, two data from Prof. Antolić's field diary and our 7 observations (Fig. 1, Fig. 2C, Tab. 1). The first description of this species was done by Ercegović (6) on the base of samples from the Adriatic Sea and the most southern observation in the

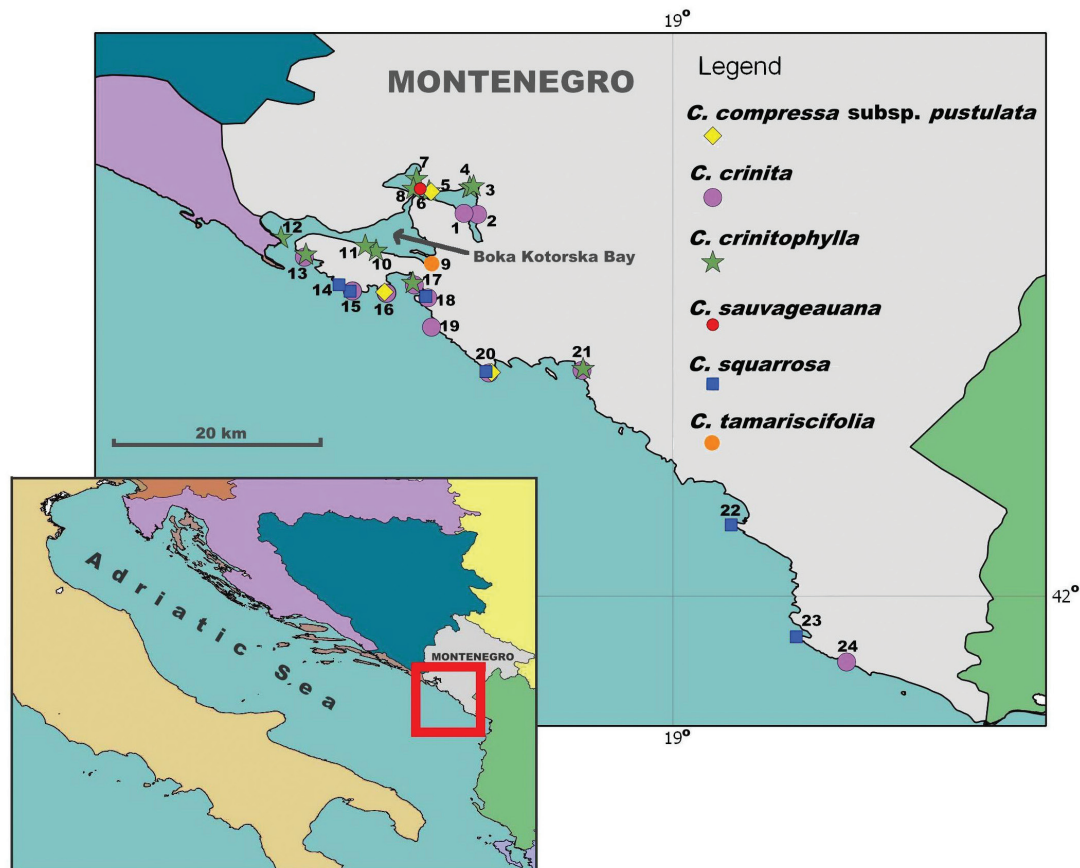


Fig. 1. Distribution of rare *Cystoseira* species along the Montenegro coast

Adriatic Sea was in Boka Kotorska Bay (29). In our research, we found *C. crinitophylla* in the bay and at a more southern locations on capes Dobrec (entrance in the Bay of Boka Kotorska) and Kamenovo (close to Budva town). Finding from Antolić's field diary for the location "uvala Trašte" was not confirmed, while report for Krašići was confirmed in 2004. Unfortunately, for location Krašići we observed also species disappearance due to new construction on the coast in 2006. Due to the limited data from earlier periods and intensive urbanisation in the Bay of Boka Kotorska, we can only assume that such habitat destruction yielded a negative anthropogenic impact on additional *C. crinitophylla* populations.

At each location in our field research, *C. crinitophylla* populations were observed as a small number of individuals, and compared with certain other *Cystoseira* species on the Montegrian coast, *C. crinitophylla* is rare.

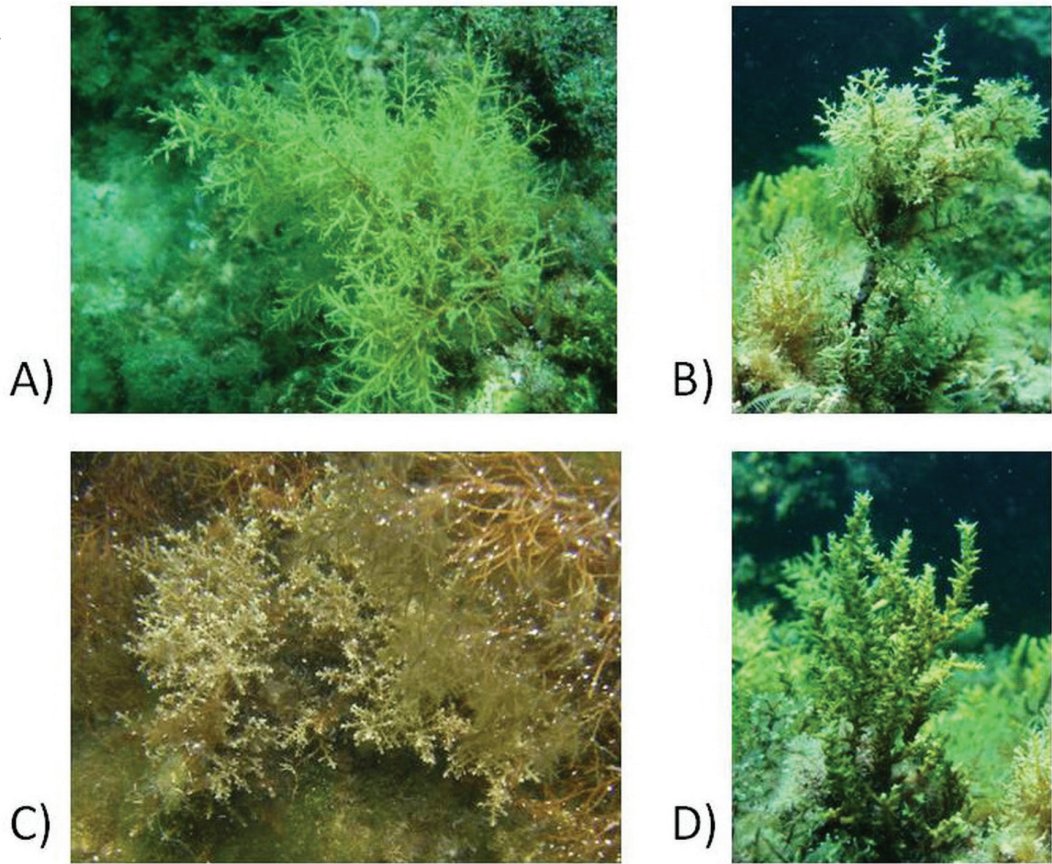
The habitat for this species is a rocky coast from the surface to a depth of 10 m, which explains why the potential threats to this alga include habitat destruction, overgrazing by sea urchins, pollution and competition with non-native species (17, 21, 28, 30, 31).

Cystoseira sauvageuana Hamel

There is only one reference available for *C. sauvageuana* distribution along the Montenegro coast, at Perast, at a depth of 10-15 m (32). We did not observe this species

during our research (Fig. 1, Tab. 1). Solazzi (32) reported the presence of *C. selaginoides* Val., which is a synonym for *C. sauvageuana* Hamel (23, 33, 34). However, Solazzi emphasised that he analysed algal material of small dimensions that, in certain cases, were incomplete and not well preserved. Researches on *C. sauvageuana* morphology, reproductivity and fenology (35, 36) showed that its taxonomical characteristics are varying throughout the year, such as pseudotophules and spines at the apex; thus, for accurate analyses, specimens should be collected from the same location throughout the year. Moreover, this species has only been referenced in the Adriatic Sea by Solazzi (32) (and Ribera et al. (7) who cited Solazzi); we did not find any additional citations for this species in the Adriatic Sea. In the Catalogue of macrophytobenthos of Italy, Furnari et al. (9) did not report *C. sauvageuana* for the Adriatic Sea, but only for Sicily, Calabria, Campania and Puglia (close to Taranto). Gomez-Garreta (25) and Ribera et al. (7) observed that this species was more common in the west Mediterranean and it is typically observed in rocky bottom environments at a few meters of depth. Solazzi (32) reported this algae at a depth of 10-15 m in the Bay of Boka Kotorska, where the water transparency is typically low (37). Based on these details, we think that this citation could be a misreported data. We did not check for the existence of herbarium samples of the material analysed by Solazzi, but we think this material should be consulted in the nearby future.

Fig. 2. Photos of rare *Cystoseira* species found along the Montenegro coast: A) *C. compressa* subsp. *pustulata*, B) *C. crinita*, C) *C. crinitophylla* and D) *C. squarrosa*



Cystoseira squarrosa De Notaris

C. squarrosa is a rare, endemic species in the Mediterranean Sea (13, 38, 39) that Ercegovic (6) observed in the South-East Adriatic Sea. For the Montenegro coast, this alga was first reported by Span and Antolic (40) on capes Voluica and Mendra. We observed *C. squarrosa* at two locations: Posejdonov Grad and Ponta Veslo (Lustica Peninsula), both at a depth of 1 m (Fig. 1, 2D, Tab. 1). During our field work, we observed only small populations with a few individuals. Furthermore, locations reported by Lovric and Rac (43) were checked again in 2010, but findings of *C. squarrosa* were not confirmed, while locations at Voluica and Mendra reported by Span and Antolic (40) were not controlled again during this research.

The decline in population for this species has been reported in different Mediterranean locations (38, 41); it is likely also vulnerable in the Montenegrin coast. Locations with *C. squarrosa* herein and in published data are not in urbanised areas of the Montenegrin coast, except location Bigova (42). Thus, habitat destruction and pollution from waste water are not a current threat, but overgrazing by sea urchins is a serious threat (17, 21, 28, 30). Competition with allochthonous species could also be a threat for this alga, especially because dense populations of *Caulerpa racemosa* and *Womersleyella setacea* on location Ponta Veslo (31, 42).

Cystoseira tamariscifolia (Hudson) Papenfuss

For the Montenegrin coast and the Adriatic Sea, *C. tamariscifolia* is reported only in one location, the Boka Kotorska Bay, Solila (43) (Fig. 1, Tab.1). Some studies described this alga as being located in the west Mediterranean and Atlantic coasts of Europe and North Africa (9, 22, 25, 44). The literature indicates (7, 9, 23, 25, 44, 45) that this species is rare and vulnerable and that its populations are highly exposed to the negative anthropogenic impact, primarily through habitat destruction and pollution. Since we did not find *C. tamariscifolia* in our field work (1998-2009), and Lovric and Rac (43) collected their algal material in 1984-1985, the species may have disappeared. But, this species was not observed in any other Adriatic Sea location (9, 10) so, it would be useful to verify the determination of the algal material collected by Lovric and Rac (43). Since *C. tamariscifolia* was reported only once, in only one location, in the absence of the sample this record should be treated as an misidentification.

CONCLUSION

Based on our 12-year-long field investigations and published data, the species *C. compressa* subsp. *pustulata*, *C. crinita*, *C. crinitophylla* and *C. squarrosa* resulted to be

rare and endangered along the Montenegro coast as they were reported only with 33 records. As a confirmation of this statement are findings of Macic et al. (17) were along the Montenegro coast, for the same investigated period, were reported 6 most common *Cystoseira* species with 264 records. Namely they are *C. amentacea* var. *spicata*, *C. barbata*, *C. compressa*, *C. corniculata* ssp. *laxior*, *C. foeniculacea* and *C. spinosa*. On the base of our survey and all previous findings presence of 9 *Cystoseira* species is confirmed.

Published data for *C. sauvageauana* is likely mistaken due to incomplete and poorly conserved algal material, while the *C. tamariscifolia* reference should be checked if a collected sample has been preserved. In the absence of the sample of *C. tamariscifolia* this record also should be treated as an misidentification.

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