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PHYTOSOCIOLOGY AND ECOLOGY OF *CRESSA CRETICA* L. (CONVOLVULACEAE) ON THE EASTERN ADRIATIC COAST

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Abstract
The present phytosociological study of the eastern Adriatic coastal salt-marsh at Blato, Croatia, is based on the Braun-Blanquet approach. Five plant associations were recorded in the area: *Juncetum maritimo-acuti*, *Puccinellio festuciformis-Sarcocornietum fruticosae*, *Scirpetum maritimi, Enteromorpho intestinalidis-Ruppietum maritimae* and *Cressetum creticae*. The association *Cressetum creticae* was found for the first time in Croatia as well as on the eastern Adriatic coast. This therophytic and halo-nitrophilous association shows a monospecific or paucispecific character and occupies the most haline and the driest parts of the salt-marsh. The association develops during the summer on silty clay substrates with organic matter derived from the decay of plants of the neighboring communities. According to key soil factor analysis no differences of grain size of the soils among the associations were found, while regarding electrical conductivity, Cl^- and Na^+ concentrations were higher in the *Cressetum creticae* than in any of the others associations. The particular original features of the site regarding its flora and vegetation would justify some measures of protection and management.
Key words: halophytic vegetation, soil analysis, *Thero-Suaedetea splendentis*, syntaxonomy, Croatia, central Adriatic, NE Mediterranean.

Izvleček
Predstavljamo fitocenološko raziskavo obalnega slanega mokrišča Blato (Hrvaška) v vzhodnem Jadranu, ki smo jo naredili po Braun-Blanquetovi metodi. V raziskovanem območju smo zabeležili pet asociacij: *Juncetum maritimo-acuti*, *Puccinellio festuciformis-Sarcocornietum fruticosae*, *Scirpetum maritimi, Enteromorpho intestinalidis--Ruppietum maritimae* in *Cressetum creticae*. Asociacija *Cressetum cretice* je na ozemlju Hrvaške in tudi na vzhodni obali Jadranskega morja opisana prvič. Terofitska in halo-nitrofilna asociacija je monospecifična ima siromašno vrstno sestavo in se pojavlja na najbolj slanih in suhih delih slanišča. Sestoji se razvijajo poleti na glineni podlagi z organsko snovjo, ki jo sestavljajo odmrli rastlinski deli s sosednjih združb. Analiza tal je pokazala, da med asociacijami ni bilo razlik v velikosti talnih delcev, električni konduktivnosti, koncentraciji Cl- in Na+ ionov pa sta bili v asociaciji *Cressetum creticae* višji kot ostalih asociacijah. Zaradi posebnosti v flori in vegetaciji bi bilo potrebno na preučevanem območju zagotoviti določene mere zaščite in ustrezen način upravljanja.
Ključne besede: halofitska vegetacija, analize tal, *Thero-Suaedetea splendentis*, sintaksonomija, Hrvaška, srednji Jadran, SV Mediteran.

1. INTRODUCTION

Coastal salt-marshes are distributed throughout the Mediterranean area (Géhu 1999). In addition to hosting some very rare plant species and communities, they are important areas for the nesting and staging of birds. In the Adriatic salt-marsh vegetation occurs mostly on the western and northern coasts, the east coast being generally rocky (Pandža et al. 2007).

Considerable research has been done on the halophyte vegetation along the western Adriatic

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(cf. Poldini et al. 1999, Merloni 2007, Tomaselli et al. 2011, Sciandrello & Tomaselli 2014, and references therein) and eastern Adriatic coasts (Janković & Stevanović 1983, Alegro et al. 2004, Kaligarič & Škornik 2006, 2007, Pandža et al. 2007, Shehu et al. 2010, Šajna et al. 2013), but there remain sites that have not yet been investigated. Among these is a coastal salt-marsh situated on the central east coast of the Adriatic in south Croatia. There is, in fact, no previous detailed study that describes the phytosociology of *Cressa cretica* L. (Convolvulaceae) – a rare plant of the salt-marshes in the Adriatic Basin. These matters are addressed by the present study, in which the halophytic vegetation with *C. cretica* is related to key soil factors.

Cressa cretica is a perennial plant (Pignatti 1982) with a lifecycle that continues in the summer period when the salt marsh area drains. Bouchard (1977) considers it an annual or perennial plant, while most authors from the Mediterranean area (cf. Ozenda 1983, Lorenzoni & Paradis 1994, Biondi et al. 2001, etc.), including Croatian authors (Milović & Marković 2003), have emphasized its therophytic character.

It occurs in the Mediterranean region and east through western and central Asia as far as India and south to northern and central Africa, also being found in South America, Australia and parts of South-east Asia, and it can be considered as a thermo-cosmopolitan halophilous species (Lansdown 2013). There is no information on whether some of these populations may be non-native. In addition, *C. cretica* is used in various folklore medicines (Priyashree et al. 2010, Rani et al. 2011). This species is included in the IUCN Red list of threatened species and being classed as Least Concern does not face any major threats (Lansdown 2013).

It has been found in the coastal areas of most Mediterranean countries (Greuter et al. 1986), and in some is included in national Red lists of plants (e.g. Italy, France, Bulgaria, etc.). According to the data in the literature, on the east Adriatic coast it is found at only one locality in Croatia (Milović & Marković 2003) and in Albania (Baldacci 1896, Ball 2011). According to the Flora Croatica Database (Nikolić 2014), this species is also found on two mid-Adriatic islands (Brač and Šolta) and the peninsula of Pelješac, mostly on gravel (Šolta, Pelješac) or gravel-muddy (Brač) substrates.

The aim of this paper is to contribute to the knowledge of the ecology and phytosociology of *C. cretica* on the eastern Adriatic coast and in the Adriatic Basin generally.

2. STUDY AREA

The study area of Blato (Gauss-Krüger coordinates X = 5571512, Y = 4840171, UTM WJ 74) is located along the Republic of Croatia's central Adriatic coast (Figure 1). Phytogeographically this area belongs to the Mediterranean vegetation zone of thermophilic evergreen vegetation of the *Fraxino orni-Quercion ilicis* alliance (Trinajstić 1995, *sensu* Biondi et al. 2014).

Average annual air temperature is 15.4 °C and precipitation averages 773.8 mm yr^{1} (data from the nearby town of Šibenik station for 1976–2006, Croatian Meteorological and Hydrological Service). The highest daily average temperature is 25.1 °C in July, and the lowest falls below 6.9 °C in January. The absolute minimum temperature (-8.6 °C) was recorded in January 1985, and the absolute maximum (39.2 °C) in August 1981. The greatest rainfall is in November (average 99.6 mm) and December (average 89.2 mm). In the period from June to August the rainfall is 121.9 mm. Northern winds prevail throughout the year. This area has 2,698 hours of sunshine per year. On average, the relative air humidity is 57%. In winter, the frequent northern wind called the 'bura' significantly decreases the relative air humidity.

The study area of Blato ('mud') is about 6 km from the town of Šibenik near the village of Zablaće and the Solaris Resort. The village of Zablaće has 500 year-round inhabitants, but this number increases several-fold in summer. Blato is a small salt-marsh about 250 m distant from the seacoast. At present it covers a surface area of ca. 5–6 ha. The vegetation is threatened by human activitivities and currently the situation is in a transitional stage of abandonment and the creation of new habitats.

The Blato coastal salt-marsh is colonized by various halophilous plant communities, whose species tolerate the periodical inundation by seawater of their growing-sites, as well as the complete desiccation that give rise to halomorphic soils, characterized by a high saline concentration in the upper stratum. In practice, Blato is a shallow depression of silty and clay soils. For most of the year the soils have a high moisture content or are inundated to 5–10 cm with salt or brackish

Figure 1: Geographical position (▲) of the study area (Abbreviations: BIH: Bosnia and Herzegovina; MNE: Montenegro; AL: Albania).

Slika 1: Geografski položaj (▲) preučevanega območja (Okrajšave: BIH: Bosna in Hercegovina; MNE: Črna gora; AL: Albanija).

water. Water-depths in some deeper ditches and hollows are ca. 40–50 cm. The excess water is led away by a drainage channel passing through the Blato area and connecting the marine lake Velika Solina to the sea in Podsolaris Bay (Carić et al. 2011). During the summer, the salt-marsh area gradually drains due to low precipitation and high evaporation. In some years the deeper parts of the soil retain some of the moisture even in the driest period (July-August) due to the presence of groundwater.

3. MATERIAL AND METHODS

Fieldwork was carried out in August 2014. For data collection the Braun-Blanquet approach (Braun-Blanquet 1964) was used. Only stands with at least the minimum area recommended for these types of vegetation were investigated (Chytrý & Otýpková 2003). In each association a reasonable degree of homogeneity was ensured. The syntaxonomic scheme in the text follows Rivas-Martínez et al. (2001). The nomenclature of higher syntaxa (alliances, classes) mentioned in the text and Table 1 was derived from Biondi et al. (2014). The nomenclature of plant taxa follows the Flora Croatica Database (Nikolić 2014). Herbarium specimens are deposited in the herbarium collection of the Laboratory for terrestrial flora and fauna of the University of Dubrovnik. The biological forms were directly verified in the field and expressed according to the acronyms reported by Pignatti (1982) and based on the classification by Raunkiaer (1934). The abbreviations of life forms (Ch – Chamaephytes, H – Hemicryptophytes, G – Geophytes, T – Therophytes; Hy – Hydrophytes; scap – scapose, rhiz – rhizomatose, caesp – caespitose, succ – succulent, frut – fruticose, ros – rosulate, suffr – suffruticose, rad – rooting, nat – natant) are given in Table 1, before the each species name.

In order to verify the traditional syntaxonomic system, the relevés were classified by numerical methods. The matrix consists of 22 species × 21 samples (relevés). Braun-Blanquet values were transformed according to van der Maarel (1979). An agglomerative, hierarchical clustering algorithm based on Euclidean distances and Ward's method for determination of group linkages was used (McCune & Mefford 2006). Differences between groups obtained in classification were tested by analysis of similarities (ANOSIM). For these purposes the PC-ORD ver. 5 and PRIMERv6 software packages (McCune & Mefford 2006, Clarke & Gorley 2006) were used.

Three soil samples were randomly taken in the association *Cressetum creticae* over the salt-marsh, and one sample each in other associations (except in *Enteromorpho intestinalidis-Ruppietum maritimae*). Samples were collected at depth profiles of 0–20 cm. For the determination of soil properties the surface soil samples (average weight 2 kg) were air-dried and well mixed. A sub-sample of about 1 kg soil was sieved through a 2 mm mesh. For the soil salinity assessment, a soil saturation extract (ECe) was analyzed (US Salinity Laboratory 1954, Rhoades 1996). Soil samples were analyzed in the laboratory and subjected to the following analyses: i) grain size distribution (dry sieving and after dispersion with sodium pyrophosphate; Dane & Topp 2002), ii) the electrical conductivity (ECe) and pH were measured in a soil saturation extract using a MettlerToledo MPC 227 conductivity/pH meter, iii) calcium carbonate ($CaCO_3$) by the volumetric calcimeter method after HCl attack, iv) element concentrations in a soil saturation extract were determined using a Skalar San+Analyzer spectrofotometer

(Cl^-) and an atomic emission spectrometer AAS PerkinElmer 3110 (Na^+). Quality control procedures consisted of reagent blanks, duplicate samples and several referenced soil and sediment samples of a similar matrix from the interlaboratory calibration programme (Houba et al. 1996). Maximum allowable relative standard deviation between replicates was set to 10%.

4. RESULTS

Cressa cretica L. appears within the four plant associations: *Juncetum maritimo-acuti* (*Juncetea maritimi*), *Puccinellio festuciformis-Sarcocornietum fruticosae* (*Sarcocornietea fruticosae*), *Scirpetum maritimi* (*Phragmito australis-Magnocaricetea elatae*) and *Cressetum creticae* (*Thero-Suaedetea splendentis*, Table 1, Figure 2).

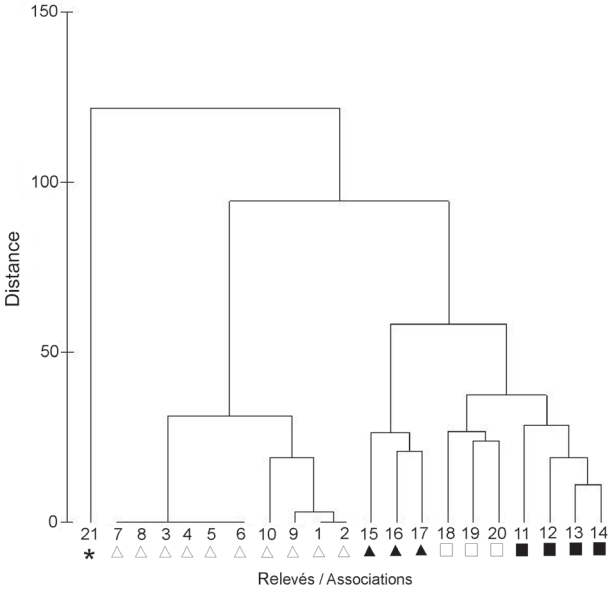

Figure 2: Dendrogram of the relevés. *Enteromorpho intestinalidis-Ruppietum maritimae* (*), *Cressetum creticae* (Δ), *Scirpetum maritimi* (▲), *Puccinellio festuciformis-Sarcocornietum fruticosae* (□), *Juncetum maritimo-acuti* (▪).

Slika 2: Dendrogram popisov. *Enteromorpho intestinalidis-Ruppietum maritimae* (*), *Cressetum creticae* (Δ), *Scirpetum maritimi* (▲), *Puccinellio festuciformis-Sarcocornietum fruticosae* (□), *Juncetum maritimo-acuti* (▪).

Among them, the *Cressetum creticae* (Figures 3 & 4) association was found for the first time in Croatia as well as on the eastern Adriatic coast.

The syntaxonomic synopsis of the *Cressetum creticae* is:

THERO-SUAEDETEA SPLENDENTIS Rivas-Martínez 1972

Thero-Suaedetalia splendentis Braun-Blanquet & O. Bolòs 1958

Thero-Suaedion splendentis Braun-Blanquet in Braun-Blanquet, Roussine & Nègre 1952

Cressetum creticae Brullo & Furnari 1976

This halo-nitrophilous community shows a monospecific or paucispecific character and it is exclusively composed of therophytes. *C. cretica* is the characteristic and dominant species of the association. In fact the companions *Salsola soda* L. and *Suaeda maritima* (L.) Dumort. appear in some relevés. Generally, the association shows highly variable vegetation cover (20–90%). This low vegetation (≤30 cm) occupies the driest depressions (aproximately 30 cm lower than surrounding vegetation types) in the salt-marsh. The association develops in summer (most commonly in August) on silty clay substrates with organic matter derived from the decay of saltmarsh bulrush (*Scirpus maritimus*) and sub-halophyte communities of rushes (*Juncetum maritimo-acuti*) and widgeon grass (*Enteromorpho intestinalidis-Ruppietum maritimae*), in depressions subject to flooding in winter. According to World Reference Base for Soil Resources (IUSS Working Group WRB, 2006), the soil belongs to Solonchaks (Alcalic Clayic Evapocrustic Humic Hypersalic).

In total, the association covered a surface area of ca. 0.05 ha in 2014. According to observations of the second author (M. Milović) over the last decade, due to climatological conditions in particular years more or less of this surface area may be covered by the association.

Cressa cretica appears in three other associations only sporadically, but it is presented over almost the whole salt-marsh surface area (Table 1). It is missing in the deepest parts of the salt-marsh covered by the *Enteromorpho intestinalidis-Ruppietum maritimae* association.

In terms of grain size, the soil samples were classified as silty-clay. Clay (<2 μm) and fine silt (2–20 μm) contents were much higher than coarse silt (20–63 μm) or sand (>63 μm). There were no differences of the soil grain-size distribution among the associations (Table 2). The main soil characteristics of the four associations of the marsh are summarized in Table 3. Among the associations, *Cressetum creticae* showed the highest electrical conductivity, Cl^- and Na^+ concentrations and *Juncetum maritimo-acuti* the lowest.

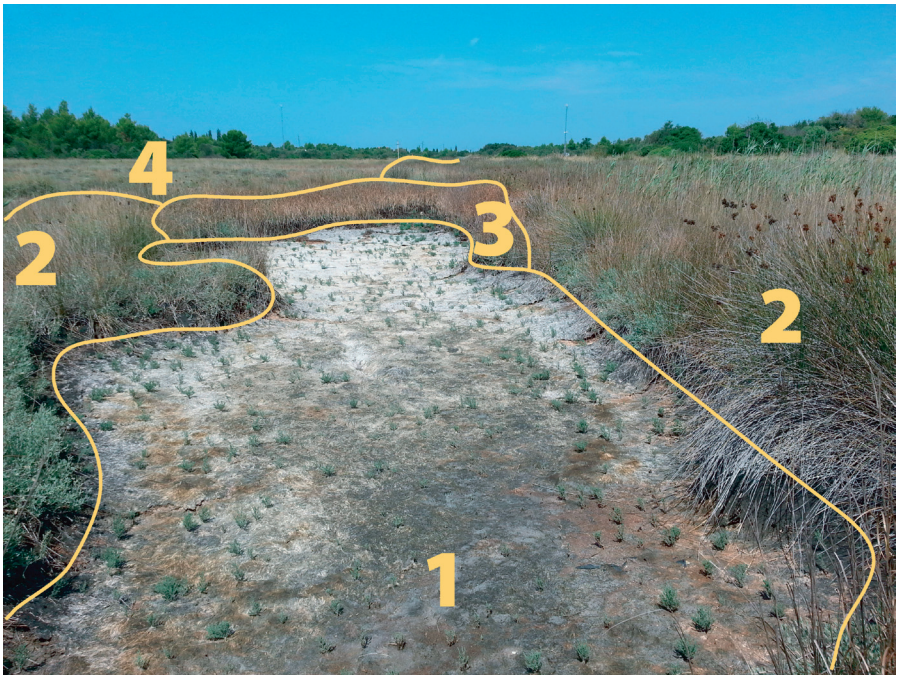

Figure 3: Spatial distribution of the associations in the investigated area: *Cressetum creticae* (1), *Juncetum maritimo-acuti* (2), *Scirpetum maritimi* (3), *Puccinellio festuciformis-Sarcocornietum fruticosae* (4) (photo: N. Jasprica, August 8, 2014).

Slika 3: Prostorska razširjenost asociacij na preučevanem območju: *Cressetum creticae* (1), *Juncetum maritimo-acuti* (2), *Scirpetum maritimi* (3), *Puccinellio festuciformis-Sarcocornietum fruticosae* (4) (foto: N. Jasprica, 8. 8. 2014).

Figure 4: *Cressetum creticae* in the study area (photo: M. Milović, August 31, 2008).

Slika 4: *Cressetum creticae* v proučevanem območju (foto: M. Milović, 31. 8. 2008).

Both of them are established on the soils with the highest content of $CaCO_3$ and humus.

5. DISCUSSION

This investigation revealed the presence of the halo-nitrophylic association *Cressetum creticae* in the eastern Adriatic coast.

This association has already been noted for Tunisia (Barbagallo et al. 1990), Corsica (Paradis & Tomasi 1991, Géhu & Biondi 1994, Lorenzoni & Paradis 1994, Paradis & Lorenzoni 1999), Sardinia (Biondi et al. 2001), Sicily (Brullo & Furnari 1976), Spain (Galán de Mera et al. 1997), and the south-western Adriatic coast (Tomaselli et al. 2010, 2011). Although *C. cretica* has also been reported from Albania, it does not build separate

plant associations (cf. Dring et al. 2002, Shehu et al. 2010, Imeri et al. 2010, etc.).

In our case, although relatively poor in species, the vegetation composition of the coastal salt-marsh is a mosaic of five plant associations that grow on soils with the same grain-size distribution. Among them, *Cressetum creticae* occupies the most haline and the driest parts of the salt-marsh. These agree well with the ecological conditions in the Tunisian and Italian associations (Barbagallo et al. 1990, Biondi et al. 2001). Some of the authors who have studied plant communities with *C. cretica* (Brullo & Furnari 1970, Cirujano 1981, Ladero Álvarez et al. 1984) note the coincidence in the frequent appearance of salty efflorescences in these soils. In our case, such salty efflorescences have been found in these soils in the very dry summer of 2008 (cf. Mileta & Likso 2009). In this study, due to the limited number of soil analysis samples collected during the exceptionally rainy summer of 2014, the results may be treated as an approximation rather than definitive.

In Croatia and in most Mediterranean sites, *Cressetum creticae* has a generally monospecific or paucispecific character. The Croatian association differed from the south-western Adriatic association (Brindisi) which included some more species (8), mostly from the *Saginetea maritimae* class (Tomaselli et al. 2011).

In our study, *Cressetum creticae* has connections with the topographic perennial halophyte communities of the *Sarcocornietea fruticosae* and *Juncetea maritimi* classes, even of the *Phragmito australis-Magnocaricetea elatae* class. This agrees with the findings of Barbagallo et al. (1990), Lorenzoni & Paradis (1994) and Biondi et al. (2001). In fact, *C. cretica* appears within four associations. Others have commented on the presence of *C. cretica* within some communities of *Thero-Suaedetea splendentis*, *Sarcocornietea fruticosae*, *Saginetea maritimae* or *Isoëto duriei-Juncetea bufonii* on Sicily (Guglielmo et al. 2012), Sardinia (Biondi et al. 2001), Corsica (Lorenzoni & Paradis 1994) and in Spain (Ladero Álvarez et al. 1984).

Despite lack of data on the phytosociological and ecological status of *C. cretica* from two Croatian islands, the most common species found with it on the gravel or gravel-muddy coasts were: *Atriplex prostrata* Boucher ex DC. in Lam. et DC., *Elymus elongatus* (Host) Runemark, *Limonium cancellatum* (Bernh. ex Bertol.) Kuntze, *Arthrocnemum fruticosum* (L.) Moq., *Inula crithmoides* L. and *Reichardia picroides* (L.) Rot. (Nikolić 2014). *C. cretica* is a quite rare and sporadic species on these localities (M. Ruščić, pers. comm.). In addition, on the peninsula of Pelješac only a few individuals have been found at a fine-pebbly beach, where organic material, carried by the sea, accumulates and decomposes (T. Nikolić, pers. comm.).

Cressetum creticae is closely related to the western Adriatic associations *Suaedo-Salicornietum patulae* and *Suaedo maritimae-Bassietum hirsutae* (Poldini et al. 1999, Tomaselli et al. 2011). Nevertheless the *Suaedo maritimae-Bassietum hirsutae* association is incompletely developed within the north Adriatic, due to the absence of two characteristic species: *Cressa cretica* is completly missing and *Bassia hirsuta* has become rare north of Ravenna (Poldini et al. 1999, Kaligarič & Škornik 2006).

Regarding syntaxonomy, we subordinated *Cressetum creticae* to the pioneer communities of annual glassworts, seablite and other halo-nitrophiles on tidal mud-flats of the *Thero-Suaedetea splendentis* class (Brullo & Furnari 1976, Lorenzoni & Paradis 1994, Rivas-Martínez et al. 2001, Di Pietro et al. 2009, Tomaselli et al. 2010, 2011). By contrast this association from the west Mediterranean has been mostly subordinated to the *Saginetea maritimae* class (cf. Biondi et al. 2001, Farris et al. 2007) or to its synonym the *Frankenietea pulverulentae* class (Ladero Álvarez et al. 1984, Galán de Mera et al. 1997, for details see Brullo & Giusso del Galdo 2003). In fact, some Spanish authors (cf. Rivas-Martínez & Costa 1976, Rivas-Martínez et al. 1980) included some associations of the *Thero-Suaedion splendentis* allliance to the *Frankenietea pulverulentae* class. However, the typical associations of the *Saginetea maritimae* class are therophytic, halo-subnitrophilous communities with their maximum expression in the early spring, being characterized by microphytes with a very early flowering (Brullo 1988, Brullo & Giusso del Galdo 2003). By contrast, the halonitrophilous associations of the *Thero-Suaedion splendentis* alliance are in particular characterized by therophytic aspects of habitus in general with a succulent summer-autumn cycle (eg. *Cressa cretica*, *Salsola soda*, *Suaeda maritima*, etc.). We think that *Cressetum creticae* must be included in *Thero-Suaedetea splendentis*.

This Croatian coastal salt-marsh, including the habitat of *C. cretica,* is exposed to many disturbances. Regarding human presence in the area, alongside urban and industrial land use, hydrologic alteration and/or eutrophication are the

main factors which influence the physiognomy and floristic composition of the salt-marsh communities (cf. Bromberg Gedan et al. 2009). This vegetation is also of interest and important from the conservational perspective as being threatened by all factors mentioned above. In addition, this salt-marsh with different types of halophyte vegetation is important due the presence of habitats of European or global significance for protection or for botanical interest (Council of the European Communities 1992, European Commission 2007). In contrast to some west Mediterranean sites (Spain, Corsica), where communities with *C. cretica* are active pastures, in our case the habitat is an important part of the ecosystem in terms of the aesthetics of landscape.

In summary, this study adds to the base of information on the structure and function of small Mediterranean coastal salt-marsh. Of particular note, the presence of the *Cressetum creticae* distinguishes this system from those of other salt-marshes in the region. Stands with *C. cretica* are extremely rare on the eastern Adriatic coast and, owing to heightened coastal development, perhaps in the process of becoming extinct. They nevertheless are an important part of the region's natural heritage in need of conservation measures to ensure their survival. It was in this context that the present ecological investigation was conducted in August 2014.

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APPENDIX

Syntaxonomic units mentioned in the text and Table 1, but not in the scheme (in alphabetical order).

Ammophiletea Braun-Blanquet & Tüxen *ex* Westhoff, Dijk & Passchier 1946

Artemisietea vulgaris Lohmeyer, Preising & Tüxen *ex* von Rochow 1951

Cakiletea maritimae Tüxen & Preising in Tüxen 1950

Enteromorpho intestinalidis-Ruppietum maritimae Westhoff *ex* Tüxen & Böckelmann 1957

Frankenietea pulverulentae Rivas-Martínez *ex* Castroviejo & Porta 1976

Fraxino orni-Quercion ilicis Biondi, Casavecchia & Gigante *ex* Biondi, Casavecchia & Gigante in Biondi, Allegrezza, Casavecchia, Galdenzi, Gigante & Pesaresi 2013

Isoëto duriei-Juncetea bufonii Braun-Blanquet & Tüxen *ex* Westhoff, Dijk & Passchier 1946

Juncetea maritimi Braun-Blanquet in Braun-Blanquet, Roussine & Nègre 1952

Juncetum maritimo-acuti Horvatić 1934

Phragmito australis-Magnocaricetea elatae Klika in Klika & Novák 1941

Puccinellio festuciformis-Sarcocornietum fruticosae (Braun-Blanquet 1928) Géhu 1976

Ruppietea maritimae J. Tüxen 1960

Saginetea maritimae Westhoff, Van Leeuwen & Adriani 1962

Sarcocornietea fruticosae Braun-Blanquet & Tüxen *ex* A. Bolòs & O. Bolòs in A. Bolòs 1950 *nom. mut. propos.* Rivas-Martínez, T.E. Díaz, Fernandez-Gonzales, Izco, Loidi, Lousã & Penas 2002

Scirpetum maritimi (Braun-Blanquet 1931) Tüxen 1937

Suaedo maritimae-Bassietum hirsutae Braun-Blanquet 1928

Suaedo maritimae-Salicornietum patulae Brullo & Funari *ex* Géhu & Géhu Franck 1984

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Table 1: Phytosociology of *Cressa cretica* in the study area.
Tabela 1: Fitocenologija vrste *Cressa cretica* na proučevanem območju.

Life form	Number of relevés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Vascular plant cover (%)	80	50	20	50	60	80	30	30	30	90	90	90	80	80	90	100	80	50	40	50	100
	Plot size (m^2)	10	6	10	12	8	10	25	10	10	16	25	25	25	20	6	10	30	25	25	25	4
	Number of species	2	2	1	1	1	1	1	1	2	3	8	11	12	12	4	5	6	8	8	11	2
	Thero-Suaedetea splendentis																					
T scap	*Cressa cretica* L.	**4**	**4**	**2**	**4**	**4**	**5**	**3**	**3**	**3**	**5**	1	+	.	+	+	+	+	.	+	+	.
T scap	*Suaeda maritima* (L.) Dumort.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
	Juncetea maritimi																					
G rhiz	*Juncus maritimus* Lam.	.	.	.	.	.	.	.	.	.	.	**4**	**3**	**3**	**2**	.	.	.	+	+	.	.
H caesp	*Juncus acutus* L.	.	.	.	.	.	.	.	.	.	.	**.**	+	**2**	**2**	.	.	.	.	.	.	.
	Phragmito australis-Magnocaricetea elatae																					
G rhiz	*Scirpus maritimus* L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**4**	**5**	**4**	.	1	+	.
G rhiz	*Phragmites australis* (Cav.) Trin. ex Steud.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	**.**	**.**	**.**	.	.	.	.
	Sarcocornietea fruticosae																					
Ch succ	*Arthrocnemum fruticosum* (L.) Moq.	.	.	.	.	.	.	.	.	.	.	2	+	+	1	.	.	.	**3**	**2**	**3**	.
Ch frut	*Halimione portulacoides* (L.) Aellen	.	.	.	.	.	.	.	.	.	.	.	1	+	+	1	1	+	**1**	**4**	**2**	.
H caesp	*Puccinellia festuciformis* (Host) Parl.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	+	.	**+**	**+**	**+**	.
H ros	*Limonium narbonense* Mill.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+	+	+	+	+	.
H caesp	*Elymus elongatus* (Host) Runemark	.	.	.	.	.	.	.	.	.	.	+	+	+	+	1	.	.	.	.	+	.
Ch suffr	*Inula crithmoides* L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.
Ch succ	*Arthrocnemum macrostachyum* (Moric.) C. Koch	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Ch suffr	*Artemisia caerulescens* L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
	Cakiletea maritimae																					
T scap	*Salsola soda* L.	+	+	.	.	.	.	.	.	+	+	+	.	.	.	.	.	+	.	.	.	.
	Saginetea maritimae																					
T scap	*Polypogon maritimus* Willd.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	+	.
T scap	*Centaurium spicatum* (L.) Fritsch	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	+	.	.
T scap	*Centaurium pulchellum* (Sw.) Druce	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	+	.
	Artemisietea vulgaris																					
T scap	*Aster squamatus* (Spreng.) Hieron.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
	Ruppietea maritimae																					
Hy rad/nat	*Ruppia maritima* L.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	**5**
	Enteromorpha intestinalis (L.) Nees	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
	Ammophiletea																					
G rhiz	*Elymus pycnanthus* (Godr.) Melderis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.

rel. 1–10. *Cressetum creticae*
rel. 11–14. *Juncetum maritimo-acuti*
rel. 15–17. *Scirpetum maritimi*
rel. 18–20. *Puccinellio festuciformis-Sarcocornietum fruticosae*
rel. 21. *Enteromorpho intestinalidis-Ruppietum maritimae*

Table 2: Grain-size of soil samples in the associations.
Tabela 2: Velikost delcev v tleh v različnih asociacijah.

Association	Grain size (%)				
	<2 μm	2–20 μm	20–63 μm	63–200 μm	200–2000 μm
Cressetum creticae (sample 1)	57	26	13	2	2
Cressetum creticae (sample 2)	47	31	17	3	2
Cressetum creticae (sample 3)	50	28	16	3	3
Juncetum maritimo-acuti	46	30	18	3	3
Puccinellio festuciformis-Sarcocornietum fruticosae	52	29	15	2	2
Scripetum maritimi	51	28	17	2	2

Table 3: The soil characteristics (± SD) of the associations of the Blato salt-marsh (SD = standard deviation).
Tabela 3: Značilnosti tal (± SD) v asociacijah v slanišču Blato (SD = standardni odklon).

Association	soil saturation extract						
	pH	ECe	Cl^-	Na^+	%	$CaCO_3$	Humus
		dS m^{-1}	g L^{-1}	g L^{-1}	saturation	%	%
Cressetum creticae (n=3)	8.03 ± 0.13	44.5 ± 10.69	18.62 ± 5.76	8.78 ± 2.40	81.81 ± 8.03	19.84 ± 9.22	2.86 ± 1.46
Juncetum maritimo-acuti	8.30	14.86	4.82	2.79	77.91	20.71	2.18
Puccinellio festuciformis-Sarcocornietum fruticosae	8.20	32.30	11.85	6.74	75.41	7.77	1.51
Scripetum maritimi	8.26	25.10	8.63	5.40	82.56	8.20	1.72