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Original Article

Soft bottom Mollusks in the Eastern Mediterranean, Syrian transitional region

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Abstract: This study aimed to describe the distribution and diversity of soft bottom mollusk community in the Syrian transitional region and to assess the state of alien species in the northern part of the Syrian coast north of Latakia (Ibn Hani site) since 2010, at depths ranging between 110-160 m. Sixty benthic samples were collected monthly using a Van-Veen grab 1/40 m^2. Water temperature, salinity, pH, and dissolved oxygen of the subsurface water were measured. Molluscan specimens were isolated and identified at the species level. The abundance and biomass for each species in the samples and per square meter were considered to assess spatial and temporal variation of Molluscan assemblages between depths within the months. A total of 167 mollusk species belonging to 3 classes were identified, 57 newly recorded in Syria, and 18 (10.7%) non-indigenous species were found. Among these, three new aliens of *Retusa truncatula, Styloptygma beatrix,* and *Afrocardium richardi* were recorded for Syria. The presence of these mollusks was associated with the soft sediments (mud), which did not differ by time or depths. The results revealed that the Molluscan community was dominant by *Bittium arenarium*, *B. tarentinum*, *Odostomia lorioli*, *Turritella turbona*, *Varicorbula gibba*, *Nucula nucleus*, and *Lembulus pella*. A significant decrease in biomass is expected due to overfishing and severe nutrient deficiency. Our study adds a large number of mollusks to the list of previously recorded species and confirms the increase in the number of aliens and the expansion of their spread in the medium depths. Greater efforts are required to detect more aliens and evaluate their progress, spread, and their relationship with natives, especially in harbors and port environments.

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Introduction

Mollusca is one of the most diversified phyla in marine fauna. Its diversity reflects the state of sublittoral soft-bottom benthic communities and water quality (Rueda et al., 2001). Mollusca play important roles in ecosystem structure and biodiversity protection (Zenetos, 1996). Also, some mollusks have been widely used in monitoring various aquatic contaminants worldwide. Number of species per taxon in this phylum refers to 1673 species of Gastropoda (Manousis et al., 2018), 430 Bivalvia, 14 Scaphopoda, and 64 Cephalopoda (Coll et al., 2010; Bruno and Marco, 2014) in the eastern Mediterranean. A few studies about mollusks were done (Bianchi and Morri, 2000), especially in the infralittoral, to the circalittoral zone, and generally restricted to particular region (Galil and Lewinsohn, 1981; Karakassis and Eleftheriou, 1997; Conides et al., 1999; Koutsoubas et al., 2000; Koulouri et al., 2006; Çinar et al., 2008; Çinar et al., 2012a). In addition, new molluscan species in the Levantine Sea have been recorded in recent years (Ozturk, 2015; Steger et al., 2018; Marco-Herrero et al., 2022). In Mersin Bay of Turkey, Mutlu and Ergev (2008) studied the spatiotemporal distribution of epifaunal mollusks, followed by more recent studies (Mutlu, 2012; Sabelli, 2014, Steger et al., 2018; Albano et al., 2020).

A few attempts estimated the biodiversity of macrobenthos, including Mollusca in Syrian marine water. Studies on soft bottom zoobenthos were first performed by the Russian-Syrian vietia's in 1992-1993 (Kusherouk et al., 1998), and then followed by a few studies (Saker et al., 1994, 1996; Ammar, 1995, 2002) in the littoral and sublittoral to the depth of 90

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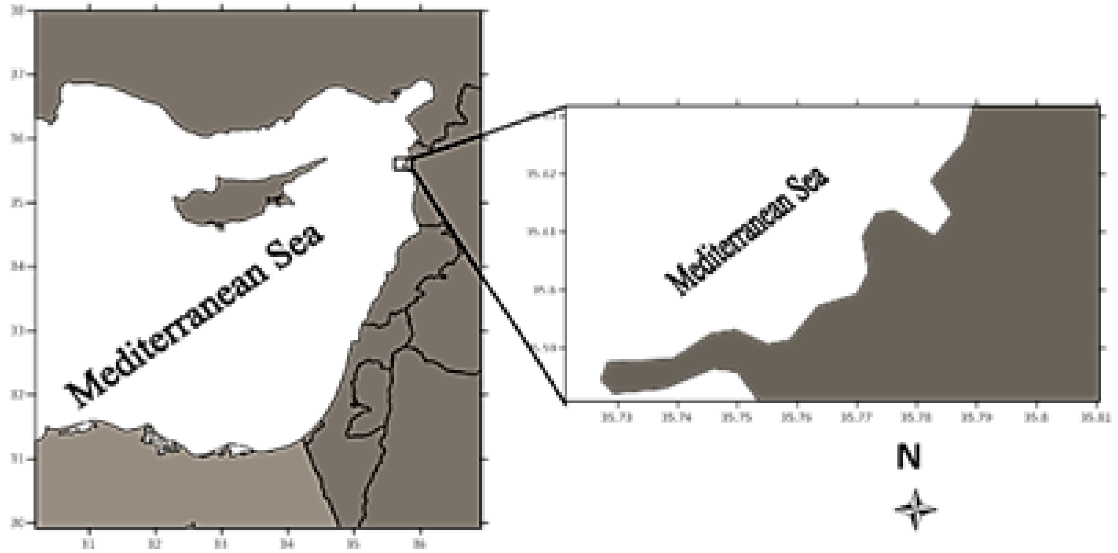

Figure 1. Map of the study area indicating sampling sites in the Syrian transitional region.

m. These studies resulted in quantitative and qualitative data on molluscan species focused on the alien invasive species and detected the impact of pollution on several populations (Ammar 2002, 2004). More recent studies recorded an increase in the number of zoobenthic species in Syria (Arabia, 2011; Ammar, 2017). Up to 2021, the studies showed the presence of more than 404 species of Mollusca, including 250 Gastropoda, 134 Bivalvia, 12 Cephalopoda, and 8 Scaphopoda at depths reaching 90 m in hard and soft bottoms in Syrian marine waters. Most of these species are native, and 79 alien species are of Indo-Pacific and Atlantic origin (Ammar, 2019).

Eastern Mediterranean including the Syrian marine waters is already facing climate change and rapid temperature rise (Lenda et al., 2014; Ozer et al., 2017), causing a decline in the native species, and creating more suitable conditions for the establishment of tropical (non-native) species (Rilov 2016; Albano et al., 2021). The number of alien species is increasing in the Mediterranean (Kourantidou et al., 2021), and more than 1000 species have been recorded and 666 were established by 2019 (Zenetos and Galanidial, 2020). They are now a real threat to native species (Lipej et al., 2018).

Alien species are most abundant in the eastern Mediterranean basin, where hundreds of species come from the Red Sea (Lispesnian species) through the Suez Canal, and settle in large populations (Albano et al., 2021). These species are present in all neighboring countries of this eastern basin and westward, towards Greece (Zenetos et al., 2018; Ammar 2019; Bariche and Fricke 2020; Crocetta et al., 2020; Çinar et al., 2021). It is noteworthy that some species reached the central Mediterranean, such as Tunisia, Italy, and France. These include 775 species belonging to 13 taxonomic groups dominated by mollusks (215 species) (Zenetos et al., 2015; Çinar et al., 2017); other studies revealed that alien mollusk species represent about 30% of the total number of species (Bitar et al., 2007; Crocetta et al., 2013; Guarnieri et al., 2017).

In Syrian coastal water, the surface water layer temperature undergoes daily, seasonal, and spatial changes, and it ranges between 16.9-30.2°C. The average annual temperature is 25.12°C and salinity ranges between 36.4-38.7‰. The average annual salinity percentage is 38.05. Local mean temperature and salinity readings for the Syrian coast are consistent with models for the Mediterranean (Pisano et al., 2020) and the Hellenic Center of Marine Research (HCMR).

Sampling and results of previous researches showed a decrease in the abundance and biomass of native species. One of the major factors that affect biodiversity is invasion by alien species since benthic

Table 1. Physical and chemical variables at north of Latakia (Syrian transitional region) (n=12).

	Mean±SD	Max	Min
Temperature (°C)	24.41±5.31	30.5	15.9
Salinity (‰)	38.58±0.87	39.2	36.5
Dissolved Oxygen (mg L)	6.68±1.17	8.13	5.37
pH	8.17±0.14	7.9	8.39
Chlorophyll a	0.05±15.15	0.15	-0.87

Table 2. No. of Species/Month in the Syrian transitional region.

	Jan.	Feb.	Mar	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Gastropoda	34	28	34	24	21	12	30	15	11	24	18	35
Bivalvia	20	26	26	20	19	24	27	12	16	30	16	31
Scaphopoda	2	3	2	3	3	2	4	1	1	4	4	2

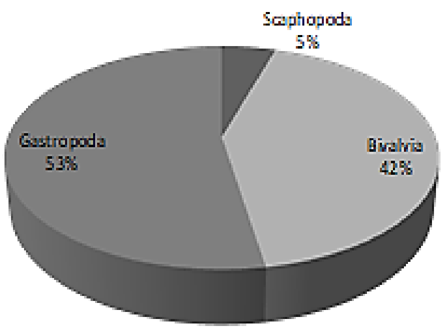

Figure 2. Percentage of total No. of species of three mollusks groups in the Syrian transitional region.

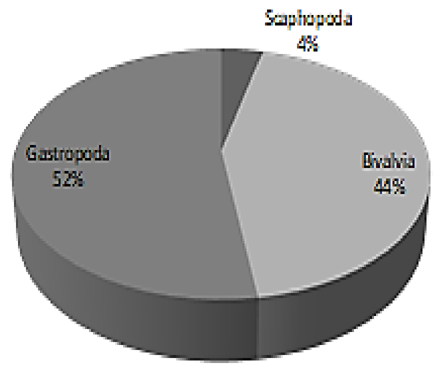

Figure 3. Percentage of total No. of individuals of three mollusks groups in the Syrian transitional region.

habitats have been densely colonized by Lessepsian species. Molluscs come second after fish in terms of the number of aliens at various depths, with a total number of 64 species (Ammar et al., 2023), and most of these species are of Indo-Pacific origins and arrived via the Suez Canal. The present study aims to describe the distribution and diversity of the soft bottom mollusk community in the Syrian transitional region at 110-160 m depths and to assess the state of alien species in it.

Materials and Methods

Twelve marine cruises were performed in the northern part of the Syrian coast north of Latakia (Ibn Hani site) at depths ranging between 110-160 m, in the coordinates of 35.598588, 35.743288 (110 m), 35.598797, 35.744403 (120 m), 35.599914, 35.742515 (140 m), and 35.601240, 35.741743 (160 m) in a location where those depths have not been studied yet (Fig. 1). Sixty benthic samples were collected monthly using a Van-Veen grab 1/40 m^2 from depths 110-160 m, in the Ibn Hani area from January-December 2010, five replicates were taken for each sample. Sampling and analysis of soft sediment macrozoobenthos were carried out using the methodology for benthic investigations of macrofauna (Blomqvist, 1991; Lardicci et al., 2004).

Water temperature, salinity, pH, and dissolved oxygen of the subsurface water were measured using a WTW MultiLine P4 set (conductivity cell, pH combined electrode, and D.O. probe). Benthic samples were sieved through a set of sieves with mesh sizes of 0.5, 1-, and 2-mm. Samples on each sieve were fixed into a 5% formalin-sea water solution.

In the laboratory, zoobenthic organisms were classified and preserved in 70% alcohol. Molluscan specimens were isolated and identified to the species level and counted. The total wet weight of the sample was taken by measuring each species' wet weight from each sample using a digital scale to the nearest 0.0001 g. The mean of abundance and biomass for every five replicate samples and per square meter were considered to assess spatial and temporal variation of Molluscan assemblages between depths within the

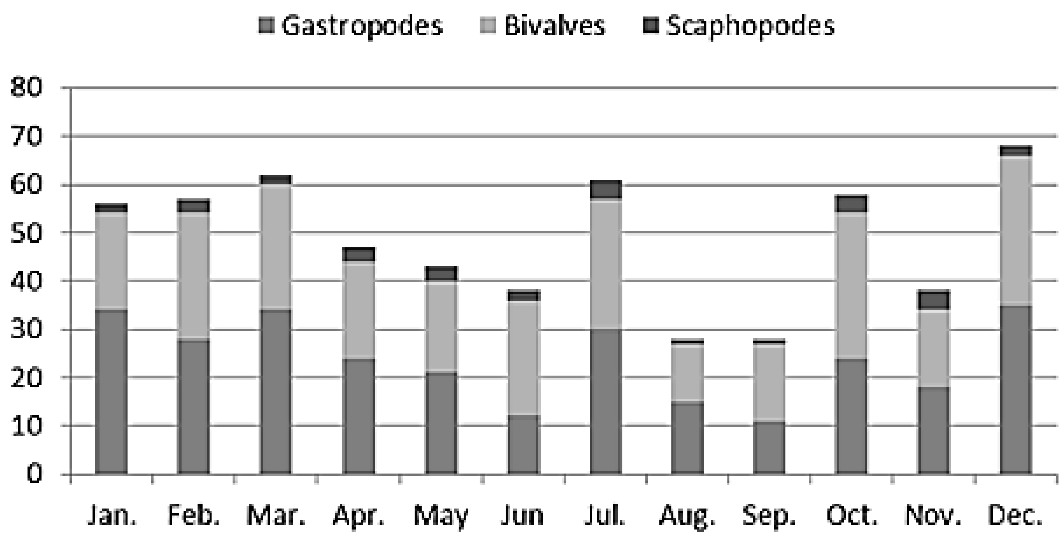

Figure 4. Temporal changes of number of species in the Syrian transitional region.

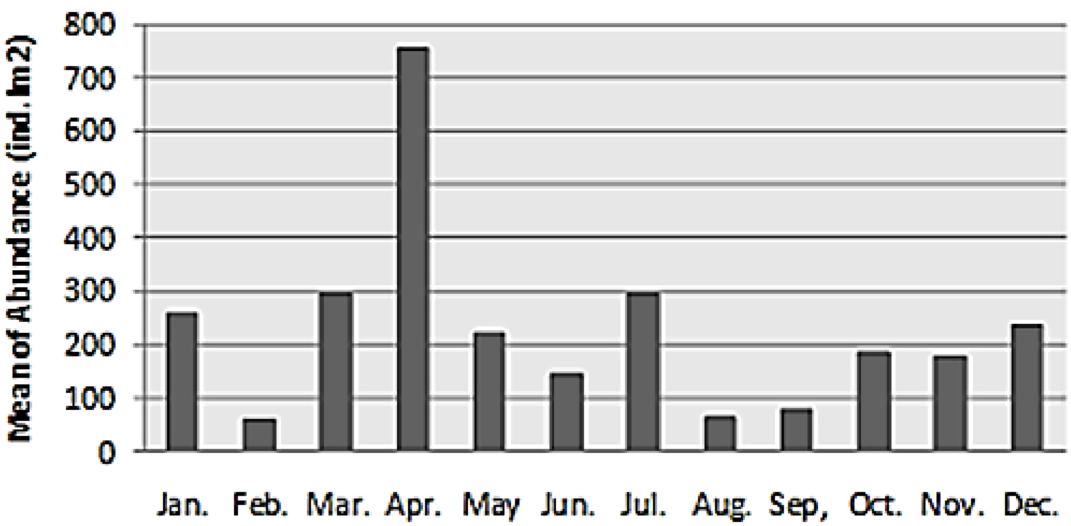

Figure 5. Temporal changes of mean of total abundance in the Syrian transitional region.

months. Specimens were deposited in the Laboratory of Marine Zoobenthos at The High Institute of Marine Research, Tishreen University.

Results and Discussions

Environmental variables: Water temperature varied seasonally between (15.9ºC in January and 30.5ºC in August. The salinity was 36.5‰ in January and 39.2‰ in August. The highest value of Do 8.13 mg/L was registered in August and the lowest 5.37 mg/L in October. The pH values were between 7.90 and 8.39, Chlorophyll-*a* concentration ranged between -0.87-0.15) (Table 1). Sediment in the survey area is generally muddy (fine mud) and its composition did not differ over time or depths.

Species composition of mollusks: A total of 167 molluscan species and 13893 individuals belonging to 3 classes (Gastropoda, Bivalvia, and Scaphopoda) were identified. The majority of species (53%, 88 species) belong to gastropods, 42% (71 species) of Bivalvia and 5% (8 species) of Scaphopoda (Fig. 2). Also, Gastropods were represented by the highest number of individuals (52% of total specimens) followed by Bivalvia (44%) and Scaphopods (4%) (Fig. 3).

Data showed that the highest number of species was recorded in December (68), March and July (61), and October (58) while the lowest number of species

Table 3. Species, first record in Syrian coast, distribution, depth and habitat (AS= Alien species, Origin: IO = Indian Ocean, IP = Indo-Pacific, NEP = PG = Persian Gulf, RS = Red).

No	Scientific name	first record in the Syrian coast	Distribution	Depth (m)	Habitat
GASTROPODA					
1	*Alectrion azoricus* (Dautzenberg, 1889)	Current study	North of Latakia (Ibn Hani)	140	Soft bottom
2	*Alvania cimex* (Linnaeus, 1758)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
3	*Alvania discors* (T. Brown, 1818)	(Arabia, 2011)	North of Latakia	25-160	Mud
4	*Alvania dorbignyi* (Audouin, 1826)**AS** IP	(Ibrahim et al., 2005)	Along the Syrian coast	25-160	Gravel, sandy, mud
5	*Amphithalamus punctulum* (Philippi, 1836)	Current study	North of Latakia	17-160	Mud
6	*Amyclina tinei* (Maravigue)	(Ammar, 2002)	North of Latakia &South of Banias	17-160	Sandy-mud
7	*Bela nebula* (Montagu, 1803)	(Ammar, 1995)	Along the Syrian coast	17-160	Mud
8	*Bittium arenarium* WoRMS.	(Arrabia, 2011)	Along the Syrian coast	17-160	Gravel, sandy, mud
9	*Bittium reticulatum* (da Costa, 1778)	(Ammar, 2002)	North of Latakia,	30-160	Sandy-mud
10	*Bittium tarentinum* (Da Costa, 1778)	(Arabia, 2011)	Along the Syrian coast	17-160	Gravel, sandy, mud
11	*Buccinum humphreysianum* (Bennet, 1824)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
12	*Bulla striata* Bruguière, 1792	(Ammar, 1995)	Along the Syrian coast	25-160	Gravel, sandy, mud
13	*Mangelia taeniata* (Rome, 1942) Rome, 1965	(Ammar, 2002)	Along the Syrian coast	25-160	Gravel, sandy, mud
14	*Cerithidium diplax* (R. B. Watson, 1886) **AS** IP, RS	(Arabia, 2011)	North of Latakia	40-160	sandy, mud
15	*Cerithiopsis tubercularis* (Montagu, 1803)	(Ammar, 1995)	Along the Syrian coast	25-160	Gravel, sandy, mud
16	*Cerithium scabridum* (Philippi, 1848) **AS**RS, IO	(Ammar, 1995)	Along the Syrian coast	25-160	Gravel, sandy, mud
17	*Columbella rustica* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
18	*Conus fumigates* (Hwass in Bruguière, 1792) **AS**RS	(Arabia, 2011)	Along the Syrian coast	17-160	Gravel, sandy, mud
19	*Conus ventricosus* Gmelin, 1791	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
20	*Coralliophila squamosa* (Bivona Ant. in Bivona And., 1838)	Current study	North of Latakia	110-160	Mud
21	*Corinnaeturris leucomata* (Dall, 1881)	(Arabia, 2011)	Along the Syrian coast	17-160	Gravel, sandy, mud
22	*Cythara albida* (Deshayes, 1838)	(Ammar, 2002)	North of Latakia, Banias	30-160	Gravel, sandy, mud
23	*Diacavolinia longirostris* (De Blainville, 1821a)	(Arabia, 2011)	North of Latakia bassite	17-160	Gravel,
24	*Diodora gibberula* (Lamarck, 1822)	(Ammar, 1995)	Latakia &Banias	17-160	Mud
25	*Diodora italica* (Defrance, 1820)	(Ammar, 1995)	Along the Syrian coast	25-160	Gravel, sandy, mud
26	*Episcomitra cornicula* (Linnaeus, 1758)	(Ammar, 1995)	North of Latakia and Banias	30-160	Gravel, sandy, mud
27	*Epitonium tiberii* (De Boury, 1890)	(Arabia, 2011)	Along the Syrian coast	25-160	Gravel, sandy, mud
28	*Euspira intricata* (Donovan, 1804)	(Arabia, 2011)	Along the Syrian coast	25-160	Gravel, sandy, mud
29	*Finella pupoides* (A. Adams, 1860) I**AS**P	(Arabia, 2011)	Along the Syrian coast	25-160	Gravel, sandy, mud

Table 3. To be continued.

No	Scientific name	first record in Syrian coast	distribution	Depth (m)	Habitat
30	*Gibbula ardens* (SalisMarschlins, 1793)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
31	*Gourmya alucastra* (Brocchi, 1814)	Current study	North of Latakia (Ibn Hani)	110-160	mud
32	*Hilinia incrassatala cepedei* (Strom)	(Ammar, 1995)	Along the Syrian coast	25-160	Gravel, sandy, mud
33	*Holiolis* sp.	(Ammar, 2002)	North of Latakia & Banias	40 - 160	sandy, mud
34	*Jujubinus exasperatus* (Pennant, 1777)	(Ammar, 2001)	Along the Syrian coast	25-30m	Gravel, sandy, mud
35	*Jujubinus gravinae* (Dautzenberg, 1881)	(Ammar, 2002)	Along the Syrian coast	25-160	Gravel, sandy, mud
36	*Jujubinus striatus* (Linnaeus, 1758)	Current study	North of Latakia	110-160	mud
37	*Mangelia costulata* (Risso, 1826)	Current study	North of Latakia	110-160	mud
38	*Mangelia unifasciata* (Deshayes, G.P., 1835)	(Arabia, 2011)	Along the Syrian coast	40 - 160	sandy, mud
39	Mathilda quadricarinata (Brocchi, 1814)	Current study	North of Latakia	110-160	Mud
40	*Melanella polita* (Linnaeus, 1758)	(Ammar, 2002)	North of Latakia & Banias	30-160	Gravel, sandy, mud
41	*Mioawateria watsoni* (Dautzenberg, 1889)	Current study	North of Latakia (Ibn Hani)	110-160	mud
42	*Mitrella scripta* (Linnaeus, 1758)	(Arabia, 2011)	North of Latakia	40 - 160	sandy, mud
43	*Monophorus perversus* (Linnaeus, 1758)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
44	*Naria spurca* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
45	*Naria turdus* (Lamarck, 1810) **AS**, RS, IO	(Arabia, 2011)	North of Latakia & Tartous	25 - 160	Gravel, mud
46	*Nassarius pygmaeus* (Lamarck, 1822)	(Arabia, 2011)	North of Latakia	40m	Mud
47	*Nassarius reticulatus* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	40 - 160	sandy, mud
48	*Neverita josephinia* (Risso 1826)	(Ammar, 1995)	North of Latakia and Banias	30-160	Gravel, sandy, mud
49	*Ocenebra erinacea* (Linnaeus, 1758)	Current study	North of Latakia	110-160	Mud
50	*Odostomia lorioli* (Hornung & Mermod, 1924) **AS**RS, PG	(Ammar, 2002)	North of Latakia and Banias	30-160	Gravel, sandy, mud
51	*Odostomia turriculata* (Monterosato, 1869)	(Arabia, 2011)	North of Latakia & AL-Bassite	30-160	Gravel, sandy, mud
52	*Philineaperta* (Linnaeus, 1767)	Current study	North of Latakia	25-160	Sandy
53	*Pseudominolia nedyma* (Melvill, 1897) **AS**RS, IO	(Ibrahim et al., 2005)	Along the Syrian coast	25-160	Gravel, sandy, mud
54	*Pseudrhaphitoma uncicostata* (Kilburn & Dekker, 2008	(Arabia, 2011)	North of Latakia & Banias	40 - 160	sandy, mud
55	*Putilla semistriata*, NBNSYS 0000177605	Current study	North of Latakia	110 - 160	mud
56	*Pyrgiscus rufus* (Philippi, 1836)	(Arabia, 2011)	North of Latakia	40 - 160	sandy, mud
57	*Pyrgostylus striatulus* (Linnaeus, 1758)	(Ammar, 2001)	North of Latakia & Banias	40 -160	sandy, mud
58	*Pyrgulinapupae formis* (Souverbie, 1865) AS RS	(Ammar, 2004)	North of Latakia	25-160	Gravel, sandy, mud
59	*Pyrunculus fourierii* (Audouin, 1826) **AS**IP, RS	(Ammar, 2002)	North of Latakia & Banias	30-160	sandy, mud

Table 3. To be continued.

No	Scientific name	first record in the Syrian coast	Distribution	Depth (m)	Habitat
60	*Rapana* sp	Current study	North of Latakia (Ibn-Hani)	110-160	sandy, mud
61	*Raphitoma pupoides* (Monterosato, 1884)	(Ammar, 2002)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
62	*Raphitoma reticulata* (Renier 1804)	(Arabia, 2011)	North of Latakia bassite	25-160	Gravel, sandy, mud
63	Corinnaeturris leucomata (Dall, 1881)	(Arabia, 2011)	Along the Syrian coast	17-160	Gravel, sandy, mud
64	*Retusa truncatula* (Bruguière, 1792) AS	Current study	North of Latakia (Ibn-Hani	110-160	mud
65	*Rhinoclavis kochi* (Philippi, 1848) **AS** IP, RS	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
66	*Ringicula conformis* (Monterosato, 1877)	(Ammar, 2002)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
67	*Rissoa auriscalpium* (Linnaeus, 1758)	(Arabia, 2011)	North of Latakia	40 - 160	Sandy-mud
68	*Rissoa euxinica* (Milaschevich, 1909)	(Ammar, 2002)	North of Latakia and Banias	25-160	Gravel, sandy, mud
69	*Rissoa parva* (da Costa, 1778)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
70	*Rissoa splendida* (Eichwald, 1830)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
71	*Rissoina bertholleti* (Issel, 1869) **AS** RS, IO	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
72	*Rissoina bruguieri* (Payraudeau, 1826)	(Ammar, 2002)	North of Latakia, banias & Tartous	25-160	Gravel, sandy, mud
73	*Samragdia viridis matonia* (Linnaeus, 1758)	(Ammar, 1995)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
74	*Steromphala adansonii* (Payraudeau, 1826)	(Ammar, 2002)	North of Latakia & South of Banias	30 -160	Sand
75	*Steromphala albida* (Gmelin, 1791)	(Ammar, 1995)	North of Latakia & South of Banias	30 - 160	Sand
76	*Steromphala umbilicalis* (da Costa, 1778)	(Arabia, 2011)	Along the Syrian coast	25-160	Gravel, sandy, mud
77	*Styloptygma beatrix* (Melvill, 1910) **AS** RS	Current study	Along the Syrian coast	17-160	Gravel, sandy, mud
78	*Syrnola fasciata* (Jickeli, 1882) **AS** IP, RS	(Arabia, 2011)	North of Latakia bassite	30-160	sandy
79	*Torellia delicate* (Philippi, 1844)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
80	*Tricolia tenuis* (Michaud, 1829)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
81	*Trigonia pulla* J. de C. Sowerby, 1826	(Ammar, 1995)	Along the Syrian coast	Littoral-160	Gravel, sandy, mud
82	*Tritia cuvierii* (Payraudeau, 1826)	(Ammar, 1995)	South of Banias	30-160	Sandy
83	*Trivia monacha* (da Costa, 1778)	Current study	North of Latakia	110-160	mud
84	*Tubiola affinis* Jeffreys	Current study	North of Latakia	110-160	mud
85	*Turboella dolium* (Nystedt)	(Ammar, 2002)	North of Latakia & Banias	40 - 160	sandy, mud
86	*Turbonilla acuta* (Donovan, 1804)	(Ammar, 2002)	North of Latakia & south of Tartous	17-160	sandy, mud
87	*Turbonilla* sp	(Arabia, 2011)	North of Latakia Bassite & Hamidia	40 - 160	sandy, mud
88	*Turritella turbona* (Monterosato, 1877)	(Ammar, 2002)	North of Latakia and banias	40 - 160	sandy, mud

Table 3. To be continued.

No	Scientific name	first record in the Syrian coast	Distribution	Depth (m)	Habitat
BIVALVIA					
No	Scientific name	first record in Syrian coast	Distribution	Depth (m)	Habitat
1	*Abra alba* (W. Wood, 1802)	(Ammar, 2002)	North of Latakia & banias		Sandy-mud
2	*Abra longicallus* (Scacchi, 1835)	(Arabia, 2011)	North of Latakia & south of Tartous	25-160	Gravel, sandy, mud
3	*Abra segmentum* (Récluz, 1843)	(Ammar, 2002)	North of Latakia, Banias & south of Tartous	17-160	sand
4	*Acanthocardi aechinata* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
5	*Cardium minimum* Philippi, 1836.	(Arabia, 2011)	Along the Syrian coast	40 - 160	Gravel, sandy, mud
6	*Acanthocardia paucicostata* (G.B. Sowerby II, 1834)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
7	*Acanthocardia spinosa* (Lightfoot, 1786)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
8	*Aequipectenopercularis* (Linnaeus, 1758)	Current study	North of Latakia (Ibn-Hani)	110-160	sand
9	*Afrocardium richardi* (Audouin, 1826) **AS** RS	Current study	Along the Syrian coast	17-159	Gravel, sandy, mud
10	*Anadara cornea* (Reeve, 1844) **AS**	Current study	North of Latakia (Ibn-Hani)	110-160	mud
11	*Arca noae* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
12	*Astarte sulcata* (da Costa, 1778)	(Ammar, 2002)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
13	*Axinulus croulinensis* (Jeffreys, 1847)	(Ibrahim et al., 2005)	Along the Syrian coast	17-160	Gravel, sandy, mud
14	*Azorinus chamasolen* (da Costa, 1778)	(Arabia, 2011)	North of Latakia, & Tartous	25-160	Gravel, sandy, mud
15	*Cardiomya costellata* (Deshayes, 1835)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
16	*Cardiomya cuspidate* (Olivi, 1792)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
17	*Cardiomya jugosa*(S. V. Wood, 1857)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
18	*Cardiomya rostrata* (Dall, 1886)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
19	*Cardites antiquatus* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
20	*Cerastoderma edule* (Linnaeus, 1758)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
21	*Cerastoderma glaucumisthmicum* (Issel, 1869)	(Ammar, 1995)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
22	*Chamelea striatula* (da Costa, 1778)	(Arabia, 2011)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
23	Chlamys sp	Current study	North of Latakia,	40m	Gravel, sandy, mud
24	*Clausinella fasciata* (da Costa, 1778)	(Ammar, 2002)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
25	*Ctena decussata* (O.G. Costa, 1829)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
26	*Ctena eburnea* (Gmelin, 1791)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
27	*Digitaria digitaria* (Linnaeus, 1758)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
28	*Anadara gibbosa (Reeve, 1844)*	Current study	North of Latakia (Ibn-Hani)	120-160	mud

Table 3. To be continued.

No	Scientific name	first record in the Syrian coast	Distribution	Depth (m)	Habitat
29	*Thracia corbuloides* Deshayes, 1824	Current study	North of Latakia (Ibn-Hani)	110-160	mud
30	*Donax semistriatus* (Poli, 1795)	(Ammar, 1995)	Latakia & south of Tartous	17-160	sandy, mud
31	*Donax trunculus* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	110-160	Gravel, sandy, mud
32	*Epilepton subtrigonum* (P. Fischer, 1874)	(Arabia, 2011)	North of Latakia &Tartous	40m	sandy, mud
33	*Ervilia castanea* (Montagu, 1803)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
34	*Flexopecten hyalinus* (Poli, 1795)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
35	*Glycymeris nummaria* (Linnaeus, 1758)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
36	*Laevicardium crassum* (Gmelin, 1791)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
37	*Lembulus pella* (Linnaeus, 1758)	(Ammar, 2001)	Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
38	*Loripes orbiculatus* Poli, 1795	(Ammar, 2002)	Latakia, Banias & Tartous	30-160	Gravel, sandy, mud
39	*Lucinoma borealis* (Linnaeus, 1767)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
40	*Mactra stultorum* (Linnaeus, 1758)	(Ammar, 1995)	Latakia & Tartous	infralittoral-160m	Sand & mud
42	*Manupecten pesfelis* (Linnaeus, 1758)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
41	*Manupecten* sp,	(Ammar, 2002)	North of Latakia & Banias	25-30m	Gravel, sandy, mud
43	*Mimachlamys varia* (Linnaeus, 1758)	(Ammar, 1995)	North of Latakia, Banias & south of Tartous	17-160	Gravel, sandy, mud
44	*Mimachlamys varianivea* (MacGillivray, 1825)	(Ammar, 2002)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
45	*Musculus costulatus* (Risso, 1826)	(Arabia, 2011)	North of Latakia	40m	sandy, mud
46	*Musculus discors* (Linnaeus, 1767)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
47	*Myrtea spinifera* (Montagu, 1803)	(Ammar, 2002)	North of Latakia & Banias		Sand & mud
48	*Mytilaster lineatus* (Gmelin, 1791)	(Arabia, 2011)	Along the Syrian coast	17-160	Gravel, sandy, mud
49	*Nucula nucleus* (Linnaeus, 1758)	(Ammar, 2002)	Along the Syrian coast	17-160	Gravel, sandy, mud
50	*Nucula nitidosa* (Winckworth, 1930)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
51	*Papillicardium minimum* (Philippi, 1836)	(Arabia, 2011)	Latakia & Banias	30-160	sandy, mud
52	*Parvicardium exiguum* (Gmelin, 1791)	(Ammar, 1995)	Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
53	*Pecten jacobaeus* (Linnaeus, 1758)	(Ammar, 1995)	Latakia & Banias	70m	mud
54	*Peronaea planata* (Linnaeus, 1758)	Current study	North of Latakia (Ibn-Hani)	120-160	sand
55	*Peronidia albicans* (Gmelin, 1791)	(Ammar, 2002)	North of Latakia & Banias		Sand & mud
56	*Pleuromeris marshalli* (Marwick, 1924)	(Arabia, 2011)	Albassit, Banias, Tartous	30m	Sand & mud
57	*Policordia gemma* (A. E. Verrill, 1880)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
58	*Proteopecten griseus* (Lamarck, 1819)	Current study	North of Latakia (Ibn-Hani)	120-160	mud

Table 3. To be continued.

No	Scientific name	first record in the Syrian coast	Distribution	Depth (m)	Habitat
59	*Proteopecten griseus subsulcatus* (Locard 1898)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
60	*Proteus glaber* (Dillwyn, 1817)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
61	*Pseudamussium sulcatum* (Müller O. F., 1776)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
62	*Saccella commutata* (Philippi, 1844)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
63	*Scrobicularia plana* (da Costa, 1778)	(Arabia, 2011)	Along the Syrian coast	17-160	Gravel, sandy, mud
64	*Serratina serrata* (Brocchi, 1814)	Current study	North of Latakia (Ibn-Hani)	110-160	mud
65	*Sphaerocardium paucicostatum*	Current study	North of Latakia (Ibn-Hani)	120-160	mud
66	*Striarca lactea* (Linnaeus, 1758)	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
67	*Tellina* sp.	Current study	North of Latakia & Tartous	160	Sand & mud
68	*Thyasira flexuosa* (Montagu, 1803)	Current study	North of Latakia (Ibn-Hani)	25m	Gravel, sandy
69	*Timoclea ovata* (Pennant, 1777)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
70	*Varicorbula gibba* (Olivi, 1792) **AS**	(Ammar, 1995)	Along the Syrian coast	17-160	Gravel, sandy, mud
71	*Venericardia* sp.	Current study	North of Latakia (Ibn-Hani)	160	Gravel, sandy, mud
SCAPHOPODA					
1	*Antalis agilis* (M. Sars in G.O. Sars, 1872)	(Ammar, 2002)	North of Latakia, & Banias	25-160	Gravel, sandy, mud
2	*Antalis dentalis* (Linnaeus, 1758)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
3	*Antalis panorma* (Chenu, 1843)	(Ammar, 2002)	North of Latakia, Banias & Tartous	25-160	Gravel, sandy, mud
4	*Antalis rossati* (Caprotti, 1966)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
5	*Antalis vulgaris* (da Costa, 1778)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
6	*Cadulus cadulusovulum*	Current study	North of Latakia (Ibn-Hani)	110-160	mud
7	*Fustiaria rubescens (*Deshayes, 1826)	Current study	North of Latakia (Ibn-Hani)	120-160	mud
8	*Rapana venosa (*Valenciennes, 1846)	Current study	North of Latakia (Ibn-Hani)	120-160	mud

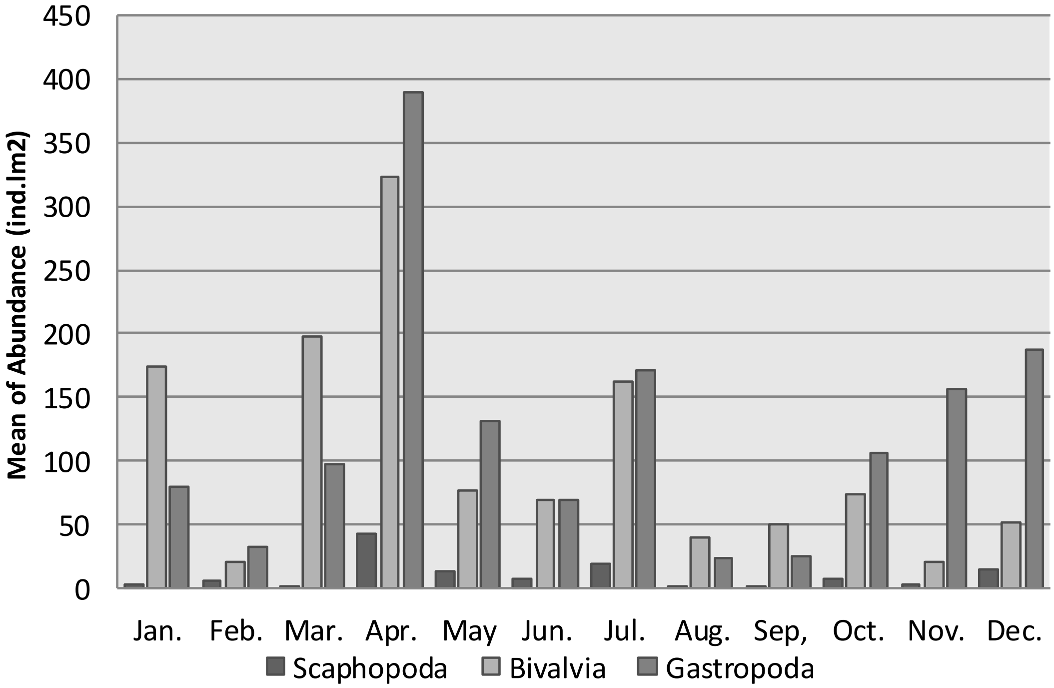

Figure 6. Temporal changes of abundance for each class in the Syrian transitional region.

was in August and September (28). The number of species for the rest months ranged between 38 and 57 species during the study period (Table 2, Fig. 4).

The mean total abundance ranged between 58-754 ind./m^2, and the highest total abundance was in April, followed by the two values recorded in July (353 ind./m^2) and March (296 ind./m^2). The lowest values of the average abundance were recorded in August and February (Fig. 5). The effect of the sampling date is clear and is related to the life cycle of bivalves and gastropod species, as their abundance increase during spring.

Figure 6 shows the changes in mean abundance for each group, Gastropods, and Bivalves recorded the highest abundance (389 and 323 ind./m^2) during April, and bivalves recorded moderate values ranging from 20-174 ind./m^2 during the other months. The abundance of scaphopods was declining throughout the research period and ranged between 1-42 ind./m^2.

Soft bottom Gastropoda: The Gastropoda community of the study area consists of 88 species belonging to 59 genera and 47 families (Table 3). The number of Gastropoda species showed clear temporal variations (Table 2). The number of taxa appeared to increase in January, March, and December (No. of species >30 and decreased from April to June and during August, September, and January, and suddenly decreased in March and increased again in October and May. However, the role of depth is limited while temporal variation appeared more evident. Four gastropods were persistent throughout the study area during all of the sampling times, namely*: Bittium tarentinum* (1-396 ind./m^2), *B. arenarium* (2-156 ind./m^2), *Turritella turbona* (1-122 ind./m^2). and *Odostomia lorioli* (1-4 ind./m^2).

Many species were recorded in more than 8 months viz. *Bulla striata* (1-6 ind./m^2), *Cerithium scabridum* (1-49 ind./m^2), *Hyalea longirostris* (1-14 ind./m^2) and *Syrnola fasciata* (1-15 ind./m^2). 37 species were recorded once during sampling times in the area. Some species of gastropods appeared in just one season. Species that were recorded during Autumn were *B. reticulatum*, *Diodora gibberala*, *Steromphala adansoni*, *S. albida*, *S. umbilicaris*, *Gourmya alucastra*, *Hilinia incrassata lacepedei*, *Mathilda quadricarineta*, *Menestho humboldti*, *Rissoina bertholleti*, *Styloptygma beatrix*, *Tricolia pulla* and *Turbonilla* sp. Species that were recorded during winter include *Alvania montagui*, *Amyclina tinei*, *Bela nebula*, *Clausinella fasclata*, *Columbella rustrica*,

Table 4. Mean biomass (g/m2) for each group during the study period.

	Jan.	Feb.	Mar	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Gastropods	85.58	38.76	81.8	47.51	40.17	17.62	67.92	27.91	1364	63.98	19.52	28.25
Bivalves	0.15	11.44	15.04	0	0	1.454	0	0	0	4.586	0.311	17.55
Scaphopods	1.858	12.08	3.203	1.117	0.776	3.355	5.266	0.234	0.148	0	0.103	3.038

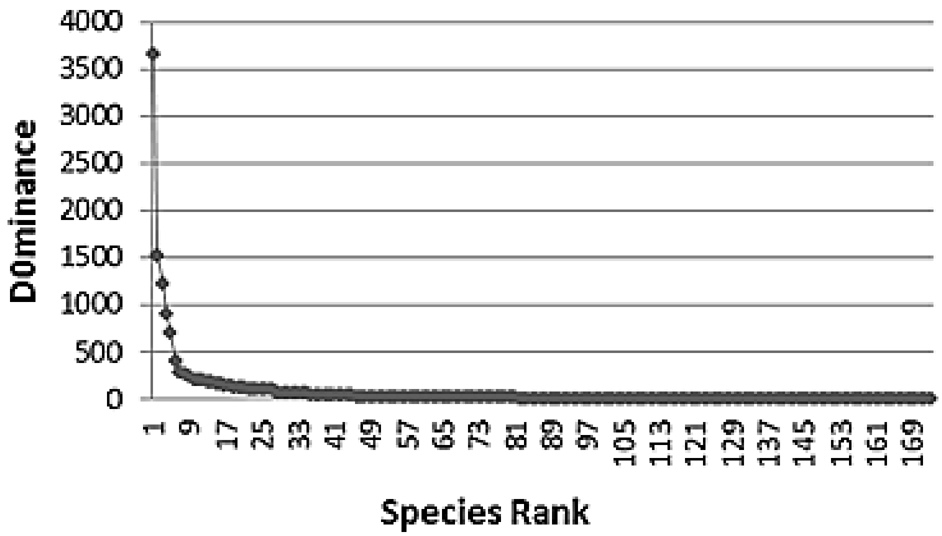

Figure 7. dominance curve of Mollusks species in the Syrian transitional region.

Coralliophila alucoides, *Cypraea spurca*, *Epitonium tiberi*, *Gibbula ardens*, *Hinia pymaea*, *Holiolis* sp., *Ocenebra erimacea*, *Odostomia turriculata*, *Putilia semistriata*, *Rapana* sp., *Raphitoma reticulate*, *Rissonia bruguuieri*, *Torellia delicate*, *Trivia monacha*, *Trochus erythraeus,* and *Turbonilla striatula*. Species that were recorded in the spring were *Erosaria turdus*, *Hinia reticulate*, *Philine aperta*, *Pyrene scripta*, and *Turbonilla delicate*. One species *Jujubinus exaperatus* was found in summer only.

Soft bottom Bivalvia: The bivalve community of soft bottom showed 71 species belonging to 59 genera and 22 families (Table 3). Syllidae was represented by 22 species, followed by Nereididae (9 species), Serpulidae (6 species), and Eunicidae (5 species). The number of species of each taxon showed some differences between sampling times (Table 2). The number of bivalvia species ranged between 19-27 species in January-July, and increased in October and December, suddenly decreasing in August/September. However, temporal variation appeared less evident. Five species were persistent throughout the study area during all of the sampling times, including *Nucula nucleus* (2-352 ind./m^2), *Varicorbula gibba* (1-172 ind./m^2)*,* *Lembulus pella* (1-111 ind./m^2), *Astarte sulcata* (1-31 ind./m^2). Other species were *persistent* during most of the sampling times: *Acanthocardia echinata* and *Thyasira flexuosa* (1-23 ind./m^2). Other species such as *Acanthocardia pauciostata*, *A. spinosa*, *A. minimum*, *Anadara cornea*, *Scrobicularia plana*, and *Donax semistriatus* were recorded in minor quantities. The rest of the 21 species were found for one time.

Soft bottom Scaphopoda: The Scaphopoda community consisted of eight species belonging to two genera and two families (Table 3). Three species of Scaphopoda viz. *Antalis dentalis, A. rossati,* and *A. rubescens* were recorded once in autumn and their abundance did not exceed 6 individuals, while *Dentalum agile* existed in the samples of autumn, spring, and summer. *Cadulus cadulusovulum* was found during most of the months and ranged between 1-41 ind./m^2. A total of 52 species are limited to the survey area (Table 3) and are considered a valuable addition to the list of mollusks in Syria showing an increase in the number of species.

Dominant Molluscan species: The dominant gastropod species were *B. tarentinum* with a total of 3662 individuals, and then *B. arenarium* with 1220 individuals. Dominant species of Bivalvia were *N. nucleus* with a total of 1518 individuals, then *V. gibba* with 905 individuals, and *Lembulus pella* with 699 individuals. The dominant species of Scaphopoda was *Rapana venosa* with a total of 206 individuals, then *Cadulus cadulusovulum* with 168 individuals. The species with the highest dominance values were *B. tarentinum* at 26%, and *N. nucleus* at 11%, *B. arenarium* at 9%, *V. gibba* at 6.7%, in addition to a high ratio of *Lembulus pella* at 5%. Most of the species recorded low ratios of less than 0.1% of the total number of specimens (Fig. 7).

Temporal changes of biomass: The mean biomass for each species was calculated monthly and the total biomass for each group was calculated (Table 4). The results showed that the highest value of the mean biomass of gastropods (1364 g/m^2) was in September, but this value ranged between 17.62 and 67.92 g/m^2 for the rest months. For bivalves, the highest mean biomass was found at 17.55, 15.04 g/m^2 in December and March, and it was low in January, Jun, and November. There were no living individuals during April, May, July, and September. The highest mean biomass for Scaphopoda was recorded in February and July (12.08, 5.266 g/m^2) respectively, and ranged between 0.103-3.209 g/m^2 in other months, no Scaphopoda was recorded in October.

The highest biomass of gastropods was for *H. longirostris* with 167.776 g/m^2 followed by *B. tarentinum* at 18.832 g/m^2, and high value was recorded for *Turritella turbona*, *Tritia cuvieri,* and *Pseudominolia nedyma* (11.803, 8.979, and 6.838 g/m^2, respectively). The lowest value was recorded for *Coralliophila squamosa*, *Naria spurca*, and *Gourmya alucastra* at less than 1 g/m^2.

For Bivalves, the highest biomass was for *N. nucleus* (1.733 g/m^2), followed by *L. pella* (0.664 g/m^2), *V. gibba* (0.207 g/m^2), and *Saccella commutata* (0.182 g/m^2), and the lowest value was recorded for *Flexopecten hyalinum* (0.002 g/m^2). A relatively high biomass was recorded for *Cadulus cadulusovulum* (2.042 g/m^2) of Scaphopoda, followed by *Dentalum (Antalis) agile* (0.539 g/m^2), and the lowest value was for *Antalis rubescens* with less than 0.002 g/m^2.

The study area in this type of bottom and depth appears to be very poor in biomass; this is the case in most studies in the eastern Mediterranean. This may be attributed to nutrient deficiencies, low primary productivity, severe diet shortage (WWFM, 2002; Zenetos et al., 2002), and the low content of organic carbon in the sediments (Baldrighi, 2012). In addition to the role of climatic changes and biological invasion with alien species, overfishing, exhaustion of marine livestock, destruction of habitats, and pollution in the Syrian environment are also the reasons for abundance and biomass decline. These results correspond with the work of Vitias 1992-1993 in the Syrian regional waters, which indicated the high diversity and decrease in abundance and biomass of miobenthic fauna at depths >100 m (Kucheruk et al., 1998). The observed seasonal or monthly changes are clear, while the effect of the depth differences is not significant. This area is the transition zone between the continental shelf and the continental slope with a complex biological composition and unstable soft bottoms in the transition (Piacenza et al., 2015).

State of the alien species: There is a steady increase in the number of discovered species of mollusks. This applies to the entire eastern Mediterranean, as is the case in some neighboring areas (Gücü et al, 2010; Mavruk et al, 2017; Crocetta et al., 2020). For this research, alien species were identified based on the atlas of exotic species of mollusks in the Mediterranean (Zenetos et al., 2003) and updates available on the CIESM website and atlases produced by the World Food and Agriculture Organization. The total number of aliens was 18 species from different origins (Indo-Pacific IO, Red Sea RS, etc), comprising about 10.7% of the total number of species and 31% of the total number of individuals in the studied area.

These aliens were distributed between the groups as follows: 15 species of Gastropods viz. *Alvania* *dorbignyi, Cerithium scabridum, Pyrgulina pupae formis, Cerithidium diplax, Conus fumigates, Naria turdus, Finella pupoides, Odostomia lorioli, Pseudominolia nedyma, Pyrunculus fourierii, Retusa truncatula, Rhinoclavis kochi, Rissoina bertholleti, Styloptygma beatrix,* and *Syrnola fasciata.* Two of these gastropods *R. truncatula* and *S. Beatrix* were recorded for the first time on the Syrian coast. Three bivalves, including *Afrocardium richardi, Varicorbula gibba,* and *Anadara cornea* were recorded in the current study, and *A. richardi* is recorded for the first time from the Syrian coast.

The four species of *Cerithium scabridum, Pyrgulina pupae formis, Finella pupoides,* and *Rhinoclavis kochi* are invasive that were established, and some of them are dominant and compete with local species. *Finella pupoides* and *R. kochi* are on the blacklist of invasive marine species. They have a negative effect on the local species or biodiversity in particular (Otero et al., 2013). *Cerithium scabridum* replaced the native *C. vulgatum*, and *C. rupestra*. *Alvania drobigni,* and *R. kochi* spread with high densities and massive biomass.

Alien gastropods were dominated and some of them recorded in high abundance, such as *F. pupoides*, *A. dorbignyi, S. fasciata*, which amounted to 432, 368, 232 ind./m^2, respectively, while the rest of the species in the studied area are represented by a small number of individuals, ranging between 8-112 ind./m^2. These are low values when compared to many other native or alien species, whose abundance exceeded several thousand ind./m^2 in other neighboring countries (Çinar et al., 2006, 2012b; Bogi and Jalil, 2013). In addition, the two bivalves, *C. gibba,* and *A. richardi* occupied an advanced rank in dominance in the sublittoral region.

The most important alien species in relation to their distribution and abundance were *P. nedyma*, *C. scabridum*, *F. pupoides*, *S. fasciata*, *R. kochi*, *Strombus persicuss* (Gastropods) and *A. cornea* (Bivalves). In terms of distribution, *A. dorbignyi*, *C. fumigates*, *F. pupoides, O. lorioli*and *P. fourierii* were represented in most areas of the Syrian coast. Although most of the new species have been recorded in the northern part, it is known that depth is the main factor affecting the assemblages of alien species, and the sediment composition plays an important role in the distribution and abundance of some alien species (Çinar et al., 2012b). Therefore, the depth and the pattern of the sandy mud bottom may have the main role in the presence of these aliens. In Syria, monitoring alien species and the expansion of their distribution and dominance, studying their relationships with native species in the same zone, needs follow-up and attention.

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