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Scleractinian diversity in the Dardanelles and Marmara Sea (Turkey): morphology, ecology and distributional patterns

by

H. Barış Özalp[1,*], Mustafa Alparslan[2]

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[1]*Faculty of Marine Science and Technology, Department of Marine Biology, Çanakkale Onsekiz Mart University, Canakkale, Turkey*

[2]*Katip Çelebi University*

Abstract

Although marine research on anthozoans began at the end of the 1800s with some reports on the occurrence in Turkey, comprehensive knowledge about their biotic features remains limited. This study is the first detailed diversity assessment of scleractinian corals inhabiting the Turkish waters. The surveys conducted on rocky habitats between 2011 and 2014 around the Dardanelles and Marmara Sea provided the distributional data of nine corals, five of which (*Caryophyllia inornata*, *Paracyathus pulchellus*, *Polycyathus muellerae*, *Phyllangia mouchezii*, *Leptopsammia pruvoti*) were recorded for the first time from the above-mentioned regions. During the surveys carried out at 200 stations down to 50 m depth, a total of 1072 scuba dives were made and the ecological features of habitats, physical characteristics of coral species and an updated list of corals as a contribution to the scleractinian fauna of Turkey were provided. The abundance rate of *Polycyathus muellerae* and *Cladocora caespitosa* in Eceabat and Dardanos regions was higher than at the other stations.

Key words: Scleractinia, coral ecology, new records, Dardanelles, Marmara Sea

* Corresponding author: *barisozalp@comu.edu.tr*

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Introduction

Scleractinian anthozoans, commonly known as hard corals, are one of the most important and distinctive groups among all marine species in the seas and oceans. Their ecological value has increased in recent years (Waller 2005). Formation of the hard substrate, which is highly important as a habitat for shelter, feeding, nursing and breeding, is the main benefit to other organisms such as fish, crustaceans, echinoderms, sponges, mollusks and polychaetes. With the help of these communities, overhangs, colony banks, encrusted rocky walls and coralligenous formations support a variety of life around these areas (Zibrowius 1980; Fabri et al. 2014).

The Mediterranean Sea is an important marine ecosystem with less than 5% of the total number (over 6000) of coral species distributed throughout the world (OCEANA 2004). Although it is a reserve for a very limited number of anthozoans when compared to those living in the tropics, the scleractinians living as both solitary animals or in colonies, also form diverse and complex habitats with their specific characteristics. Due to the coralligenous formations and other calcareous bio-concretions around the rocky substrate, also accepted as major contributors to coral frameworks, the area may be considered as a coral reef system in its ecosystem (Kružić & Požar-Domac 2003; Ballesteros 2006; Kružić & Rodić 2008; Coll et al. 2010). Whether or not the Mediterranean scleractinians do not basically create the reef form, their geographical and bathymetrical limits are broader (Barbeitos et al. 2010). Owing to the contribution of the Mediterranean to the biodiversity and the increased habitat loss resulting from the global warming, studies of these species have recently also increased around these regions. To date, a number of surveys have been carried out on benthic invertebrates distributed in the Mediterranean, Aegean, Marmara and Black Sea coasts of Turkey. However, coral facies that are also highly important to other aquatic species have not yet been thoroughly researched with regard to the community structure. This caused data deficiency on taxonomy, ecology, biology and distributional features of the species over time. Although the complete checklist of anthozoans has recently been released for the Turkish coasts (Çınar et al. 2014), scleractinian corals are still the least studied order among marine species groups.

In Turkey, the anthozoan studies started with new geographical reports from the Aegean Sea (Forbes 1844). During surveys conducted by the author, two scleractinian species (*Cladocora caespitosa*, *Madracis pharensis*) were recorded from the Turkish coasts and the acquired data are known as early research on the occurrence of the hard corals in the above-mentioned regions.

The Turkish Straits System and the Marmara Sea have been important to the research on corals in Turkey since the end of the 1800s. *Caryophyllia cyathus*, *Caryophyllia smithii*, *Balanophyllia europaea*, *Coenocyathus anthophyllites* and *Dendrophyllia ramea* were the first scleractinians reported for the Turkish fauna from the Dardanelles, the Marmara Sea and the Bosphorus (Colombo 1885; Ostroumoff 1984; 1896; Marion 1898). The first comprehensive data on the morphology and ecology of the species were presented by Demir (1952).

The 1970s, more comprehensive surveys were conducted on zoogeographic and ecological features of the species at the Aegean Sea coasts of Turkey. The first information on the anthozoan fauna of the above-mentioned area was provided by Băcescu et al. (1971), Geldiay & Kocataş (1972), Coşar (1974) and Kocataş (1978). The huge effort made by Zibrowius' (1979, 1980), so far the most extensive research on scleractinians around the Mediterranean Sea, added four species (*Balanophyllia europaea*, *Caryophyllia inornata*, *Polycyathus muellerae*, *Phyllangia mouchezii*) to the Turkish Inventory representing the Aegean and Mediterranean coasts. These surveys resulted in the first findings of *Madracis pharensis* and *P. mouchezii* from the Mediterranean coasts of Turkey. The Mediterranean endemic *C. caespitosa*, which is well-known for its unique reef-like structure similar to tropical corals in some places, was first described for the Levantine fauna in the same study. *Oculina patogonic*a was first sampled by Çınar et al. (2006) from the Mediterranean coasts of Turkey during the surveys conducted under the TUBITAK project. In the Guidebook for Marine Species in Turkey, 34 species were reported, eight of which were new to the Aegean and Marmara Sea fauna. Nine hard corals are listed in this book, two of which (*Leptopsammia pruvoti*, *Hoplangia durotrix*) are recorded for the first time from the Aegean Sea coasts of Turkey (Gökalp 2011).

In addition to these data, Gözcelioğlu (2011) added 10 coral species (Hexacorallia, Octocorallia) to the scleractinian inventory, three of which (*B. europaea*, *L. pruvoti*, *C. inornata*) were recently sampled from the Mediterranean coasts of Turkey.

The surveys in the Turkish coasts were limited until 2011 and only some distributional records which did not cover the ecological and morphological features of species were released. Some limited ecological information regarding the Scleractinia was also given in the references. However, the particular point as to the more advanced assessments of the subject began with the surveys in the Dardanelles (Özalp & Alparslan 2011). This was also a critical time because a scleractinian corallite was subjected to a detailed laboratory procedure and in-situ measurements regarding the marine ecology were performed for the first time in Turkey. The Dardanelles (Çanakkale Strait) as part of the Turkish Straits, has served as a significant sampling area in other researches. When considering the current knowledge, it can be observed that there are a number of ongoing investigations into the benthic invertebrate fauna of the strait (Çelik et al. 2007; Palaz et al. 2010; Ateş et al. 2014). During the first regional ROV observations referred to as the MARNAUT cruise onboard the French R/V *L'Atalante* around the deep-water coral sites in the Marmara Sea (Çınarcık Basin), *Desmophyllum dianthus* was discovered for the first time between 900 and 1200 m (Taviani et al. 2011). The colonial azooxanthellate coral *Polycyathus muellerae* was the only scleractinian first sampled from the Levantine Sea during these surveys (Çınar et al. 2014).

No thorough research has been carried out in the past few years on the species taxonomy, ecology, morphology and regional distribution in the above-mentioned coastal waters. Although some studies made a major contribution to the zoogeographical data, the knowledge of scleractinians is still scarce. In this sense, the current investigation carried out in the Dardanelles and the Marmara Sea represents the initial stage of a large-scale research on hard coral communities occurring in the Turkish seas.

Materials and methods

Study area

The Dardanelles is known as the longest and deepest waterway of the Turkish Straits System, which extends nearly 65 km between the eastern coasts of the Gallipoli peninsula (Seddülbahir-Gelibolu) and the coastline of Çanakkale city up to Lapseki province (Fig. 1). It is an important

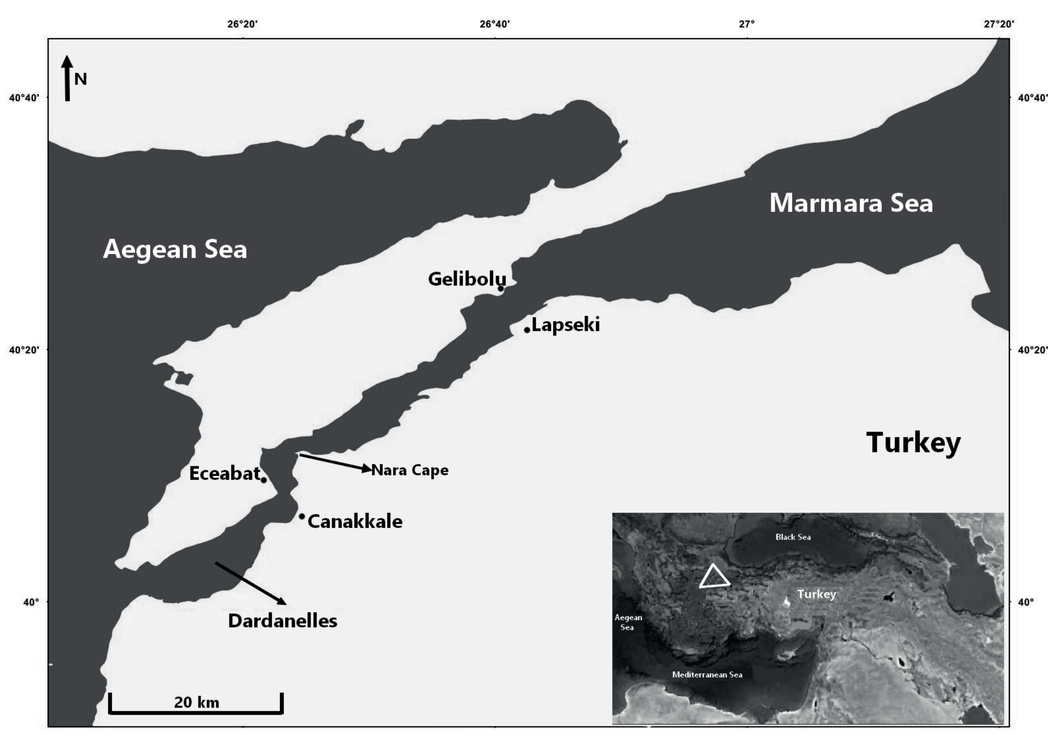

Figure 1

Map of the study area

connection between the Aegean and Black Sea via the Marmara Sea and Bosphorus. There are two current systems in the strait with some special areas such as the Capes of Nara and Eceabat, where strong water turbulence occurs. While the more saline Aegean waters enter the Marmara Sea as the bottom layer, the upper flow on the surface transports the waters of the Black Sea into the Aegean Sea (Beşiktepe 2003). The salinity and temperature values range from 20 to 40 (PSU) and from 6 to 20°C, respectively. In summer time, temperature of 25°C may also be observed at some locations (Baba et al. 2007; Özalp 2012). The Nara Cape where currents have the highest speed (150 cm s^{-1}) in the strait is the narrowest (1260 m) and the deepest point with the maximum depth of 113 m.

This area has a coarser sediment compared to other areas (Gökaşan et al. 2008). The Dardanelles is a specific habitat representing the abundance of the Mediterranean species. The dense occurrence of seagrasses such as *Posidonia oceanica*, *Zostera marina* and many invertebrates observed up to the Marmara Islands, form a unique community at the studied stations.

There is also an extensive spread of coralligenous concretions around the rocky substrate. Due to its benthic features, affected mainly by the Aegean deep waters, the Dardanelles resembles the Mediterranean ecological conditions to some extent (Özalp & Alparslan 2011; Özalp & Ateş 2015; Topçu & Öztürk 2015).

Sampling, techniques, in situ measurements

This study was carried out mainly in the Dardanelles (Çanakkale Strait) at 197 stations to a maximum depth of 50 m during the BASI coral research, between 2011 and 2014 (Fig. 2). Three sampling stations were also selected as pilot locations in the south of the Marmara Sea to compare the scleractinian distribution and ecological features. SCUBA equipment was the main tool during the ecological research in situ. For some other critical stations where the current was strong and effective up to deep waters, technical diving instruments also supported the field studies. A scooter was also used throughout the surveys to observe the characteristic of benthos. Assessment of the species occurrence, as well as ecological, biological and distributional measurements were conducted at six different depth levels (0-5 m; 6-10 m; 11-20 m; 21-30 m; 31-40 m; 41-50 m). At the first depth level (0-5 m), both SCUBA and free diving techniques were used as required. The manta-tow technique (one of the most suitable methods for monitoring the coral reefs in the tropics) was successfully applied at all stations between 0 and 5 m depth, where the visibility is good (Kenchington 1978).

During these studies, a free diver was towed at certain intervals behind the research vessel by holding a rope (20 m) and a total of 324 tows were carried out along the Dardanelles coasts up to the initial point of the Marmara Sea (Karabiga stations included) and the distributional pattern of species, the substrate type, the number of individuals (or colonies) and GPS points were noted on the data sheet. Since the sandy substrates cover a larger area than rocky habitats in the strait, there was no fixed timing during the tow survey. Thus, the intervals varied depending on the benthic character of the region so that some nonstop tows lasted about two hours. The SCUBA manta-tow technique was also used approximately once for each station to check the general occurrence of species around the rocky substrates. The 50 m transect and visual counting were the suitable methods for colonial corals to determine their abundance, the number of individuals and the cover area, while a 20 × 20 cm quadrat technique was randomly applied to solitary species with the same purpose.

For colonial species (Fig. 3), lengths of D1/D2 and height of each colony (H) were measured with a plastic ruler under the water (D1: Width 1; D2: Width 2; H: Height of a colony measured from the substrate). The total corallite number for each colony was estimated with a 2 × 2 cm quadrat (Peirano et al. 2001). For solitary and colonial species, length, width and height of the sampled individual corallite were also measured (Length: the maximum axis of the oral disc; Width: the minimum axis of the oral disc; H: height of a corallite individual) (Caroselli et al. 2012). A 20 × 20 cm quadrat was also used to determine the abundance of solitary individuals (Bianchi et al. 2004).

In addition to the above measurements, all specimens were photographed and recorded with a wide-angle featured HD camera in situ and the ecological characteristics such as temperature (by depth), substrate type, bottom declination, depth at which a species occurred and the water current were determined. Macro photographs of the species were also taken. Salinity was another physicochemical factor measured, representative of

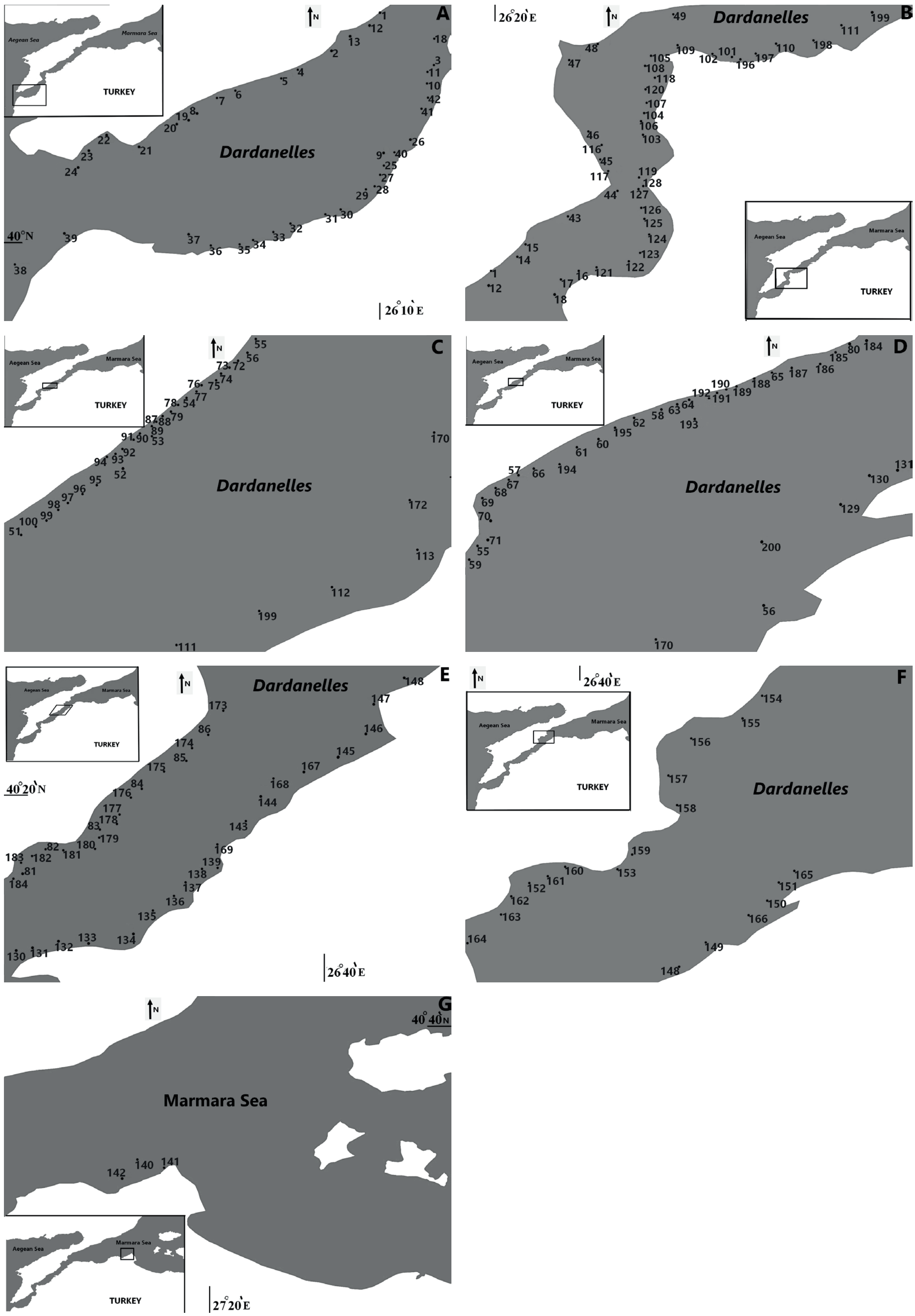

Figure 2

GPS-supported map of the study stations in the Dardanelles and Marmara Sea

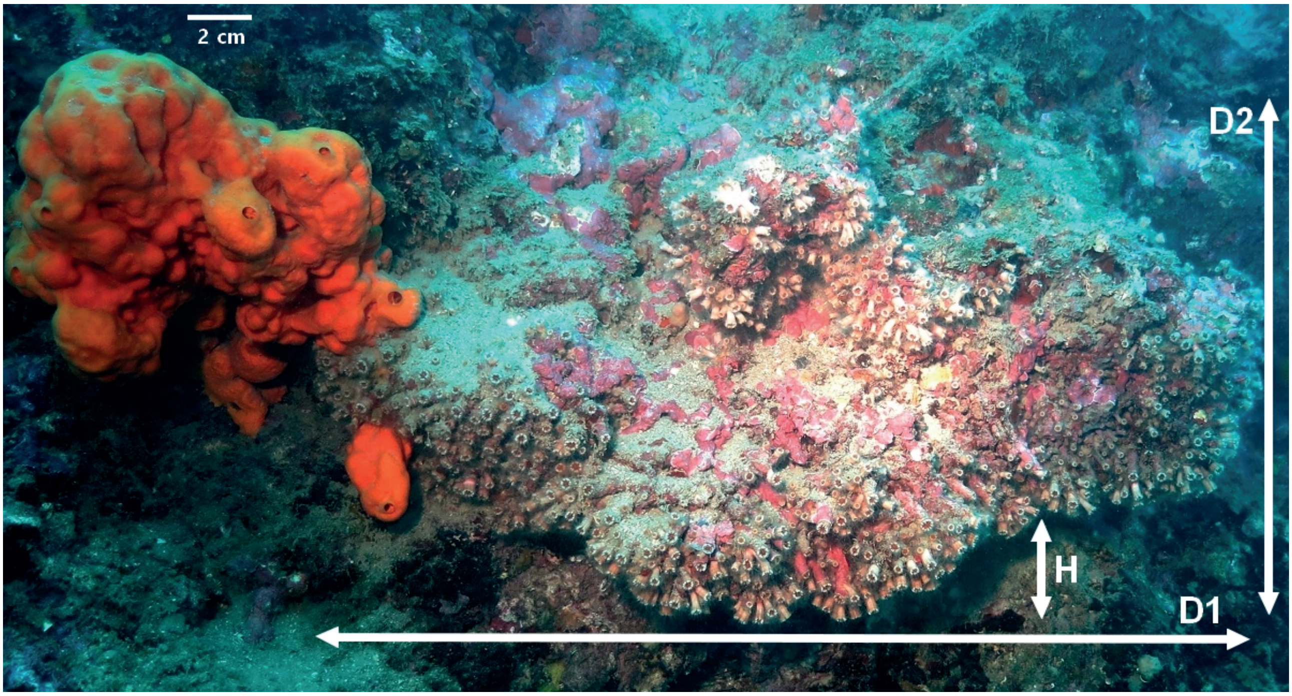

Figure 3

Wide-angle photo of *Polycyathus muellerae* showing the measured diameters of the coral colony in situ (D1: Width 1; D2: Width 2; H: Height of the colony from the substrate level)

15 stations (rocky habitats).

To prevent habitat damage, only 10 corallites were carefully sampled with pliers from the main colony or its position on the rock, and later used in biomass analyses. All collected corallites were first washed in clean water, soaked in H_2O_2 solution (Peirano et al. 2001) for about three days to remove the organic matter and then dried at 80°C for 48 hours in a laboratory. To determine the skeletal weight, ten corallites representing one colony were weighed on an analytical balance. These procedures were followed by the examination of skeleton structures under an Olympus binocular stereo microscope for taxonomic analyses. The photograph of each corallite structure was also taken under the microscope via an Olympus HD camera. Later, all specimens were deposited in the Piri Reis Naval Museum, the Faculty of Marine Science and Technology, the University of Çanakkale Onsekiz Mart, with the pre-code "OM/PRM".

Analysis

The dried corallites were examined for morphological differences in calyx, columella, palus, coenosteum, costa, theca, septa and basal structure. The scleractinian species reported here were taxonomically identified according to Zibrowius (1980). For each colony, mean values of ecological characteristics such as biomass, the total number of corallites, the total number of colonies, dimensions of corallites (the greatest length and the smallest length of a calix, height of corallites) and the cover rate on the substrate were determined by using PAST and MTB software and standard errors were given. The frequency and dominance of species was calculated using the Soyer's (1970) (F%) and Bellan-Santini's (1969) dominancy index (DI%), respectively.

The frequency index was estimated by:

$$F = \frac{m}{M \times 100}$$

where m = the number of occurrence of a given species and M = the number of occurrence of all species, while the dominance index was specified by:

$$DI = \frac{m}{M \times 100}$$

where m = the total number of individuals and M = the number of individuals of all species. According to *F* value (*F*>49; 25≤*F*≤49; *F*<25) obtained as a result of calculations, the species' existing condition in the community was defined as constant, common and rare. The Bray-Curtis similarity and multiple correspondence analyses (MCA) were used to determine the correlation between the number of individuals/colonies and stations.

Results and discussion

A total of nine scleractinian coral species, two of them zooxanthellates, were found between 0 and 50 m in this study, five of which were reported for the first time from the Dardanelles. Four of them were solitary species, while five were colonial. According to the recently updated anthozoan list from the Turkish Seas, 75 corals (15 scleractinians) have been recorded to date. For instance, the Marmara Sea is represented by 52 species, nine of which are the hard corals (Çınar et al. 2014). Considering the checklist, the colonial coral *Polycyathus muellerae* and the solitary species *Leptopsammia pruvoti* sampled during the current study are also new to the fauna of the Marmara Sea. With this finding, the number of scleractinians reached eleven.

Phylum CNIDARIA
Class ANTHOZOA
Order SCLERACTİNİA
Suborder ASTROCOENIINA
Family POCILLOPORIDAE
Madracis pharensis Heller, 1868

Material examined: supplementary file S1

Diagnosis: Encrusting and nodular colonies. Light pink and brownish colored corallites fused with the columella (conical) and closed with each other. Polyps brilliant white and brownish. No branching. Calyx up to 4 mm in length and cylindrical shape for specimens from the Dardanelles. First septa cycle connected to the base of columella and highly visible (Fig. 4).

Habitat: Dardanelles: up to 39 m depth; rocky substrates associated with dense calcareous algae and sponges.

Distribution: The first and the last report on the species were given from the Pacific Ocean by Veron (2000); from the Atlantic Ocean by Zibrowius & Grieshaber (1977), Monteiro et al. (2013); from the Mediterranean Sea by Zibrowius & Grieshaber (1977), Kipson et al. (2014), Kružić et al. (2014), Kružić & Požar-Domac (2003), Çınar et al. (2014); from the Aegean Sea by Forbes (1844) and Sini et al. (2014). The first reports from the Mediterranean and Aegean Sea coasts of Turkey were released by Zibrowius (1979) and Forbes (1844), respectively. The occurrence of the species in the Dardanelles was recently recorded for the first time by Özalp & Alparslan (2015). The new localities of the species are reported in the current study. Global additional records of *M. pharensis* are also submitted according to the latest reference (AIMS 2009).

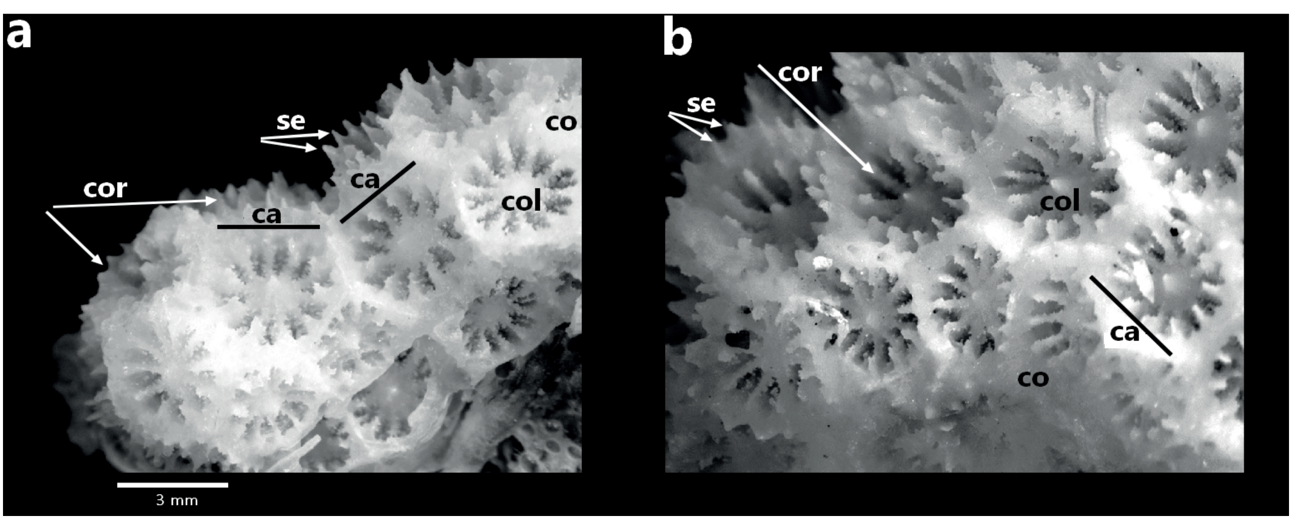

Figure 4

Skeleton image of *Madracis pharensis* under a microscope. Calix, Septa, Columella, Corallites and Coenosteum structure around the corallites. (Ca: calix, Se: septa, Col: columella, Cor: corallites, Co: coenosteum)

Family FAVIIDAE
Cladocora caespitosa Linnaeus, 1767

Material examined: supplementary file S1

Diagnosis: Colonies phaceloid and massive. Branching corallites up to 5 cm in height, dark green and brownish in color, some curved. Some individuals grow on theca wall of adult specimens. Calyx circled, up to 5-6 mm in length in samples from the Dardanelles. Columella and palus hardly observed. Theca serrate, bright on calyx. Regular septa cycle and likely similar in height (Fig. 5).

Habitat: Dardanelles: up to 24 m depth; rock, hard substrates associated with Polychaeta, some colonies densely spreading among *P. oceanica* colonies.

Distribution: The first and the last report on the species were given from the Atlantic Ocean by Zibrowius & Saldanha (1976), Cairns et al. (2001); from the Mediterranean Sea by Zibrowius (1980) and Kersting et al. (2014), Pitacco et al. 2014, Cánovas Molina et al. (2014), Pititto et al. (2014), Kružić et al. (2014); from the Aegean Sea by Zibrowius (1979) and Gökalp (2011). The first reports from the Mediterranean, the Aegean Sea and the Dardanelles coasts of Turkey were released by Öztürk et al. (2004), from Saros Bay by Gökalp (2011), from the Dardanelles by Özalp and Alparslan (2011). The new localities and the updated number of colonies are reported in the current study. Additional GIS records on *C. caespitosa* for the Mediterranean regions are also submitted according to the latest reference (ArcGIS 2014).

Family CARYOPHYLLIIDAE
Caryophyllia smithii Stokes & Broderip, 1828

Material examined: supplementary file S1

Diagnosis: Solitary columnar corallites, dark red and white in color, up to 18 mm high in samples from the Dardanelles. Columella clearly visible, rod-like structured and distinctly white in color. Theca flat. Palus visible. Calyx fully cylindrical even in adult individuals, up to 1.5-21 mm long. First septa cycle distinct (Fig. 6).

Habitat: Dardanelles, Marmara Sea: up to 44 m depth; rock, hard substrates associated mainly with Polychaeta and mussel shell.

Distribution: The first and the last report on the species were given from the Atlantic Ocean by Lindström (1877) and Monteiro et al. (2013); from the Mediterranean by Zibrowius (1980), Kružić (2002, 2007), Teixidó et al. (2014), David & Guillemain (2014); from the Aegean Sea by Zibrowius (1979) and Sini et al. (2014). The first reports from the Mediterranean, Aegean and Marmara Sea coasts of Turkey were released by Öztürk et al. (2004), from Bodrum by Gökalp (2011) and from the Turkish Strait System (Dardanelles, Bosphorus) by Ostroumoff (1896). The new localities in the Dardanelles are reported for the first time in the current study.

Caryophyllia inornata Duncan, 1878

Material examined: supplementary file S1

Diagnosis: Solitary columnar corallites, dark red

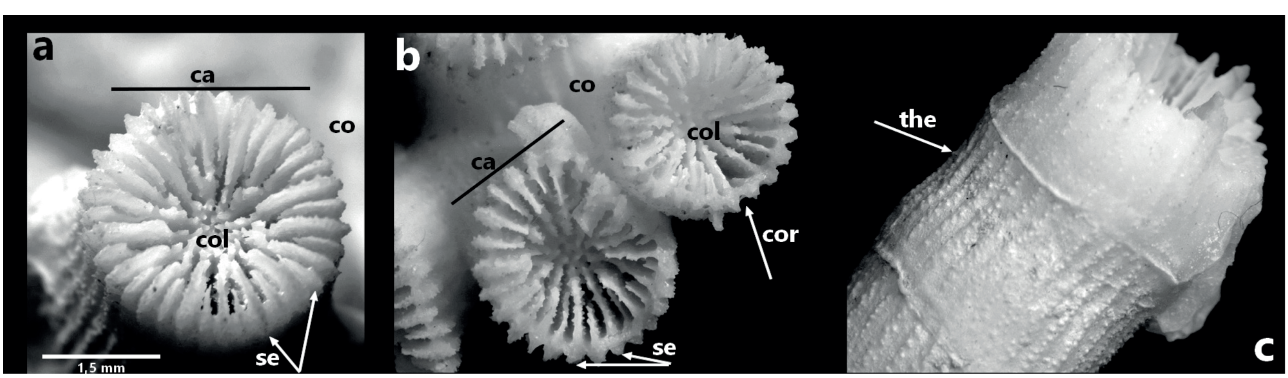

Figure 5

Skeleton images of *Cladocora caespitosa* under a microscope. Calix, Septa, Columella (left), adjacent corallites, coenosteum part behind the corallites (middle) and theca structure (right). (Ca: calix, Se: septa, Col: columella, Cor: corallites, Co: coenosteum, the: theca)

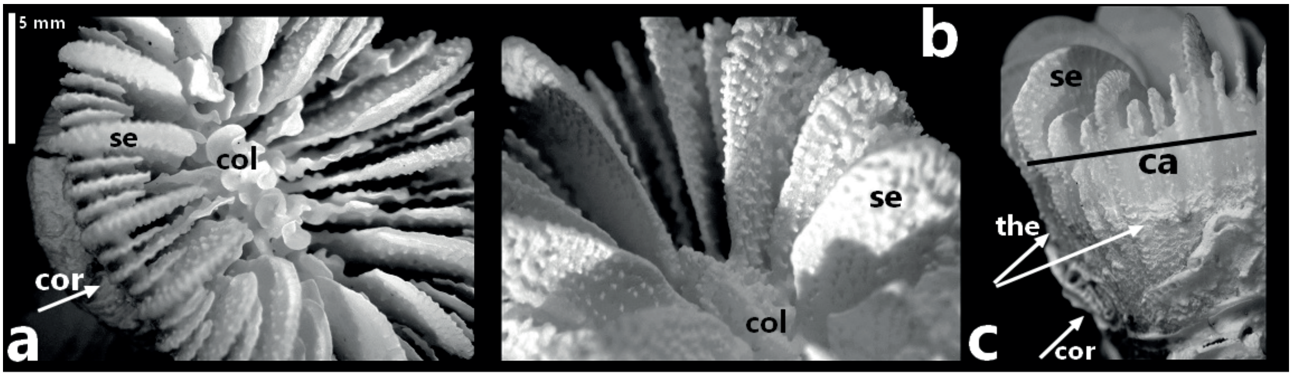

Figure 6

Skeleton image of *Caryophyllia smithii* under a microscope. Calix, Columella (left), septa (middle) and theca (right) structure of corallite. (Ca: calix, Se: septa, Col: columella, Cor: corallites, the: theca)

and white in color, up to 14 mm high in samples from the Dardanelles. Columella well visible, rod-like structured and distinctly white in color. Theca flat. Palus visible. Calyx fully cylindrical even in adult individuals, up to 1-9 mm long. First septa cycle distinct (Fig. 7).

Habitat: Dardanelles: up to 40 m depth; rock, hard substrates associated mainly with bryozoans and coralligenous formations, occurring densely around the facies of *Neopycnodonte cochlear*.

Distribution: The first and the last report on the species were given from the Atlantic Ocean by Cairns (1977) and Monteiro et al. (2013); from the Mediterranean by Zibrowius (1980), Kružić (2002, 2007), Teixidó et al. (2014), Kipson et al. (2014), David & Guillemain (2014); from the Aegean Sea by Zibrowius (1979) and Sini et al. (2014). The first reports from the Aegean and Mediterranean Sea coasts of Turkey were released by Zibrowius (1979) and Gözcelioğlu (2011), respectively. The occurrence of the species in the Dardanelles is newly recorded.

Paracyathus pulchellus Philippi, 1842

Material examined: supplementary file S1

Diagnosis: Solitary columnar corallites, red and orange in color, up to 17 mm high in samples from the Dardanelles. Columella clearly visible, broad, rod-like structured and distinctly white in color. Theca flat and clear. Palus clearly visible. Calyx

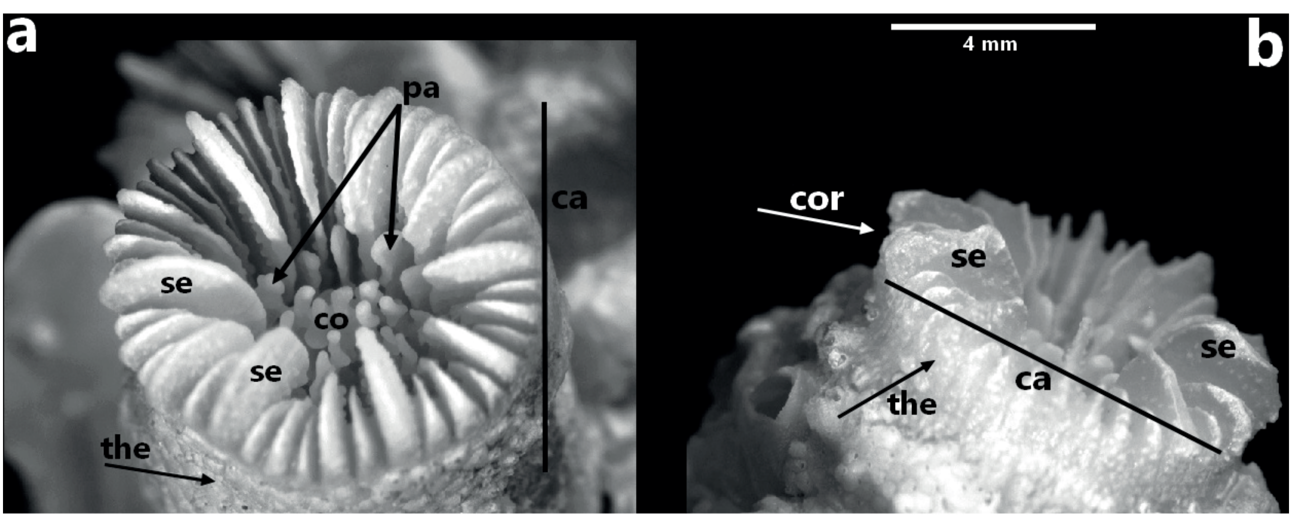

Figure 7

Skeleton image of *Caryophyllia inornata*. Calix, columella, septa, palus (left) and theca structure of corallite (right). (Ca: calix, Se: septa, Col: columella, Cor: corallites, the: theca, pa: palus) conical, up to 5-18 mm long and larger than basal plate of corallite in adult individuals. Septa cycles hardly visible (Fig. 8).

Habitat: Dardanelles: up to 43 m depth; rock, hard substrates associated mainly with coralligenous communities, sponges and bryozoans, soft substrates (sponges)

Distribution: The first and the last report on the species were given from the Atlantic Ocean by Cairns (1977) and Monteiro et al. (2013); from the Mediterranean by Zibrowius (1980) and Cairns et al. (2001); from the Aegean Sea by Zibrowius (1979) and Sini et al. (2014). The first report from the Marmara Sea coasts of Turkey was released from the Bosphorus strait by Demir (1952). The occurrence of the species in the Dardanelles is newly recorded.

Phyllangia mouchezii Lacaze-Duthiers, 1897

Material examined: supplementary file S1

Diagnosis: Colony form. Corallites tubular, up to 36 mm high, 15 mm wide and brownish in color, at some points fully encrusted with calcareous algae. Calyx circular in general, rarely elliptical in adult

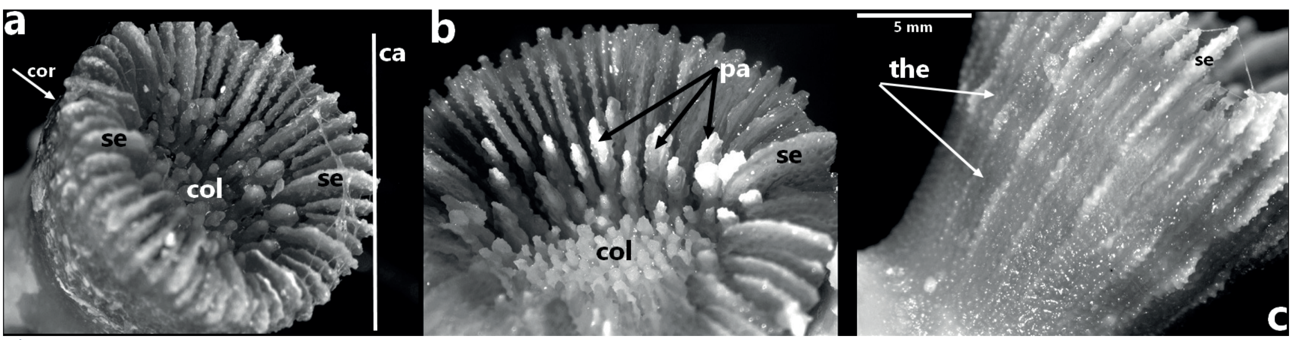

Figure 8

Skeleton image of *Paracyathus pulchellus*. Calix (left), columella, septa, palus (middle) and theca structure of corallite (right). (Ca: calix, Se: septa, Col: columella, Cor: corallites, the: theca, pa: palus)

Polycyathus muellerae Abel, 1959

Material examined: supplementary file S1

Diagnosis: Colony form. Corallites tubular, up to 27 mm high, 6 mm wide and reddish brown in color, at some points fully encrusted with calcareous algae. Calyx circular and up to 5 mm long in samples from the Dardanelles and Marmara Sea. Some individuals grow on theca wall of adult specimens. Columella conical and ribbed. Palus highly visible (Fig. 9).

Habitat: Dardanelles, Marmara Sea: up to 44 m depth; rock, hard substrates with coralligenous communities and bryozoans, soft substrates (sponges)

Distribution: The first and the last reports on the species were given from the Atlantic Ocean by Zibrowius and Saldanha (1976), Monteiro et al. (2013); from the Mediterranean by Zibrowius (1980) and Koukouras (2010); from the Aegean Sea by Zibrowius (1979) and Sini et al. (2014). The first reports from the Aegean and Mediterranean Sea coasts of Turkey were released by Zibrowius (1979) and Çınar et al. (2014), respectively. The occurrence of the species in the Marmara Sea and Dardanelles is newly recorded.

specimens and up to 11-14 mm long in samples from the Dardanelles. Some individuals grow on theca wall of adult specimens. Columella conical and closer to corallite's basal plate. Theca and costa highly visible. First septa cycle more significant than others (Fig. 10).

Habitat: Dardanelles: up to 19 m depth; rocky substrate with dense calcareous algae.

Distribution: The first and the last reports on the species were given from the Atlantic Ocean by Zibrowius & Saldanha (1976), Monteiro et al. (2013); from the Mediterranean Sea by Zibrowius (1980) and Gökalp (2012); from the Aegean Sea by Vafidis et al. (1997) and Sini et al. (2014). The first reports from the Mediterranean and Aegean Sea coasts of Turkey were released from Marmaris Bay and Iskenderun by Zibrowius (1980). The

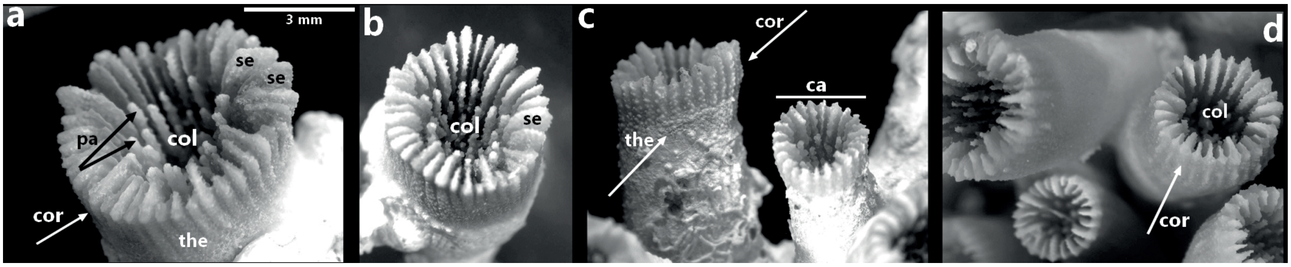

Figure 9

Skeleton image of *Polycyathus muellerae*. Calix, septa, palus (left), columella, theca (middle two) and colony structure of corallites (right). (Ca: calix, Se: septa, Col: columella, Cor: corallites, the: theca, pa: palus)

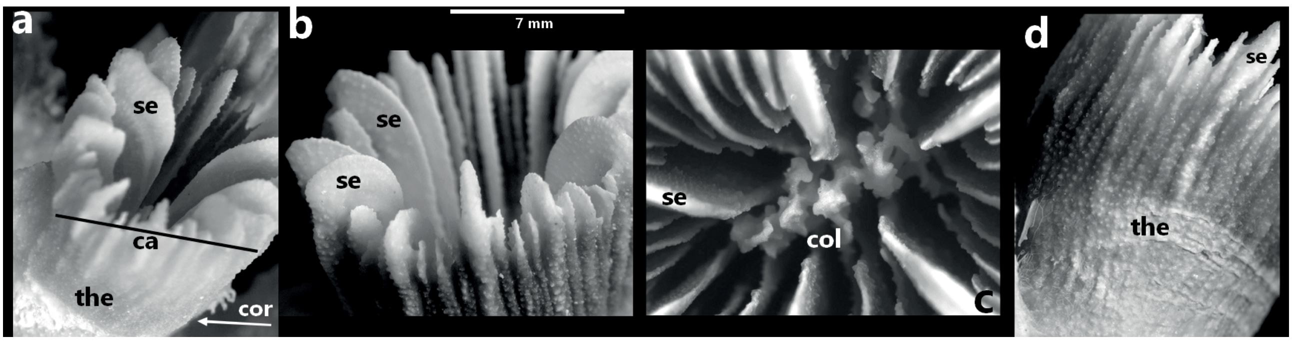

Figure 10

Skeleton image of *Phyllangia mouchezii*. Calix (left), septa, columella (two middle) and theca structure of corallite (right). (Ca: calix, Se: septa, Col: columella, Cor: corallites, the: theca)

occurrence of the species in the Dardanelles is newly recorded.

Family DENDROPHYLIIDAE
Balanophyllia europaea Risso, 1826

Material examined: supplementary file S1

Diagnosis: Corallites up to 39 mm high, yellow, dark brown, and cream in color. Solitary columnar. Some individuals very large and compressed. Calyx circular in general, rarely elliptical, fully curved and at some points irregularly narrowed, larger in adult specimens, up to 5-24 mm long in samples from the Dardanelles. Sometimes observed in dense clusters resembling the colony structure. Younger corallites rarely grow on large individuals. Columella porous, broad and elliptical. Theca ribbed, serrate and at some points with holes. Septa slightly visible (Fig. 11).

Habitat: Dardanelles: up to 23 m depth; rock, hard substrates with algae and coralligenous communities, rhizomes of *P. oceanica*.

Distribution: The first and the last report on the species were given from the Atlantic Ocean by Zibrowius (1980) and Cairns et al. (2001); from

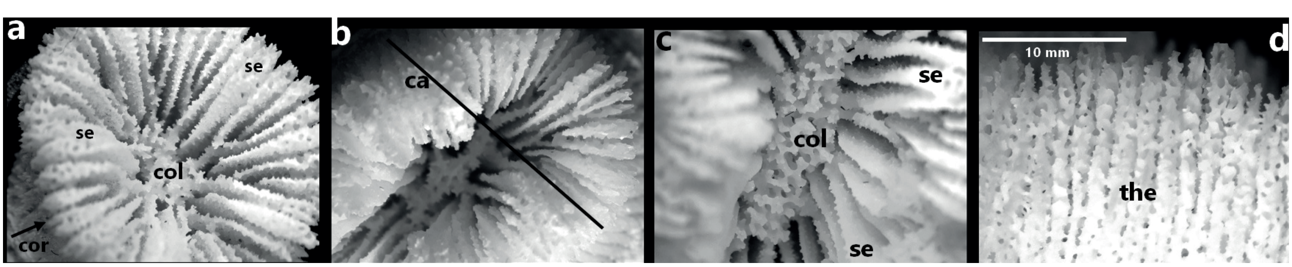

Figure 11

Skeleton image of *Balanophyllia europaea*. Calix, septa (left), columella (two middle) and theca structure of corallite (right). (Ca: calix, Se: septa, Col: columella, Cor: corallites, the: theca)

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the Mediterranean by Zibrowius (1980) and Kružić (2002; 2007), Kružić and Popijač (2015); from the Aegean Sea by Zibrowius (1979) and Koukouras (2010). The first reports from the Mediterranean, Aegean and Marmara Sea coasts of Turkey were released by Gözcelioğlu (2011) and by Zibrowius (1979), and from the Dardanelles by Ostroumoff (1896). The new localities in the Dardanelles are reported for the first time in the current study. Additional GIS records on *B. europaea* for the Mediterranean regions are also submitted according to the latest references (Reefcheck 2008).

Leptopsammia pruvoti Lacaze - Duthiers, 1897

Material examined: supplementary file S1

Diagnosis: Solitary columnar, yellowish corallites. Seen sometimes in dense clusters resembling colony structure. Columella porous, broad and elliptical. Theca ribbed, serrate and at some points with holes. Calyx up to 15 mm long and corallite up to 39 mm high in samples from the Dardanelles and Marmara Sea (Fig. 12).

Habitat: Dardanelles, Marmara Sea: up to 44 m depth; rock, hard substrates with coralligenous communities and bryozoans, soft substrates (sponges)

Distribution: The first and the last report on the species were given from the Atlantic Ocean by Zibrowius & Saldanha (1976) and Borges et al. (2010); from the Mediterranean by Zibrowius (1980) and Koukouras (2010); from the Aegean Sea by Zibrowius (1979) and Sini et al. (2014). The first reports from the Mediterranean and Aegean Sea coasts of Turkey were released by Gözcelioğlu (2011) and from Datça by Gökalp (2011). The occurrence of the species in the Marmara Sea and Dardanelles is newly recorded. Additional GIS records on *L. pruvoti* for the Mediterranean regions are also submitted according to the latest references (ArcGIS 2014).

In total, 208 colonies and 556 solitary individuals (polyps/corallites) belonging to four families were observed on rocky, gravelly and shingly substrates at 200 stations. Sixty seven stations were excluded from the statistical assessment due to the nonexistence of the species. Ten corallites per colony/individual were assessed. *Leptopsammia pruvoti* was the dominant with the index value of 43.34%, followed by *Caryophyllia smithii*, *Balanophyllia europaea*, *Caryophyllia inornata* and *Paracyathus pulchellus* with 32.19%, 14.92%, 5.93% and 3.59% (Fig. 13). *Polycyathus muellerae* and *Cladocora caespitosa* were the most abundant species among the colonial corals with dominance values of 50% and 48.07%. *Madracis pharensis* showed the low value (1.44%). Since *Phyllangia mouchezii* was represented by only one colony at Station 2, the species had the lowest value of 0.48%.

According to Soyer's Index, *C. smithii* received the highest value of occurrence frequency (F=5.51), while *B. europaea*, *L. pruvoti*, *P. pulchellus* and *C. inornata* had values of 0.93, 0.65, 0.37 and 0.18, respectively. Although *C. smithii* was common, the number of corallites was few and recorded only as one individual at most of the stations. Also the frequency values were low in the colonial corals due to the rare occurrence at the stations. *P. muellerae* had the highest value of 2.38%.

C. caespitosa occurred with the frequency of 1.12%, while *M. pharensis* and *P. mouchezii* – below 1% (F= 0.37 and 0.12) (Fig. 14). In terms of depth intervals estimated with four replicate quadrats for each depth level at the stations, *L. pruvoti* reached the highest mean number of individuals, i.e. 850 between 41 and 50 m (MNC: mean number of corallites; MNI: mean number of individuals). The MNI gradually decreased to 50 after the depth level

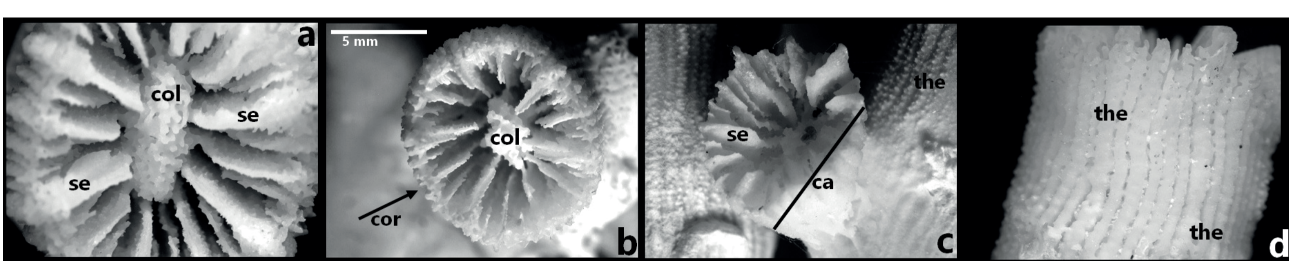

Figure 12

Skeleton image of *Leptopsammia pruvoti*. Calix, columella, septa (left), columella (middle left), juvenile corallite (middle right) and theca structure of corallite (right). (Ca: calix, Se: septa, Col: columella, Cor: corallites, the: theca)

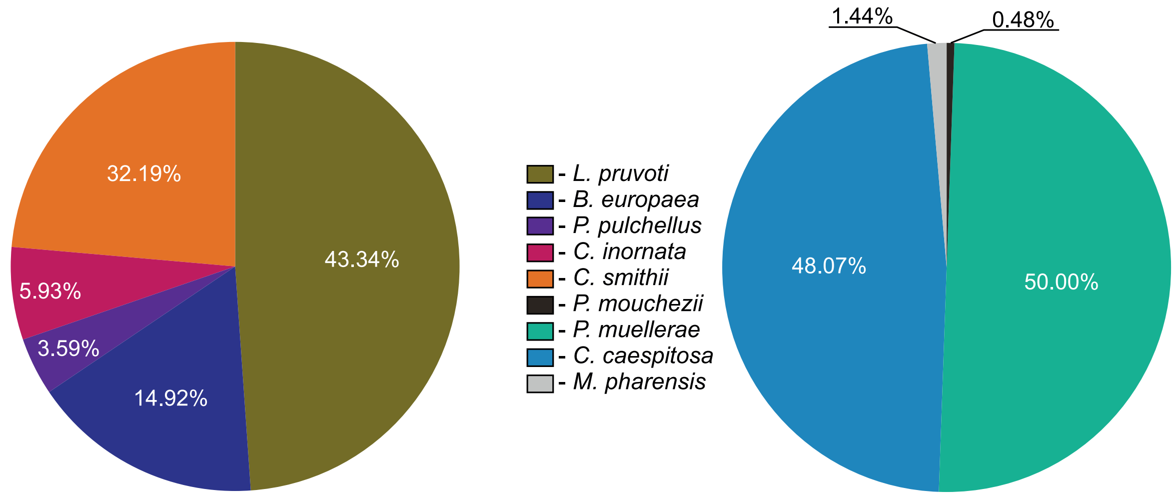

Figure 13

Dominance values of solitary and colonial corals

of 11-20 m. *C. smithii* was found dominant at the same depth range with 650 individuals per square meter. The species density was at the second highest value (312 ind. m^{-2}) at depths of 21-30 m and reached 131 polyps. The lowest MNI (6 ind. m^{-2}) was observed between 41 and 50 m.

The largest total number of *B. europaea* individuals occurred at depths of 11-20 m (393 polyps m^{-2}), while the smallest abundance was observed at the second depth level (6-10 m). *C. inornata* and *P. pulchellus* were dominant between 21 and 30 m. The first surveyed depth level between 0 and 5 m was in general the most deprived area of the coral distribution and, in comparison, the last depth level may also be qualified as one of the least populated zones by the species. The second most abundant localities were found at the depth range of 11-30 m (Fig. 15). *C. caespitosa* had the largest number of colonies (61) between 0 and 5 m depths, while the smallest number was observed at the fourth depth level. *P. muellerae* was dominant at depths of 21-30 m and rarely found in the last depth range. *M. pharensis* was represented by four colonies at two stations between 21 and 40 m. *P. mouchezii* was observed at Station 2 only as one colony between 11 and 20 m.

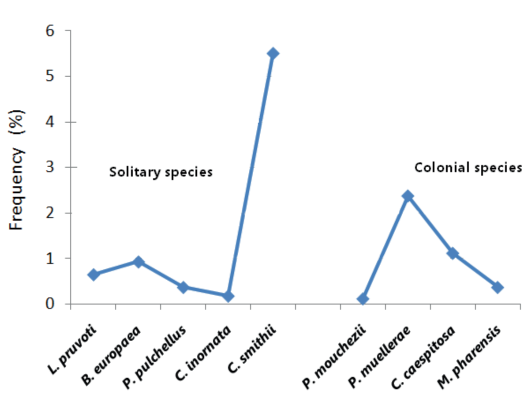

Figure 14

Frequency of coral species evaluated over stations

Dendrophylliidae and Caryophylliidae are the dominant families of the colonial and solitary corals, respectively. Although these Mediterranean originated corals are rare in the studied areas and their occurrence is limited to the rocky substrate, their presence in the Marmara Sea is still remarkable. *P. muellerae* was the only colonial coral found in deep waters (44 m) of the Southern Marmara. *L. pruvoti* and *C. smithii* were yet another solitary scleractinians in the same region, while all species occurred abundantly in the Dardanelles. According to the cluster analysis (Fig. 16), *C. inornata* and *P. pulchellus* were correlated by the value of 34% and the value of similarity between *B. europaea* and *C. smithii* was also relatively high 5%. With reference to 25 stations where the colonial corals occurred, the cluster analysis revealed that *C. caespitosa* and *P. muellerae* were correlated species (17%).

At only 17 stations out of the 133 studied ones (4 replicated assessments at six depth ranges), the number of species was more than two. The correspondence analysis was conducted in relation to the number of stations where at least two species occurred. As a result, there was a clear relation

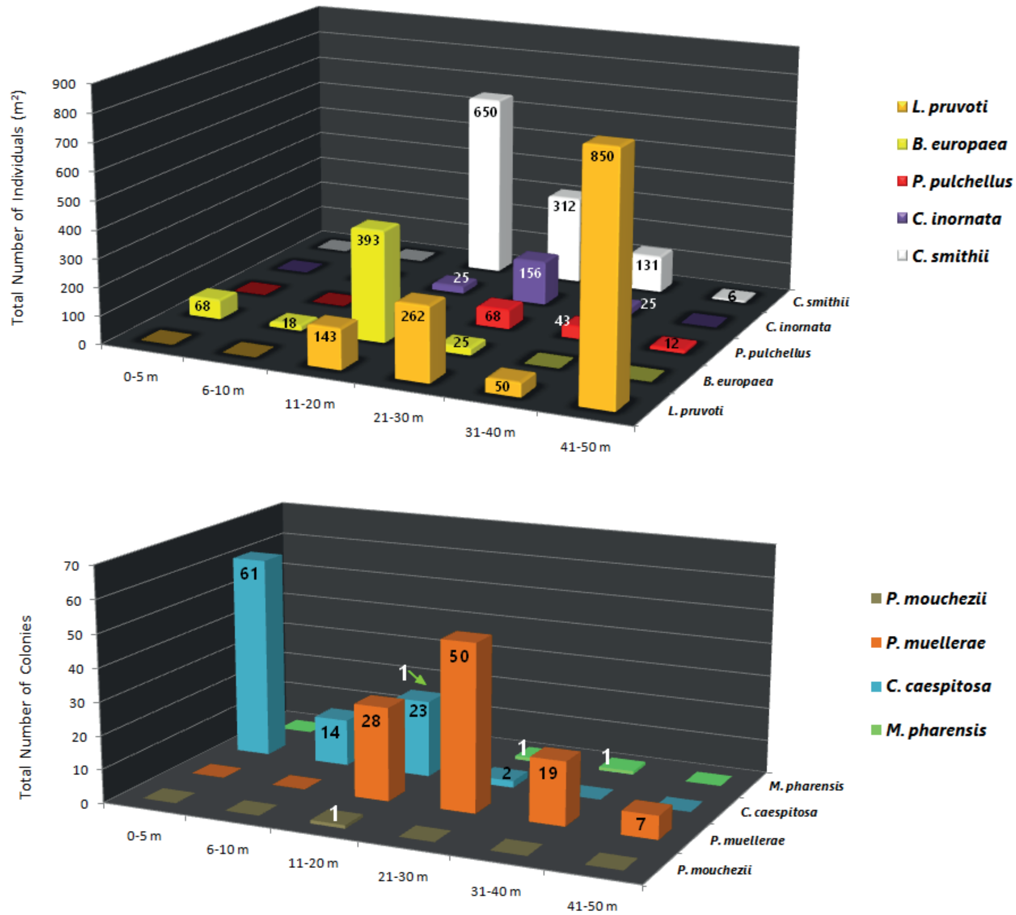

Figure 15

Depth-related distribution of the total mean number of individuals of solitary corals and the total number of colonies in colonial corals

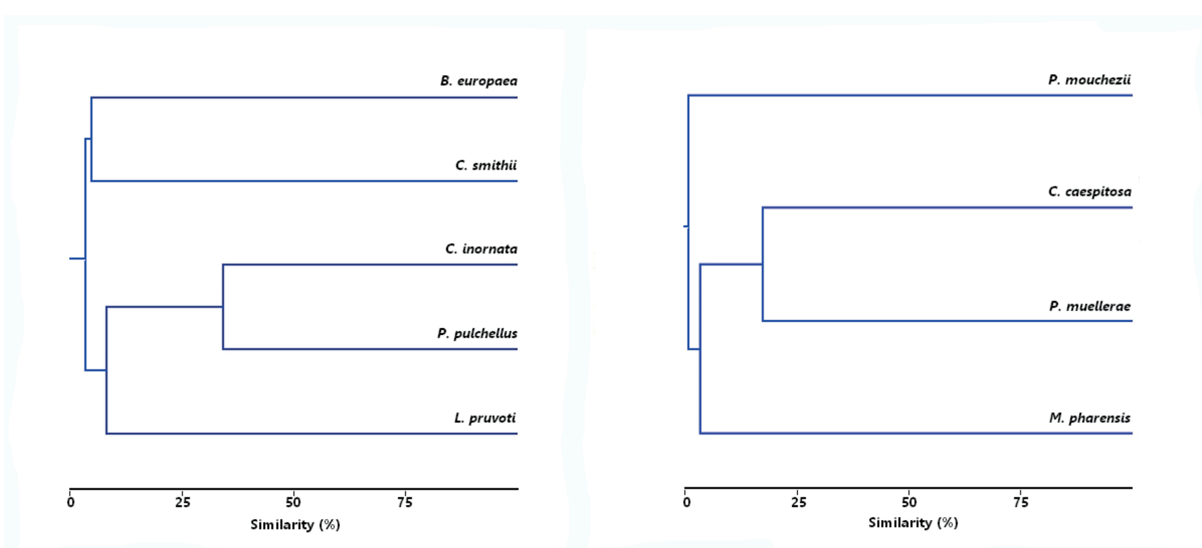

Figure 16

Similarity between the scleractinian species in relation to the sampling stations (Bray-Curtis index) between the stations 45 and 103 for *C. inornata*, since the species was abundant around these ones at depths of 11-30 m. Similarly, there was a correspondence between *P. pulchellus* and *C. smithii* at station 104. The occurrence of *P. pulchellus* at stations 45, 51 and 56 was also high. *L. pruvoti* densely populated many other stations. Due to the high abundance, *B. europaea* occurrence (c: 11-20 m; d: 21-30 m) at different depth ranges of station 27 was correlated with each other. More than two colonies were found at five stations and the stations with only one colonial species were excluded from the correspondence analysis. A dense occurrence of *M. pharensis* was observed at stations 1 and 45 between depths of 21-40 m.

Similarly, the distance of *C. caespitosa* was different compared to other species at station 1. With reference to the presence of *P. muellerae* and *M. pharensis*, the correlation is presented in the diagram (Fig. 17).

The mean morphological diameters and coral cover values are presented in the tables (Tables 1, 2). Stations with the zero mean value (i.e. study stations where only one colony or solitary individuals of the coral species occurred) were excluded from the assessments, but they were added to the tables to provide the ecological information. *C. smithii* occurred as a single individual at nearly 97.5% of the surveyed stations. Thus, mean values of the species were calculated for the stations where more

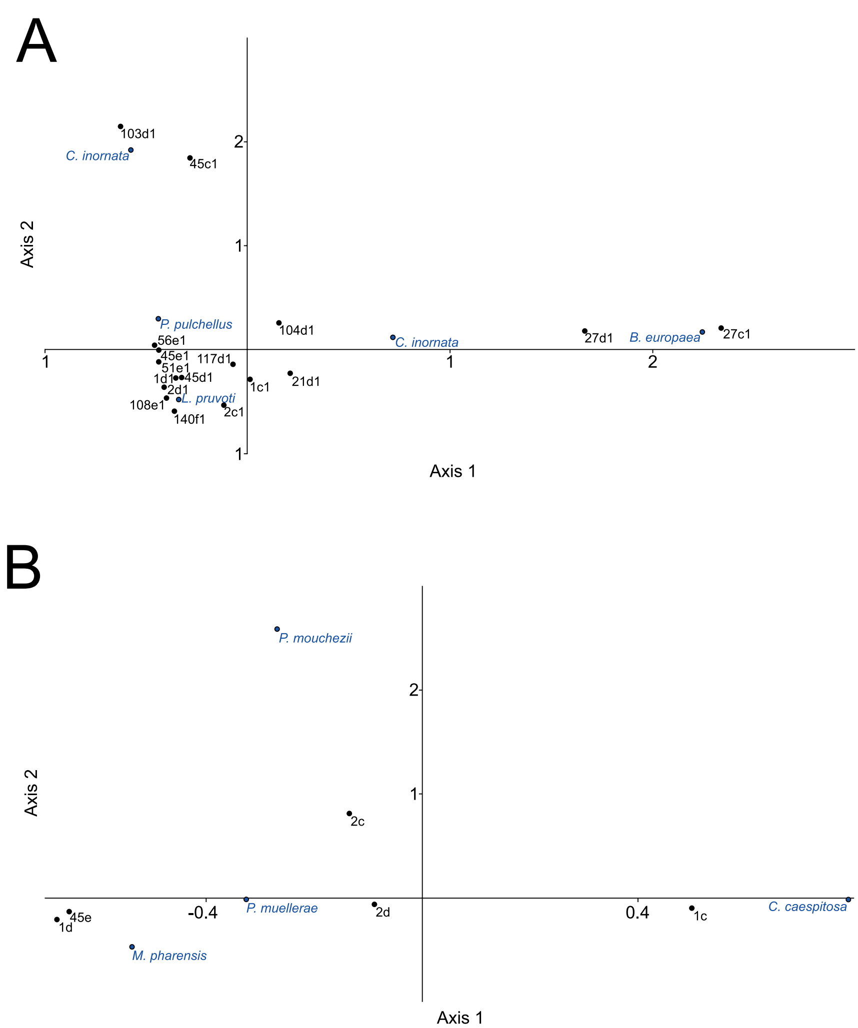

Figure 17

A: Correspondence analysis of solitary coral species with replicated quadrats in relation to stations/depth. Only stations with more than two species were assessed, while stations with only one species were excluded from the assessment. B: Correspondence analysis of colonial coral species in relation to stations/depth. (a,b,c,d,e,f: Depth ranges; the numbers with letters as "1,2,3,4": replicate numbers)

Table 1

Colonial corals, morphological diameters and coral cover values assessed per station

	TNC	Covering Area	Total Biomass	Length	Width	Height
		(cm^2)	(g)		(cm)	
	Mean±SE (Range)					
Madracis pharensis						
Station 1	674.5±329.5 (345-1004)	2850±550 (2300-3400)	285.3±87.15 (198-372)	77±1 (76-78)	37.5±7.5 (30-45)	6±1 (5-7)
Station 45	761±41 (720-802)	2340±400 (1900-2700)	70.09±12.31 (57-82)	64±4 (60-68)	36±4 (32-40)	3±1 (2-4)
Cladocora caespitosa						
Station 1	112±17 (16-300)	630±150 (80-2100)	4.979±0.384 (2.81-9.9)	29.83±3.113 (17-61)	19.28±2.15 (10-39)	9.17±1.17 (2-19)
Station 2	214±84 (64-355)	520±100 (350-710)	2.873±0.576 (2.1-4)	26.67±2.96 (21-31)	19.23±1.86 (17-23)	8.33±2.33 (4-12)
Station 3	251±19 (67-1000)	2400±140 (570-6900)	5.412±0.185 (2.64-10.14)	56.77±1.59 (30-96)	41.31±1.38 (19-72)	8.4±0.35 (3-20)
Station 4*	112 (112)	300 (300)	3.43 (3.43)	26 (26)	14 (14)	5 (5)
Station 20	1518±1408 (110-2925)	1240±1160 (80-2400)	5.48±1.22 (4.26-6.69)	31±32.5 (23-54)	28±25.5 (10-46)	14±14.1 (4-24)
Station 24*	78 (78)	800 (800)	5.54 (5.54)	30 (30)	27 (27)	8 (8)
Station 41*	23 (23)	100 (100)	3.44 (3.44)	15 (15)	7 (7)	3 (3)
Polycyathus muellerae						
Station 1	73±12 (19-270)	610±170 (100-4600)	4.082±0.35 (1.9-8.6)	20.69±2.18 (9-60)	28.54±2.65 (13-78)	5.11±0.5 (2-11)
Station 2	71±12 (32-136)	240±50 (140-600)	4.537±0.422 (1.8-5.75)	10.44±1.21 (7-18)	22.78±2.17 (18-34)	5.67±1.08 (2-11)
Station 21*	40 (40)	100 (100)	3.1 (3.1)	8 (8)	21 (21)	3 (3)
Station 45	228±52 (30-1600)	7540±4220 (90-151000)	3.585±0.152 (1.94-5.6)	47.7±9.74 (6-345)	66.4±13.5 (15-440)	6.56±0.61 (2-17)
Station 51*	90 (90)	700 (700)	4.66 (4.66)	30 (30)	26 (26)	6 (6)
Station 52*	40 (40)	100 (100)	3.51 (3.51)	10 (10)	15 (15)	2 (2)
Station 56*	140 (140)	1200 (1200)	4.4 (4.4)	30 (30)	40 (40)	4 (4)
Station 103	37±7 (23-55)	20±3 (10-30)	3.105±0.434 (2.17-4.21)	4.75±0.47 (4-6)	5.5±0.95 (4-8)	3.5±0.28 (3-4)
Station 104*	46 (46)	200 (200)	4.88 (4.88)	10 (10)	20 (20)	4 (4)
Station 108	212±176 (36-388)	950±850 (100-180)	4.045±0.205 (3.84-4.25)	19±5 (14-24)	43.5±31.5 (12-75)	7.5±4.5 (3-12)
Station 109*	41 (41)	400 (400)	2.23 (2.23)	22 (22)	21 (21)	4 (4)
Station 110*	86 (86)	900 (900)	3.24 (3.24)	22 (22)	41 (41)	4 (4)
Station 117	108±21 (10-423)	510±100 (30-1700)	4.66±0.219 3.12-6.22	16.29±2.33 5-54	19.95±1.99 7-40	4.04±0.51 2-12
Station 140*	12 (12)	20 (20)	1.68 (1.68)	4 (4)	7 (7)	4 (4)
Phyllangia mouchezii						
Station 2*	210 (210)	2000 (2000)	17 (17)	41 (0-41)	55 (0-55)	21 (0-21)

TNC: The total mean Number of Corallites in colonies (decimals integrated).*Since only one coral colony was found at one station, these values were excluded from the calculations of mean. Mean dimensions were calculated according to the total value of 10 corallites per station. (Length: largest diameter D1; Width: lowest diameter D2; Height: height of a colony from the substrate level. Please refer Fig. 3)

than one individual occurred per square meter (Table 2). In the case of *M. pharensis*, two colonies were found per station and the highest MNC in colonies was estimated at 761 and the maximum number of corallites was 1004. Of the total number of four colonies observed at the stations, one was abundantly represented with the cover area of 2850 cm^2. The mean biomass at Station 1 calculated on the basis of the weight of 10 corallites was 285.3 g. The highest MNC in two different colonies of *C. caespitosa* at Station 20 was assessed at 1518 and the maximum number of corallites in one colony was 2925. Of the 74 colonies at Station 3, the highest MNC was 251 with the maximum value of 1000 corallites and the maximum mean cover area assessed at 2400 cm^2, and the total number of corallites reaching 6900. The highest biomass value was 5.48 g at Station 20.

Of the 14 stations, the maximum MNC of *P. muellerae* was calculated as 228 in 37 colonies at Station 45, with the largest number of 1600 individuals. The mean cover value was 7540 cm^2 at the same stations and the range number reached here the highest value of about 15 m^2. The highest mean value of biomass (4.66 g) was determined at Station 117, with 21 colonies observed. There was only one station with *P. mouchezii*. The cover area of the colony was calculated as 2000 cm^2 and the biomass assessed on the basis of the weight of ten corallites was 17 g. Of the solitary species, the highest MNI of *C. smithii* between two different groups was observed at Station 140, i.e. 96 individuals per square meter with the maximum of 187 and the highest biomass value of 28.53 g at Station 6. The second highest value (131 ind. m^{-2}) was determined at Station 142, where only one corallite group was found. Three different corallite groups of *C. inornata* were determined at depths of 18-31 m at Station 45 with the maximum MNI of 16 per m^2 and the total biomass of 2.61 g calculated per ten corallites.

The largest number of corallites from one group was found at 23 m depth, i.e. 137 individuals (Station 103). The highest MNC among five groups

Table 2

Solitary corals, morphological diameters calculated per station

	TNI	Total Biomass (g)	Length (cm)	Height (cm)
	Mean±SE (Range)			
Caryophyllia smithii				
Station 6*	18 (18)	28.53 (28.53)	0.65±0.15 (0.5-0.8)	1.2±0.2 (1-1.4)
Station 27*	18 (18)	10.42 (10.42)	0.34±0.05 (0.15-0.5)	0.96±0.06 (0.6-1.2)
Station 103*	18 (18)	15.63 (15.63)	0.59±0.03 (0.4-0.9)	0.76±0.05 (0.5-1.2)
Station 140	96±128 (6-187)	18.43±11.78 (10.1-26.76)	1.87±0.11 (1.69-2.1)	1.67±0.19 (1.4-1.8)
Station 141*	31 (31)	24.66 (24.66)	1.74±0.09 (1.59-1.82)	1.56±0.06 (1.5-1.7)
Station 142*	131 (131)	8.24 (8.24)	1.92±0.11 (1.69-2.1)	1.64±0.15 (1.5-1.8)
Caryophyllia inornata				
Station 1*	6 (6)	2.49±0.67 (2.01-2.97)	0.65±0.15 (0.5-0.8)	1.2±0.2 (1-1.4)
Station 45	16±9 (6-25)	2.61±0.57 (1.98-3.09)	0.34±0.05 (0.15-0.5)	0.96±0.06 (0.6-1.2)
Station 103*	137 (137)	2.91 (2.91-2.91)	0.59±0.03 (0.4-0.9)	0.76±0.05 (0.5-1.2)
Station 117*	6 (6)	1.88 (1.88-1.88)	0.6 (0.6-0.6)	0.9 (0.9-0.9)
Paracyathus pulchellus				
Station 1*	18 (8)	8.8 (8.8)	0.6±0.06 (0.6-0.8)	1.1±0.5 (1-1.2)
Station 2*	12 (12)	8.21 (8-21)	0.6±0.1 (0.5-0.7)	1.05±0.05 (1.-1.1)
Station 45	8±5 (6-18)	9.15±0.88 (7.89-10.11)	0.87±0.14 (0.5-1.2)	1.4±0.15 (1-1.7)
Station 51*	6 (6)	9.13±1.52 (8.05-10.2)	1.05±0.05 (1-1.1)	1.45±0.05 (1.4-1.5)
Station 52*	6 (6)	9 (6)	1.8 (1.8)	1.5 (1.5)
Station 56*	12 (12)	8.77 (6)	0.9±0.3 (0.6-1.2)	1.35±0.35 (1-1.7)
Station 103*	18 (18)	6 (6)	0.8±0.1 (0.7-1)	1.2±0.15 (1-1.5)
Station 104*	6 (6)	7.55 (7.55)	0.5 (0.5)	1 (1)
Station 108*	6 (6)	6.54 (6.54)	0.7 (0.7)	1.2 (1.2)
Station 117*	6 (6)	11.3 (11.3)	0.7 (0.7)	1.1 (1.1)
Balanophyllia europaea				
Station 1*	12 (12)	29.9 (29.9-29.9)	1.65±0.25 (1.4-1.9)	2.65±0.15 (2.5-2.8)
Station 2*	6 (6)	24 (24-24)	1.4 (1.4-1.4)	2.5 (2.5-2.5)
Station 3*	6 (6)	21.98 (21.98-21.98)	0.6 (0.6-0.6)	1.6 (1.6-1.6)
Station 9*	6 (6)	25 (25-25)	1 (1-1)	2.1 (2.1-2.1)
Station 10*	6 (6)	21.28 (21.28-21.28)	1.9 (1.9-1.9)	3 (3)
Station 11*	12 (12)	13.9 (13.9-13.9)	0.75±0.05 (0.7-0.8)	1.75±0.15 (1.6-1.9)
Station 18*	12 (12)	10.66 (10.66-10.66)	0.75±0.05 (0.7-0.8)	1.35±0.15 (1.2-1.5)
Station 20*	6 (6)	33.95 (33.95)	0.7 (0.7)	1.6 (1.6)
Station 23*	6 (6)	28.3 (28.3)	1.8 (1.8)	2.3 (2.3)
Station 24*	12 (12)	20 (20)	1.4±0.3 (1.1-1.7)	2.5±0.1 (2.4-2.6)
Station 26*	6 (6)	24.41 (24.41)	1.1 (1.1)	1.9 (1.9)
Station 27	122±116 (6-237)	32.97±4.53 (28.44-37.5)	1.32±0.07 (0.5-2.4)	2.54±0.1 (1.2-3.9)
Station 30*	12 (12)	12.65 (12.65)	0.7±0.1 (0.6-0.8)	1.3±0.1 (1.2-1.4)
Station 35*	12 (12)	14.2 (14.2)	1.15±0.05 (1.1-1.2)	2.2±0.3 (1.9-2.5)
Station 38*	18 (18)	12.47 (12.47)	1.4±0.11 (1.2-1.6)	2.43±0.32 (1.8-2.9)
Station 39*	18 (18)	11.98 (11.98)	1.73±0.12 (1.5-1.9)	2.5±0.2 (2.2-2.9)
Station 40*	18 (18)	10.1 (10.1)	1.36±0.03 (1.3-1.4)	2.36±0.06 (2.3-2.5)
Station 41*	6 (6)	15.45 (15.45)	1.1 (1.1)	1.8 (1.8)
Station 42*	6 (6)	15 (15)	1.3 (1.3)	1.9 (1.9)
Station 43*	6 (6)	14.64 (14.64)	0.8 (0.8)	1.9 (1.9)
Station 44*	6 (6)	12.08 (12.08)	1.3 (1.3)	2.2 (1.9)
Station 103*	6 (6)	42 (42)	1.6 (1.6)	2.5 (2.5)
Station 117*	6 (6)	16.76 (16.76)	2.3 (2.3)	2.2 (2.2)
Station 119*	6 (6)	11.4 (11.4)	1.1 (1.1)	2 (2)
Leptopsammia pruvoti				
Station 1	87±6 (81-93)	7.79±0.63 (7.16-8.42)	1.57±0.04 (1.2-1.5)	1.09±0.02 (0.8-1.4)
Station 2	49±12 (37-62)	4.21±0.1 (4.11-4.32)	1.59±0.06 (1.2-1.5)	1.08±0.03 (0.8-1.4)
Station 21*	6 (6)	4.19 (4.19-4.19)	1.5 (1.5)	1.1 (1.1)
Station 45	124±56 (68-181)	11.67±3.03 (6.64-14.7)	1.41±0.02 (1.1-1.4)	2.41±0.12 (1.5-3.9)
Station 51*	6 (6)	11.18 (11.18)	1.5 (1.5)	1.1 (1.1)
Station 52*	6 (6)	12.43 (12.43)	1.3 (1.3)	1.5 (1.5)
Station 56*	6 (6)	9.86 (9.86)	1.5 (1.5)	3 (3-3)
Station 104*	6 (6)	8.89 (8.89)	1.4 (1.5)	1.4 (1.4)
Station 108*	6 (6)	18.85 (18.85)	1.4 (1.4)	3.1 (3.1)
Station 109*	6 (6)	12.71 (12.71)	1.5 (1.5)	1.1 (1.1)
Station 110*	6 (6)	10.65 (10.65)	1.4 (1.4)	1.8 (1.8)
Station 117*	50 (50)	12.5 (12.5)	1.22±0.1 (1-1.5)	1.66±0.13 (1.3-2)
Station 140*	850 (850)	4.22 (4.22)	0.48±0.02 (0.4-0.6)	0.67±0.03 (0.5-0.9)

TNI: The total mean Number of Individuals per square meter (decimals integrated). *Since only one coral individual or group was found at the station, these values were excluded from the calculations of means. Mean dimensions were calculated according to the total value of 10 corallites per station. (Length: the maximum axis of the oral disc; Width: the minimum axis of the oral disc) of *P. pulchellus* was eight individuals with the maximum number of 18 and the total mean value of biomass reaching 9.15 g. The MNI at the above-mentioned station for *B. europaea* was 122. *L. pruvoti* was sampled from twenty different areas at Station 45 and the highest MNI reached 181 per m^2. Although there was only one occurrence area of *L. pruvoti* at station 140, it reached its peak level of 850 individuals per m^2.

The abundance of the rocky substrate and its cover area were calculated in the assessment of the coral cover.

Since the distributional area of corals is small, only stations with a dense cover of colonial corals were included in the calculations. *P. muellerae* occurred with the highest cover of 27.89 m^2 at Station 45. *C. caespitosa* was characterized by the second largest spread and covered an area of 18.11 m^2 (Table 3). In total, 18 colonies of *C. caespitosa* were observed at Station 1 and the highest percentage of rock-substrate cover was determined as 100% at four different rocks (Table 4). The percentage cover of *P. mouchezii* at Station 2 – the only station with the species' occurrence – was 33.3%. *M. pharensis* was sampled as four different colonies at two stations.

The scleractinian communities (Fig. 18) in the Dardanelles form mainly separate colonies, bank-type structures and solitary assemblages. Despite the strait's characteristics which mostly reflect the combined characteristics of the waters in the Mediterranean Sea, the Black Sea and the Sea of Marmara, the species adapted to the specific conditions that occur in the range of habitats associated with rocky overhangs, ceilings, coralligenous, calcareous bio-concretions, sponge-dominated localities and seaweed roots, some of

Table 3

Coral cover determined in terms of the rocky substrate range at the stations with the highest species abundance

station/tars (m^2)	species/cover area (m^2)			
	M. pharensis	*C. caespitosa*	*P. muellerae*	*P. mouchezii*
Sta 1 – 800	0.63	1.14	1.58	-
Sta 2 – 410	-	0.15	0.22	0.2
Sta 3 – 350	-	18.11	-	-
Sta 20 – 200	-	0.24	-	-
Sta 45 – 1120	0.48	-	27.89	-
Sta 108 – 208	-	-	0.19	-
Sta 117 – 110	-	-	1.07	-

TARS: Total Spreading Area of Rocky Substrate at a given station; Cover area: total cover area of the species at a station

Table 4

Rock-based percent cover of *P. muellerae* at Station 45, *C. caespitosa* at Station 1, *P. mouchezii* at Station 2 and *M. pharensis* at Stations 1 and 45

Colony's number	Cover Area (m^2)	Surface Area of Rock (m^2)	Percent Cover on Rock (%)
P. muellerae			
p1	0.009	0.33	2.72
p2	0.036	0.42	8.57
p3	0.09	0.33	27.27
p4	0.03	0.19	15.7
p5	0.039	0.18	21.6
p6	0.032	1.01	3.16
p7	0.03	0.3	10
p8	0.15	0.68	22.05
p9	0.036	0.33	10.9
p10	4.8	7.6	63.15
p11	2.2	2.76	79.71
p12	1.1	3	36.6
p13	15.1	20	75.5
p14	0.08	1.15	6.95
p15	0.12	0.15	80
p16	0.02	0.18	11.1
p17	0.03	1.26	2.38
p18	0.34	1.25	27.2
p19	0.14	1.54	9.09
p20	0.17	0.25	68
p21	0.1	0.5	20
p22	0.14	0.25	56
p23	0.09	0.3	30
p24	0.05	1.33	3.75
p25	0.14	0.87	16.09
p26	0.2	1.2	16.6
p27	0.13	1.4	9.28
p28	0.28	1.11	25.22
p29	0.12	2.52	4.76
p30	0.08	0.6	13.3
p31	0.29	2.43	11.93
p32	0.3	1.5	20
p33	0.08	0.9	8.8
p34	0.3	1.14	26.31
p35	0.6	3.36	17.85
p36	0.35	0.48	72.91
p37	0.09	0.8	11.25
C. caespitosa			
c1	0.057	0.095	60
c2	0.027	0.09	30
c3	0.048	0.096	50
c4	0.056	0.08	70
c5	0.026	0.34	7.64
c6	0.2	0.2	100
c7	0.07	0.093	75.26
c8	0.023	0.04	57.5
c9	0.029	0.029	100
c10	0.018	0.02	90
c11	0.075	0.075	100
c12	0.022	0.028	78.57
c13	0.033	0.88	3.75
c14	0.008	0.06	13.3
c15	0.036	0.072	50
c16	0.18	0.39	46.15
c17	0.21	0.21	100
c18	0.022	0.16	13.75
P. mouchezii			
pm1	0.2	0.6	33.3
M. pharensis			
m1	0.23	2.08	11.05
m2	0.34	0.64	53.12
m3	0.19	1.12	16.96
m4	0.27	1.88	14.36

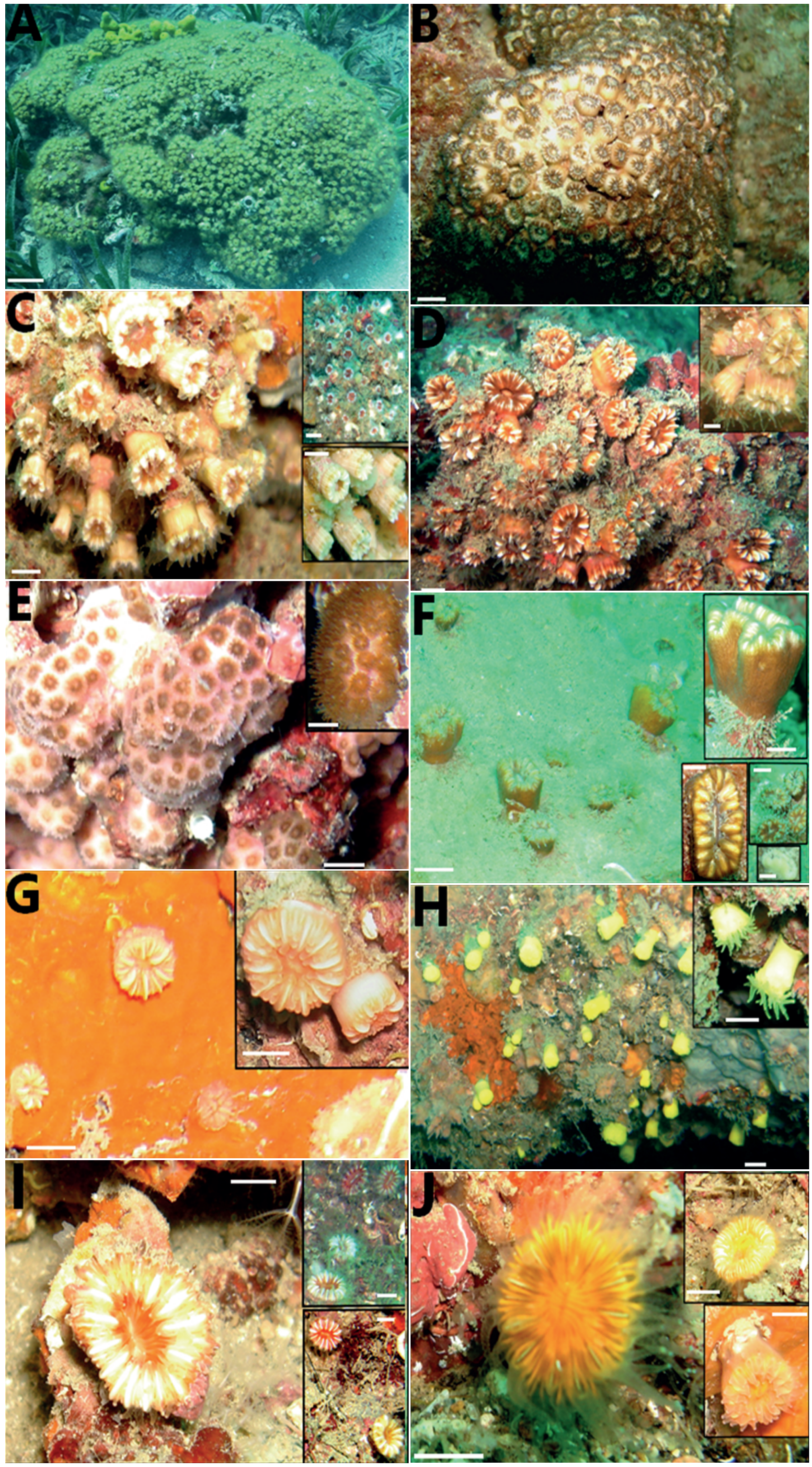

Figure 18

A. *Cladocora caespitosa* colony on the sandy substrate around the Posidonia beds at 7 m depth (Scale bar: 5 cm); B. *Cladocora caespitosa* colony on the rocky substrate at 19 m depth; C. *Polycyathus muellerae* colonies at 34 m depth; D. *Phyllangia mouchezii* colony on the rocky overhang at 19 m depth; E. *Madracis pharensis* colonies strongly associated with the coralligenous outcrops on the rock ceiling at 25 m depth; F. *Balanophyllia europaea* corallites on a stony substrate between 2 and 23 m depth; G. *Caryophyllia inornata* corallites associated with the calcareous sponges on the rock ceiling at 21 m depth; H. *Leptopsammia pruvoti* corallites on the rocky overhang at 36 m depth; I. *Caryophyllia smithii* corallites on the rocky substrate between 6 and 29 m depth; J. *Paracyathus pulchellus* corallites on the rocky substrate at 24 m depth. (Scale bar for all figures except figure A: 1 cm) which are widely distributed around the shaded parts of hard substrates and amidst the beds of *Posidonia oceanica*. Their constructional potential is significantly higher at some sites (Özalp & Alparslan 2011).

Additionally, the fact that the Mediterranean-originated colonial corals and several solitary individuals were discovered in the Marmara Sea draws attention with respect to the species' distributional behavior. The species extend their distributional limits in the Aegean Sea (Çınar et al. 2014) to the northern part of the Marmara Sea. Although there were no reports regarding the scleractinians in the Dardanelles and the surrounding seas, the investigations showed that the coral colonies and solitary species in the strait have older facies, well-developed on the rocky substrate and thus occurring for years, especially around the calcareous bioherms. In terms of ecosystem differences, many well-structured and complex hard coral assemblages can be observed in other strait habitats worldwide (Loya 2004; Cairns 2004; Álvarez-Pérez et al. 2005; Riegl et al. 2012). Some coral surveys were successfully carried out for nearly 35 years in the Red Sea, in the Strait of Bap el Mandeb and around their coastal waters aiming at species' sustainability (Rosenberg & Loya 2004). In other studies concerning the same issue, the water characteristics and light were regarded as the most important factors for the distribution of scleractinians in the strait of Gibraltar (Álvarez-Pérez et al. 2005).

It has been found, in a detailed manner, that the Dardanelles is strongly influenced by saline waters after nearly 12 m and salinity continues to increase with depth to deep levels (lower layer flow) with an average value of 38.67 PSU (Beşiktepe 2003, Baba et al. 2007, Artüz 2013). According to recent studies, the wide distribution of *Posidonia oceanica* and *Zostera marina* meadows as well as other Mediterranean-originated invertebrate species such as sponges, crustaceans, soft corals, gorgonians, coralligenous, etc. is completely dependent on saline waters at depth levels of the strait (Topaloğlu 1999; Kubanç et al. 2009; Palaz & Çolakoğlu 2009). Our study has also revealed that the great majority of colonial and solitary species live densely below 12 m depth, where there is an interface limit for higher salinity levels. The range of salinity in the whole area of the strait varied between 20 and 38.2 PSU at depths of 5-40 m. The upper limit of *C. caespitosa* colonies occurred at a depth of 2 m, while *B. europaea*'s individuals were observed below 1 m. Additionally, the largest patchy communities of *C. caespitosa* in the strait (Özalp & Alparslan 2011) were found at the Dardanos station at the depths of 4-6 m. The fact that the two corals are zooxanthellates may be considered as another important factor in their propagation at shallower depths.

C. caespitosa has been known to occur mainly above 40 m depth (Zibrowius 1980; Hofrichter 2003). In our study, the lower limit was 24 m. In terms of the total number of colonies and coral cover, *P. muellerae* represented the second largest colony area in the Dardanelles (104 colonies) and the presence of the species in the Marmara Sea was found to be remarkable when considering the nature of its occurrence in the Mediterranean Sea. Previously, Álvarez-Pérez et al. (2005) reported the species between 13 and 65 m depth from the Gibraltar Strait. The authors also mentioned in their study that the nutrient supply, the substrate type and the sedimentation rate were the most efficient factors in the coral distribution. They also pointed out the necessity of the current regime in the area. *C. caespitosa*, *C. inornata* and *P. pulchellus* were yet another corals reported during the same study (as deep water records) from the depths of 13-443 m. As indicated by Bo et al. (2009), the organic matter and running currents had positive effects on the coral abundance.

In comparison, there was an extensive distribution of scleractinians in the Dardanelles, mainly below 15 m depth due to physical conditions similar to those discussed above. Morri et al. (2000) recorded *M. pharensis* in Milos Island as commonly spread around the volcanic rock walls, overhangs and vent sites between 8 and 44 m with the cover rate of 30%. It was also sampled from deep depths (50-150 m) of the Bahamas, Colombian and Venezuelan coasts (Reed 1985; Reyes 2000; Frade et al. 2010) and reported from some cave habitats in the Canary Islands and in the eastern Mediterranean (Gerovasileiou et al. 2015). Recent studies have shown that it is the most climate-change affected coral species, suffering from bleaching and tissue necrosis (Kružić and Rodić 2014). The species forms a well-developed structure at certain depth levels of the strait with the lower limit of 20 m and the highest rock-substrate cover of 53.12% at Station 1.

Since the new communities of coral species discovered after 2014 were excluded from the statistical analysis, they were represented by only one station (Station 2). Colonies of species from the deep waters of the Adriatic Sea were also reported by Kružić (2002). When comparing the habitat characteristics, it was also revealed that *P. mouchezii* preferred to live on peak points or far edges of rocks which were located toward open water and were under the influence of a constant stream, while other corals usually inhabited the crevices, lit/dimly-lit points and ceilings, walls and overhangs.

C. caespitosa is the only scleractinian coral forming broad banks up to 40 m in the Mediterranean Sea (Kružić & Požar-Domac 2003; Peirano et al. 2009; Kersting 2013), while the others form disperse colonies, communities of varying size and patchy beds. In the national park of Mljet Island (Veliko jezero) in the Adriatic Sea, the colonies show a fused-shaped growth with the cover area of 650 m^2 and this bioherm is recognized as a special location because of its development type (linkage distance). According to the above-mentioned authors, the currents, as a result of tidal exchange and nutrient-rich supplies, were the main factors in the progressive expansion of colonies in the area (Kružić & Benković 2008). Kersting & Linares (2012) reported that the total cover area of *C. caespitosa* was 2900 m^2 in the bay of Illa Grossa and the highest abundance was found at depths ranging from 10 to 20 m. The mean colony length was calculated as 31.48±21.02 cm (±SD). The largest buildups of the species, the length of which ranged from 68 to 107 cm (the widest D1 sizes), were examined at the Bozcaada Station (Aegean Sea), specified in the current study as the second pilot area where not separated colonies covered 130 m^2 of the seabed at a depth of 14 m. In the Dardanos region (Station 3), where the highest abundance of the species in the strait is observed, the colonies were distributed at a depth range of 0-5 m. However, the results obtained at the third depth level (11-20 m) resembled, in terms of depth-based expansion, the research carried out in Illa Grossa Bay.

Additionally, it was also found that the mean colony length (D1), measured on the basis of 74 colonies in the Dardanos region, showed a higher value (56.77±1.59 cm). The lower and upper limits, accepted as significantly important for the calcification of *C. caespitosa*, were reported by Kružic & Požar-Domac (2002) from the Adriatic Sea as 11-25°C. Vaniček et al (2000) reported the maximum value of temperature (28°C) from the same region. The same peak value was also measured in the northwestern Mediterranean (Kersting et al. 2013).

In the current study, the temperature varied between 8 and 26°C in the Dardanelles. There was one colony of *C. caespitosa* affected by bleaching at Station 3. It is known that an increase in temperature values can trigger mortality and tissue necrosis in the species (Rodolfo-Metalpa et al. 2005). A number of studies have reported the occurrence of scleractinian species on habitats with dense encrusting algae formations and calcareous bio-concretions (Vafidis et al. 1997; Harrington 2004; Ballesteros 2006). All species, except for *C. caespitosa* and *B. europaea*, studied in the current research were observed to occur in calcareous buildups.

At some locations, corallites of *P. muellerae* and *P. mouchezii* were adversely affected by encrusting algae, so that the calix was almost invisible.

Among the solitary corals, *L. pruvoti* reached its maximum density at the depth range of 41-50 m (850 ind. m^{-2}) due to the high abundance at Station 140 in the Marmara Sea. It is known that the population density in the Mediterranean Sea may reach 17.000 individuals per square meter at depths ranging between 15 and 21 m (Goffredo et al. 2007). Irving (2004) reported the highest abundance of 1200 ind. m^{-2} from British waters. *C. smithii*, which was identified in recent years as *C. cyathus* (synonym) in the Dardanelles by Colombo (1885), represented the second highest abundance in the strait, especially with the distribution of pilot stations in the Marmara Sea (650 ind. m^{-2}). The deepest location in the current study was 44 m, while the species was recorded from 139 m depth in the Mediterranean Sea (McCulloch et al. 2012). This species (*C. smithii*) was the most common species with the frequency rate of 5.51% and it was sampled from 95 stations. The density at Station 140 (186 ind. m^{-2}) was significantly higher and the corallites measured in situ were much larger than those found in the Dardanelles according to the maximum calyx length (21 mm) and the corallite (18 mm) height. In another study carried out in the Irish waters, the highest density value was 87 individuals per square meter with the height of 15.8 mm (Bell & Turner 2000). There was a significant difference in height and the height/calyx length ratio of *C. smithii*, although corallites over 18 mm were very rarely observed in the current study.

Also *L. pruvoti* occurred with a high abundance at Station 140, where lower values of salinity were determined compared to the Dardanelles. We believe that the extensive spreading of both species at this station largely depends on the input of organic matter coming from the Bosphorus and coastal areas of the Marmara Sea. *B. europaea* reached its maximum density at Station 27 in the Dardanelles (237 ind. m^{-2}) and the highest height was 39 mm with the maximum length of 24 mm. The largest total MNI was determined at the depth level of 11-20 m (393 ind. m^{-2}). Interestingly, the maximum species density in the Mediterranean was recorded at depths shallower than 10 m (Goffredo et al. 2004). The highest abundance was determined in the other research by Goffredo & Telo (1998) from the Calafuria region in the Tyrrhenian Sea – 121 individuals per square meter, while Goffredo et al (2004) reported lower abundance at the same station (113 ind. m^{-2}). According to Goffredo et al (2008), the largest corallite measured 25.95 mm in length.

Consequently, the highest calix length in the current study was determined as 24 mm. Comparing the data from the Dardanelles to the other studies presented above, it appears that the species' dimensions are similar despite lower salinity levels in the strait. *C. inornata* occurred in the strait mainly amidst the coralligenous formations and on a ceiling of rocks that are entirely dimly lit. Goffredo et al (2012) reported the highest mean density (6025 ind. m^{-2}) of the species from a wreck habitat in Elba Island and quoted the largest dimension of a corallite as 13.5 mm. There are also several other studies discussing the species' habitats around ceilings and calcareous facies (Ballesteros 2006; Micael et al. 2005). The species was reported from 443 m in the Strait of Gibraltar (Álvarez-Pérez et al. 2005). The highest abundance determined in our measurements was 156 individuals per square meter at depths of 21-30 m and the highest corallite height was 14 mm. No occurrence of the species was observed during our surveys on ship wrecks. A recent study relating the solitary scleractinians to their biological parameters showed that *C. inornata* had a higher tolerance to the artificial substrate and fluctuations of the sea surface temperature compared to *B. europaea* and the biometric parameters of *C. inornata* were found to be significantly correlated with increasing temperature. In the same study, *L. pruvoti* was yet another species identified as highly resistant to temperature ranges (not higher than *C. inornata*) (Caroselli et al. 2015). *P. pulchellus* was least abundant in the strait (56 ind. m^{-2}), similarly to *C. inornata* at the depth level of 21-30 m. Dense individuals were reported at depths of 12-30 m in the Adriatic Sea with the maximum

Table 5

List of scleractinian corals from the Turkish coasts with the updated distributional data

Species	BS	M	AE	MS	D	Habitat	DR
Phylum: Cnidaria							
Class: Anthozoa							
Family: Pocilloporidae							
Madracis pharensis [1]	-	FL1	FL2	-	FL3-PR	H	VII
Family: Faviidae							
Cladocora caespitosa [2]	-	FL4	FL5-PR	-	FL6-PR	H	II
Family: Caryophylliidae							
Caryophyllia smithii [3]	-	FL7	FL7*	FL8-PR	FL10-PR	H	IV
Caryophyllia cyathus [10]	-	-	-	FL23	-	H	70-300 m**
Coenocyathus anthophyllites [11]	-	-	-	FL10	-	H	65-250 m**
Hoplangia durotrix [13]	-	-	FL22	-	-	H	0-150 m**
Caryophyllia inornata [4]	-	FL11	FL12	-	PR	H	IX
Paracyathus pulchellus [5]	-	-	-	FL13	PR	H	VIII
Polycyathus muellerae [6]	-	FL14	FL15	PR	PR	H,S	V
Phyllangia mouchezii [7]	-	FL16	FL17	-	PR	H	III
Desmophyllum dianthus [12]	-	-	-	FL24	-	H	8-2460 m**
Family: Dendrophylliidae							
Alanophyllia europaea [8]	-	FL18	FL19	-	FL19-PR	H,R	I
B. Leptopsammia pruvoti [7]	-	FL21	FL22*	-	PR	H	VI
Dendrophyllia ramea [9]	-	-	-	FL10	-	H	40-150 m**
Oculina patogonica [14]	-	FL25	-	-	-	H	0-10 m**

BS: Black Sea; M: Mediterranean Sea; AE: Aegean Sea; MS: Marmara Sea; D: Dardanelles (Çanakkale Strait); DR: Depth range in the current study; H: hard substrate; S: soft substrate; R: Posidonia oceanica roots; PR: Present research; Authors: [1] Heller, 1868; [2] Linnaeus, 1767; [3] Stokes & Broderip, 1828; [4] Duncan, 1878; [5] Philippi, 1842; [6] Abel, 1959; [7] Lacaze-Duthiers, 1897; [8] Risso, 1826; [9] Linnaeus, 1758; [10] Ellis and Solander, 1786; [11] Milne-Edwards and Haime, 1848; [12] Esper, 1794; [13] Gosse, 1860; [14] De Angelis, 1908; I: 0-23 m; II: 2- 23 m; III: 18-19 m; IV: 12-44 m; V: 15-44 m ; VI : 17-44 m; VII: 20-39 m; VIII: 20-43 m; IX: 25-40 The first and the latest report of scleractinian coral from the Turkish coasts: FL1: Zibrowius 1979; FL2: Forbes 1844/Gökalp 2011; FL3: Özalp and Alparslan 2015; FL4: Öztürk et al. 2004/Öztürk et al. 2013; FL5: Forbes 1844/PR; FL6: Özalp and Alparslan 2011/PR; FL7: Öztürk et al. 2004/Gönülal and Güreşen 2014*; FL8: Öztürk et al. 2004; FL9: Ostroumoff 1896/PR; FL10: Ostroumoff 1896/PR; FL11: Gözcelioğlu 2011; FL12: Zibrowius 1979; FL13: Demir 1952; FL14: Çınar et al. 2015; FL15: Zibrowius 1979a/Gökalp 2011; FL16: Zibrowius 1980**/Bitar and Zibrowius 1997; FL17: Zibrowius 1980/Gökalp 2012; FL18: Gözcelioğlu 2011; FL19: Zibrowius 1979/PS; FL20: Ostroumoff 1896/PR; FL21: Gözcelioğlu 2011; FL22: Gökalp 2011/ Gönülal and Güreşen 2014*; FL23: Colombo 1885; FL24: Taviani et al. 2011; FL25: Çınar et al. 2006.

height of 20 mm (Kruzic 2007). Although, according to IUCN, the distributional limit of the species reaches 500 m (IUCN 2014), it was also recorded at 1260 m on the Colombian coasts (Reyes 2000). It was observed that the species was spreading in the Dardanelles among the calcareous substrates down to 43 m depth (reaching the height of 17 mm).

Despite all the efforts spent on diving surveys and measurements aimed at carrying out the first detailed scleractinian research on the Turkish coasts, we believe that there may be more species to be found attached to dimly-lit cryptic localities of rocky habitats and coralligenous formations at deep waters in the Dardanelles. All species surveyed within the current study (Table 5) were the Mediterranean-originated corals. It is interesting that species (*P. mouchezii*, *P. muellerae*, *L. pruvoti*, *P. pulchellus*) reported in other studies as rare scleractinians (Irving 2004; Fenner et al. 2008; Goffredo et al. 2011) were frequently encountered in the current study, while the species (*Astroides calycularis*, *Hoplangia durotrix*, *Cladopsammia rolandi*) considered common were not observed at the survey stations of this research. Additionally, we could explore only a very limited area of the Marmara Sea as pilot stations during this study, to compare the ecological condition monitored in the strait. But given the recent observations made at deep water levels (Taviani et al. 2011), it can be concluded that there is a pressing need for further advanced research on their ecology and demographic patterns around the whole area and Marmara Islands to obtain a broad knowledge of anthozoans.

Although some of the projects on monitoring and conservation biology were successfully implemented for the strait's communities, the general information about their population dynamics still needs to be increased.

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