

MACROFAUNA ASSOCIATED WITH A BANK OF *CLADOCORA CAESPITOSA* (ANTHOZOA, SCLERACTINIA) IN THE GULF OF TRIESTE (NORTHERN ADRIATIC)

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ABSTRACT

The Mediterranean stony coral *Cladocora caespitosa* (Linnaeus, 1767) is a native colonial, zooxanthellate, shallow-water coral, particularly sensitive to global changes and anthropogenic activities. Due to its shape and size, it is able to host a diversified faunal assemblage, which is still relatively unknown. A recently discovered bank of *C. caespitosa*, discovered close to Cape Ronek (Gulf of Trieste, Slovenia), was investigated in November 2010. Altogether 121 invertebrate taxa, belonging to 9 different phyla were found. Taxa composition in colonies differed markedly from the surrounding areas within the bank. Only 5 taxa (4 % of the total) were found both within and without *C. caespitosa* colonies. Our results confirm the role of *C. caespitosa* as a habitat builder and indicate the importance of the studied bank for biodiversity.

Key words: *Cladocora caespitosa*, bioconstruction, macroinvertebrates, circalittoral, Northern Adriatic

MACROFAUNA ASSOCIATA AD UN BANCO DI *CLADOCORA CAESPITOSA* (ANTHOZOA, SCLERACTINIA) NEL GOLFO DI TRIESTE (ADRIATICO SETTENTRIONALE)

SINTESI

La madrepora a cuscino (*Cladocora caespitosa*, Linnaeus, 1767) è un corallo madreporario di acque poco profonde, sensibile ai cambiamenti climatici ed alle attività antropiche. Grazie alla sua struttura e alle dimensioni, questo madreporario è in grado di ospitare una comunità faunistica molto diversificata. Un banco di *C. caespitosa*, scoperto recentemente vicino a Capo Ronco (Golfo di Trieste, Slovenia), è stato studiato nel novembre 2010. In totale sono stati trovati 121 taxa di invertebrati, appartenenti a 9 diversi phyla. La composizione faunistica all'interno delle colonie differiva notevolmente da quella della zona circostante sul banco. Solo 5 taxa (4 % del totale) sono stati trovati sia all'interno che nei pressi delle colonie. I nostri risultati confermano il ruolo di *C. caespitosa* come biocostruttore e pongono l'accento sull'importanza del banco oggetto di studio per la biodiversità.

Parole chiave: *Cladocora caespitosa*, biocostruzioni, macroinvertebrati, circalitorale, Adriatico settentrionale

INTRODUCTION

The Mediterranean stony coral *Cladocora caespitosa* (Linnaeus, 1767) is the only native colonial and obligate zooxanthellate coral of the Mediterranean Sea (Zibrowius, 1980; Peirano *et al.*, 1999). It occurs throughout the Mediterranean on rocky and sandy bottoms from shallow waters to those at more than 30 m depth (Zibrowius, 1980). However, in the Adriatic Sea it is rarely found below 30 m (Kružić *et al.*, 2008). *C. caespitosa* is one of the major carbonate producers in the Mediterranean Sea (Peirano *et al.*, 2001) and forms hemispherical, bush-like colonies. Due to its shape and size, it is physiologically and morphologically similar to the typical tropical reef-building corals (Zibrowius, 1982; Schuhmacher & Zibrowius 1985; Peirano *et al.* 1994; Kružić & Požar-Domac, 2003) and consequently, is able to host a diversified faunal assemblage (Koukouras *et al.*, 1998). Much has been reported about the fauna associated with tropical corals (e.g., Cantera *et al.*, 2003; Idjadi & Edmunds, 2006; Martins Garcia *et al.*, 2008) but very little is known about the macrofauna associated with colonies of *C. caespitosa*. Species associated with this Scleractinian coral have been reported from different sites in the Adriatic (Sciscioli & Nuzzaci, 1970; Zavodnik, 1976; Schiller, 1993), Ionian (Lumare, 1965) and Aegean Seas (Arvanitidis & Koukouras, 1994; Koukouras *et al.*, 1998; Antoniadou & Chintiroglou, 2010). Nevertheless, most of these reports focus on specific taxonomic groups, namely polychaetes (Sciscioli & Nuzzaci, 1970; Arvanitidis & Koukouras, 1994) and echinoderms (Zavodnik, 1976). The most comprehensive study of macrofaunal assemblages associated with *C. caespitosa* was carried out by Koukouras *et al.* (1998) in the Aegean Sea.

Colonies of *C. caespitosa* can be solitary, can form 'beds' (numerous colonies living more or less close to each other) or 'banks' (colonies connected together in large formations) (Zibrowius, 1980; Kühlmann *et al.*, 1991; Schiller, 1993; Morri *et al.*, 1994; Peirano *et al.*, 1994). Solitary colonies can be locally abundant (Zibrowius, 1980), beds are known from several sites, such as the western Mediterranean (Majorca, Port-Cros and Villefrance), northern Adriatic and Ionian coasts (Peirano *et al.*, 1994), while banks are uncommon and have been reported only in the Ligurian Sea (Morri *et al.*, 1994), off the Tunisian coast (Zibrowius, 1980) and in the Adriatic (Kružić & Požar-Domac, 2003) and Aegean Seas (Kühlmann, 1996).

The circalittoral belt in the Gulf of Trieste is mostly composed of the biocoenosis of the muddy detritic bottom, with a patch of coastal detritic biocoenosis in the Bay of Piran (Lipej *et al.*, 2006). A bank of *C. caespitosa* was recently discovered close to Cape Ronek in Slovenian waters (Lipej *et al.*, 2006). The bank was investigated according to Marine Strategy Framework Directive (MSFD, 2008/56/EC) requirements. During the first survey of this bank, performed using SCUBA diving techniques,

coralline algae were sampled. Seven coralline algal species (three of them new for Slovenia) as well as fossil rhodoliths were found (Falace *et al.*, 2011). Given the important role of *C. caespitosa* as bioconstructor, the aim of the present work was to investigate the invertebrate fauna associated with this almost unknown biogenic formation in order to estimate to what extent this coral contributes to local biodiversity. Moreover, since some authors reported that the Mediterranean stony coral is undergoing a rapid decrease in both size and spatial distribution in the Mediterranean Sea (Morri *et al.*, 2001; Rodolfo-Metalpa *et al.*, 2005), it is of great importance to study the biological and ecological aspects of this bank and to consider possible measures of protection as well.

MATERIAL AND METHODS

Study area and sampling site

The Gulf of Trieste is a shallow semi-enclosed embayment located in the northernmost part of the Adriatic Sea. It is characterized by the lowest winter temperatures in the Mediterranean Sea, which can fall below 10 °C in winter (Boicourt *et al.*, 1999). Salinity is about 37 on average, but is influenced near the coast by fresh water input from rivers, mainly the Isonzo River (Mozetič *et al.*, 1998). During the summer, a typical thermal stratification of the water column develops due to surface heating and fresh water inflow (Boicourt *et al.*, 1999). In winter, the water column is characterized by consider-

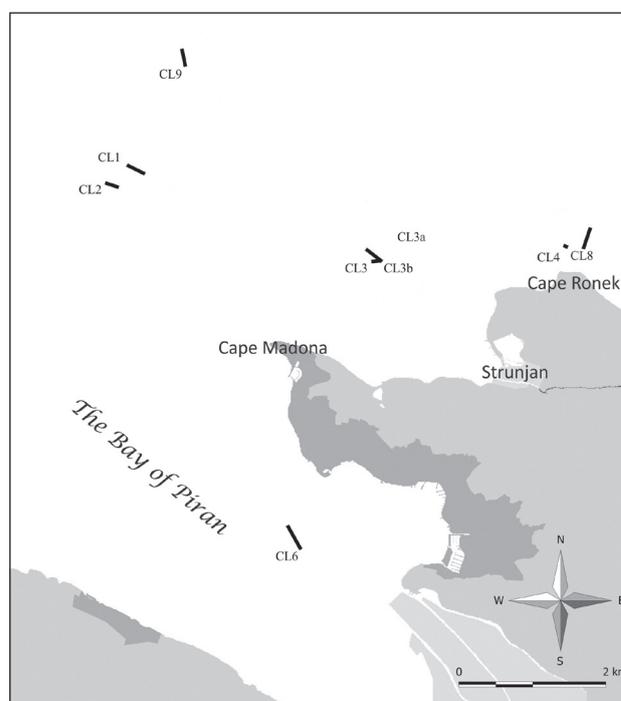


Fig. 1: Map of the study area with sampling sites.
Sl. 1: Obravnavano območje in mesta vzorčenja.

able vertical homogeneity due to autumnal cooling and wind mixing (Mozetič *et al.*, 1998).

The sampling site (Fig. 1) is located off the coast of Strunjan (Cape Ronek), where a biogenic bank of *C. caespitosa* is present. This bank extends on a surface of about 200 × 100 m, at a depth range between 12.4 and 21 m and is a few meters higher than the surrounding bottom. The bank (Fig. 2) presents the highest density of *C. caespitosa* colonies ever recorded in Slovenian coastal water: 6.52 colonies m⁻² on average (*unpubl. data*). On this bank colonies are surrounded by an area made of dead corallites and, to a lesser extent, of coralline algae (mainly rhodoliths of *Lithothamnion* spp.) (Fig. 3).

Fieldwork and laboratory work

Sampling was performed in November 2010, dredging the selected area at a constant speed of 1 knot for 5 minutes. The dredge is considered to be more appropriate than grabs and cores for the estimation of the densities of small benthic species (Pérès & Picard, 1964; Castelli *et al.*, 2003). The biogenic bank was investigated on two levels in order to better characterize the benthic community associated with this formation. The first level comprises the area that surrounds the colonies of *C. caespitosa*. The largest, easily identifiable animals were identified on the boat immediately after the sampling and were then released. The smallest animals were fixed in ethanol (70 %) and classified later in the laboratory. The second level addresses the infauna living inside colonies of *C. caespitosa*. Thirty colonies of *C. caespitosa* were chosen. Each colony was weighed and measured (minimum axis width and maximum axis length), and the percentage of the number of living corallites was visually estimated. The bottom surface covered by

those colonies was calculated from colony axes. Afterwards the colonies were preserved in 70 % ethanol. In the laboratory they were broken apart completely and sieved through a 1 mm mesh. Each corallite was broken and invertebrates living inside were carefully collected with fine pipettes and tweezers. Invertebrates were then sorted, counted and identified according to the relevant literature: Tebble (1966), Ghisotti & Sabelli (1970), Parenzan (1970/1976), Torelli (1982) and Cossignani *et al.* (1992) for molluscs; Fauvel (1923, 1927) and Bianchi (1981) for polychetes; Naylor (1972), Ruffo (1982/1993), Harrison & Ellis (1991), Falciai & Minervini (1992) and Hayward & Ryland (1995) for crustaceans, Occhipinti Ambrogi (1981) for bryozoans; Tursi (1980) for tunicates and Sarà (1972) for sponges. The nomenclature follows WoRMS (WoRMS, 2013). Only living invertebrates were taken into consideration and counted. Colonial species were also determined and their coverage on a surface of 20 × 20 cm was calculated, but they were excluded from indices calculations.

Each species was assigned to one of the following trophic groups: motile predators (P), ectoparasites and specialized carnivores feeding on larger animals (EC), deposit feeders feeding on organic particles contained in the sediment (DF), suspension feeders capturing seston particles with their gills or with mucous strings (SF), and grazers feeding on algae, cyanobacteria or detritus attached to algal fronds (G). Feeding guilds were assessed according to Fauchald & Jumars (1979), Bianchi (1981), Chintiroglou (1996), Solis-Weiss *et al.* (2004) and Rueda *et al.* (2009).

Moreover, each species was assigned to one of four functional groups, following the classification of Reed & Mikkelsen (1987) and Hrs-Brenko & Legac (2006): free living, motile species (FL), epilithic species, living their



Fig. 2: The biogenic bank of Cape Ronek with colonies of *C. caespitosa* and the bottom made of dead corallites. (Photo: B. Mavrič)

Sl. 2: Biogena formacija pred rtom Ronek s kolonijami sredozemske kamene korale (*C. caespitosa*) in dno, ki ga sestavljajo mrtvi koraliti. (Foto: B. Mavrič)



Fig. 3: Colonies of *C. caespitosa* and other epifauna on the biogenic bank at Cape Ronek. (Photo: B. Mavrič)

Sl. 3: Kolonije sredozemske kamene korale (*C. caespitosa*) in drugih elementov epifavne na biogeni formaciji pred rtom Ronek. (Foto: B. Mavrič)

Tab. 1: Minimum axis and maximum axis (cm), wet weight (kg), coverage of each colony (cm²) and proportion of living corallites per colony of *C. caespitosa*.**Tab. 1: Minimalna in maksimalna os (cm), mokra teža (kg), pokrovnost posamezne kolonije (cm²) in delež živih koralitov na koloniji sredozemske kamene korale.**

	Max axis (width) in cm	Min axis (length) in cm	Wet weight in kg	Surface covered in cm ²	% of living corallites
Average	13.1	9.3	0.60	391.3	60
SD (±)	2.7	1.5	0.24	125.3	27
Max	20.0	13.0	1.10	816.8	100
Min	8.6	6.3	0.14	170.2	0

entire life attached to a substrate (EP), endolithic species, living in holes bored in hard substrates (EN) and soft bottom dwelling species (SB). Species which were known to live attached to the substrate when juveniles and to move freely when adults (Hrs-Brenko & Legac, 2006) were considered separately (FL/EP).

Eventually, ecological groups were defined mainly following Pérès (1967), De Min & Vio (1997), and Solis-Weiss *et al.* (2004).

Data analysis

Correlation between colonies' weight, axes, percentage of living polyps and bottom surface coverage by each colony was analyzed with Spearman's coefficients for non-parametric distributions (Spearman, 1907) using R version 2.4.0.

Number of taxa (S), number of individuals (N), Margaleff index of richness (d), Shannon diversity index (H'), Pielou index of equitability (J') and Simpson index of dominance (L') (Clarke & Warwick, 2001) were calculated for the macrobenthic taxa found within colonies of *C. caespitosa* and for those taxa found on the surrounding area within the bank. A group-average sorting classification (Cluster) analysis based on Sorensen similarity (Clarke & Warwick, 2001) was performed using invertebrates presence/absence data in order to compare Cape Ronék with other sites sampled in Slovenian marine waters using the same method in the same year for other studies related to the implementation of the MSFD. These statistical analyses were carried out using the software package Primer 6, developed by the Plymouth Marine Laboratory.

RESULTS

Description of *C. caespitosa* colonies

The analyzed colonies of *C. caespitosa* were small to medium in size with a minimum axis ranging from 6.3 to 13 cm and a maximum axis ranging from 8.6 to 20

cm (Tab. 1). The majority (71 %) had a maximum axis ranging from 10 to 15 cm.

The shape of the colonies varied from almost circular to elliptical and there was no significant correlation between the maximum and minimum axes of colonies ($r_s = 0.295$, $p = 0.113$). Colony weight ranged from 0.14 to 1.1 kg (Tab. 1). Both axes were positively correlated with colony weight, but the maximum axis showed the best correlation ($r_s = 0.641$, $p < 0.001$). The surface covered by each colony was correlated with colony weight ($r_s = 0.742$, $p < 0.001$). The percentage of living polyps in each colony was extremely variable, ranging from colonies with all polyps alive (100 %) to totally dead colonies (0 %) (Tab. 1). This percentage was not correlated with colonies' weights ($r_s = 0.149$, $p = 0.429$) nor with the surface covered by each colony ($r_s = 0.117$, $p = 0.535$).

Macrofaunal community description

During the present study a total of 121 taxa belonging to 9 different phyla (Porifera, Bryozoa, Cnidaria, Sipunculida, Mollusca, Anellida, Arthropoda, Echinodermata and Tunicata) were found within the bank of *C. caespitosa*. Among the 13 colonial taxa determined, 8 were sponges and 5 were bryozoans. Within non-colonial taxa 3605 individuals were counted.

On the area within the bank that surrounds colonies of *C. caespitosa*, 223 individuals belonging to 26 different taxa were analyzed. Echinoderms were the most abundant phyla (70 %), followed by molluscs (22 %). Taxa richness was higher within molluscs (58 %) and echinoderms (27%) (Fig. 4).

Within the 30 colonies of *C. caespitosa* collected and analysed in the laboratory 89 taxa of infauna were determined (Tab. 2). About 50 % of them were polychaetes, 25 % molluscs and 16 % crustaceans (Fig. 4). Regarding taxa abundance, 3386 organisms were counted (Tab. 2). The most abundant were molluscs (50 %), followed by polychaetes (20 %) and crustaceans (7 %). Many of these specimens were juveniles.

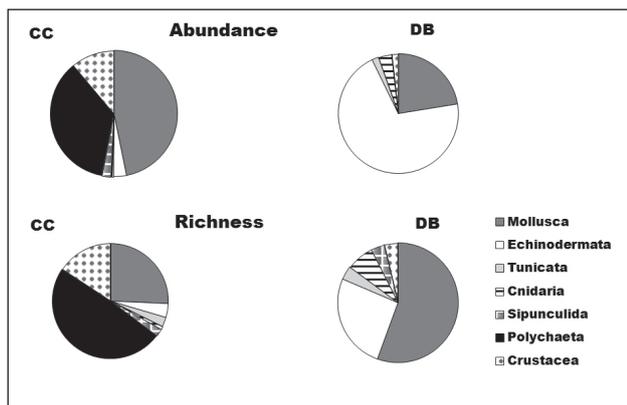


Fig. 4: Percentage of (A) abundance and taxa richness (B) within different phyla (colonial organisms excluded) within the colonies of *C. caespitosa* (CC) and in the surrounding area within the bank (DB).

Sl. 4: Delež abundance (A) in pestrosti taksonov (B) različnih debel (brez kolonijjskih organizmov) znotraj kolonij kamene korale (CC) in na okoliškem dnu znotraj biogene formacije (DB).

Only 5 taxa (4 % of the total) were found in both micro-habitats (within and without *C. caespitosa* colonies) (Tab. 3).

The area within the bank was dominated by the sea urchin *Psammechinus microtuberculatus* (with 42 % of dominance), whereas the infauna of *C. caespitosa* was dominated by two boring bivalves, *Hiatella artica* (with 27 % of dominance) and *Rocellaria dubia* (19 %).

The overall diversity of the community was quite high (Shannon index $H' = 3.05$; Tab. 2). The contribution of infaunal organisms associated with colonies of *C. caespitosa* to richness and abundance values of the sampled area was consistent (74 % of total richness and 94 % of total abundance). Also considering infaunal taxa, the Margalef index (d) passed from a value of 4.28 to a value of 13 and the global diversity of the community (H') increased (Tab. 2). Conversely, the index of equitability (J') showed no significant differences, since both

infaunal communities and the surrounding area within the bank were dominated by few taxa with a high abundance (comparable L').

The majority of taxa found in the sampled area are of wide ecological distribution or of uncertain bionomic affinity. On the area surrounding colonies only the mollusc *Vermetus triquetrus* is characteristic of the biocoenosis of Photophilic Algae (AP), and the serpulid *Ditrupa arietina* is characteristic of the biocoenosis of Coastal Detritic (DC), but neither were significantly abundant (< 1 % of dominance). In those samples, taxa usually associated with AP were present together with taxa associated with DC.

Among the infauna of colonies of *C. caespitosa*, taxa usually associated with AP and DC were found, but no characteristic species of any biocoenosis were present. Also some typical species for sandy and muddy bottoms namely the bivalves *Diplodonta rotundata* and *Nucula nucleus*, and the polychaetes *Lumbrineris impatiens* and *Cirriformia tentaculata*, were found.

The benthic community on the biogenic bank at Cape Ronek (without the infauna of colonies of *C. caespitosa*) differed greatly from other sampled sites at a comparable depth during the same period in Slovenian waters, as shown in other studies (unpublished data). Cluster analysis shows that Cape Ronek (Fig. 5, ACL8) can't be grouped with any other sites along the Slovenian coast.

Macrofaunal feeding guilds

Non-colonial organisms were subdivided into four feeding categories: grazers, suspension feeders, predators, ectoparasites and specialized carnivores and deposit feeders. Among them, 36 taxa were predators (P), 35 suspension feeders (SF), 11 grazers (G), and 17 deposit feeders (DF) (Tab. 3). Predators were mainly polychaetes and crustaceans, suspension feeders were represented by molluscs and serpulid polychaetes, grazers were mainly sea urchins, and deposit feeders were other echinoderms and sipunculids.

Within the infauna of *C. caespitosa* colonies, suspension feeders were the dominant group (64 % of total

Tab. 2: Taxa richness, abundance and diversity indices of invertebrates within *C. caespitosa* colonies (CC), in the surrounding area (DB) and in the overall sampled area (colonial organisms excluded). S = number of taxa, N = number of individuals, d = Margaleff index, J' = Pielou index, H' = Shannon-Wiener index (\log_e), L' = Simpson index ($1-\lambda$).

Tab. 2: Pestrost, taksonov, abundanca in diverzitetni indeksi za nevretenčarje znotraj kolonij kamene korale (CC), na okoliškem dnu (DB) in na celotnem vzorčnem območju (brez kolonijjskih organizmov). S = število taksonov, N = število osebkov, d = Margaleffov indeks, J' = Pieloujev indeks, H' = Shannon-Wienerjev indeks (\log_e), L' = Simpsonov indeks ($1-\lambda$).

Sample	S	N	d	J'	H'	L'
CC	89	3386	10.828	0.641	2.879	0.875
DB	24	215	4.283	0.683	2.172	0.789
TOTAL	108	3605	13.06	0.651	3.050	0.889

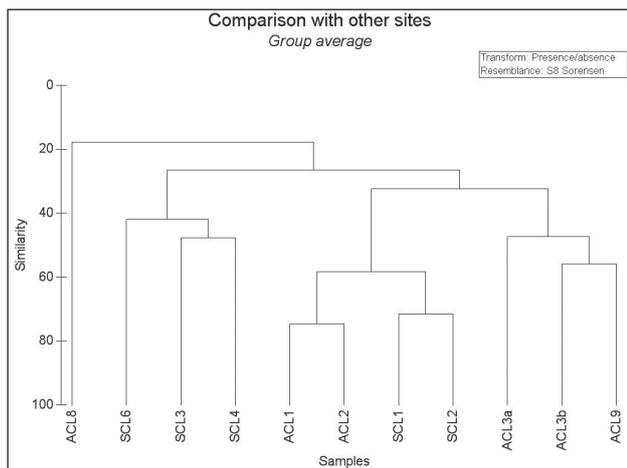


Fig. 5: Comparison between the sampling site (ACL8) and other sites along the Slovenian coast sampled with the same technique in the same year (unpubl. data). Spring samples: SCL1, SCL2, SCL3, SCL4, SCL6; autumn samples: ACL1, ACL2, ACL3a, ACL3b, ACL8, ACL9. Sl. 5: Primerjava med postajo vzorčenja (ACL8) in drugimi postajami ob slovenski obali, ki so jih avtorji vzorčili z isto metodo v istem letu (neobjavljeni podatki). Pomladni vzorci: SCL1, SCL2, SCL3, SCL4, SCL6; jesenski vzorci: ACL1, ACL2, ACL3a, ACL3b, ACL8, ACL9.

abundance and 34 % of total taxa richness) (Fig. 6), but predators had the highest richness (35 % of total taxa richness). Among suspension feeders, the most dominant were the bivalves *H. artica* and *R. dubia*, followed by the bivalve *Anomia ephippium*, serpulids (mainly *Serpula concharum*) and the crustacean decapod *Pisidia longimana*. The most abundant predators were polychaetes belonging to the families Eunicidae, Syllidae and Polynoidae, together with decapods like *Alpheus dentipes* and *Athanas nitescens*.

On the bank around colonies of *C. caespitosa*, grazers were dominant (more than 56 % of total abundance and 37 % of total taxa richness). Relevant also was the presence of suspension feeders and predators (see Fig. 6). The most abundant grazers were sea urchins *P. microtuberculatus* and *Sphaerechinus granularis*, while the most abundant suspension feeder was the bivalve *Arca noae*. Predators were mainly represented by molluscs (*Calliostoma zizyphinum* and *Hexaplex trunculus*) and cnidarians.

Macrofaunal functional groups

The proportion of taxa richness among functional groups from the bank around colonies of *C. caespitosa* and functional groups within the colonies did not differ significantly (Fig. 7). Free living taxa were dominant (45 % within colonies and 54 % on the area around them), followed by epilithic (25 % both within colonies and on

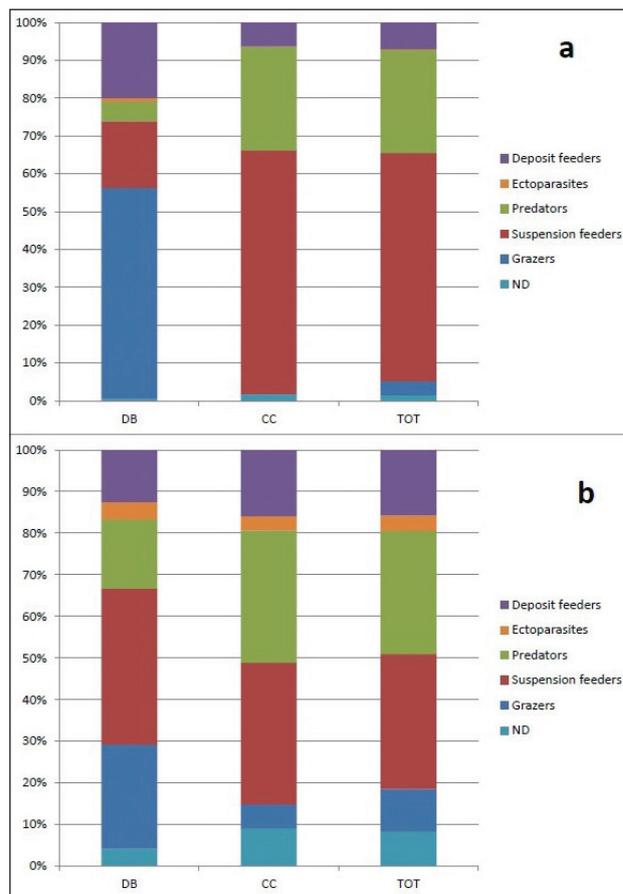


Fig. 6: Abundance (a) and taxa richness (b) of feeding guilds in the total sampled area (TOT), inside *C. caespitosa* colonies (CC) and within the bank without infauna (DB). ND = no data available.

Sl. 6: Abundanca (a) in pestrost taksonov (b) prehranjevalnih cehov na celotnem vzorčnem območju (TOT), znotraj kolonij kamene korale (CC) in na okoliškem dnu znotraj bioformacije brez infavne (DB). ND = ni razpoložljivih podatkov.

the surrounded area), while endolithic were only 8 % of all taxa, both within colonies and on the detritic bottom within the bank.

The results were different regarding relative abundance. Among the infauna, endolithic taxa were dominant (50 % of total abundance), followed by free-living organisms (27 %), and by epilithic taxa (13 %). Conversely, on the surrounding area free living organisms were dominant (78 % of total abundance), followed by epilithic animals (16 %), while endolithic taxa were very scarce (2 %) (Fig. 7).

More precisely, in the fauna within colonies the dominant endolithic species were *H. artica* (27 % of dominance) and *R. dubia* (19 %), accompanied by endolithic sipunculids (*Phascolosoma* sp.) and polychaetes (*Eunice siciliensis*, *Lysidice ninetta* and *Dodecaceria conchar-*

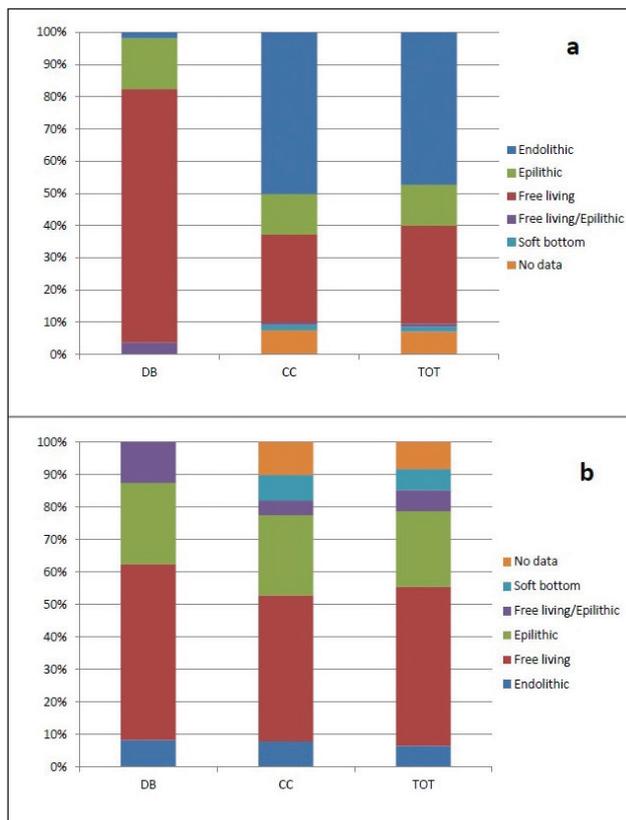


Fig. 7: Abundance (a) and taxa richness (b) of functional groups in the total sampled area (TOT), inside *C. caespitosa* colonies (CC), and on the surrounding detritic bottom within the bank (DB). EN = endolithic, EP = epilithic, FL = free living, FL/EP = changing mode with growth, SB = soft bottom, ND = no data available.

Sl. 7: Abundanca (a) in pestrost taksonov (b) funkcionalnih skupin na celotnem vzorčnem območju (TOT), znotraj kolonij kamene korale (CC) in na okoliškem dnu znotraj bioformacije (DB). EN = endolitski, EP = epilitiski, FL = prostoživeč, FL/EP = spremenil način z rastjo, SB = mehko dno, ND = ni razpoložljivih podatkov.

um). The bivalves *H. artica* and *R. dubia* were present also on the surrounded area, but with a low number of individuals (< 2 % of dominance).

The sea urchin *P. microtuberculatus* (41 % of dominance) was the dominant free-living species on the bank around colonies, while among infauna the dominant free-living species was the polychaete *Ceratonereis costae* with only 9 % of dominance.

DISCUSSION

The biogenic bank at Cape Ronek is made of a detritic layer of dead corallites and, to a lesser extent, of coralline algae, on the top of which living colonies of *C. caespitosa* grow. Only four comparable formations (in Sicily, Sardinia, Corsica and the Aegean Sea) have

been reported in the Mediterranean Sea (Peirano *et al.*, 1994; Koukouras *et al.*, 1998). Such formations offer a diversified habitat for benthic fauna, which is still mostly unknown.

Cladocora caespitosa's role as a bioconstructor

In optimal ecological conditions the colonial coral *C. caespitosa* forms large connected formations called coral bioherms or banks (Kružić & Benković, 2008). To our knowledge, up to now only one paper (Koukouras *et al.*, 1998) reported data on macrofauna living on such biogenic formations. Those banks were located close to Diaporos Island (Aegean Sea) and presented a similar structure made of dead corallites on the top of which living colonies of *C. caespitosa* grow, comparable to that which we found in the Slovenian sea. Compared with the bank at Cape Ronek, the Aegean formations were smaller (max 4 × 5.5 m vs. 200 × 100 m at Cape Ronek). Colonies on the bank at Cape Ronek were of medium-small size, with a maximum axis smaller than 20 cm.

At Cape Ronek, dead corallites and coralline algae created a secondary hard bottom where living colonies of *C. caespitosa* and other typically hard bottom species were able to settle. Consequently, the studied bank hosts a unique faunistic community which, even without taking into consideration *C. caespitosa* infauna, differed greatly from communities in other sites at a comparable depth (Fig. 5, ACL8). The massive presence of species with a wide ecological distribution and the almost complete absence of species described as characteristic of any biocoenosis make the exact nature of this community difficult to assess.

The consistent contribution of infaunal organisms to the total richness and abundance of the studied area confirms the importance of living colonies of *C. caespitosa* for local biodiversity. Moreover, only a few species were found to inhabit both examined microhabitats (the colonies of *C. caespitosa* and the area around the colonies). The general structure of these communities was very different, since the assemblage of the bank around colonies was dominated by echinoderms and big molluscs, while the community within the colonies was dominated by small animals like polychaetes, molluscs and crustaceans. The relatively low number of co-occurring species suggests that this coral, acting as a refuge for animals originating from different habitats, is able to create an 'enclave' supporting different species and is not simply changing species abundance. These results suggest that *C. caespitosa* plays an important role as a habitat builder both through living colonies and with the accumulation of dead and subfossil corallites.

Infaunal community associated with *C. caespitosa*

Of the 89 taxa found within colonies 57 were determined to the species level and 21 species are here

Tab. 3: List of invertebrate taxa found in the bank of *C. caespitosa*: inside (infauna, CC) and/or outside (DB) colonies. Feeding guilds: P = predator, EC = ectoparasite and specialized carnivore, G = grazer, O = omnivore, SF = suspension feeder, DF = deposit feeder, ND = no data available. Functional groups: FL = free living, motile, EP = epilithic (fouling), EN = endolithic (boring), ND = no data available.

Tab. 3: Seznam taksonov nevretenčarjev, najdenih na formaciji sredozemske kamene korale: znotraj (infauna, CC) in/ali v okolici (DB) kolonij. Prehranjevalni cehi: P = predator, EC = ektoparazit in specializiran karnivor, G = strgalec, O = vsejed, SF = suspenzijofag, DF = detritivor, ND = ni razpoložljivih podatkov. Funkcionalne skupine: FL = prostoživeč, gibljiv, EP = epilitski (pritrjen), EN = endolitski (vrtalec), ND = ni razpoložljivih podatkov.

Taxa	Location	Feeding guilds	Functional groups
Mollusca			
<i>Acantochitona fascicularis</i>	CC	G	FL
<i>Anomia ephippium</i>	CC	SF	EP
<i>Arca noe</i>	CC and DB	SF	EP
<i>Bittium reticulatum</i>	CC	G	FL
Bivalvia indet.	CC	SF	ND
<i>Calliostoma zizyphinum</i>	DB	EC	FL
Cardidae juv.	CC	SF	ND
<i>Cerithiopsis tubercularis</i>	CC	EC	FL
<i>Chama gryphoides</i>	CC	SF	EP
<i>Chiton sp.</i>	DB	G	FL
<i>Chlamys sp.</i>	DB	SF	FL/EP
<i>Mimachlamys varia</i>	CC	SF	FL/EP
Dendrodoridae indet.	DB	ND	FL
<i>Diodora graeca</i>	CC	G	FL
<i>Diodora cf. italica</i>	DB	G	FL
<i>Diplodonta rotundata</i>	CC	SF	ND
<i>Fissurella nabecula</i>	CC	G	FL
<i>Galeomma turtoni</i>	CC	ND	FL
<i>Gibbula magus</i>	DB	G	FL
<i>Hexaplex trunculus</i>	DB	P	FL
<i>Hiatella artica</i>	CC and DB	SF	EN
<i>Telochlamys multistriata</i>	DB	SF	FL/EP
<i>Limaria hians</i>	CC	SF	FL/EP
<i>Limaria tuberculata</i>	DB	SF	FL/EP
<i>Marshallora adversa</i>	CC	EC	FL
<i>Modiolarca subpicta</i>	CC	SF	EP
<i>Modiolus barbatus</i>	CC	SF	EP
<i>Mytilus sp.</i>	DB	SF	EP

<i>Nucula nucleus</i>	CC	DF	ND
<i>Ostrea edulis</i>	CC	SF	EP
<i>Pseudochama gryphina</i>	CC	SF	EP
<i>Rocellaria dubia</i>	CC and DB	SF	EN
<i>Striarca lactea</i>	CC	SF	EP
<i>Vermetus triquetrus</i>	DB	SF	EP
Echinodermata			
<i>Amphipholis squamata</i>	CC	SF/DF	FL
<i>Astropecten irregularis</i>	DB	P	FL
<i>Cucumaria planci</i>	DB	DF/SF	FL
<i>Holothuria tubulosa</i>	DB	DF/SF	FL
<i>Ophioderma longicauda</i>	DB	SF/DF	FL
<i>Paracentrotus lividus</i>	DB	G	FL
<i>Psammechinus microtuberculatus</i>	DB	G	FL
<i>Sphaerechinus granularis</i>	DB	G	FL
Echinoidea juv.	CC	G	FL
<i>Ophiotrix cf. fragilis</i>	CC	SF/DF	FL
Tunicata			
<i>Microcosmus sp.</i>	CC and DB	SF	EP
Tunicata indet.	CC	SF	EP
Cnidaria			
<i>Adamsia palliata</i>	DB	P	EP
Cnidaria indet.	CC and DB	P	EP
Sipunculida			
<i>Phascolosoma sp.</i>	CC	DF	EN
<i>Aspidosiphon sp.</i>	CC	DF	EN
Polychaeta			
<i>Eunice torquata</i>	CC	P	FL
<i>Eunice schizobranchia</i>	CC	P	FL

<i>Eunice siciliensis</i>	CC	P	EN
<i>Eunice vittata</i>	CC	P	FL
<i>Eunice harassi</i>	CC	P	FL
Eunicidae 1	CC	P	ND
Eunicidae 2	CC	P	ND
<i>Lysidice ninetta</i>	CC	P	EN
<i>Marphysa sanguinea</i>	CC	P	SB
<i>Nematonereis unicornis</i>	CC	P	FL
<i>Lumbrineris impatiens</i>	CC	P	SB
<i>Lumbrineris coccinea</i>	CC	P	FL
<i>Lumbrineris latreilli</i>	CC	P	SB
<i>Lumbrineris gracilis</i>	CC	P	FL
Syllinae indet.	CC	P	ND
<i>Haplosyllis spongicola</i>	CC	P	FL
<i>Ceratonereis costae</i>	CC	P	FL
<i>Nereis rava</i>	CC	P	FL
<i>Serpula concharum</i>	CC	SF	EP
<i>Vermiliopsis striaticeps</i>	CC	SF	EP
<i>Hydroides pseudouncinatus</i>	CC	SF	EP
<i>Serpula vermicularis</i>	CC	SF	EP
<i>Spirobranchus triqueter</i>	CC	SF	EP
<i>Spirobranchus lamarcki</i>	CC	SF	EP
<i>Ditrupa arietina</i>	CC	SF	DB
Spirorbidae indet.	CC	SF	EP
Serpulidae indet.	CC	SF	EP
Sabellidae indet.	CC	SF	EP
<i>Harmothoe areolata</i>	CC	P	FL
<i>Harmothoe spinifera</i>	CC	P	FL
<i>Polynoe sp.</i>	CC	P	FL
Polynoidae indet.	CC	P	FL
<i>Notomastus cf. latericeus</i>	CC	DF/SF	FL/EP
<i>Dodecaceria concharum</i>	CC	DF/SF	EN
<i>Cirriformia tentaculata</i>	CC	DF/SF	SB
<i>Aphelochaeta sp.</i>	CC	DF/SF	SB
Polychaetae indet.	CC	ND	ND

Cirratulidae indet.	CC	DF/SF	ND
Phyllodocidae indet.	CC	ND	FL
<i>Phyllodoce cf. mucosa</i>	CC	P	FL
Maldanidae indet.	CC	DF	SB
Terebellidae indet.	CC	DF	FL/EP
<i>Amphitrite variabilis</i>	CC	DF	EP
Crustacea			
<i>Alpheus dentipes</i>	CC	O/P	FL
Amphipoda indet.	CC	ND	FL
Anisopoda indet.	CC	SF	FL
<i>Athanas nitescens</i>	CC	O/P	FL
<i>Balanus sp.</i>	CC	SF	EP
<i>Galatea sp.</i>	CC	DF	FL
<i>Gnathia sp.</i>	CC	P	FL
<i>Janira maculosa</i>	CC	ND	FLi
<i>Leucothoe sp.</i>	CC	ND	FLi
<i>Liljeborgia dellavallei</i>	CC	ND	FLi
<i>Maera grossimana</i>	CC	ND	FL
<i>Pilumnus cf. hirtellus</i>	CC	G/P/DF	FL
<i>Pisidia longimana</i>	CC	SF	FL
<i>Synalpheus gambarelloides</i>	CC	P/EC	FL
<i>Thoralus chranchii</i>	CC	O/P	FL
Porifera			
<i>Aplysina aerophoba</i>	DB	SF	EP
<i>Haliclona mediterranea</i>	DB	SF	EP
<i>Hippospongia communis</i>	DB	SF	EP
<i>Geodia cydonium</i>	DB	SF	EP
<i>Ircinia variabilis</i>	DB	SF	EP
<i>Ircinia fasciculata</i>	DB	SF	EP
<i>Chondrosia reniformis</i>	DB	SF	EP
<i>Tethya aurantium</i>	DB	SF	EP
Bryozoa			
<i>Schizobrachiella sanguinea</i>	DB	SF	EP
<i>Schizoporella errata</i>	DB	SF	EP
<i>Schizoporella cf. unicornis</i>	CC	SF	EP
Diastoporidae indet.	CC	SF	EP
Celleporidae indet.	CC	SF	EP

reported for the first time as inhabitants of the Mediterranean stony coral *C. caespitosa*. The present results are not directly comparable with data reported by other researchers (Lumare, 1965; Sciscioli & Nuzzaci, 1970; Zavadnik, 1976; Schiller, 1993; Arvanitidis & Koukouras, 1994; Antoniadou & Chintiroglou, 2010) since the field sampling and the statistical analysis were different. The overall diversity (Shannon diversity) of the infauna of the bank at Cape Ronek was quite high. However, even higher values were reported for the bank in the Aegean Sea (Koukouras *et al.*, 1998), but such results could be distorted by the smaller colonies' size in the Slovenian bank and consequently the lower sampled volume. Considering colonial organisms as well, in particular sponges, the diversity would be higher. Those organisms were excluded from indices calculation due to the difficulties in the proper quantification of endolithic colonial organisms.

Scleractinian corals are known to influence the invertebrate community in two ways (Reed & Mikkelsen, 1987). Firstly, increasing the three dimensional structures of the seafloor and locally modifying water movement, they create a physical space for facultative associated invertebrates, which can be endolithic, epilithic or free living species. Secondly, they may host obligate symbionts, which can be ectoparasites or predators feeding on coral tissue (e.g. some molluscs, as reported by Robertson (1970) and Reed & Mikkelsen (1987)), or commensals eating coral mucus and entrapped detritus (e.g. some decapods, as reported by Castro (1978) and Carricart-Ganivet *et al.* (2004)). The consistent abundance and richness of endolithic, epilithic and free living invertebrates found in the present work is related to *C. caespitosa* morphology, which is similar to the typical tropical reef-building scleractinian corals. Its long and packed corallites provide a cryptic habitat for many small invertebrate species (Zibrowius, 1982; Schuhmacher & Zibrowius, 1985). The presence of species typical of sandy and muddy bottoms among the infauna is probably related to the role of trapping sediment played by *Cladocora* colonies. The sediment trapped among corallites consolidates coral structure and offers a suitable habitat for small soft bottom species like the polychaetes *Lumbrineris impatiens* and *Cirriformia tentaculata*.

We were unable to find any evidence of obligatory species-specific relationships between the Mediterranean stony coral and the associated infauna since, to our knowledge, all invertebrates found within *C. caespitosa* colonies so far (Koukouras *et al.*, 1998; present work) were also present in other communities in the Mediterranean Sea, mainly on hard substrate. Nevertheless, in the present work the presence of deposit feeders such

as ophiurids and sipunculids suggests that a facultative commensalism exists with associated taxa feeding on mucus produced by coral and entrapped within sediments.

Threats and conservation

C. caespitosa is a species subject to mass-mortality events, such as those recently recorded in the NW Mediterranean Sea (Rodolfo-Metalpa *et al.*, 2005). Global warming and the related acidification of the ocean pose a serious threat for this species and the associated macrofauna (Rodolfo-Metalpa *et al.*, 2005, 2006, 2011). In the Adriatic Sea additional pressures are present, such as coastal modifications and the spread of the non-native invasive green algae *Caulerpa racemosa* (Kružić & Benković, 2008), which has not yet been recorded in the Gulf of Trieste. Moreover, evidence of *C. caespitosa* bleaching in the Gulf of Trieste indicates that this species is subjected to some stress, probably related to increasing seawater temperatures (Lipej *et al.*, 2013).

Since large biogenic formations of *C. caespitosa* are extremely rare in the Mediterranean Sea (Cape Ronek, Sicily, Sardinia, Corsica and Diaporos Island), the peculiarity and high diversity of the associated community and the threat posed by habitat loss and climate change indicate the immediate need for more conservation action. Increasing our knowledge of the role played by *C. caespitosa* in maintaining marine biodiversity at different levels is of crucial importance for conservation efforts. Studies of tropical corals affected by bleaching events have shown that interactions with other associated taxonomic groups emerged as very important for coral resilience and recovery (McCook *et al.*, 2001; Baker *et al.*, 2008). Therefore, further intensive investigation is required to elucidate the complex interactions between *C. caespitosa* and the community of invertebrates living inside and near its corallites. A better understanding of these relationships is basic not only to quantify the importance of *C. caespitosa* as habitat builder, but also to elucidate the potential role of associated organisms in the maintenance of coral health and recovery after stressful events.

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MAKROFAVNA, POVEZANA Z BIOFORMACIJO SREDOZEMSKÉ KAMENE KORALE,
CLADOCORA CAESPITOSA (ANTHOZOA, SCLERACTINIA), V TRŽAŠKEM ZALIVU
(SEVERNI JADRAN)

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POVZETEK

Sredozemska kamena korala (*Cladocora caespitosa*, Linneus, 1767) je predstavnik kolonijskih koralnjakov zmerne pasu. Občutljiva je na podnebne spremembe in na antropogene dejavnosti. Zaradi svoje oblike in velikosti lahko kamena korala gosti zelo raznoliko živalsko skupnost. Novembra 2010 so avtorji raziskovali bioformacijo sredozemske kamene korale, ki je bila pred kratkim odkrita pred rtom Ronek (Tržaški zaliv, Slovenija). Potrdili so prisotnost 121 taksonov nevretenčarjev, ki spadajo v 9 različnih debel. Sestava favne znotraj kolonij je bila precej različna od tiste v njihovi okolici znotraj bioformacije. Le 5 taksonov (4 % vseh) je bilo najdenih tako znotraj kolonij kot v njihovi okolici. Rezultati potrjujejo vlogo sredozemske kamene korale kot biogradnika in poudarjajo pomen te izjemne bioformacije za biotsko raznovrstnost.

Ključne besede: *Cladocora caespitosa*, biogradniki, makro-nevretenčarji, cirkalitoral, severni Jadran

REFERENCES

- Antoniadou, C. & C. Chintiroglou (2010):** Biodiversity of zoobenthos associated with a *Cladocora caespitosa* bank in the North Aegen Sea. Rapp. Comm. int. Mer Médit., 39, pp. 4–32.
- Arvanitidis, C. & A. Koukouras (1994):** Polychaete fauna associated with the coral *Cladocora caespitosa* (L.) in the eastern Mediterranean. Mém. Mus. Nat. Hist. Nat., 162, 347–353.
- Baker, A., P. Glynn & B. Riegl (2008):** Climate change and coral reef bleaching: An ecological assessment of long-term impacts, recovery trends and future outlook. Estuar. Coast. Shelf Sci., 80, 435–471.
- Bianchi, C. N. (1981):** Policheti Serpuloidei. Guida al riconoscimento delle specie animali delle acque lagunari e costiere italiane. CNR Roma, AQ/1/96 5, 189 p.
- Boicourt, W. C., M. Kuzmić & T. S. Hopkins (1999):** The Inland Sea: Circulation of Chesapeake Bay and the Northern Adriatic. In: Malone, T. C., A. Malej, L. W. Harding Jr., N. Smolaka & R. E. Turner (eds.): Ecosystems at the Land-Sea Margin: Drainage Basin to Coastal Sea. Coastal and Estuarine Studies 55, pp. 81–129.
- Cantera, K., R. Jaime, C. Orozco, E. Londono-Cruz & G. Toro-Farmer (2003):** Abundance and distribution patterns of infaunal associates and macroborers of the branched coral (*Pocillopora damicornis*) in Gorgona Island (eastern tropical Pacific). Bull. Mar. Sci., 72, 207–219.
- Carricart-Ganivet, J. P., L. F. Carrera-Parra, L. I. Quan-Young & M. S. Garcia-Madriral (2004):** Ecological note on *Troglocarcinus corallicola* (Brachyura: Cryptochiridae) living in symbiosis with *Manicina areolata* (Cnidaria: Scleractinia) in the Mexican Caribbean. Coral Reefs, 23, 215–217.
- Castelli, A., C. Lardicci & D. Tagliapietra (2003):** Il macrobenthos di fondo molle. Biol. Mar. Mediterr., 10 (Suppl.), 109–144.
- Castro, P. (1978):** Movements between coral colonies in *Trapezia ferruginea* (Crustacea: Brachyura), an obligate symbiont of scleractinian corals. Mar. Biol., 46, 237–245.
- Chintiroglou, C. (1996):** Feeding guilds of polychaetes associated with *Cladocora caespitosa* (L.) (Anthozoa, Cnidaria) in the north Aegean Sea. Isr. J. Zool., 42, 261–274.
- Clarke, K. R. & R. M. Warwick (2001):** Change in marine communities. An approach to statistical analysis and interpretation. 2nd Edition. PRIMER-E, Plymouth, UK, 172 p.
- Cossignani, T., A. Di Nisio & M. Passamonti (1992):** Atlante delle conchiglie del Medio Adriatico. L'informatore Piceno Ed., Ancona, 114 p.
- De Min, R. & E. Vio (1997):** Molluschi conchiferi del litorale sloveno. Annales, Ser. Hist. Nat., 11, 241–258.
- European Commission (2008):** Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Off. J. Eur. Union, L164, 19–40.
- Falace, A., S. Kaleb, M. Orlando-Bonaca, B. Mavrič & L. Lipej (2011):** First contribution to the knowledge of the coralline algae distribution in the Slovenian circalittoral zone (Northern Adriatic). Annales, Ser. Hist. Nat., 21, 27–40.
- Falciai, L. & R. Minervini (1992):** Guida dei Crostacei Decapodi d'Europa. Franco Muzzio Editore, Padova, 282 pp.
- Fauchald, K. & P. Jumars (1979):** The diet of worms: a study of polychaete feeding guilds. Oceanogr. Mar. Biol. Annu. Rev., 17, 193–284.
- Fauvel, P. (1923):** Faune de France. Polychètes errantes. Fédération Française des sociétés de sciences naturelles, Paris, 488 p.
- Fauvel, P. (1927):** Faune de France. Polychètes sédentaires. Fédération Française des sociétés de sciences naturelles, Paris, 494 p.
- Ghisotti, F. & B. Sabelli (1970):** Polyplacophora de Blainville, 1816. Schede Malacologiche del Mediterraneo, serie 87–88, 6 p.
- Harrison, K. & J. Ellis (1991):** The Genera of the Sphaeromatidae (Crustacea: Isopoda): a Key and Distribution List. Invertebr. Taxon., 5, 915–952.
- Hayward, P. J. & J. R. Ryland (eds.) (1995):** Handbook of the marine fauna of North-West Europe. Oxford University Press, Oxford, 800 p.
- Hrs-Brenko, M. & M. Legac (2006):** Inter- and intra-species relationships of sessile bivalves on the eastern coast of the Adriatic Sea. Nat. Croat, 15, 203–230.
- Idjadi, J. & P. Edmunds (2006):** Scleractinian corals as facilitators for other invertebrates on a Caribbean reef. Mar. Ecol. Prog. Ser., 319, 117–127.
- Koukouras, A., D. Kühlmann, E. Voultsiadou, D. Vafidis, C. Dounas, C. Chintiroglou & D. Koutsoubas (1998):** The macrofaunal assemblage associated with the scleractinian coral *Cladocora caespitosa* (L.) in the Aegean Sea. Ann. Inst. océanogr. Paris Nouv. ser., 74, 97–114.
- Kružić, P. & A. Požar-Domac (2003):** Banks of the coral *Cladocora caespitosa* (Anthozoa, Scleractinia) in the Adriatic Sea. Coral Reefs, 22, 5–36.
- Kružić, P. & L. Benković (2008):** Biocostructural features of the coral *Cladocora caespitosa* (Anthozoa, Scleractinia) in the Adriatic Sea (Croatia). Mar. Ecol., 29, 125–139.
- Kružić, P., A. Žuljević & V. Nikolić (2008):** Spawning of the colonial coral *Cladocora caespitosa* (Anthozoa, Scleractinia) in the Southern Adriatic Sea. Coral Reefs, 27, 337–341.
- Kühlmann, D. H. H. (1996):** Preliminary report on Holocene submarine accumulations of *Cladocora caespitosa* (L. 1767) in the Mediterranean. In: Reitner, J., F. Neuweiller & F. Gunkel (eds.): Global and regional controls on biogenic sedimentation, 1. Reef evolution.

Göttinger Arb. Geol. Paläont., Research Reports, Göttingen, Sb2, pp. 65–69.

Kühlmann, D. H. H., Ch. Chintiroglou, D. Koutsoubas & A. Koukouras (1991): Korallenriffe in Mittelmeer? Naturw. Rdsch., 44, 3–16.

Lipej, L., R. Turk & T. Makovec (2006): Endangered species and habitat types in the Slovenian Sea. Zavod RS za varstvo narave, Ljubljana, 264 p.

Lipej, L., M. Orlando-Bonaca, B. Mavrič, M. Vodopivec & P. Kružić (2013): Monitoring of marine biodiversity in Strunjan Nature Reserve (Gulf of Trieste, Slovenia), with special emphasis on climate change impacts on selected biological elements. In: Vranješ, M., I. Škornik, S. Santi & M. Costa (eds.): Climate change and management of protected areas: Studies on biodiversity, visitor flows and energy efficiency. Climaparks project, pp. 31–41.

Lumare, F. (1965): Sulla scogliera a *Cladocora* di Crotone e le sue biocenosi. Rend. Accad. Naz. XL, Serie IV, Vol. 1617, pp. 101–131.

Martins Garcia, T., H. Cascon & W. Franklin-Junior (2008): Macrofauna associated with branching fire coral. Thalassas, 24, 11–19.

McCook, L. J., J. Jompa & G. Diaz-Pulido (2001): Competition between corals and algae on coral reefs: a review of evidence and mechanisms. Coral Reefs, 19, 400–417.

Morri, C., A. Peirano, C.N. Bianchi, M. Sassarini (1994): Present-day bioconstructions of the hard coral, *Cladocora caespitosa* (L.) (Anthozoa, Scleractinia), in the Eastern Ligurian Sea (NW Mediterranean). Biol. Mar. Mediterr., 1, 371–372.

Morri, C., A. Peirano & C. N. Bianchi (2001): Is the Mediterranean coral *Cladocora caespitosa* an indicator of climatic change? Archo. Ocanogr. Limnol., 22, 139–144.

Mozetič, P., S. Fonda Umani, B. Cataletto & A. Malej (1998): Seasonal and inter-annual plankton variability in the Gulf of Trieste (Northern Adriatic). ICES J. Mar. Sci., 55, 711–722.

Naylor, E. (1972): British Marine Isopods. Linnean Synopsis of the British Fauna (New Series), No. 3. Academic Press, London., 86 p.

Occhipinti Ambrogi, A. (1981): Briozoi lagunari. Guida per il riconoscimento delle specie animali delle acque lagunari e costiere italiane. CNR AQ/1/126, 7, Genova, 145 p.

Parenzan, P. (1970-1976): Carta d'identità delle conchiglie del Mediterraneo: 1. Gasteropodi, pp. 1–283. 2. Bivalvi I parte, pp. 1277. 2. Bivalvi II parte, pp. 278–546. Bios Taras, Taranto.

Peirano, A., C. Morri, G. Mastronuzzi & C. N. Bianchi (1994): The coral *Cladocora caespitosa* (Anthozoa, Scleractinia) as a bioherm builder in the Mediterranean Sea. Memorie Descrittive Carta Geologica d'Italia, 52, 59–74.

Peirano, A., C. Morri & C. N. Bianchi (1999): Skeleton growth and density pattern of the temperate, zooxanthellate scleractinian *Cladocora caespitosa* from the Ligurian Sea (NW Mediterranean). Mar. Ecol. Prog. Ser, 185, 195–201.

Peirano, A., C. Morri, C. N. Bianchi & R. Rodolfo-Metalpa (2001): Biomass, carbonate standing stock and production of the Mediterranean coral *Cladocora caespitosa* (L.). Facies, 44, 75–80.

Pérès, J. M. (1967): The Mediterranean benthos. Oceanogr. Mar. Biol. Annu. Rev., 5, 449–533.

Pérès, J. M. & J. Picard (1964): Nouveau manuel de Bionomie benthique de la Mer Méditerranée. Recueil des Travaux de la Station Marine d'Endoume, 47, 31–37.

R Core Team (2012): R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. <http://www.R-project.org/> (Accessed 7 February 2013)

Reed, J. & P. Mikkelsen (1987): The molluscan community associated with the scleractinian coral *Oculina varicosa*. Bull. Mar. Sci., 40, 99–131.

Robertson, R. (1970): Review of the predators and parasites of stony corals, with special reference to symbiotic prosobranch gastropods. Pac. Sci., 24, 43–54.

Rodolfo-Metalpa, R., C. N. Bianchi, A. Peirano & C. Morri (2005): Tissue necrosis and mortality of the temperate coral *Cladocora caespitosa*. Ital. J. Zool., 72, 271–276.

Rodolfo-Metalpa, R., C. Richard, D. Allemand & C. Ferrier-Pagès (2006): Growth and photosynthesis of two Mediterranean corals, *Cladocora caespitosa* and *Oculina patagonica*, under normal and elevated temperatures. J. Exp. Biol., 209, 4546–4556.

Rodolfo-Metalpa, R., F. Houlbrèque, É. Tambutté, F. Boisson, C. Baggini, F. P. Patti, R. Jeffrey, M. Fine, A. Foggo, J-P. Gattuso & J. M. Hall-Spencer (2011): Coral and mollusc resistance to ocean acidification adversely affected by warming. Nature Climate Change, 1, 308–312.

Rueda, J. L., S. Gofas, J. Urrea & C. Salas (2009): A highly diverse molluscan assemblage associated with eelgrass beds (*Zostera marina* L.) in the Alboran Sea: Micro-habitat preference, feeding guilds and biogeographical distribution. Sci. Mar., 73, 679–700.

Ruffo, S. (1982-1993): The Amphipoda of the Mediterranean. Parts 13. Mém. Inst. Océanogr. Monaco.

Sarà, M. (1972): Guida ai Porifera della fauna Italiana. Quad. Civ. Stazione Idrobiol. Milano, 34, 53–97.

Schiller, C. (1993): Ecology of the symbiotic coral *Cladocora caespitosa* (L.) (Faviidae, Scleractinia) in the Bay of Piran (Adriatic Sea): I Distribution and biometry. Mar. Ecol., 14, 205–219.

Schuhmacher, H. & H. Zibrowius (1985): What is hermatypic? A redefinition in ecological groups in corals and other organisms. Coral Reefs, 4, 1–9.

Sciscioli, M. & G. Nuzzaci (1970): Anellidi Policheti associati a *Cladocora caespitosa* (L.) del litorale pugliese. Atti Soc. Peloritana, 16, 151–157.

- Solis-Weiss, V., F. Aleffi, N. Bettoso, P. Rossin, G. Orel & S. Fonda-Umani (2004):** Effects of industrial and urban pollution on the benthic macrofauna in the Bay of Muggia (industrial port of Trieste, Italy). *Sci. Total Environ.*, 328, 247–263.
- Spearman, C. (1907):** Demonstration of Formulae for True Measurement of Correlation. *Am. J. Psychol.*, 18, 161–169.
- Tebble, N. (1966):** British Bivalve Seashells: a handbook for identification. Trustees of the British Museum (Natural History), London, 213 p.
- Torelli, A. (1982):** Gasteropodi conchigliati. Guide per il riconoscimento delle specie animali delle acque lagunari e costiere italiana. CNR AQ/1/96, 8, Genova, 233 p.
- Tursi, A. (1980):** Ascidiacei. Guide per il riconoscimento delle specie animali delle acque lagunari e costiere italiana. CNR AQ/1/93, 4, Genova, 85 p.
- WoRMS (2013):** World Register of Marine Species. <http://www.marinespecies.org> (Accessed on 2013-10-02).
- Zavodnik, D. (1976):** Adriatic echinoderms inhabiting benthic organisms. *Thalassia Jugosl.*, 12, 375–380.
- Zibrowius, H. (1980):** Les Scléactiniaires de la Méditerranée et de l'Atlantique nord-oriental. *Mém. Inst. Océanogr. Monaco*, 11, 12–84.
- Zibrowius, H. (1982):** Taxonomy in ahermatypic scleractinian corals. *Paleontogr. Am.*, 54, 80–85.