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Research Article

Sipunculan Fauna in the Fethiye-Göçek Specially Protected Area (Turkey, Eastern Mediterranean)

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Abstract

This study deals with sipunculan species collected from 0 to 31 m depths at 83 stations in the Fethiye-Göçek Specially Protected Area (Turkey). A total of 7 species and 1397 individuals belonging to four families were encountered. Among the species, *Nephasoma* (*Nephasoma*) *rimicola* is new to the eastern Mediterranean fauna and 5 species are new to the marine fauna of the southern coast of Turkey. *Phascolosoma* (*Phascolosoma*) *stephensoni* has the highest dominance and frequency index values in the area. *Aspidosiphon* (*Aspidosiphon*) *elegans* and *Apionsoma* (*Apionsoma*) *misakianum* are alien species. Of the biotopes examined, *Posidonia oceanica* was characterized by the highest number of species (6 species). In the present study, brief descriptions of the species, and their distributional and ecological characteristics are given and discussed.

Keywords: Sipuncula; Ecology; Fethiye-Göçek; Specially protected area; Eastern Mediterranean; Turkey.

Introduction

Protected areas are known to be the most effective way of conserving biological diversity *in situ,* maintaining productivity, especially overexploited fish stocks (GREEN & PAINE, 1997; ABDULLA *et al.,* 2008). Additionally, marine protected areas can act as a means to preserve traditional uses that have survived as sustainable over long periods of human history (AGARDY, 1994).

A total of 14 Specially Protected Areas, which cover almost a total area of 12111 km^2 , have been established in Turkey so far. The Fethiye-Göçek Specially Protected Area was established in 1988 and has an area of 345 km^2. To assess the biodiversity of the area, a project was undertaken in June and September 2008, and all marine groups including Sipuncula were determined.

Sipunculans are known to play an important role in the bioturbation of sediments and as a food source for higher trophic levels (CUTLER, 1994; KEDRA & WŁO-

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DARSKA-KOWALCZUK, 2008). Sipunculans can transform suspension material from the water column, sediment interface, or sediment itself (MURINA, 1984). They can also alter their habitat through bioerosion of coral reefs and soft rocks (CUTLER, 1994; KLEIN *et al.,* 1991).

Sipunculans inhabiting the southern coast of Turkey have not been studied in detail to date. The only report was given by AÇIK (2008a), who reported the alien species *Aspidosiphon* (*Aspidosiphon*) *elegans* on calcareous rocks, *Brachidontes pharaonis* and *Corallina mediterranea* between 0 and 3 m depths in Iskenderun and Mersin Bays.

The purpose of this study is to present the sipunculan species inhabiting habitats of the Fethiye-Göçek Specially Protected Area and to give some notes on their bioecological features.

Material and Methods

Two cruises were held to the Fethiye-Göçek Specially Protected Area in June 2008 and September 2008 to investigate the biodiversity of the area. Scuba diving and snorkelling were used to take samples from various habitats such as rocks, mud, sand, algae and phanerogames at 83 stations between the depth interval 0–31 m. Divers used a bag to collect soft sediments at stations. A total of 246 scuba dives and 148 snorkelling were performed in the area (Fig. 1).

Samples taken from habitats were sieved through 0.5 mm mesh and the retained material was placed in separate jars contain-

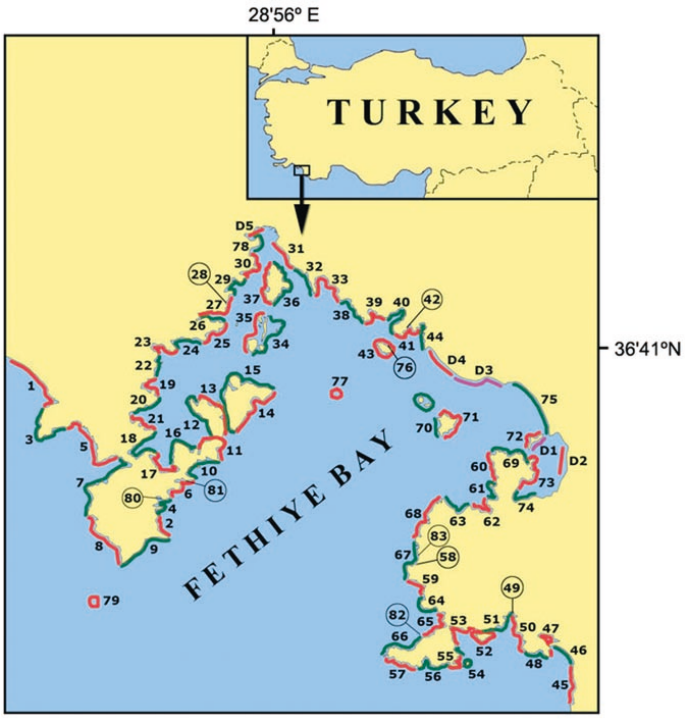


Fig. 1: Location of the investigated area and the sampling sites.

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ing 4% seawater formaldehyde solution. In the laboratory, samples were rinsed in fresh water and sorted according to taxonomic groups under a stereomicroscope, and preserved in 70% ethanol. In the laboratory, sipunculans were identified and counted using both stereo- and compound microscopes. Biometrical measurements of the largest and smallest individuals of each species such as the lengths of trunk, introvert, papillae, retractors, nephridia and hooks were measured by using an ocular micrometer. The Jaccard Similarity Index (presence-absence data) was used to distinguish species assemblages in the area. The SOYER's (1970) Frequency Index (F) was used for classifying species according their occurrences in samples. According to this index, species with F≥50% are considered 'Constant', those with F between 25% and 49% are 'Common', while F values <25% are considered as 'Rare'.

Photographs were taken using a digital camera (Olympus, Camedia C–7070) attached to the stereo- and compound microscopes.

Results

Faunistic analysis of a total of 110 samples collected from different biotopes along the Fethiye-Göçek Specially Protected Area revealed a total of 7 species and 1397 individuals belonging to four families [Golfingiidae, Phascolionidae, Phascolosomatidae and Aspidosiphonidae] (Table 1). The family Phascolosomatidae had the majority of specimens (1186 individuals, 85% of the total specimens), followed by Aspidosiphonidae (188 individuals, 13.4%), Phascolionidae (14 individuals, 1%) and Golfingiidae (9 individuals, 0.6%) respectively (Fig. 2A). Among the species encountered in the area, *Nephasoma* (*N.*) *rimicola* is new to the eastern Mediterranean fauna, and *Golfingia* (*Golfingia*) *vulgaris vulgaris, Onchnesoma steenstrupii steenstrupii, Phascolosoma* (*Phascolosoma*) *stephensoni, Apionsoma* (*Apionsoma*) *misakianum* and *Aspidosiphon* (*Aspidosiphon*) *misakiensis* are new to the marine fauna of the southern coast of Turkey.

Phascolosoma (*P.*) *stephensoni* was the most dominant species in the area, comprising

Table 1

Sipunculan species found in the Fethiye-Göçek Specially Protected Area and their total abundance in different biotopes (DR: Depth range, A: Rock; B: *Cystoseira spinosa;* C: *Posidonia oceanica;* D: Mud and Sand bottoms).

Species	DR (m)	A	B	C	D	Stations
Golfingia (*G.*) *vulgaris vulgaris*	0–30	2	3	3	-	29, 34, 40, 50, 71
Nephasoma (*N.*) *rimicola*	24	-	-	1	-	69
Onchnesoma steenstrupii steenstrupii	0–30	-	1	5	8	22, 55, 68, 69, 71
Phascolosoma (*P.*) *stephensoni*	0–31	1086	91	1	4	1-27, 29-34, 36, 40-41, 43, 46-48, 50-56, 59-72, 75, 78
Apionsoma (*A.*) *misakianum*	24	-	-	4	-	69
Aspidosiphon (*A.*) *elegans*	0–5	2	-	-	-	5
Aspidosiphon (*A.*) *misakiensis*	0–30	71	109	5	1	5, 10-14, 22, 26, 31, 34, 40, 41, 46, 47, 55, 63-66, 69, 71, 72

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84.6% of the total number of specimens (Fig. 2B). Although it was collected in all habitats, this boring species particularly dominated on calcareous rocks. The species represented by only one specimen in the area was *Nephasoma* (*N.*) *rimicola.* As a result of the SOYER's frequency index values (F), *P. (P.) stephensoni* (F= 94.5%) could be classified as 'Constant' and the other six species as 'Rare'.

Among the biotopes, *Posidonia oceanica* was represented by the highest number of species (6 species), followed by *Cystoseira spinosa* (4 species), rocks (4 species), and muddy sand bottoms (3 species). *Nephasoma* (*N.*) *rimicola* and *Apionsoma* (*A.*) *misakianum* occurred only on *P. oceanica; Aspidosiphon* (*A.*) *elegans* only on rocks. The highest number of individuals was found on rocks (1161 individuals; 83.1%), followed by *C. spinosa* (204 individuals; 14.6%), *P. oceanica* (19 individuals; 1.4%), and muddy sand bottoms (13 individuals; 0.9%), respectively (Table 1).

The dominant and frequent species, and their relative percentages varied among biotopes. *Cystoseira spinosa* was particularly dominated by *Phascolosoma* (*P.*) *stephensoni* and *Aspidosiphon* (*A.*) *misakiensis.* In

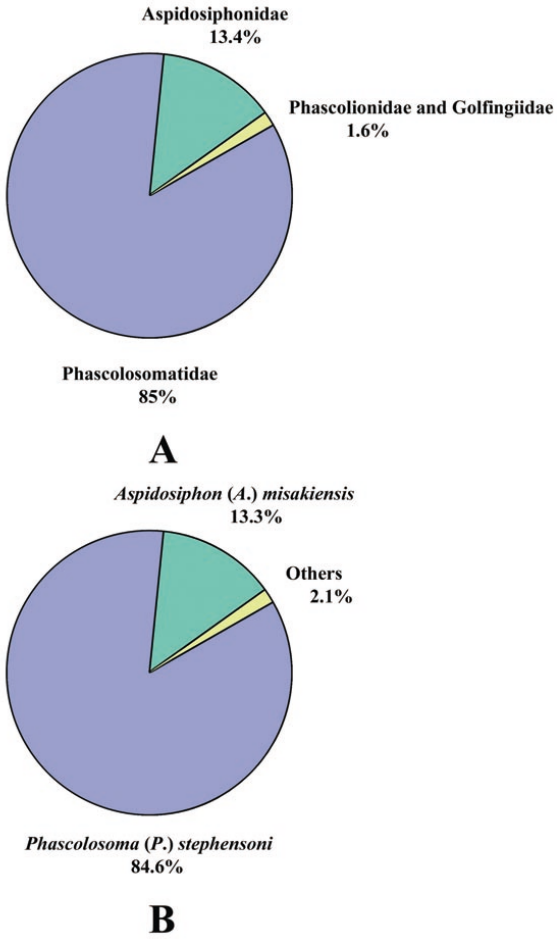


Fig. 2: Relative dominance of the families (A) and species (B) in the area by numbers of individuals.

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P. oceanica meadows, *Onchnesoma steenstrupii steenstrupii* and *Golfingia* (*G.*) *vulgaris vulgaris* became important in terms of dominance and frequency values. Certain species represented particular importance on some habitats. *P.* (*P.*) *stephensoni* was the most dominant species on rocks and *Onchnesoma steenstrupii steenstrupii* on muddy sand bottoms (Table 2).

The result of the cluster analysis showed that two species associations were present in the area (Fig. 3). The first group (group A) included the three species *Nephasoma* (*N.*) *rimicola, Apionsoma* (*A.*) *misakianum* and *Onchnesoma steenstrupii steenstrupii,* which were present only on *P. oceanica.* The latter species was also found on *Cystoseira spinosa* and muddy sand substratum. The other association (group B) included the species *Aspidosiphon* (*A.*) *misakiensis* and *P.* (*P.*) *stephensoni,* which frequently occurred on rocks. *A.* (*A.*) *elegans,* which was present in only one sample, showed no correlation with the other species encountered.

Table 2

The number of species (S) and individuals (N), and the dominant and frequent species found in biotopes sampled in the Fethiye-Göçek Specially Protected Area. R shows the number of samples taken in the area.

Biotopes	R	S	N	Dominant species (%)	Frequent species (%)
Cystoseira spinosa	9	4	204	*A.* (*A.*) *misakiensis* (53.4)	*P.* (*P.*) *stephensoni* (100)
Posidonia oceanica	4	6	19	*A.* (*A.*) *misakiensis* (26.3) *O. steenstrupii steenstrupii* (26.3)	*A.* (*A.*) *misakiensis* (50) *G.* (*G.*) *vulgaris vulgaris* (50) *O. steenstrupii steenstrupii* (50)
Rock	93	4	1161	*P.* (*P.*) *stephensoni* (93.5)	*P.* (*P.*) *stephensoni* (98.9)
Mud & Sand	4	3	13	*O. steenstrupii steenstrupii* (61.5)	*O. steenstrupii steenstrupii* (100)

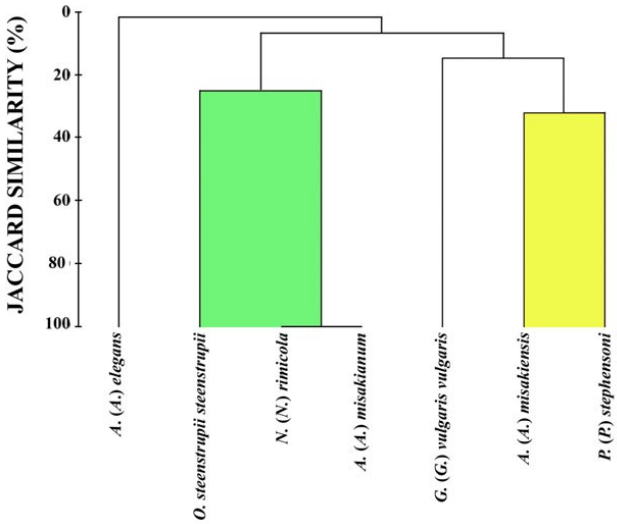


Fig. 3: Cluster showing the similarity among sipunculan species found in the area.

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Biometrical features of the species as well as their distributional and ecological features are as follows.

***Golfingia (Golfingia) vulgaris vulgaris* (de Blainville, 1827)**

Remarks: Body cylindrical and semi-transparent (Fig. 4A). Trunk 1.8–8 mm long, 0.6–3 mm wide. Introvert 1.5–5.5 mm long, 0.3–1 mm wide. Dark brown papillae present on both ends of trunk. Papillae on base of introvert 20–40 μm height, 20–30 μm in diameter. Papillae on posterior end of trunk 25–45 μm in length, 15–40 μm in diameter. Mid-trunk with small, spare papillae; 12.5–15 μm in diameter. Introvert with scattered hooks; 25–50 μm in height (Figure 4B). Intestinal spiral with 9–18 coils. Two pairs of retractors present. Nephridiopores and anus placed at same level. Pear-shaped nephridia 0.3–2 mm height, 0.1–0.5 mm wide. Nephridia length 16–25% of trunk length. Two reddish-black eye spots present.

Ecology: This species was found on *Posidonia oceanica, Cystoseira spinosa* and rocks at 0–30 m depth in the area.

Distribution: Northeast Atlantic, Northwest Pacific and Indian Oceans (SAIZ SALINAS, 1993); Mediterranean Sea and Red Sea (CUTLER, 1994).

***Nephasoma (Nephasoma) rimicola* (Gibbs, 1973)**

Remarks: Body wall smooth and semi-transparent (Fig. 4C). Trunk 2.8 mm long, 0.6 mm wide. Introvert 2.6 mm long, 0.3 mm wide. Introvert shorter than trunk length. Skin bodies on posterior part of trunk 0.03–0.04 mm in diameter. Hooks arranged in 12 rings of hooks (Fig. 4D); 60–70 μm in length. Intestinal spiral with 18 coils. Distance between posterior end of trunk and base of retractors 1.9 mm. Retractors originating from 67.9% of distance to end of trunk. Nephridiopores anterior to anus. Two reddish eye spots present.

Ecology: This species was only found on *P. oceanica* at 24 m depth in the area.

Distribution: Southwestern England, Western Mediterranean Sea (CHIMENZ, 1989; CUTLER, 1994; PANCUCCI-PAPADOPOULOU *et al.,* 1999). This species is new to the Eastern Mediterranean Sea.

***Onchnesoma steenstrupii steenstrupii* Koren & Danielssen, 1875**

Remarks: Pear-shaped trunk 1.5–4 mm long, 0.5–2 mm wide. Introvert 5–8 times trunk length. 20–22 radiating keels present at posterior part of trunk. Chitinous plate with keel-like structures 15–30 μm long. Small wart-like papillae on surface of trunk; 12.5–25 μm long, 15–30 μm in diameter. Spindle and wing muscle absent. Anus located near mouth. Intestine with several coils. Only one retractor attached at posterior part of body. Nephridia single, elongate. Some specimens with eggs in coelom cavity, elliptical; longer axis 100–175 μm in diameter, smaller axis 95–145 μm in diameter (Fig. 4E).

Ecology: This species was found on *P. oceanica* and mud & sand substratum at 0–30 m depth in the area.

Distribution: Atlantic, Western Pacific and Southwest Indian Oceans, Mediterranean Sea (CUTLER, 1994) and Red Sea (PANCUCCI-PAPADOPOULOU *et al.,* 1999).

***Phascolosoma (Phascolosoma) stephensoni* (Stephen, 1942)**

Remark: Body wall opaque, light brownish. Trunk 2.2–27.5 mm long, 0.8–6 mm wide.

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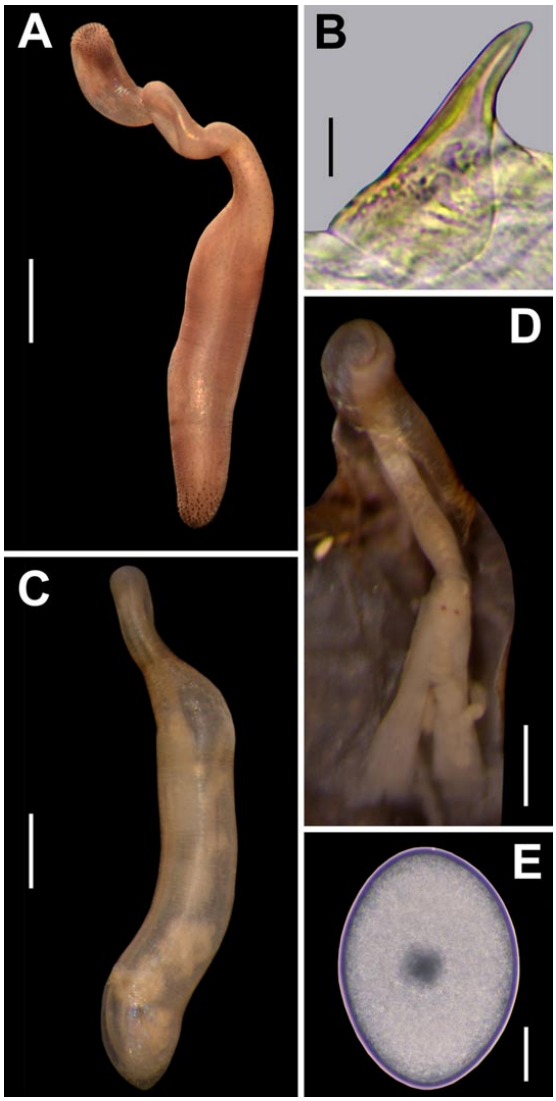


Fig. 4: *Golfingia (Golfingia) vulgaris vulgaris* (A–B): A= Trunk and partly everted introvert; B= Hook on the introvert; *Nephasoma (Nephasoma) rimicola* (C–D): C= Trunk and partly everted introvert; D= Rings of hooks on the introvert; *Onchnesoma steenstrupii steenstrupii* (E): Egg in the colemic cavity. Scale bars: A= 1 mm, B=10 μm, C= 0.5 mm, D= 0.3 mm, E= 30 μm.

Introvert 3–21 mm long, 0.5–2.8 mm wide. Longitudinal muscle bands numbering 10–23 at nephridia level. Distinctive smooth, cone-like preanal and posterior papillae present on surface of trunk. Posterior papillae 15–220 μm long; Preanal papillae 30–240 μm long. Hooks arranged in 60–90 rings. Hooks with distinct streak, triangular space and crescent (Fig. 5A). Most hooks with distinct secondary tooth. Hooks on proximal part of introvert 20–60 μm long, 25–65 μm thick at base. Intestinal spiral with 5–13 coils. Distance between posterior end of trunk and base of retractors 1.1–9 mm. Retractors orig-

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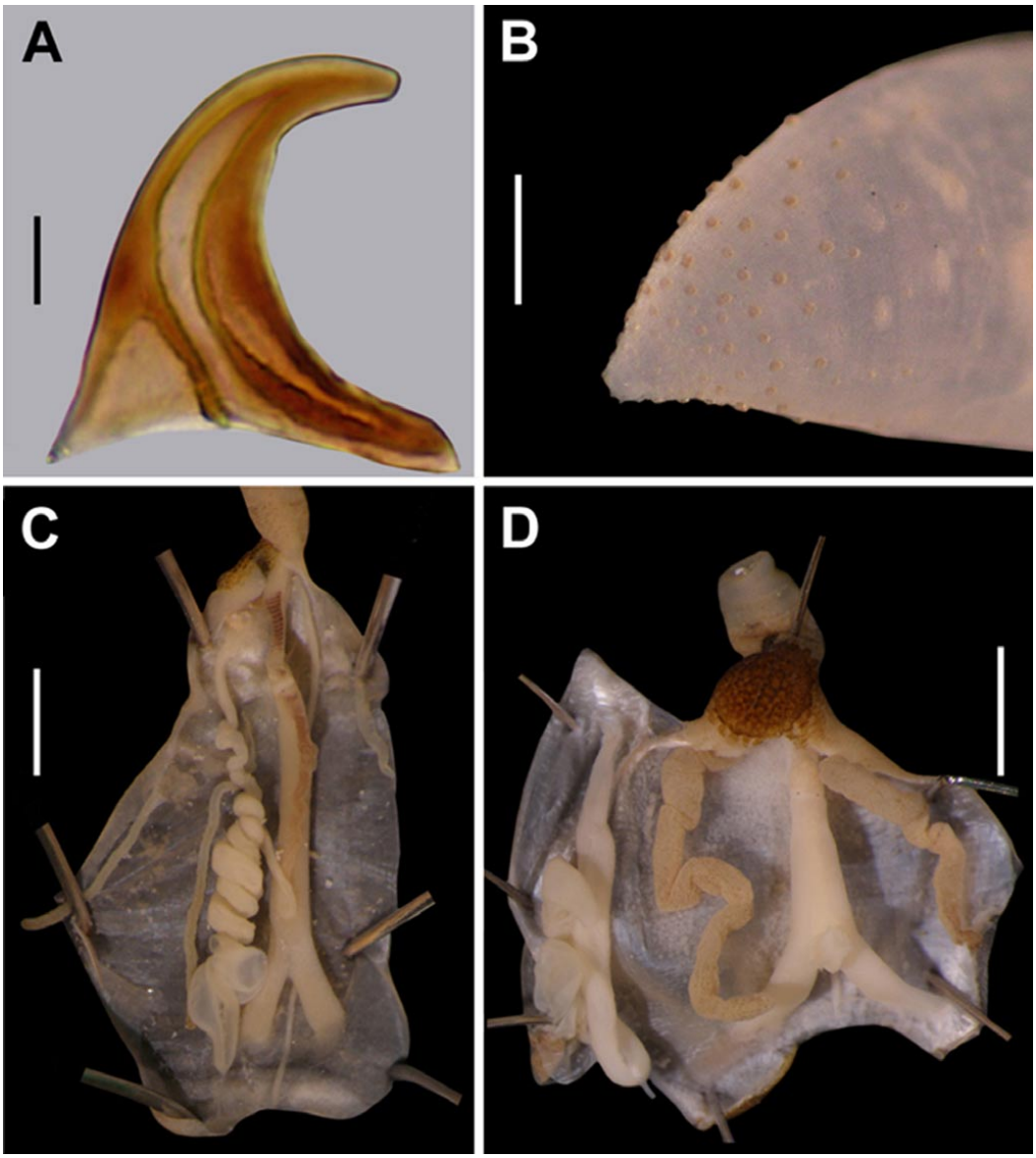


Fig. 5: Hook on the introvert of *Phascolosoma (Phacolosoma) stephensoni* (A); Small brown papillae on posterior part of the trunk of *Apionsoma (Apionsoma) misakianum* (B); Internal organs of *Aspidosiphon (Aspidosiphon) elegans* (C); Internal organs of *Aspidosiphon (Aspidosiphon) misakiensis* (D). Scale bars: A= 10 μm, B=0.4 mm, C= 1.5 mm, D= 1 mm.

inating from 33–50% of distance to end of trunk. Nephridia 1.3–18 mm height, 0.1–1.3 mm wide. Nephridia length 59–65% of trunk length. Two black eye spots present. Some specimens with eggs; elliptical, longer axis 100–140 μm in diameter, smaller axis 90–130 μm in diameter.

Ecology: This species was found on *P. oceanica, C. spinosa* and muddy sand substratum between 0–31 m in the area.

Distribution: Western and Northwestern Indian Ocean, Eastern Atlantic and

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Western Pacific Oceans and Mediterranean Sea (CUTLER, 1994).

***Apionsoma (Apionsoma) misakianum* (Ikeda, 1904)**

Remarks: Body wall thin, semi-transparent. Flask shaped trunk 1.5–3 mm long, 0.6–1.2 mm wide. Introvert 14–30 mm long, 0.3–0.4 mm wide. Small, numerous brown papillae on posterior part of trunk, 17.5–25 μm long, 15–35 μm in diameter (Fig. 5B). Introvert with 50–82 rings of hooks. Hooks located near tip of introvert; 20–27.5 μm high, 15–25 μm thick at base. Most distal rings of small hooks with 4–5 spinelets. Intestine spiral with 6–11 coils attached to posterior part of trunk by spindle-muscle. Biloped nephridia similar in size. Nephridiopores located in front of anus. Four thin retractor muscles originating near middle of trunk, both pairs close to ventral nerve cord. Two black eye spots present.

Ecology: This species was only found on *P. oceanica* at 24 m depth in the area.

Distribution: Indian, Pacific and Western Atlantic Oceans (CUTLER, 1994); and Mediterranean Sea (AÇIK, 2007).

***Aspidosiphon (Aspidosiphon) elegans* (Chamisso & Eysenhardt, 1821)**

Remarks: Body wall semi-transparent. Trunk 7 mm long, 1.5 mm wide. Introvert as long as trunk length. Ungrooved anal shield granulous. Caudal shield usually weakly developed. Introvert with 13 rings. Bidentate hooks on rings located on distal part of introvert; 40–50 μm high, 35–42.5 μm thick at base. Dark conical hooks scattered on proximal part of introvert; 25–30 μm high, 27.5–45 μm thick at base. Intestinal spiral with 12 coils (Fig. 5C). Distance between posterior end of trunk and beginning of retractors 1 mm long. Retractors originating from 14% of distance to end of trunk. Nephridiopores anterior to anus. Brown or black nephridia 3–3.8 mm height, 0.15–0.25 mm wide. Nephridia length 48–61% of trunk length. Two black eye spots present.

Ecology: This species was only found on rocks at 0–5 m depth in the area.

Distribution: Common species in shallow waters of the Indian and Western Pacific Oceans, the Red Sea (CUTLER, 1994). This species was also reported from the Mediterranean and Aegean Seas (WESENBERG-LUND, 1957; AÇIK, 2008a).

***Aspidosiphon (Aspidosiphon) misakiensis* Ikeda, 1904**

Remarks: Body wall semi-transparent. Trunk 1.5–8 mm long, 0.6–3 mm wide. Introvert 2–4 mm long, 0.3–0.9 mm wide. Introvert 0.5–1.3 times trunk length. Anal shield absent grooves or furrows. Caudal shield with vague radial grooves. Spine-like papillae scattered on introvert 17.5–25 μm long. Introvert with 65–94 rings. Bidentate hooks on rings located on distal part of introvert; 15–35 μm high, 17.5–40 μm thick at base. Unidentate hooks scattered on proximal part of introvert; 22.5–40 μm high, 20–45 μm thick at base. Gut loosely wound in ill-defined coils (Fig. 5D). Two retractors joined for most of their length, arising very close to posterior end of trunk. Nephridiopores behind anus or at same level. Nephridia length (large individual) 5 mm; 62.5% of trunk length. Two black eye spots present. Some specimens with eggs; elliptical, longer axis 60–100 μm in diameter, smaller axis 50–80 μm in diameter.

Ecology: This species was encountered in all biotopes in the area at depths ranging from 0 to 30 m.

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Distribution: Pacific, Western and Eastern Atlantic Oceans, Western and Eastern Mediterranean Sea (CUTLER, 1994; AÇIK, 2008b).

Discussion

Benthic samples collected from different biotopes along the coast of the Fethiye-Göçek Specially Protected Area comprised a total of 7 sipuncula species, of which *Nephasoma* (*N.*) *rimicola* is new to the eastern Mediterranean; *Golfingia* (*G.*) *vulgaris vulgaris, Onchnesoma steenstrupii steenstrupii, Phascolosoma* (*P.*) *stephensoni, Apionsoma* (*A.*) *misakianum* and *Aspidosiphon* (*A.*) *misakiensis* are new to the fauna of the southern coast of Turkey. The present study increased the total number of sipunculan species known from the Levantine basin from 19 to 22; that known from the eastern Mediterranean from 28 to 29.

Nephasoma (*N.*) *rimicola* was previously reported from the eastern Atlantic (coasts of England and Spain) and the Western Mediterranean Sea (coast of Spain) (CUTLER, 1994). The report of the species in the present study expands its distributional range to the Eastern Mediterranean Sea. *Nephasoma* (*N.*) *rimicola* was previously found on muddy and sandy substratum with shell fragments of molluscs, and on cracks of rocks (SAIZ SALINAS, 1986; SAIZ SALINAS & VILLAFRANCHA URCHEGUI, 1990), whereas it was found only on *Posidonia oceanica* in the present study. SAIZ SALINAS & VILLAFRANCHA URCHEGUI (1990) reported this species in deep waters (max: 720 m) from the coast of Spain, whereas in the present study only one specimen was found at 24 m from the southern coast of Turkey. This species has been found at very shallow waters (CHIMENZ, 1989; GIBBS, 1973, 1977), mostly on muddy sand filling rock crevices.

Golfingia (*G.*) *vulgaris vulgaris* was found at 0–30 m in the study area. This species was previously reported from 0 to 20 m on the Aegean coast of Turkey (ERGEN *et al.,* 1994), 10 m from the coast of Cyprus (AÇIK *et. al.,* 2005), 10 to 55 on the Israeli coast (STEPHEN, 1958), 15 to 1112 m on the north Atlantic coast (MURINA & SORENSEN, 2004) and 1500 to 1590 in the Indian Ocean (SAIZ SALINAS, 1993). The height of hooks on the introvert of specimens collected from the coasts of Spain and Indian Ocean (max: 225 μm) (SAIZ SALINAS, 1986; 1993) is much greater than that (max: 50 μm) of the specimens found in the present study.

The most abundant and frequent species in the present study was *Phascolosoma* (*P.*) *stephensoni,* which occured on all biotopes at 0–31 m depths. This species was previously reported from the coast of Spain and the southwestern coast of Africa at intertidal zones (SAIZ SALINAS, 1986; 1988). The maximum trunk length (27.5 mm) and height of hooks (20–60 μm) of *P.* (*P.*) *stephensoni* in the present study are much smaller than those reported from the coast of Spain (40 mm; 80 μm) (SAIZ SALINAS, 1986) and from the North Aegean Sea (40 mm; 110 μm) (MURINA *et al.,* 1999).

Apionsoma (*A.*) *misakianum* was only found at 24 m depth in Fethiye Bay. This species was previously reported in shallow waters (1–77 m) of the Indian Ocean (CUTLER & CUTLER, 1996; SAIZ SALINAS, 1993); from intertidal to 160 m depths on the coast of Japan (CUTLER *et al.,* 1984); and from 41 to 195 m depths in the Mediterranean Sea (AÇIK, 2007).

The Lessepsian species, *Aspidosiphon* (*A.*) *elegans,* was previously found within limesandstones at 0.5 m depth along the Israeli coast (WESENBERG-LUND, 1957); in crevices of calcareous rocks, and on *Brachi-*

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dontes pharaonis and *Corallina mediterranea* at 0–3 m depths on the coasts of Levantine and Aegean Seas (AÇIK, 2008a). This species was found on rocks at 0–5 m depth in the present study.

The maximum trunk length of *Aspidosiphon* (*A.*) *misakiensis* collected from the coast of Japan (18 mm; CUTLER *et al.,* 1984) and the coast of Spain (27 mm; SAIZ SALINAS, 1986) is much longer than that reported from the coast of the Fethiye-Göçek Specially Protected Area (8 mm). This species was previously found on sandy patches, rocks, corals photophilic algae, sponges, *P. oceanica* and sandy mud (CUTLER *et al.,* 1984; SAIZ SALINAS, 1986; AÇIK, 2008b). In the study area, this species was found in all biotopes (rocks, *P. oceanica, C. spinosa* and, mud and sand bottoms).

The present study enhances our knowledge of the sipunculan fauna inhabiting the southern coast of Turkey and provides faunistical, ecological and biometrical features of sipunculan species in the region, where no detailed study on this group has been undertaken till now. It is obvious that future studies would enable us to understand the real sipunculan diversity of the region.

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