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First monitoring of *Cladocora caespitosa* (Anthozoa, Scleractinia) in the Boka Kotorska Bay (Montenegro)

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ABSTRACT

The scleractinian coral *Cladocora caespitosa* (Linnaeus 1767) is a colonial, long-lived and reef-building coral. It is endemic for the Mediterranean Sea, protected by national and international legislation and recently included in the IUCN Red List as an endangered species. This study reports preliminary results on the first monitoring of *C. caespitosa* populations on 3 locations (Verige, Sv. Nedjelja and Sv. Đorđe) in the Boka Kotorska Bay (Montenegro). Along 11 transects (each 50 m^2) in total 98 colonies were intercepted and measured (minimum and maximum diameters, and height of the colony). Great majority (71%) of measured colonies were found in the depth range from 10 to 15 m depth. Diameter of colonies was varying from 1.5 cm up to 35 cm, but colonies are generally small, 7.9 cm on average and a degree of sphericity (IS index) was 0.6. Unfortunately, many colonies were partially or completely dead and bleaching was observed on all three locations.

Keywords: *Cladocora caespitosa,* monitoring, Adriatic Sea, distribution, growth

INTRODUCTION

One of the major carbonate producers in the Mediterranean Sea is the stony coral *Cladocora caespitosa* (Linnaeus, 1767) (Peirano 2001; Lipej et al., 2016). This species belongs to Subclass Hexacorallia, while taxonomic position of the genus is still not very clear and it was changed from Faviidae to Caryophylliidae and Oculinidae (Kersting, Linares, 2012). *C. caespitosa* is endemic to Mediterranean and occurs at different type of mostly rocky substrates, in shallow waters (up to 50m depths) where the amount of light is sufficient for the photosynthesis of the endosymbiotic zooxanthellae. This species is slow growing and consists of radially growing and branched individual, calcified corallites (Zibrovius 1980, Trainito, Baldacconi 2016). Between these corallites there are many

cervices filled with water and/or trapped sediment. Therefore, structures formed by this species are very important as a builders of few different microhabitat types: hard substrate for epilithic organisms on the surface of the colony and endolithic for organisms within the colony; intermediary space for vagile fauna and trapped sediments for infauna that dig and burrow in the soft bottom (Lipej et al., 2016). Because of this high complexity of microhabitats in a small volume there is a high biodiversity, and because of slow grow of coral it is reflecting state of the environment during a long period.

Fossils of this species were found in different parts of the Mediterranean since the Miocene (6 million years ago), but unfortunately, also in many parts of this area, in recent decades, mass mortality of *C. caespitosa* have been reported (Kružić et al., 2014, Lipej et al., 2016; Jimenez et al., 2014). Because of that, although it is included as protected species in many national laws and international conventions, since 2008 it has been also included as an endangered species in the IUCN Red List (Otero, et al., 2017).

Big populations of *C. caespitosa* in the Boka Kotorska Bay, and coralligenous biocenosis covering about 8% (1.98km^2) of Kotor-Risan Bay has been reported by Stjepčević and Parenzan (1980). The key role of *C. caespitosa* in the ecosystem of the bay has been confirmed in study by RAC SPA (2013), but unfortunately huge colonies were observed dead and *C. caespitosa* was present in the shallow water of the bay mainly with medium and small colonies. In the Kotor-Risan bay are confirmed also particular coralligenous assemblages characterized by the presence of *C. caespitosa*, large-sized sponges (*Axinella sp.*) and cnidarians, notably the gorgonian *Leptogorgia sarmentosa* and of yellow cluster anemone *Parazoanthus axinellae i(*RAC SPA 2013). Furtermore, extraordinary colonies of *Savalia savaglia* were mapped and they should be particularly protected not only for its specific rarity, endemism and vulnerability, but also because they have a prominent role in sustaining high levels of biodiversity and ecosystem functioning in the surrounding benthos of the twilight zone (Eusebio et al., 2007; Cerrano et al., 2010; RAC SPA 2013).

Although living and dead colonies of *C. caespitosa* are very important for the benthic communities of the Kotor Risan bay unfortunately there was no any study describing their morphology, evolution, or relation with the environmental factors. In this study we started monitoring of the *C. caespitosa* in terms of spatial distribution, size structure and growth rates, in order to provide first data that could be compared with published results from other areas and over time.

MATERIAL AND METHODS

Surveys were performed in the Boka Kotorska Bay, on three locations (Sv. Đorđe, Verige and Sv. Nedelja) by SCUBA diving during summer 2018 (Tab. 1).

Some of the data were collected in situ using transect methodology and others were elaborated in the laboratory. At all three sites transect belt 50m long was laid down perpendicular to the coast line. All *C. caespitosa* colonies within 0.5m on each side of the transect belt were photographed and counted to obtain population density. In addition to that for each colony the maximum axis, length (D1) the minimum axis, width (D2) and the height (h) were measured in situ, as well as depth and distance along the transect. To evaluate annual polyp growth rate 5 corallites

Table 1. Few characteristics of the surveyed locations

Location	Coordinates	No. of transects	Depth range	Orientation	Slope
Island Sv. Đorđe	N 42.485272º E 18.691251º	6	5-19	S	medium
Verige	N 42.476309º E 18.689125º	2	7-18	N	high
Sv. Nedjelja	N 42.459827º E 18.676704º	3	13-19	S	medium

were sampled from each location, cleaned in H_2O_2 (30%) for 24h and x –radiographed with a medical unit (Kersting, Linares, 2012).

The relationship between the hydrodynamics and the shape of the *C. caespitosa* colonies were analysed through the sphericity (IS) index (IS = h/D1) (Riegl, 1995). ANOVA (analysis of variance) was performed in order to evaluate differences in colonies sizes among sites.

RESULTS AND DISCUSSION

The depth distribution of measured *C. caespitosa* colonies on the location island Sv. Đorđe and Sv. Nedjelja ranged from 5 to 19m and from 7 to 18m respectively while on location Verige depth range was only from 13 to 19m. In general, the majority of *C. caespitosa* colonies (71%) were situated on the depth range from 10.1 to 15m depth. On all three locations bottom is rocky in very small portion (5-15%), while smaller rocks (10-50cm) and muddy sand are dominant (55-75%), while muddy bottom is present only in deeper parts of surveyed transects (10-20%). Results from other areas in the Mediterranean indicate the lack of hard substrate as one of the limiting factors for the development of *C. caespitosa* colonies, so this could be one of the reasons for the lack of higher density of colonies in the Boka Kotorska Bay (Zibrowius 1980, Kersting, Linares, 2012, Zunino et al., 2018). In addition to that (although without more data we can only speculate) spring of fresh water on location Verige and huge change of the environmental factors during the year could be one of the main reasons for distribution of *C. caespitosa* only in the deeper areas on this micro-location.

It seems that also some other factors have negative effects on *C. caespitosa* in the bay. On the location island Sv. Đorđe we observed the highest percentage of dead colonies (25%). It is not only that we observed bleached (Fig. 1) and dead colonies, but on this location we observed also very huge quantities of corallites died long time ago (Fig. 2).

Figure 1. Few bleached coralites on location island Sv. Đorđe

As it was reported by RAC SPA (2013) it is possible that *C. caespitosa* had its climax phase in the area of Boka Kotorska bay hundreds to thousand years ago and currently lies in a recession phase due to the environmental changes e.g. sea level rise, increase in temperature, in water turbidity etc. More detailed study of living and dead colonies would be needed to understand evolution of these communities in the Boka Kotorska Bay (RAC SPA 2013). In the meantime the dead corallites together with coralline algae created a secondary hard bottom where living colonies of *C. caespitosa* and other typically hard bottom species were able to settle, as it was case in some other parts of the Mediterranean (Pitaco et al., 2014, Lipej et al., 2016).

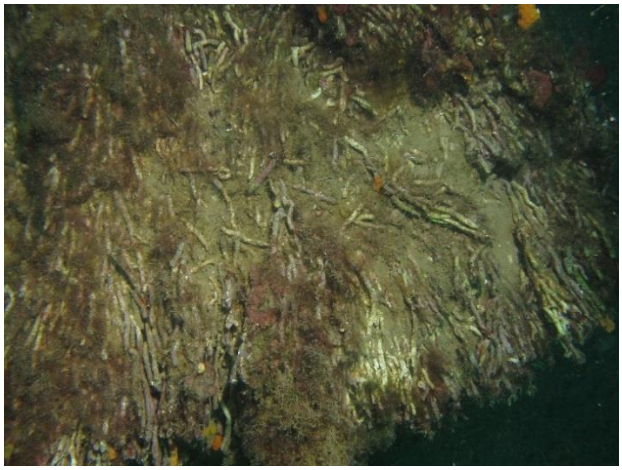

Figure 2. Part of the dead colony on location island Sv. Đorđe

On all three locations dominant size class was small, from 5.1 to 10cm (n=54) (Fig. 3). Colonies bigger than D1 =15cm were only few and the largest colony was recorded on location Sv. Nedjelja (D1 = 35cm).

The size frequency distribution of all three locations in relation to different depth ranges are shown on Figures 4-6. On almost all depth ranges dominant was small size class (6-10cm), and the differences in colony size between locations were not significant (ANOVA, $p<0.05$).

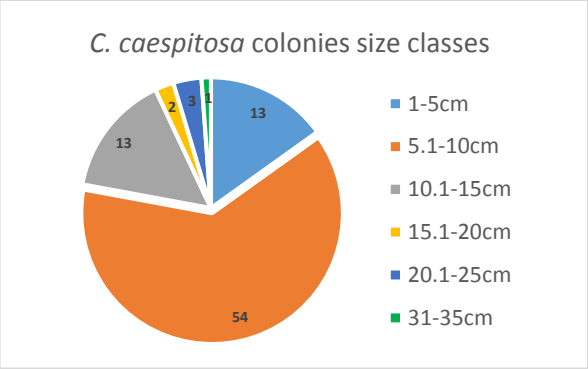

Figure 3. Size classes on all three locations

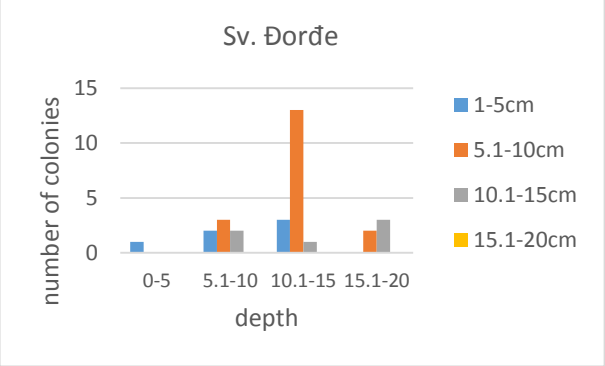

Figure 4. The size frequency distribution on location Sv. Đorđe in relation to different depth ranges

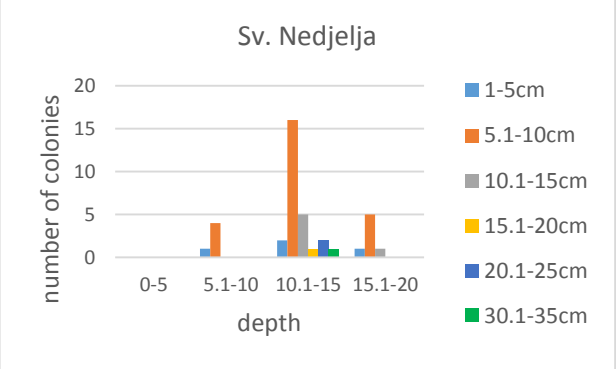

Figure 5. The size frequency distribution on location Sv. Nedjelja in relation to different depth ranges

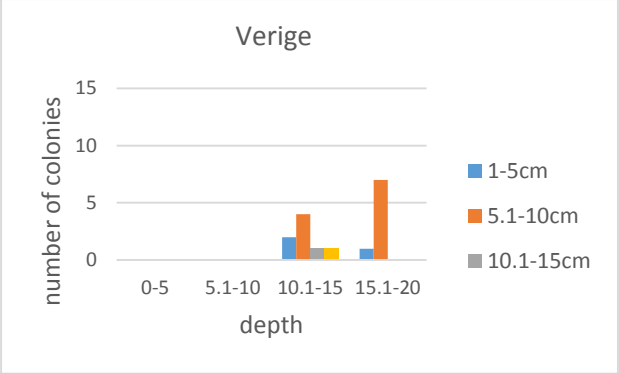

Figure 6. The size frequency distribution on location Verige in relation to different depth ranges

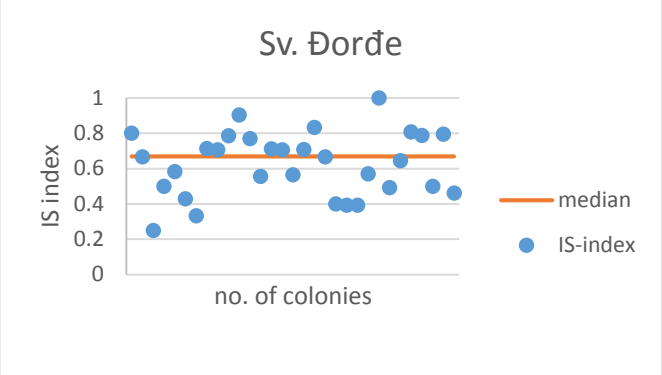

Figure 7. Is - index on location Sv. Đorđe

Variation in the morphology of the colonies was relatively high but the median value of Is-index was similar on all three locations, ranging from the lowest 0.54 on location Verige up to 0.67 on Sv. Đorđe (Fig 7-9). The influence of sea currents on the morphology of colonies was reported by several authors and flat colonies were related to high hydrodynamism (Kružić, Benković, 2008, Kersting, Linares 2012, Zunino et al., 2018). Unfortunately for our area of survey we don't have data on bottom currents regime and also data on surface currents are scares (Bellafiore et al., 2011). In general, our surveyed sites are in the bay that is well protected from different winds and waves. But specific situation in this bay is presence of "vrulja"-specific habitats of underwater freshwater springs that are creating periodically strong inflow of freshwater and currents in relation to that.

Peirano et al (1997) reported that *C. caespitosa* corallites create two bands per year: a high density band (HD) and a low density (LD) band. Unfortunately in our case on only few sampled and radiographed corallites annual HD and LD bands were clearly visible (Fig 9). They were all from the site island Sv. Đorđe and the mean annual grow obtained was 3mm.

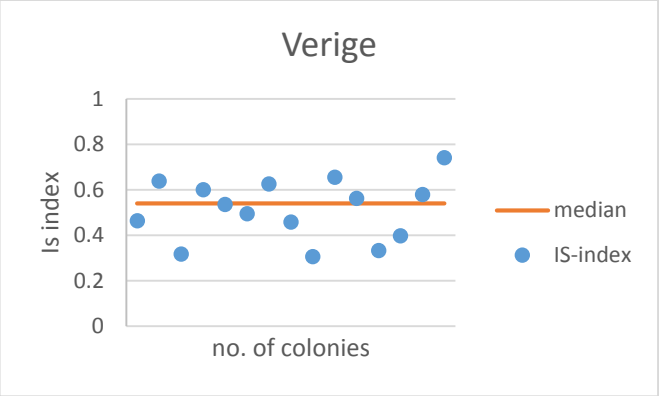

Figure 8. Is - index on location Verige

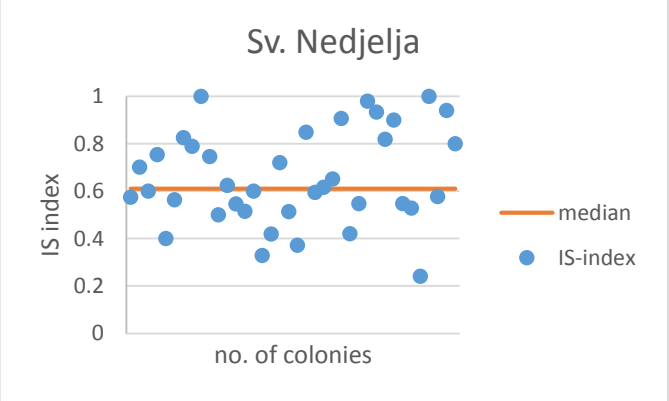

Figure 9. Is - index on location Sv. Nedjelja

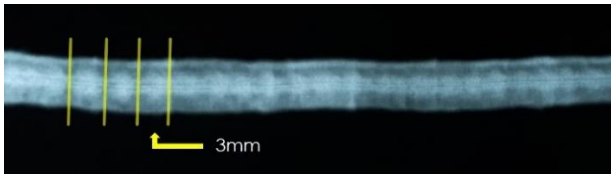

Figure 10. Image of x-radiographed corallite

This was very small number of analysed corallites to make any solid conclusion, but based on this preliminary results we can say that annual grow rate in Boka Kotorska Bay fits into the range of results from other areas in the Adriatic that varies from 2.6 to 4.7 mm/year (Kersting, Linares 2012). Based on this we can also roughly estimate that majority of the living colonies on surveyed locations in the Boka Kotorska Bay are about 20-30 years old. Coral *C. caespitosa* is a long living species and based on the reports of Stjepčević and Parenzan (1980) about huge areas of *C. caespitosa* it would be expected to have much bigger/older colonies. Here we have to mention that on deeper areas of island Sv. Đorđe there are few bigger colonies, but they were out of the area of this survey. More important and of more concern is the fact of many dead corallites on all three sites, but especially on island Sv. Đorđe (Fig. 2). Very big blocks of broken, dead colonies could be consequence of the anchoring. Although anchoring is prohibited on all of these three locations, because of extensive development of yachting tourism during last 10 years anchoring happens on location island Sv. Đorđe more often. That could be explanation for broken dead colonies, but a main reason of *C. caespitosa* regression in the Boka Kotorska Bay is still unknown.

Having in mind importance of *C. caespitosa* as a habitat forming species, its slow grow and rarity on one side and increasing treats caused by climate change, invasive species, pollution, human disturbance, etc. it is not strange why *C. caespitosa* is classified on the IUCN Red List as endangered, since 2008 (Otero et al, 2017). That is one more reason why further analysis are needed to evaluate state of the *C. caespitosa* colonies in the whole Boka Kotorska bay, their population dynamics and possible treats. Furthermore comparison with other populations in the Adriatic and Mediterranean could be useful to evaluate connectivity and impacts from global threats.

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Prvi monitoring *Cladocora caespitosa* (Anthozoa, Scleractinia) u Bokokotorskom zalivu (Crna Gora)

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ABSTRACT

Kameni koral *Cladocora caespitosa* (Linnaeus 1767) je kolonijalni, dugoživeći koral koji gradi grebene. Za Sredozemno more je endemska vrsta, zaštićena prema domaćoj i međunarodnoj legislativi, a od skoro je uključen u IUCN Crvenu listu kao ugrožena vrsta. Ovaj rad prikazuje preliminarne rezultate prvog monitoringa populacija *C. caespitosa* na 3 lokacije (Verige, Sv. Nedjelja and Sv. Đorđe) u Bokokotorskom zalivu (Crna Gora). Duž 11 transekata (svaki 50 m^2) ukupno 98 kolonija je nađeno i izmjereno (minimalni i maksimalni prečnici i visina kolonije). Velika većina (71%) mjerenih kolonija je bila nađena u dubinskom pojasu od 10 do 15m dubine. Prečnik kolonija je varirao od 1.5cm do 35cm, ali kolonije su uglavnom male, u prosjeku 7.9cm i indeks sferičnosti (IS index) je bio 0.6. Nažalost mnoge kolonije su bile djelimično ili potpuno mrtve, a bijeljenje korala je bilo opaženo na sve tri lokacije.

Keywords: *Cladocora caespitosa*, monitoring, Jadransko more, distribucija, rast