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DIVERSITY AND DISTRIBUTION OF CLASS DEMOSPONGIAE (PHYLUM PORIFERA) IN THE BOKA KOTORSKA BAY

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ABSTRACT

Diversity of class Demospongiae in the Boka Kotorska Bay (Montenegro, Adriatic Sea) is presented with 2 subclasses, 25 families and 46 species. Among them six species are Mediterranean endemics and 12 are under protection by national and international legislation. This paper is a compilation of already published literature and recently collected data. The information was collected on 33 locations around the Boka Kotorska Bay. According to the literature 38 species are distributed in the area, while personal data confirm the presence of eight species new for the area. Fauna of Porifera in the Boka Kotorska Bay is still partially known, although new data are constantly acquired and further studies are necessary for better assessing the sponge diversity in this area.

Keywords: diversity, Demospongiae, sponges, Boka Kotorska Bay

INTRODUCTION

According to available data, about 6,100 marine species have been described in the class Demospongiae all around the world, or slightly more than 80% of all marine sponges (Van Soest *et al*., 2019). In the Mediterranean region about 1,400 species have been identified (Pansini & Longo, 2003). Their skeleton is very variable: it can be formed exclusively by spicules or by spongin, it can have both spicules and spongin, and in very rare cases there are neither spicules nor spongin, but the skeleton is a high density mesoglea. The Demospongiae class currently comprises out of three subclasses: Heteroscleromorpha, Keratosa, Verongimorpha, while the former Homoscleromorpha subclass has been separated into a distinct class (Hooper & Van Soest, 2002; WoRMS, 2020).

The first significant data on sponges in the Mediterranean date to the second half of the nineteenth century (Schmidt, 1862, 1864, 1868; Lendenfeld, 1894, 1898). For the Croatian coast of the Adriatic Sea 275 species are reported while for the South Adriatic Sea

182 are noted (Bakran-Petricioli *et al*., 2016). Studying the Italian coast of the South Adriatic Sea Longo *et al*. (2018) described 143 species. In the Greek part of the Mediterranean Sea 193 species of Demospongiae are reported (Voultsiadou *et al*., 2016), while the Western Mediterranean Sea shows a higher diversity, with around 350 species identified (Van Soest *et al*., 2019).

Between the end of the last and the beginning of this century, numerous researches and surveys on benthic communities on the Montenegrin coast were conducted, but a very small number of researches focused exclusively on sponges (Stjepčević & Parenzan, 1980; RAC SPA, 2013; Petović & Marković, 2017; Trainito, 2019). During the research of the distribution of species from the genus *Axinella* along the Montenegrin coast, the presence of three species in the area of the Boka Kotorska Bay was ascertained (Mačić *et al*., 2015). The most comprehensive data on Demospongiae in the Boka Kotorska Bay can be found in Petović & Marković (2017).

Given that information on the diversity and distribution of Demospongiae in the Boka Kotorska Bay is changed and new data are obtained, the aim of this paper is to compile all data published so far as well as the most recent information collected during personal surveys.

MATERIAL AND METHODS

Study area

The Boka Kotorska Bay is a complex unit consisting of three parts that are interconnected by straits. The entrance to the Bay is the area between Cape Oštro and Cape Arza, where Herceg Novi Bay begins. The outer part is connected to the central part of the Bay (Tivat Bay) via the Kumbor Strait. The Strait of the Verige connects the central and inner part of the Bay. The inner part of the bay consists of two parts, the Bays of Kotor and Risan. The coastline of the Bay is about 105.7 km, mostly made up of steep rocky terrain. Steep and rocky terrain extends all the way to the bottom of the Bay, which is flat and covered with sandy or muddy substrate. The Boka Kotorska Bay is the largest bay in the Adriatic, with an area of 87 km^2. The average depth of the entire Bay is 27.6 m, while the greatest depth was measured in the Bay of Kotor (64 m).

Methods

Current research on sponges was conducted in 33 locations in the Boka Kotorska Bay (Figure 1) by SCUBA diving. During the field work, photo documentation was made for the species that could be determined *in situ*, while for the others it was necessary to take a sample for further laboratory analysis. Sample processing was done in the Laboratory for benthos and protection of the sea. The following references were used as a source of literature data in the paper: Karaman & Gamulin-Brida, 1970; Stjepčević & Parenzan, 1980; Gašić *et al*., 1983; Badalamenti *et al*., 2012a; 2012b; RAC SPA, 2013; Petović & Drakulović, 2014; Mačić *et al*., 2015; Petović & Marković, 2017; IBMK-UCG, 2010, 2011, 2012, 2017, 2018, 2019a, 2019b; Petović *et al*., 2019; Trainito 2019.

RESULTS AND DISCUSSION

The analysis of data collected in the field and recently published report (Trainito, 2019) showed the presence of 42 species of Demospongiae that inhabit the area of the Boka Kotorska Bay. These data are supplemented by historical data so that the total number of species is 46 (Table 1) which

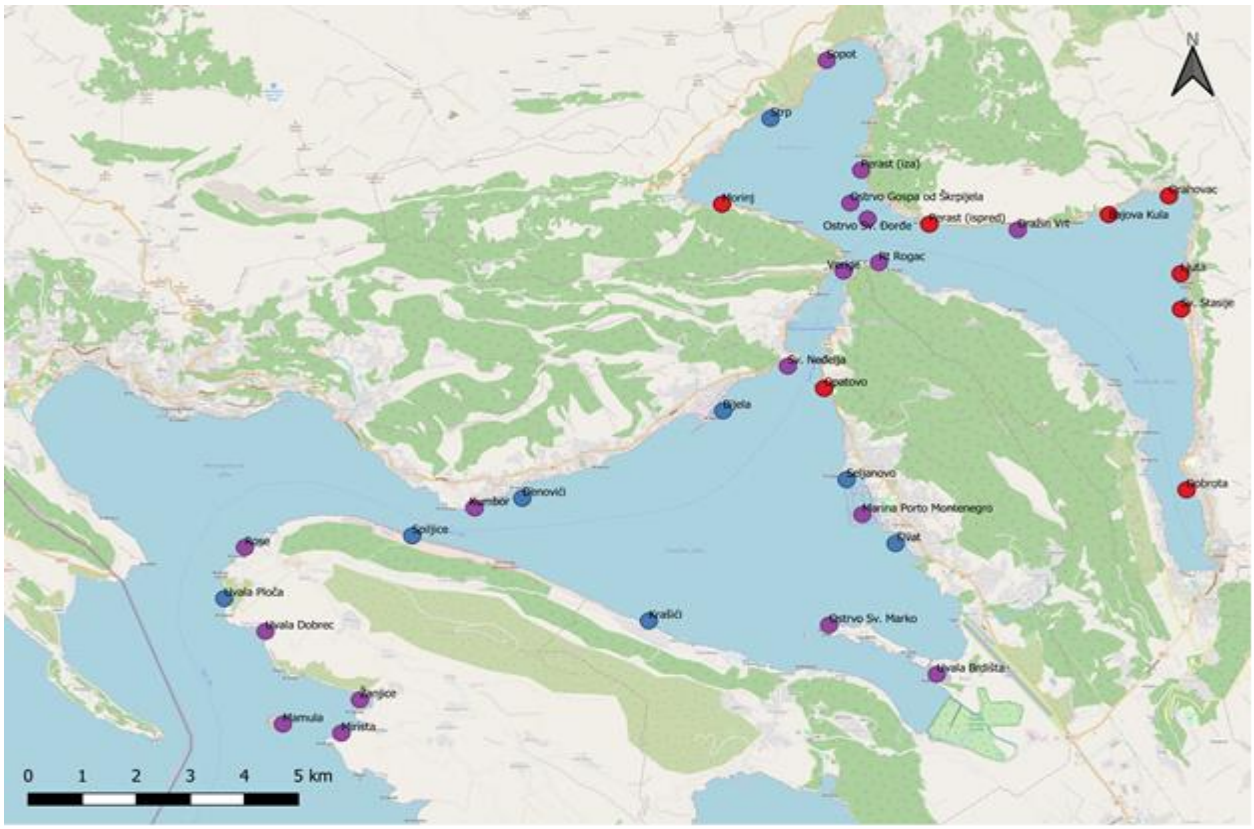

Figure 1. Sampling Locations: Red-personal data, Purple-personal and literature data, Blue-literature data

represents 25.2% of the identified Demospongiae in the Southern Adriatic, or 16.7% in the entire Adriatic (Bakran-Petricioli *et al*, 2016; Van Soest *et al*., 2019). Of the total number of identified species, we can say that the largest number is present in Risan Bay (36 species or 78%), followed by the Bay of Kotor (35 species or 76%), Tivat Bay (24 species or 52%) and Herceg Novi Bay (23 species or 50%).

Among the species present in the study area *Agelas oroides*, *Aplysina cavernicola*, *Axinella cannabina*, *Calyx nicaeensis*, *Cliona rhodensis* and *Crambe crambe* are Mediterranean endemics. According to national legislation, eight species have been identified as protected (*Aplysina aerophoba*, *Aplysina cavernicola*, *Axinella cannabina*, *Axinella damicornis*, *Axinella verrucosa*, *Axinella polypoides*, *Spongia officinalis* and *Tethya aurantium*) (Sl. List SRCG, 76/2006), while ten species (*Aplysina aerophoba*, *Aplysina cavernicola*, *Axinella cannabina*, *Axinella polypoides*, *Geodia cydonium*, *Sarcotragus foetidus*, *Spongia officinalis*, *Tethya aurantium*, *Tethya citrina* and *Tethya meloni*) are protected under the Annex II of the Barcelona Convention (UNEP/MAP-SPA/RAC, 2018).

A. aerophoba has been documented at the highest number of locations within the Boka Kotorska Bay, which is confirming previous studies (Petović & Drakulović, 2014; Petović & Marković, 2017; Petović et al., 2019; IBMK-UCG, 2019a; IBMK-UCG, 2019b). According to the findings we can conclude that this sponge is much more present in the inner part of the Boka Kotorska Bay (Kotor and Risan Bay). *A. cavernicola* has been documented only in the Bay of Kotor and Risan and the Strait of Verige (RAC SPA, 2013; Petović & Marković, 2017; Trainito 2019).

Sponges of the genus Axinella have been

recorded in the entire Boka Kotorska Bay, but the highest concentration of these sponges was found in the Bay of Kotor and Risan (RAC SPA, 2013; Mačić et al., 2015; Petović & Marković, 2017). Recent survey conducted near submerged freshwater spring near Sopot, reports findings of *A. polypoides* for the first time inside the Boka Kotorska Bay (Trainito, 2019).

Species from the genus *Tethya* (*T. aurantium, T. citrina*) have been recorded in the Strait of Verige and its surroundings, as it was indicated in previous surveys (RAC SPA, 2013; Petović & Marković, 2017) while *T. meloni* is for the first time recorded at Risan bay (Trainito, 2019).

Recent study expanded data on distributional area for *S. officinalis* adding new sites (Tivat Bay, Risan Bay and the very entrance to the Boka Kotorska Bay).

Comparing with the latest sponge check list in the Boka Kotorska Bay (Petović & Marković, 2017), eight species were added (*Antho inconstans, Axinella polypoides, Clathria compressa, Cliona rhodensis, Haliclona mediterranea, Myxilla incrustans, Pleraplysilla spinifera* and *Tethya meloni*), while new locations were documented for a large number of species.

During personal research, we were unable to find four species (*Haliclona cratera, Mycale massa, Raspailia viminalis* and *Suberites carnosus*) recorded in previous research (Karaman & Gamulin-Brida, 1970; Stjepčević & Parenzan, 1980; Petović & Marković, 2017). One of the possible explanations is the application of different sampling methods.

Statistical analyses applying Bray-Curtis dissimilarity index show high similarity according to present species between the Kotor Bay and Risan Bay (90%) (Fig. 2).

From the dendrogram we can conclude that the Herceg Novi Bay is the least similar to other parts of the Boka Kotorska Bay. We also assume that due to the environmental factors and the influence of the open sea Herceg Novi Bay is characterized by specific ecological conditions which result with the smallest number of species, but it hosts four species that have not been found in the rest of the Boka Kotorska Bay.

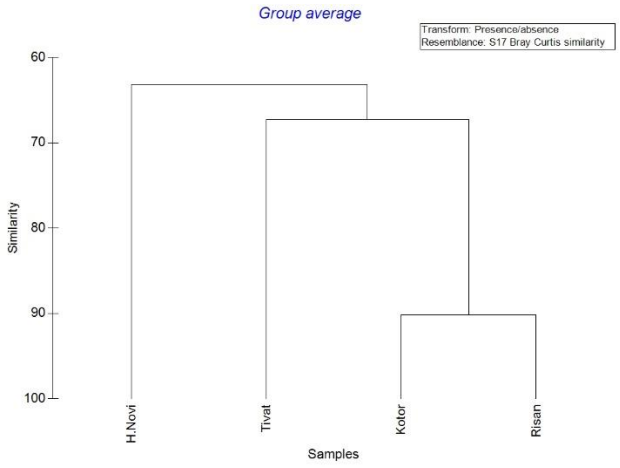

Figure 2. Cluster analysis of 4 bays inside the Boka Kotorska Bay: H.Novi Bay, Tivat Bay, Kotor Bay and Risan Bay.

CONCLUSSIONS

Data presented in the paper were compiled from literature and personal research. The total number of identified species is 46, which represents 25.2% of the total species of class Demospongiae identified in the South Adriatic Sea. Out of them 12 are under protection by international and national legislation while six are identified as Mediterranean endemics.

In comparison to the historical data eight species are new in the area although four species are unconfirmed. The possible reason for that could be different method of sampling. This study confirmed the higher richness of sponge species in the inner bays (Kotor and Risan Bay) comparing to the rest of studied area.

Table 1. List of species belonging to the class Demospongiae in the Boka Kotorska Bay

Taxa	Kotor	Tivat	H.Novi	Risan
Subclass: Heteroscleromorpha				
Family: Agelasidae				
1. *Agelas oroides* (Schmidt, 1864)	X			X
Family: Axinellidae				
2. *Axinella cannabina* (Esper, 1794)	X	X		X
3. *Axinella damicornis* (Esper, 1794)	X	X	X	X
4. *Axinella verrucose* (Esper, 1794)	X	X	X	X
5. *Axinella polypoides* Schmidt, 1862				X
Family: Raspailiidae				
6. *Raspailia (Raspailia) viminalis* Schmidt, 1862	X			X
Family: Dictyonellidae				
7. *Acanthella acuta* Schmidt, 1862	X	X		X
8. *Dictyonella incisa* (Schmidt, 1880)	X			X
Family: Clionaidae				
9. *Cliona celata* Grant, 1826	X	X	X	X
10. *Cliona rhodensis* Rützler & Bromley, 1981			X	
11. *Cliona schmidti* (Ridley, 1881)	X		X	X
12. *Cliona viridis* (Schmidt, 1862)	X	X	X	X
Family: Spirastrellidae				
13. *Spirastrella cunctatrix* Schmidt, 1868	X	X	X	X
Family: Chalinidae				
14. *Haliclona (Reniera) cratera* (Schmidt, 1862)	X			
15. *Haliclona (Halichoclona) fulva* (Topsent, 1893)	X		X	X
16. *Haliclona (Reniera) mediterranea* Griessinger, 1971				X
17. *Haliclona (Soestella) mucosa* (Griessinger, 1971)	X			X
Family: Petrosiidae				
18. *Petrosia (Petrosia) ficiformis* (Poiret, 1789)	X	X	X	X
Family: Phloeodictyidae				
19. *Calyx nicaeensis* (Risso, 1827)		X		
Family: Merliidae				
20. *Merlia normani* Kirkpatrick, 1908		X		
Family: Crambeidae				
21. *Crambe crambe* (Schmidt, 1862)	X			X
Family: Microcionidae				
22. *Antho (Antho) inconstans* (Topsent, 1925)			X	
23. *Clathria (Clathria) compressa* Schmidt, 1862			X	
Family: Myxillidae				
24. *Myxilla (Myxilla) incrustans* (Johnston, 1842)			X	
Family: Hymedesmiidae				

25. *Phorbas tenacior* (Topsent, 1925)	X	X	X	X
Family: Mycalidae				
26. *Mycale (Mycale) massa* (Schmidt, 1862)	X			X
Family: Suberitidae				
27. *Suberites carnosus* (Johnston, 1842)				X
28. *Suberites domuncula* (Olivi, 1792)	X	X		X
Family: Tethyidae				
29. *Tethya aurantium* (Pallas, 1766)	X	X		
30. *Tethya citrina* Sarà & Melone, 1965	X	X		
31. *Tethya meloni* Corriero, Gadaleta & Bavestrello, 2015	X			X
32. *Geodia cydonium* (Linnaeus, 1767)	X	X		X
Subclass: Keratosa				
Family: Dysideidae				
33. *Dysidea avara* (Schmidt, 1862)	X	X	X	X
34. *Dysidea fragilis* (Montagu, 1814)	X	X	X	X
35. *Pleraplysilla spinifera* (Schulze, 1879)				X
Family: Irciniidae				
36. *Ircinia oros* (Schmidt, 1864)	X		X	X
37. *Ircinia variabilis* (Schmidt, 1862)	X		X	X
38. *Sarcotragus foetidus* Schmidt, 1862		X		
39. *Sarcotragus spinosulus* Schmidt, 1862	X	X	X	X
Family: Spongiidae				
40. *Spongia (Spongia) officinalis* Linnaeus, 1759	X	X	X	X
Family: Thorectidae				
41. *Scalarispongia scalaris* (Schmidt, 1862)	X	X	X	X
Subclass: Verongimorpha				
Family: Chondrillidae				
42. *Chondrilla nucula* Schmidt, 1862	X	X	X	X
Family: Chondrosiidae				
43. *Chondrosia reniformis* Nardo, 1847	X		X	X
Family: Aplysinidae				
44. *Aplysina aerophoba* (Nardo, 1833)	X	X	X	X
45. *Aplysina cavernicola* (Vacelet, 1959)	X	X		X
Family: Ianthellidae				
46. *Hexadella racovitzai* Topsent, 1896	X			X

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RAZNORVRSNOST I RASPROSTRANJENOST KLASE DEMOSPONGIAE (FILUM PORIFERA) U BOKOKOTORSKOM ZALIVU

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SAŽETAK

Raznovrsnost klase Demospongie u Bokokotorskom zalivu (Crna Gora, Jadransko More) predstavljena je sa 2 podklase, 25 porodica i 46 vrsta. Među njima je šest vrsta mediteranskih endema, a 12 je pod zaštitom nacionanog i međunarodnog zakonodavstva. Ovaj rad predstavlja kompilaciju već objavljenih podataka iz literature i novo prikupljenih podataka. Podaci su prikupljeni na 33 lokacije širom Bokokotorskog zaliva. Prema litaraturi, 40 vrsta je rasprostranjeno na tom području, dok lični podaci potvrđuju prisustvo šest novih vrsta na tom području. Fauna Porifera u Bokokotorskom zalivu i dalje je nedovoljno istražena, mada se konstantno prikupljaju novi podaci i neophodne su dalje studije za bolju procjenu raznolikosti sunđera na ovom području.

Ključne riječi: raznovrsnost, Demospongiae, sunđeri, Bokokotorski zaliv