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MACROINVERTEBRATES ASSOCIATED WITH THE BLACK SPONGE *Sarcotragus foetidus* SCHMIDT, 1862 (PORIFERA: DEMOSPONGIAE) IN ISKENDERUN BAY, WITH SPECIAL EMPHASIS ON ALIEN SPECIES

ABSTRACT

The macroinvertebrate fauna associated with the sponge *Sarcotragus foetidus* Schmidt, 1862 was determined in the present study. The study was carried out at five different stations (1-2m) chosen in Iskenderun Bay in July 8-15, 2016 and samples were obtained in three different stations. As a result of the present study, a total of 424 specimens belonging to 38 species of seven systematic groups were identified. Among the species determined, *Synalpheus gambaroloides* (Nardo, 1847) was the most dominant species representative with dominance value of 32.31%, followed by *Brachidontes pharaonis* (P. Fischer, 1870) with of 11.32% and other species with a value of 56.37%. *Ostrea* sp. is firstly reported in association with the sponge species. Two alien species [*Alpheus rapacida* de Man, 1908 and *B. pharaonis*] were detected and *B. pharaonis* was one of the continuous species with the highest frequency value.

Keywords: Sponge, *Sarcotragus foetidus*, Alien Species, Macroinvertebrates, Iskenderun Bay

1. INTRODUCTION

Sponges are represented by approximately 7,000 species worldwide [1]. According to the World Porifera Database, the Mediterranean sponge fauna is composed of 780 species [2 and 3]. This comprehensive list encompasses a total of 183 species of porifera. These species are distributed across 52 families, 16 orders and 3 classes within the Turkish seas [2]. Up to date, eight species of the genus *Sarcotragus* have been described worldwide [4]. A wide variety of organisms are known to live in association with sponges. Within the Turkish seas, two species of the genus *Sarcotragus* (*Sarcotragus spinosulus* Schmidt, 1862 and *Sarcotragus foetidus* Schmidt, 1862) are distributed along the Aegean, the Sea of Marmara and Mediterranean coasts [2]. These sponges have been demonstrated to provide shelter and sustenance for numerous organisms [5]. The benefits provided by sponges to their close associates include protection from predators by providing shelter e.g. juvenile spiny lobsters, small crustaceans, ophiuroids, scyphozoans, zoanthids) and food [6]. Consequently, numerous organisms, including polychaetes, nematodes and crustacea species (shrimps and crabs) in habit sponge channels [7]. Sponges in their capacity known as hosts for a multitude of organisms, establish epi-or endobiotic relationships with these species [8]. The composition of the fauna

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associated with sponges can be influenced by environmental factors, such as habitat type and depth [9]. The predominant endofauna categories within sponges comprise polychaetes, amphipods, decapods, and mollusks, which inhabit either the channel systems as endobionts or the sponge surface as epibionts [5, 9, 10, 11, 12, 13, 14, 15 and 16]. To date, however, only a limited number of faunal studies have been conducted on the *S. foetidus* sponge [10, 13, 14, 15, 16 and 17]. Single study on the sponge *S. foetidus* and its macroinvertebrates is presented here. The aim of this study is to determine the macroinvertebrate fauna associated with *S. foetidus* in Iskenderun Bay and the species diversity and alien species in this fauna. It is expected that the data obtained from this study will contribute to bio-ecological studies on the macroinvertebrate fauna and diversity of the region and will assist scientists working on this topic.

2. RESEARCH SIGNIFICANCE

In this study, the macrozoobenthic invertebrate fauna associated with the black sponge *S. foetidus* in Iskenderun Bay was revealed.

Highlights:

- The study investigated in detail the relationships between the black sponge *S. foetidus* and associated macrozoobenthic invertebrate species.
- This paper shows the status of alien species associated with the black sponge *S. foetidus*.
- This study underscores the potential ecological significance of sponges in the marine environment.

3. MATERIALS AND METHODS

The Iskenderun Bay, situated in the north-eastern region of the Levantine Basin within the Mediterranean Sea, has measures approximately 65km long, 35km in width, and encompasses an area of about 2275km² [18] (Figure 1).



Figure 1. Map of the study showing the sampling points (Station where the sponge sample was found: Star; Station where no sponge sample was found: Rectangle)



Despite the average depth in the bay being 70m, and the amount of light and nutrients in the entire water column being 2-4 times higher than in the offshore, there is neither a significant oxygen depletion with depth nor a significant eutrophication due to the dynamic structure of the bay [19]. The bay predominantly covered with waves, and the presence of sand and rocks is evident in the Arsuz region, with vegetated and muddy areas in the Dört Yol region, and rocks in Yumurtalık and Karataş regions. Despite the fact that only one river (Ceyhan) flows into Iskenderun Bay, it is influenced by the Seyhan River west of Karataş and the Orontes (Asi) River south of Samandağ [20]. In order to determine the macroinvertebrate species associated with the sponge *S. foetidus* in Iskenderun Bay, samplings were carried out at 5 different locations representing Iskenderun Bay. between 08-15 July 2016 by a SCUBA diver in 3 replicates. The scanning area was 100mX100m. After collecting, all samples were placed in 3 litre bags and 5 litre plastic drums and fixed in 4% formaldehyde.

Samples of *S. foetidus* brought to the laboratory was placed in a tub and placed in a bucket filled with water. The volume of the sponge was measured using a burette. Samples were washed with pressurised fresh water through a 0.5mm mesh sieve. The organisms were then separated according to their systematic groups by breaking them out of their pores using a falcata in a flask. The remaining sample was examined under a binocular stereomicroscope, and the organisms were separated into the systematic groups to which they belonged and placed in tubes containing 70% alcohol. After the organisms were identified to genus and species level, they were placed in 2ml plastic bottles in alcohol and preserved.

All individuals were examined using a binocular stereo microscope based on works of [21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, and 33].

The data were statistically evaluated. The frequency index of Soyer [34] was used to determine the frequency of association of the detected species with *S. foetidus*. In this index, formulated as $F = m/M \times 100$, 'm' is the number of occurrences of a species in the samples, and 'M' is the total number of samples. As a result of this process, if the F value is $F > 49$, the species is considered as 'abundant', if $25 \leq F \leq 49$, it is considered 'common', if $F < 25$, it is considered as 'rare'. The dominance formula of Bellan-Santini [35] ($D = m/M \times 100$) was used to determine the dominance of species. In this procedure, m represents the total number of individuals of a species obtained in the sampling, and M represents the number of individuals of all species detected in the sampling.

4. RESULTS AND DISCUSSION

A total of 38 species belonging to 7 taxonomic groups (Cnidaria 2, Platyhelminthes 1, Spinculida 3, Polychaeta 4, Crustacea 20, Mollusca 6, and Echinodermata 2) and a total of 424 individuals were counted (Table 1). A comparison of the macrozoobenthic groups identified by sponge sampling reveals that 20 species (52.6%) out of 38 species represent the Crustacea group, followed by Mollusca with 6 species (15.8%) and Polychaeta with 4 species (10.5%). The remaining systematic groups are represented by the following numbers of species: Spincula (3); Cnidaria and Echinodermata (2); and Platyhelminthes (1). (See Table 1.) A comparison of the zoobenthic groups in terms of the number of individuals reveals that the Crustacea is in first place with a total of 222 individuals (52.4%). This is followed by Polychaeta with 80 (18.4%) individuals and Mollusca with 69 (16.3%) individuals. The remaining groups, namely Echinodermata (7.1%),



Cnidaria (2.6%), Sipuncula (2.1%) and Platyhelminthes (0.7%), are represented by smaller numbers of individuals (Table 1).

Table 1. Distribution of macrozoobenthic species at the sampling stations (Σ: Individual Number; F: Frequency; D: Dominance)

MACROINVERTEBRATE SPECIES	Station / Depth (m)			Σ	F	D
	I (1)	II (2)	III (1,5)			
CNIDARIA						
<i>Actinia cari</i> Delle Chiaje, 1825	3	-	-	3	33.33	0.71
<i>Anthozoa</i> sp	-	8	-	8	33.33	1.89
PLATYHELMINTHES						
<i>Turbellaria</i> sp.	1	-	2	3	66.67	0.71
SIPUNCULA						
<i>Aspidosiphon muelleri</i> Diesing, 1851	1	-	3	4	66.67	0.94
<i>Phascolosoma stephensoni</i> (Stephen, 1942)	2	1	-	3	66.67	0.71
<i>Phascolion</i> sp.	2	-	-	2	33.33	0.47
POLYCHAETA						
<i>Ceratonereis costae</i> (Grube, 1840)	14	10	11	35	100	8.25
<i>Nereis zonata</i> Malmgren, 1867	7	4	6	17	100	4.01
<i>Harmothoe spinifera</i> (Ehlers, 1864)	6	-	9	15	66.67	3.54
<i>Serpula vermicularis</i> Linnaeus, 1767	5	8	-	13	66.67	3.07
CRUSTACEA						
<i>Apseudes</i> sp.	5	1	-	6	66.67	1.42
<i>Dynamene</i> sp.	-	3	-	3	33.33	0.71
<i>Chondrochelia savignyi</i> (Krøyer, 1842)	7	2	6	15	100	3.54
<i>Idotea balthica</i> (Pallas, 1772)	1	-	2	3	66.67	0.71
<i>Amphithoe ramondi</i> Audouin, 1826	5	2	-	7	66.67	1.65
<i>Leucothoe spinicarpa</i> (Abildgaard, 1789)	3	1	1	5	100	1.18
<i>Liljeborgia dellavallei</i> Stebbing, 1906	1	-	-	1	33.33	0.24
<i>Maera</i> sp.	2	3	-	5	66.67	1.18
<i>Alpheus dentipes</i> Guerin, 1832	2	1	1	4	100	0.94
<i>Alpheus rapacida</i> de Man, 1908	1	-	-	1	33.33	0.24
<i>Cestopagurus timidus</i> (Roux, 1830)	-	3	-	3	33.33	0.71
<i>Pisidia bluteli</i> (Risso, 1816)	1	2	1	4	100	0.94
<i>Porcellana platycheles</i> (Pennant, 1777)	1	-	1	2	66.67	0.47
<i>Acanthonyx lunulatus</i> (Risso, 1816)	1	-	2	3	66.67	0.71
<i>Pachygrapsus marmoratus</i> (Fabricus, 1787)	2	-	4	6	66.67	1.42
<i>Pilumnus hirtellus</i> (Linnaeus, 1761)	3	4	1	8	100	1.89
<i>Athanas nitescens</i> (Leach, 1814)	4	-	2	6	66.67	1.42
<i>Synalpheus gambarellloides</i> (Nardo, 1847)	32	44	61	137	100	32.31
<i>Calcinus tubularis</i> (Linnaeus, 1767)	1	1	-	2	66.67	0.47
<i>Galathea intermedia</i> Liljeborg, 1851	-	-	1	1	33.33	0.24
MOLLUSCA						
<i>Brachidontes pharaonis</i> (Fischer, 1870)	29	8	11	48	100	10.32
<i>Modiolarca subpicta</i> (Cantraine, 1835)	1	-	-	1	33.33	0.24
<i>Musculus costulatus</i> (Risso, 1826)	3	-	5	8	66.67	1.89
<i>Callochiton septemvalvis</i> (Montagu, 1803)	2	6	-	8	66.67	1.89
<i>Chiton olivaceus</i> Spengler, 1797	1	-	-	1	33.33	0.24
<i>Ostrea</i> sp	1	1	1	3	100	0.71
ECHINODERMATA						
<i>Ophiothrix fragilis</i> (Abildgaard in O.F. Müller, 1789)	13	8	2	23	100	5.42
<i>Amphiura chiajei</i> Forbes, 1843	2	-	5	7	66.67	1.65
	165	121	138	424	-	100
Species Number	38	22	23			
Individuals Number	165	121	138			

The distribution of species detected at 3 stations as a result of sampling at 5 selected stations in the study area was analysed. It was found that Station 1 had the highest number of species (36 species; 94.7%). This was followed by station 3 with 23 species (57.9%) and Station 2 with 22 species (60.5%) (Figure 2).

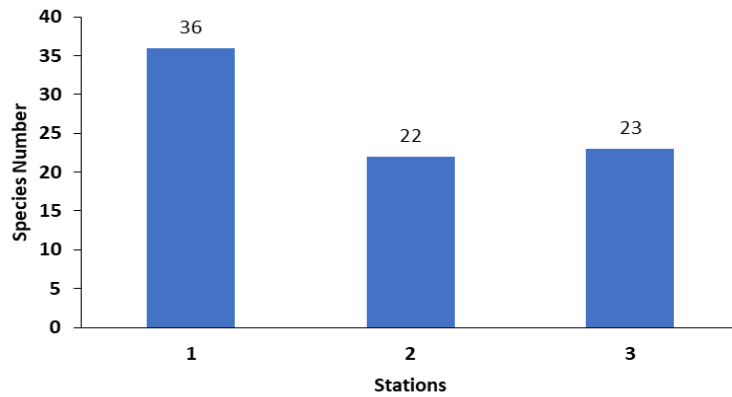


Figure 2. Distribution of macroinvertebrates by station

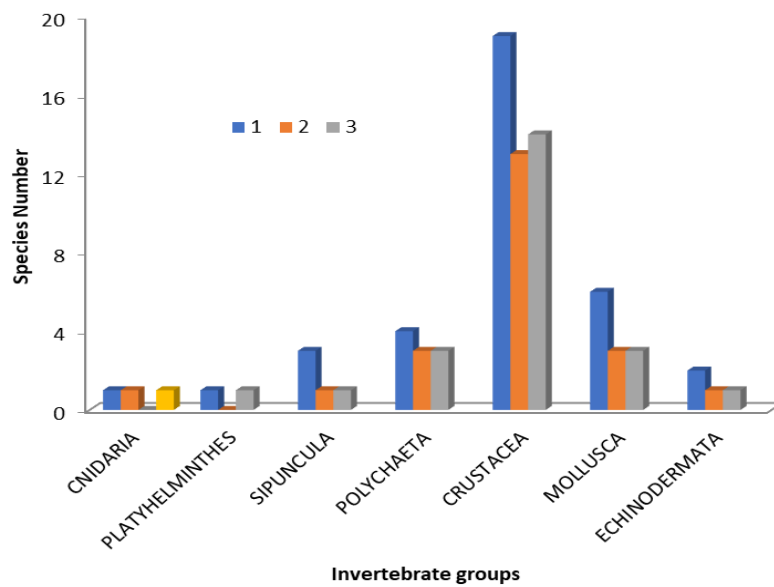


Figure 3. Distribution of invertebrate groups by station

The distribution of the invertebrate groups detected in the study area according to the stations was analysed, with the Crustacea group being represented by 19 species at station 1 and 13 species at station 2. The Cnidaria group was represented by one species at stations 1 and 2, while it was not detected at station 3. A similar pattern was observed for the Platyhelminthes group, which was represented by one species at stations 1 and 3, but not at station 2 (Figure 3).

Upon evaluation of the taxonomic groups and species identified in the study are evaluated in terms of frequency index values, it was observed that 18 of them exhibited a continuous distribution. The remaining species were found to be widespread. The species with the highest frequency values and a continuous distribution were identified as follows: *Ceratonereis costae* (Grube, 1840), *Nereis zonata* Malmgren, 1867, *Chondrochelia savignyi* (Krøyer, 1842), *Leucothoe spinicarpa* (Abildgaard, 1789), *Alpheus dentipes* Guerin, 1832, *Pisidia bluteli* (Risso, 1816), *Pilumnus hirtellus* (Linnaeus, 1761), *Synalpheus gambarelloides* (Nardo, 1847), *B. pharaonis*, *Ostrea* sp. and *Ophiothrix fragilis* (Abildgaard in O.F. Müller, 1789) (100%) and *Turbellaria* sp., *Aspidosiphon muelleri* Diesing, 1851, *Phascolosoma stephensoni* (Stephen, 1942), *Harmothoe spinifera* (Ehlers, 1864), *Serpula*

vermicularis Linnaeus, 1767, *Apseudes* sp, *Idotea balthica* (Pallas, 1772), *Amphithoe ramondi* Audouin, 1826, *Maera* sp., *Porcellana platycheles* (Pennant, 1777), *Acanthonyx lunulatus* (Risso, 1816), *Pachygrapsus marmoratus* (Fabricius, 1787), *Athanas nitescens* (Leach, 1814), *Calcinus tubularis* (Linnaeus, 1767), *Musculus costulatus* (Risso, 1826), *Callochiton septemvalvis* (Montagu, 1803) and *Amphiura chiajei* Forbes, 1843 species (66.67%) belong to the group of continuous species. The remaining species have a frequency index (widespread) value of 33.3%. The underlying reason for the continuous and widespread distribution of the species is that the study was conducted in only 3 stations.

When analysing the dominance values of the species according to the stations, *S. gambarelloides* has the highest value with 32.31%, followed by *B. pharaonis* with 11.32%, *C. costae* with 8.25%, *O. fragilis* with 5.42%, *N. zonata* with 4.01%, *H. spinifera* and *C. savignyi* with 3.54% and *S. vermicularis* with 3.07%. The remaining 30 species were grouped into a category designated "others". As demonstrated in in figure 4 and table 1, this group exhibits a dominance value of 28.54% (Figure 4, Table 1).

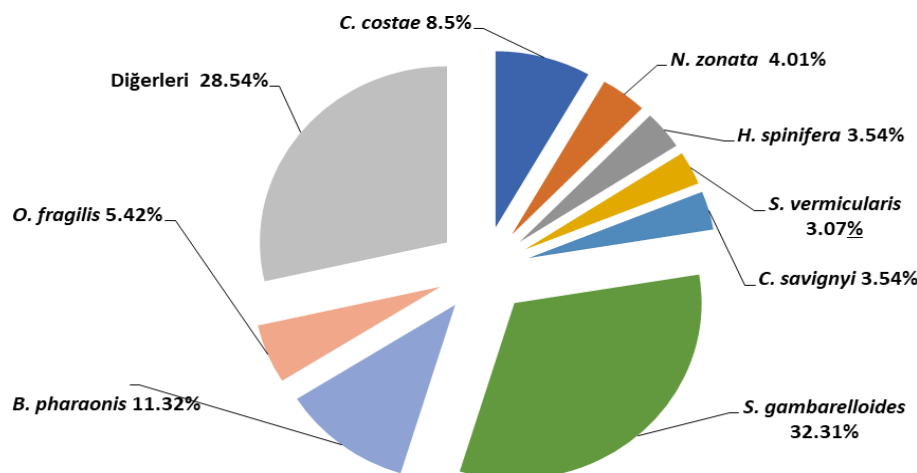


Figure 4. Species with the highest value of dominance

In previous studies on the fauna associated with *S. foetidus* in different regions of the Mediterranean coast, Çınar et al. [14] reported a total of 148 zoobenthic species (2 Cnidaria, 2 Platyhelminthes, 3 Spinula, 90 Polychaeta, 32 Crustacea, 15 Mollusca and 5 Echinodermata species) and 5299 individuals belonging to them. As stated by Özcan and Katağan [15], reported 12 decapod species and 711 individuals were reported in the Mediterranean coast of Turkey. In a separate study, Koukouras et al. [10] documented 90 species associated with sponge species in their study of 7 sponge-associated fauna on the coasts of the northern Aegean Sea. Çınar and Ergen [13] identified 89 species belonging to 23 families in their study of the polychaeta fauna in the Aegean Sea. *Ceraumereis costae* was reported to be the most dominant species. In a further study of the fauna fauna associated with this species on the coasts of Cyprus and Greece (North Aegean Sea), Pavloudi et al. (17) identified 90 species from 46 families belonging to 8 phyla. Notably, 8 of these species were documented for the first time in the Levant Basin. Çınar et al. [16] described 134 species belonging to 8 taxonomic groups associated with



this sponge on the Aegean and Levantine Sea coasts of Turkey. A study conducted on the coasts of Israel reported 4 different polychaeta species (*Harmothoe spinifera*, *Ceratonereis costae*, *Leonnates jousseaumei* and *Hydroides heteroceros*) associated with this sponge [36].

A comparison the zoobenthic groups identified during the sponge survey in terms of number of individuals reveals that the first group, Crustacea, represents 52.4% (222 individuals) of the total number of individuals. This group is followed by Polychaeta with 80 individuals and Mollusca with 69 individuals. Echinodermata is represented by 30 individuals, Cnidaria by 11 individuals, Spinacula by 9 individuals and Platyhelminthes by 3 individuals.

Özcan and Katağan [15] reported that *S. gambaroloides* was the most abundant species, with 616 individuals and a dominance value of 86.64%. Çınar et al. [14] reported that although 60% of the species were found in the Polychaeta group, 71% of the individuals and 40% of the biomass belonged to the Crustacea group. They also reported that *S. gambaroloides*, *Tritaeta gibbosa* (Crustacea) and *Hiatella arctica* (Bivalvia) were the most abundant sponge species in terms of individuals and biomass. Çınar et al. [16] reported that the most abundant group was Polychaeta, which accounted for 55% of the total number of species, followed by Crustacea (30%) and Mollusca (5%). The results of this study indicated that *S. gambarelloides* constituted 32.31% of all species and was present in three stations. This was followed by the species *B. pharaonis* with 11.32%. In their study, Özcan and Katağan [15] reported for the first time that *A. rapacida* was related to this sponge. Çınar et al. [16] identified a total of 16 alien species belonging to four taxonomic groups (Polychaeta, Crustacea, Mollusca and Echinodermata) on sponges, including 12 polychaeta's, 1 crustacean, 2 bivalves and 1 ophiuroid species. It has been reported that certain alien species, most notably in particular the ophiuroid *Ophiactis savignyi* and the polychaeta *Leonnates indicus*, have been observed to extensively invade the porous sponge systems in the Levantine Sea. Moreover, ALEX Biotic Index indicates that the ecological situation in the region is moderate in terms of the impact of alien species on local biodiversity.

As a consequence of the sampling process conducted at five stations that collectively represent Iskenderun Bay, a total of 38 species belonging to seven distinct taxonomic groups were identified, including 2 species of Cnidaria, 1 species of Platyhelminthes, 3 species of Spinulida, 4 species of Polychaeta, 20 species of Crustacea, 6 species of Mollusca, and 2 species of Echinodermata.

It is noteworthy that some species were not reported in previous studies, and it is reported for the first time that the *Ostrea* sp. individuals found in our study are related to this sponge. Previous studies have demonstrated that the fauna associated with *S. foetidus* is species rich. The primary factor contributing to the reduced species diversity observed in this study is the limited number of stations sampled. Furthermore, two alien species [*A. rapacida* and *B. pharaonis*] associated with the sponge were identified, with *B. pharaonis* being found to be one of the species with the highest abundance value.

In conclusion, this study has identified the macroinvertebrate fauna associated with *S. foetidus* sponge distributed in Iskenderun Bay. The evaluation of the associated fauna in terms of alien species and the data obtained have been provided for future studies on the subject. This will facilitate a more profound comprehension of temporal changes, ecological changes and the abundance of species in the fauna associated with the sponge species.



NOTICE

This article is based on the MSc. thesis of Celal Alkan, entitled "Macroinvertebrate fauna association with sponge *Sarcotragus foetidus* Schmidt, 1862 (Porifera: Demospongiae) in Iskenderun Bay", a thesis which was carried out under the supervision of Assoc. Prof. Tahir Özcan at Iskenderun Technical University, Iskenderun, Turkey.

CONFLICT OF INTEREST

The author(s) declare that they have no potential conflict of interest.

FINANCIAL DISCLOSURE

This research received no financial support.

DECLARATION OF ETHICAL STANDARDS

The authors of the article declare that the materials and methods used did not require ethics committee approval and/or regulatory approval.

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