Mediterranean Marine Science

Vol 17, No 2 (2016)

Bryozoa from the Mediterranean coast of Israel

N. SOKOLOVER, P. D. TAYLOR, M. ILAN

doi: 10.12681/mms.1390

Research Article

Mediterranean Marine Science
Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS
The journal is available on line at http://www.medit-mar-sc.net
DOI: http://dx.doi.org/10.12681/mms.1390

Bryozoa from the Mediterranean coast of Israel

N. SOKOLOVER[1,2], P.D. TAYLOR[3], M. ILAN[1]

[1] Department of Zoology, Tel Aviv University, Tel Aviv 69978, Israel
[2] The Steinhardt Museum of Natural History and National Research Center, Israel
[3] Department of Earth Sciences, Natural History Museum, London SW7 5BD, UK

Corresponding author: nogasoko@gmail.com

Handling Editor: Carla Morri

Received: 12 June 2015; Accepted: 11 March 2016; Published on line: 25 April 2016
Zoobank Registration: urn:lsid:zoobank.org:pub:2933137A-8533-4606-AF56-C3B36E9113F5

Abstract

The impact of global warming on the composition of marine biotas is increasing, underscoring the need for better baseline information on the species currently present in given areas. Little is known about the bryozoan fauna of Israel; the most recent publication concerning species from the Mediterranean coast was based on samples collected in the 1960s and 1970s. Since that time, not only have the species present in this region changed, but so too has our understanding of bryozoan taxonomy. Here we use samples collected during the last decade to identify 47 bryozoan species, of which 15 are first records for the Levant Basin. These include one new genus and species (*Crenulatella levantinensis* gen. et. sp. nov.), two new species (*Licornia vieirai* sp. nov. and *Trematooecia mikeli* sp. nov.), and two species that may be new but for which available material is inadequate for formal description (*Reteporella* sp. and *Thalamoporella* sp.). In addition, *Conopeum ponticum* is recorded for the first time from the Mediterranean Sea. Non-indigenous species make up almost one-quarter of the 47 species identified. All of the non-indigenous species are native to tropical and subtropical regions, implying a change of the Levant bryozoan biota from a temperate to a more tropical state, probably related to both higher temperature and salinity and to the opening of the Suez Canal connecting the Red Sea and the Eastern Mediterranean.

Keywords: Bryozoa, Israel, Mediterranean, taxonomy, global change.

Introduction

The bryozoan fauna of the Mediterranean Sea is among the most intensively studied of all bryozoan faunas (Rosso, 2003; Ayari *et al.,* 2008). However, the main focus of these studies has been the Western Mediterranean, leaving the Eastern Mediterranean still poorly investigated (Harmelin *et al.,* 2007). A paucity of bryozoan research is particularly evident for the Levant area, including Israel, where the few published studies generally deal with small collections, or comprise species lists with little commentary (reviewed in Harmelin *et al.,* 2009). The last major paper on Israeli Mediterranean Bryozoa was published by d'Hondt (1988) and described the bryozoan collection in the Steinhardt Museum of Natural History and National Research Center, (SMNHTAU), consisting mostly of samples collected in the 1960s and 1970s. Another survey focused on alien Indo-Pacific bryozoans along the Israeli coast (Powell, 1969). Since the studies of Powell (1969) and d'Hondt (1988), advances in bryozoan taxonomy have been achieved through scanning electron microscopy (SEM) of skeletal characters, and more recently the application of molecular techniques.

The Levant Basin in the Eastern Mediterranean, stretching from Port Said in Egypt, to Marmaris in Turkey, is an oligotrophic basin characterized by low primary productivity, and high salinity and temperature (the warmest in the Mediterranean). It differs greatly from the Western Mediterranean in biotic and abiotic characteristics, as well as in the extent of research and current knowledge (Coll *et al.,* 2010; Harmelin, 2014 a,b). The proximity to the Suez Canal alongside the warm climate makes the Levant Basin especially susceptible to invasion from species originating in the tropics (Occhipinti-Ambrogi, 2007; Lejeusne *et al.,* 2010; Zenetos *et al.,* 2010).

Bryozoans are adept at fouling man-made structures such as docks, pilings, boats and even drift plastics (e.g., Winston, 1982; Watts *et al.*, 1998; Gordon *et al.*, 2008). Many species are able to survive adverse conditions through dormancy, making them relatively immune to large-scale environmental disturbances and particularly suited to human-mediated invasion processes (McCann *et al.*, 2007). The Mediterranean Sea is one of the major recipients of alien species (Galil, 2007; 2009; Zenetos *et al.,* 2010; Katsanevakis *et al.*, 2014), and the trend through time along the Israeli coast is of a decline in indigenous species and an increase in Red Sea invasive species (Fishelson, 2000).

The lack of up-to-date information about bryozoans in the Israeli marine environment signals the need for new research, especially along the Mediterranean coast where biodiversity is more vulnerable to anthropologically induced changes. The current paper uses recently collected samples to census the bryozoan species present in shallow waters of the Mediterranean in Israel. Twenty-

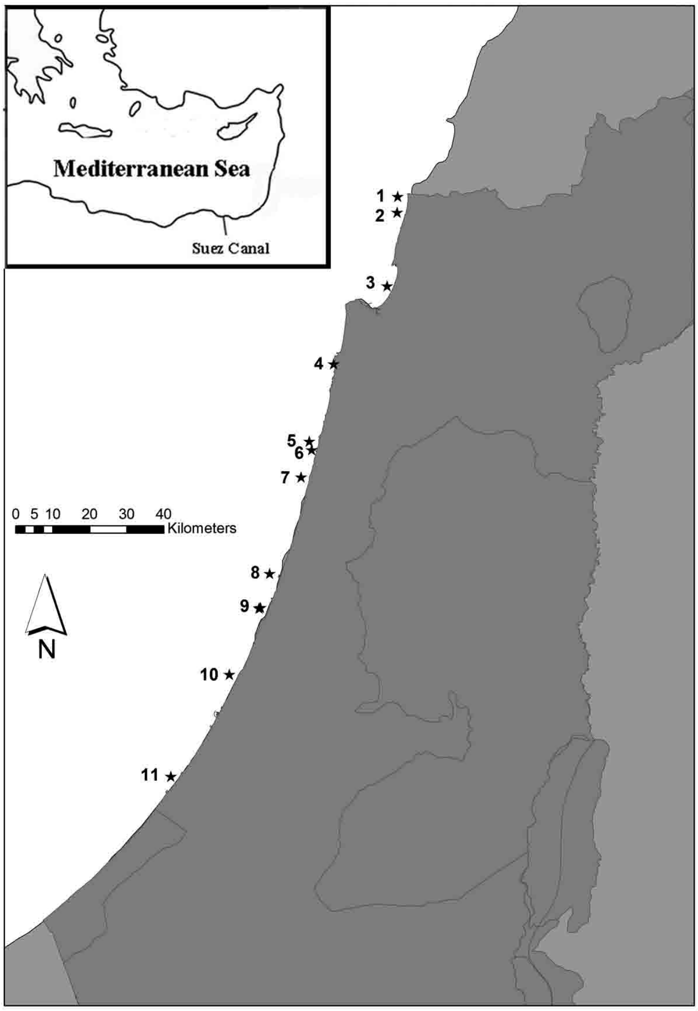

Fig. 1: Main collection sites along the Mediterranean coast of Israel. 1. Rosh-Hanikra; 2. Achziv; 3. Haifa bay; 4. Neve-Yam; 5. Sdot-Yam; 6. Hadera; 7. Michmoret; 8. Herzeliya; 9. Tel-Aviv marina and Gordon beach; 10. Palmachim; 11. Ashkelon.

one percent of the 47 species recognized represent first records for the Levant Basin, and three new species and one new genus are introduced.

Material and Methods

Seventy-five bryozoan-containing samples were collected by scuba diving (4–30 m) along the Israeli coast (Fig. 1, Table 1). The samples were collected from both natural and artificial hard substrates (mainly stones and shells) and also from artefacts such as pieces of cloth and aluminum. Most of the sampled substrates had more than one bryozoan colony on them.

Bryozoans with calcareous skeletons (i.e. cheilostomes and cyclostomes) were bleached in 2.5% sodium hypochlorite or domestic bleach, rinsed in fresh water, and dried using an incandescent light bulb or overnight in a chemical hood. Soft-bodied bryozoans (i.e. ctenostomes) were fixed in seawater/formaldehyde 4% solution for 24 hours, and later preserved in 70% ethanol. Taxonomic identification of the samples was based on study of images taken at the Natural History Museum, London (NHMUK) using a LEO 1455VP scanning electron microscope equipped to take large uncoated samples.

Samples are registered in the collection of the SMNHTAU. Measurements of zooid length and width, orifice length and width, and other morphological features were obtained using ImageJ software (Rasband, 1997–2014).

A rarefaction analysis of species accumulation curves was undertaken in order to estimate the percentage of species richness discovered in the current study, and how much sampling would be necessary in order to recover 95% of the local fauna. The rarefaction and extrapolation were carried out using EstimateS online software (Colwell, 2013).

Results

Forty-seven bryozoan species could be identified to at least genus level. Most are cheilostomes but two cyclostomes and one ctenostome species were also recorded (Table 2). Full descriptions are given below only for new species and species that are new records for the Mediterranean. In addition, brief descriptions are given for some species that have been inadequately described from the

Table 1: Location, coordinates and depth of sampling sites.

Station number	Location	Latitude (N)	Longitude (E)	Depth (m)
1	Rosh-Hanikra	33° 5.256'	35° 6.059'	25
2	Achziv (+ NIZAN Wreck)	33° 2.927'	35°5.960'	1-4, 20
3	Haifa bay	32° 52.199'	35° 3.317'	20
4	Neve-Yam	32° 40.787'	34° 55.504'	2
5	Sdot-Yam	32° 29.453'	34° 53.154'	4, 30
6	Hadera (under the Electric Co. coal conveyor)	32° 28.227'	34° 52.307'	15-20
7	Michmoret	32° 24.235'	34° 51.973'	0.5-2
8	Herzeliya	32° 10.157'	34° 47.370'	10
9	Tel-Aviv marina	32° 5.181'	34° 46.037'	<0.5
9	Tel-Aviv Gordon beach	32° 5.112'	34° 45.837'	6
10	Palmachim	31° 55.405'	34° 41.524'	3-10
11	Ashkelon	31° 40.510'	34° 32.986'	3, 13, 30

Table 2: List of bryozoan species identified in this study from the Mediterranean coast of Israel. *First record in the Levant Basin. **First record in the Mediterranean Sea. ***New genus or species.†Species known prior to the current study as non-indigenous in the Mediterranean.

Species	Station	Habitat/substrate	Remarks
Class Gymnolaemata; Order Ctenostomata			
Amathia pustulosa (Ellis & Solander, 1786)*	5	Natural rock	
Class Gymnolaemata; Order Cheilostomata			
Aetea (sica?)	2	Bivalve shell & Phidoloporid skeleton	
Acanthodesia savartii (Audouin, 1826)	10	Natural rock	
Conopeum ponticum (Hayward, 2001)**	5	Piece of tar, washed to shore	
Electra tenella (Hincks, 1880)* †	2	NIZAN wreck (20 m)	
?*Copidozoum* sp.*	2	Bivalve shell	
Ellisina gautieri (Pulpeiro, 1993)*	1	Stone	
Bugula neritina (Linneaeus, 1758)	6, 9	Plastic buoy & conveyor pole	
Crisularia plumosa (Pallas, 1766)	6	Conveyor pole	
Beania mirabilis (Johnston, 1840)	1	Natural rock	
Licornia vieirai sp. nov. ***	6,8,11	Conveyor pole & natural rock	
Licornia jolloisi (Audouin, 1826)†	11	Natural rock	
Scrupocellaria maderensis (Busk, 1860)	5,11	Natural rock & piece of cloth	
Onychocella vibraculifera (Neviani, 1895)	1	Stone	
Onychocella marioni (Jullien, 1882)	1,5	Stone & natural rock,	
Thalamoporella harmelini (Soule, Soule & Chaney, 1999) †	5	Small hatch in natural rock	Known only from the Levant. See Supplementary Material for SEM.
Thalamoporella sp.	2	Bivalve shell	The only *Thalamoporella* species known from the Mediterranean is *T. harmelini.*
Monoporella bouchardii (Audouin & Savigny, 1826)	1	Natural rock	Also found on an ancient anchor collected at Rosh Carmel in 60 m depth (no coordinates available)
Adeonella palasii (Heller, 1867)	Rosh Carmel at 60 m depth (no coordinates available)	Ancient anchor	

(continued)

Table 2 *(continued)*

Species	Station	Habitat/substrate	Remarks
Puellina picardi (Harmelin, 1988)	1	Natural rock	
Savignyella lafontii (Audouin, 1826)	5	Natural rock	
Hippothoa flagellum (Manzoni, 1870)	1,2, 9	Stone, bivalve shell & natural rock	
Trypostega venusta (Norman, 1864)	1,9	Stone & natural rock	
Celleporaria aperta (Hincks, 1882)†	5	Natural rock	
Drepanophora birbira (Powell, 1967) †	1,9	Phidoloporid skeleton, stone & bivalve shell	This is the second record from the Mediterranean. See Supplementary Material for SEM.
Exechonella antillea (Osburn 1927) *	1	Phidoloporid skeleton	Also found on an ancient anchor found at Rosh Carmel at 60 m depth (no available coordinates)
Reptadeonella violacea (Johnston, 1847)	4,5,8	Natural rock	Also found on an ancient anchor found at Rosh Carmel at 60 m depth (no coordinates available)
Watersipora sp.1	2,7	Piece of aluminum & natural rock	A method using the operculum is needed to distinguish species of this genus (Ryland, 2009; Vieria *et al*., 2014)
Watersipora sp.2	2	Natural rock	See above
Hippoporina pertusa (Esper, 1796)*	11	Piece of cloth	
Schizoporella errata (Waters, 1878)	2, 3,6,9	Natural rock, SHELLY wreck, conveyor pole plastic buoy, ropes, metals	
Schizoporella unicornis (Johnston, 1847)*	2	Stone	
Therenia rosei Berning, (Tilbrook & Rosso, 2008)*	1	Stone	Also found on an ancient anchor found at Rosh Carmel at 60 m depth (no coordinates available)
Margaretta cereoides (Ellis & Solander, 1786)	2,4	Natural rock	
Cosciniopsis ambita (Hayward, 1974)*	1	Stone	
Parasmittina egyptiaca (Waters, 1909)†	9	Bivalve shell	
Parasmittina protecta (Thornely, 1905)†	2	Bivalve shell	
Microporella harmeri (Hayward, 1988) †	2,11	Bivalve shell, piece of cloth	Also found on an ancient anchor found at Rosh Carmel at 60 m depth (no coordinates available). See Supplementary Material for SEM.
Mucropetraliella thenardii (Audouin 1826)†	Rosh Carmel at 60 m depth (no available coordinates)	Ancient anchor	Was also reported from artificial reef in Israel (Kress, 2002). See Supplementary Material for SEM.
Trematooecia ligulata (Ayari & Taylor, 2008)	1	Natural rock & stone	See supplementary material for SEM.
Trematooecia mikeli sp. nov.***	3	SHELLY wreck	
Crenulatella levantinensis sp. nov.***	1,9	Natural rock & phidoloporid skeleton	
Reteporella sp.		On sponge	Picked up using ROV at 100 m (no coordinates available)
Schizoretepora hassi (Harmelin, 2007)* †	11	Natural rock	See Supplementary Material for SEM.
Hippaliosina depressa (Busk, 1854)	1	Natural rock	Also found on an ancient anchor found at Rosh Carmel at 60 m depth (no coordinates available)
Class Stenolaemata; Order Cyclostomata			
Crisia sp.	1,11	Piece of cloth, natural rock	
Annectocyma major (Johnston, 1847)*	1,11	Piece of cloth, natural rock	

region. For species that have not been well illustrated in the literature, scanning electron micrographs can be found in the Supplementary Material.

Taxonomy

Class Gymnolaemata Allman, 1856
Order Ctenostomata Busk, 1852
Family Vesiculariidae Hincks, 1880
Genus ***Amathia*** Lamouroux1812

Amathia pustulosa **(**Ellis & Solander, 1786)

Material. TAU-BR25013, Sdot-Yam, 4 m.

Description. Colony arborescent, branching, branches formed by cylindrical kenozooids separated by transverse septa. Kenozooids distally bearing dense group of up to 30 autozooids, forming a long helix undergoing slightly more than half a spiral turn around the stolon. Separation of autozooids at growing tips giving a characteristic feathery appearance. Autozooids subcylindrical with quadrangular apertures, budding at growing tips as small vesicles arranged in two spiral series, causing slight torsion of the kenozooids; torsion becoming less clear in older branches.

Remarks. This species was previously assigned to *Bowerbankia*,which a recent molecular study has shown to be a junior synonym of *Amathia* (Waeschenbach *et al*., 2015). According to Hayward (1985), this species ranges from the Barents Sea to the Atlantic coast of Europe and the western Mediterranean and possibly as far south as Senegal. The current record is the first from the Levant Basin.

Order Cheilostomata Busk, 1852
Suborder Malacostegina Levinsen, 1909

Family Electridae d'Orbigny, 1851
Genus ***Conopeum*** Gray, 1848
Conopeum ponticum Hayward, 2001
(Fig. 2)

Material. TAU-BR25017,encrusting a piece of tar washed up on the beach at Sdot-Yam after a storm.

Description. Colony encrusting, unilaminar. Autozooids distinct, elongate-oval, mean length = 527 µm (r = 437–592 µm; CV = 7; n = 20), mean width = 304 µm (r = 242–357 µm; CV = 13; n = 20), a smoothly calcified area of gymnocyst present in the latero-proximal corners; cryptocyst narrow, extending along the entire length of the opesia, inner edge finely granulated with granules tending to be arranged in radial rows, without spinules. Spines lacking. Distolateral vertical walls containing two multiporous septula.

Remarks. This species has been previously recorded from the Great Barrier Reef (Lamouroux, 1816; Hayward, 2001), the Solomon Islands (as *Aplousina inornamentata* Tilbrook, 2006; see Gordon *et al.*, 2007) and Bangladesh (Gordon *et al.*, 2007). The dimensions of the Israeli specimen correspond with material from Bangaladesh and are only slightly smaller than the Solomon Islands and the Great Barrier Reef material. Even though this speciman have very few skeletal characteristics they match closely the illustrations and descriptions of these three records. Putative *C. ponticum* has also

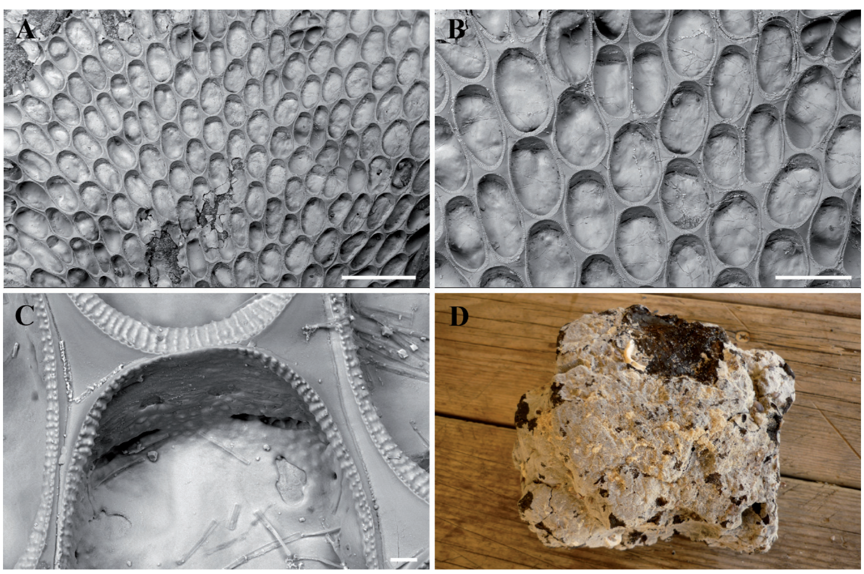

Fig. 2: *Conopeum ponticum* (TAU-BR25017). A. Part of colony. B. Group of zooids with row bifurcations. C. Multiporous septulae at distolateral corners of a zooid. D. Dried colony encrusting a piece of tar. Scale bars: 1 mm (A); 500 µm (B); 20 µm (C).

been described from northern New Zealand (Gordon *et al.*, 2008), though the figured specimen appears different from the Israeli specimen. The single specimen described by Tilbrook (2006) was recorded on floating wood, while the original description of *C. ponticum* by Hayward (2001) was based on colonies settled onto a plastic dish from larvae collected in the open sea. Along with the Israeli occurrence encrusting tar, this suggests that *C. ponticum* may be primarily a colonizer of floating substrates.

Genus ***Electra*** Lamouroux, 1816
Electra tenella Hincks, 1880
(Fig. 3)

Material. TAU-BR25018, Naharia, 20 m, fouling the *Nitzan* shipwreck.

Description. Colony encrusting, unilaminar. Autozooids oval, longer than wide; proximal gymnocyst smooth, all zooids possessing a proximal pair of long, pointed, hollow spines protruding from the raised gymnocyst. Some zooids with four additional pairs of lateral spines; cryptocyst barely visible; opesia extensive, occupying most of the surface.

Remarks. This species is unusual in having paired proximal spines. Another species of *Electra*, *E. angulata* Levinsen, 1909, is reported sometimes to have two proximal spines but the gymnocyst seems to be less developed and smaller based on the illustrations in Levinsen (1909) and Harmer (1926). In the Israeli sample the spines are always paired unlike Hincks's specimen which has both paired and single spines (nodules).

Electra tenella was first reported from the Mediterranean as a non-indigenous species by Rosso (1994). The illustrations in Rosso's report show variation in the number of pairs of lateral spines which are greater in number than in the Israeli specimen. However, other characters, such as the absence of the lateral spines from some zooids and the paired proximal spines, conform between the Sicilian and Israeli occurrences. The species was later reported from more sites in Italy (Thessalou-Legaki *at al*., 2012), including the Western and Central Mediterranean. It has been suggested that *E. tenella* is spreading by means of shipping activity based on its presence in harbours and ability to colonize drift plastics and sea-chests of vessels.

This species is known from Florida and the tropical western Atlantic as far south as Brazil, and is also reported from Japan, New Zealand and India (reviewed by Rosso in Thessalou-Legaki *at al*., 2012). However, the occurrence described here is the first report of *E. tenella* from the Eastern Mediterranean and Levant Basin.

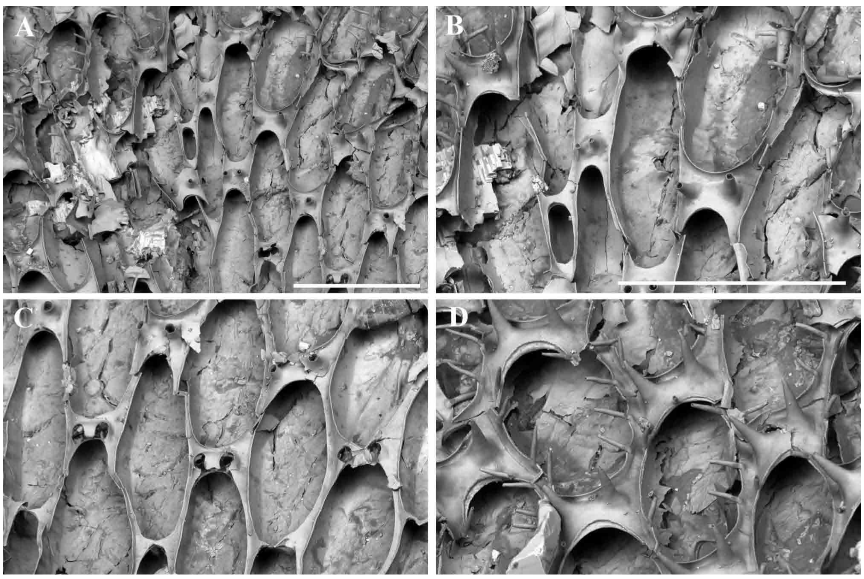

Fig. 3: *Electra tenella.* (TAU-BR25018). A. Part of colony with both spinose and non- spinose zooids. B. Oblique view of paired proximal spines. C. View of zooids with proximal spines broken-off. D. Zooids with marginal spines. Scale bars: 500 μm.

Suborder Neocheilostomatina d'Hondt, 1985
Family Calloporoidae Norman, 1903
Genus ***Copidozoum*** Harmer, 1926
?*Copidozoum* sp.
(Fig. 4)

Material. TAU-BR25019, Achziv, 4 m, on a bivalve shell.

Description. Colony encrusting, unilaminar, a small irregular patch. Autozooids irregularly oval, separated by deep

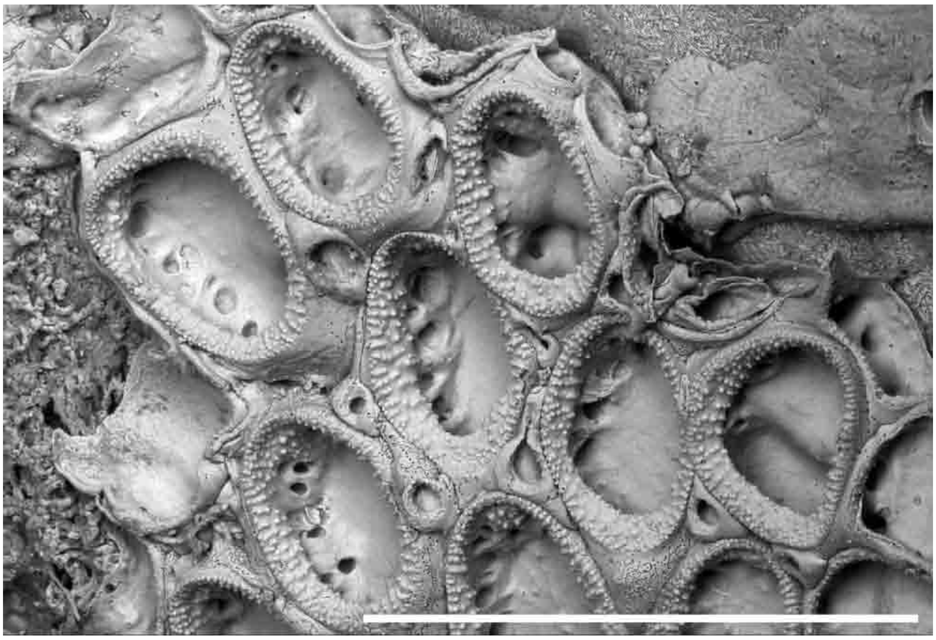

Fig. 4: *Copidozoum* sp., in oblique view (TAU-BR25019). Scale bar: 500 µm.

grooves, the walls thick; cryptocyst coarsely granulated; gymnocyst poorly developed; spines lacking. Pore chambers absent, walls perforated by large multiporous rosette plates. Ovicells not observed in the colony studied. Interzooidal avicularia, triangular, long and narrow rostrum.

Remarks: The single colony found was very small, probably young, and has no ovicells, which makes its identification problematic.

Genus ***Ellisina*** Norman, 1903
Ellisina gautieri Fernandez Pulpeiro & Reverter Gil, 1993
(Fig. 5)

Material. TAU-BR25020, TAU-BR25022, Achziv Canyon at 25 m, on stones.

Description. Colony encrusting, unilaminar. Autozooids oval, separated by distinct grooves; opesia extensive, occupying most of the surface; cryptocyst narrow, granular; gymnocyst smooth, minimal; spines lacking; ovicells prominent, always associated with a distal avicularium, frontal surface with a small ridge or umbo. Avicularia interzooidal, located at the distal end of most autozooids, directed distolaterally. Pore chambers present.

Remarks. This species is known from the English Channel, the Atlantic coast of Spain, Marseilles in the western Mediterranean, Italy and Croatia in the Adriatic Sea (Hayward & Ryland, 1998; Hayward, 2002; Rosso, 2010). This is a first record from the Levant Basin.

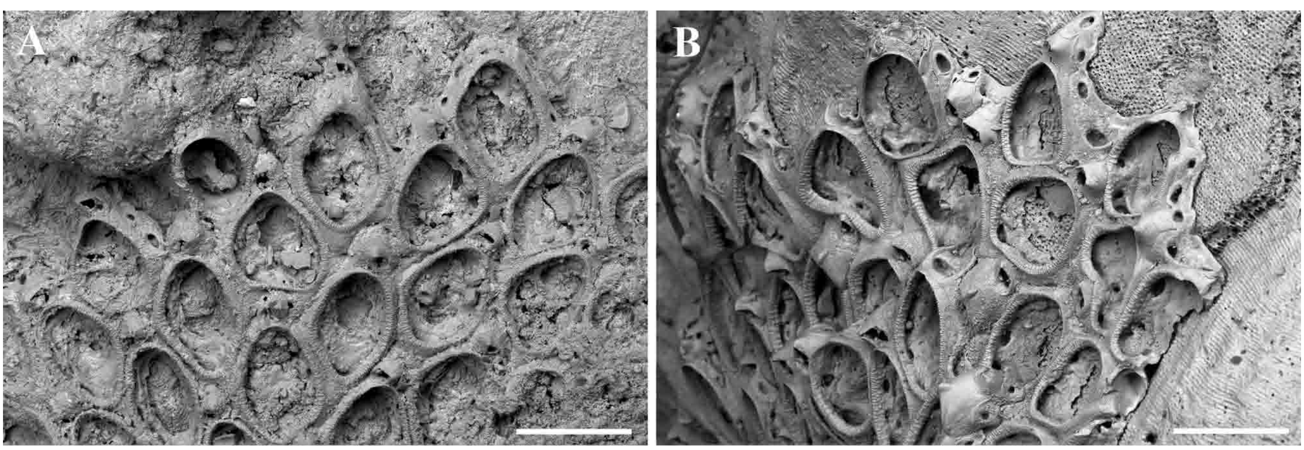

Fig. 5: *Ellisina gautieri* (TAU-BR25020). A. Zooids close to the growing edge. B. Oblique view showing pore windows at growing edge. Scale bars: 500 µm.

Family Candidae d'Orbigny, 1851
Genus ***Licornia*** van Beneden, 1850
Licornia vieirai sp. nov.
(Fig. 6)

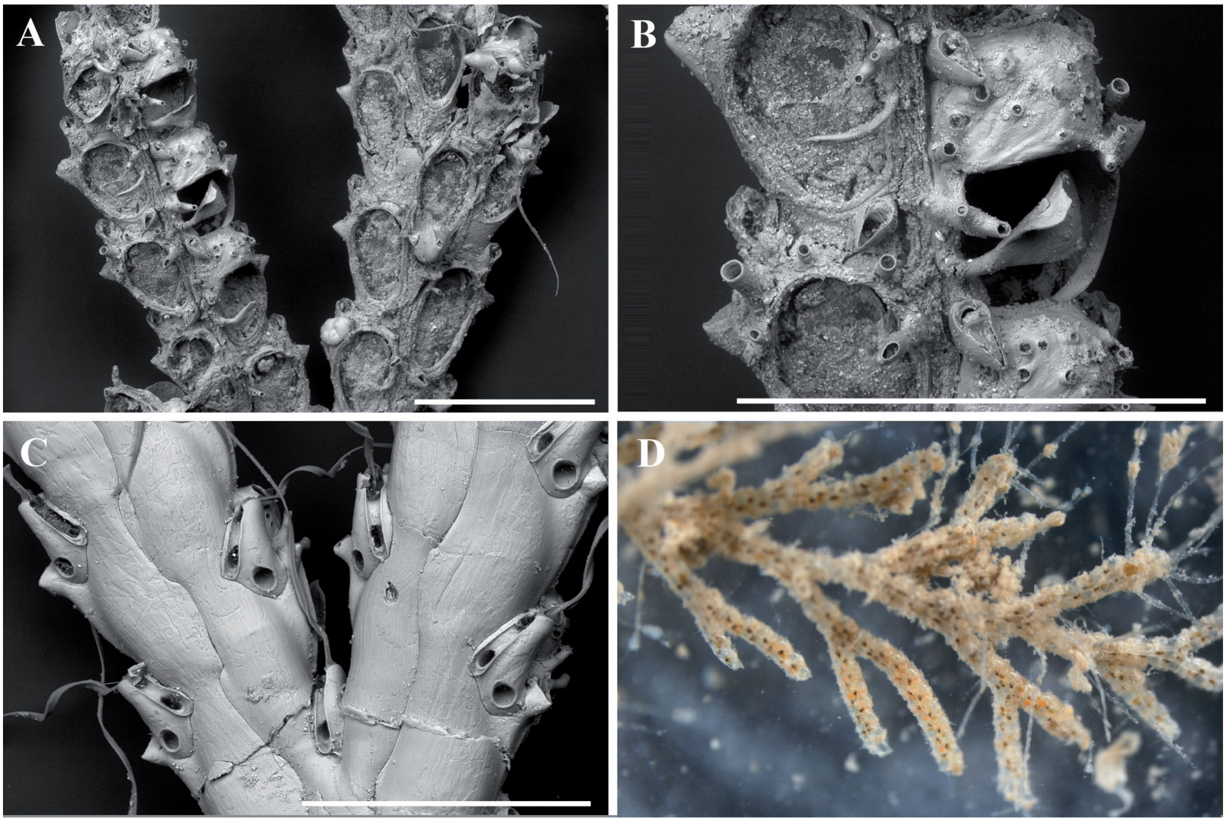

Fig. 6: *Licornia vieirai* sp. nov. A. Branches with large frontal avicularia (TAU-BR25012). B. Ovicellate and non-ovicellate zooids (TAU-BR25012). C. Abfronal view showing vibracula (TAU-BR25009). D. Part of a living colony (TAU-BR25012). Scale bars: 500 µm.

Material. Holotype:TAU-BR25009, Hrzelia, 10m**.** Paratypes: TAU-BR25010, Hadera, 15 m, fouling a pillar of a coal conveyer. NHMUK 2015.5.5.7, Ashkelon, 13 m. TAU-BR25012, Ashkelon, 30 m.

Derivation of name. In recognition of the research of the Brazilian bryozoologist Leandro Vieira.

Description. Colony erect, bushy, branches biserial, with autozooids at a slight angle to each other. Chitinous joints crossing the proximal opesia of outer zooids and below the opesia of the inner zooids at the bifurcation. Autozooids elongate, almost rectangular, with curved distal edges (Length =379 µm; r = 318–495 µm; CV = 16; n = 17. Width: 184 µm; r = 151–236 µm; CV = 11; n = 17). Opesia oval, occupying most of zooid length; scutum polymorphic, inserted at midline edge of opesia, in ovicellate zooids, club-shaped (but may be smaller and rounded probably depending on development stage), concave, directed forward and curved over the frontal membrane; in non-ovicellate zooids, if evident, appearing as a distomedial spiniform process. Oral spines numbering 4 or 5, two inner and two outer spines, the two most proximal spines may bifurcate; axial zooid with 5 oral spines and a larger frontal avicularium situated at the proximal edge of the zooid and directed outward. Lateral avicularium present near the distal outer edge of each autozooid, small, laterally directed; rostrum triangular, serrated; mandible hooked. Frontal avicularium, when present, located at inner proximal margin of opesia; rostrum and mandible triangular, varying in size. Vibracular chamber present on basal surface of each autozooid, tapering distally, almost triangular; setal groove straight (Vibraculum chamber length: 151 µm; r = 124–187 µm; CV = 12; n = 17). One proximal rhizoidal foramen; vibracular setae smooth, as long as two autozooids. Single axial vibraculum. Rhizoids tubular. Ovicell parasol-shaped over distal edge of opesia (ovicell length: 115 µm; r = 86– 178 µm; CV = 21; n = 15; ovicell width: 184 µm; r = 148–213 µm; CV = 10; n = 15); ectooecium perforated by about a dozen circular or elliptical pores.

Remarks. Following Vieira *et al.* (2013) most species of *Licornia* occur in the Indo-Pacific region and the only species so far recorded from the Mediterranean is *L. jolloisii* (d'Hondt, 1988).

Licornia vieirai sp. nov. shares many characters with *L. (Scrupocellaria) diadema* Busk, 1852 but differs mainly in the ovicell, which has significantly fewer pores in Busk's species. In addition, *L. diadema* has large aquiline frontal avicularia raised on a tubular base (Tilbrook & Vieira, 2012), different from those of *L. vieirai*.

Family Thalamoporellidae Levinsen, 1902
Genus ***Thalampororella*** Hincks, 1887
***Thalamoporella* sp.**
(Fig. 7)

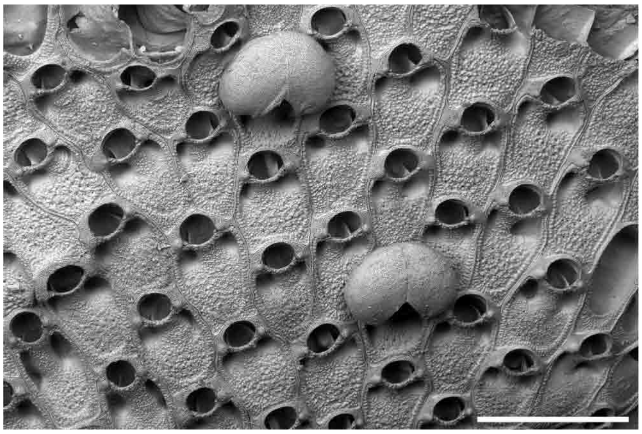

Fig. 7: *Thalamoporella* sp., part of colony showing two ovicells (TAU-BR25040). Scale bars: 500 µm.

Material. TAU-BR25040, Achziv, 4 m, on a bivalve shell.

Description. Colony encrusting, unilaminar. Autozooids almost rectangular, mean length = 493 (r = 444–562 µm; CV = 0.06; n = 15), widest at level of opesiules, mean width = 308 µm (r = 280–340 µm; CV = 0.07; n = 15); cryptocyst granular, lacking pores; lateral walls beaded; orifice wider than long (mean length = 123 µm; r = 137–101 µm; CV = 0.08; n = 15; mean width = 156 µm; r = 174–141 µm; CV = 0.07; n = 15), oval, condyles barely noticeable; small tubercles paired on each side of opesia; polypide tube short and wide, depressed; opesiules usually uneven; ovicells large (length = 364 µm; width = 517 µm; n = 2), bivalved with a median line of fusion. Avicularia lacking. Spicules comprising small and medium compasses.

Remarks. *Thalamoporella rozieri* has been described from Lebanon and has a similar ovicell shape and size, but the orifice and tubercles seem quite different from the species found in Israel (Harmelin, 2014 a). The unique specimen studied here cannot be confidently assigned to any of the species described so far but further material is required to justify erection of a new species.

Suborder Ascophorina Levinsen, 1909

Family Exechonellidae Harmer, 1957
Genus ***Exechonella*** Duvergier, 1924
Exechonella antillea Osburn, 1927
(Fig. 8)

Material. TAU-BR25058, Achziv Canyon, 25 m on *Schizoretepora* skeleton. TAU-BR25059, 60 m, on an ancient anchor found off Rosh Camel.

Description. Colony encrusting, small. Autozooids large, broad and flat, distinct, separated by shallow grooves; frontal shield with large, evenly spaced pores, each set in a depression centered on a slightly raised area; orifice longer than wide, with lateral condyles separating a semielliptical anter from a broad, U-shaped poster at about one-third length; Ovicells and avicularia wanting.

Remarks. This species is known from the Gulf of California, the Caribbean, Gulf of Mexico, Florida, West Africa and the Red Sea (Kocak *et al.,* 2002). In the Eastern Mediterranean it was described from the Aegean island of Chios (Hayward, 1974) and Cyprus (Kocak *et al.,* 2002), the new occurrences in Israel representing the first records from the Levant Basin.

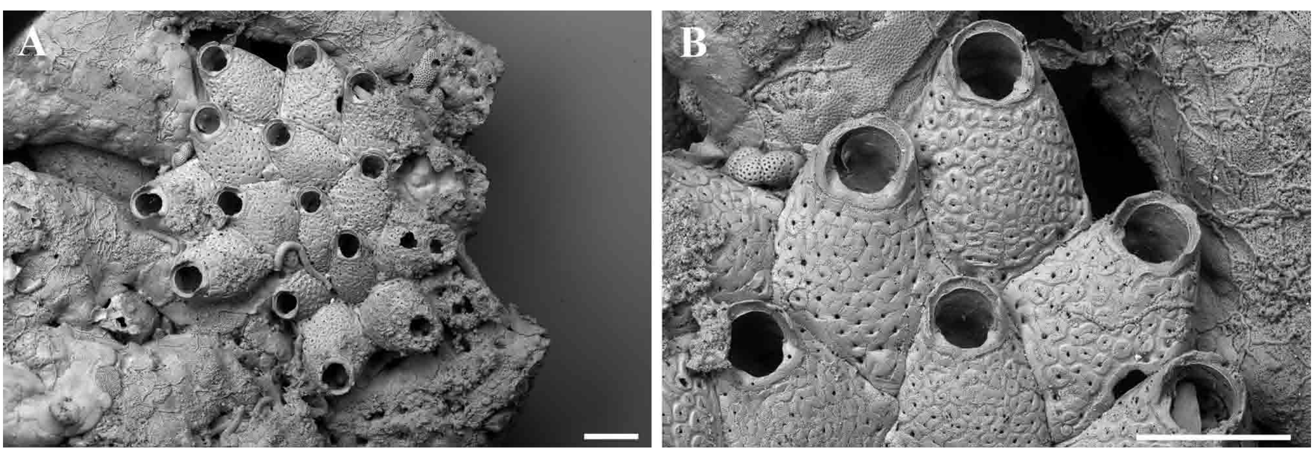

Fig. 8: *Exechonella antillea* (TAU-BR25058). A. Colony. B. A Zooids at colony edge. Scale bars: 500 µm.

Family Hippoporinidae Bassler, 1935
Genus ***Hippoporina*** Neviani, 1895
Hippoporina pertusa Esper, 1796
(Fig. 9)

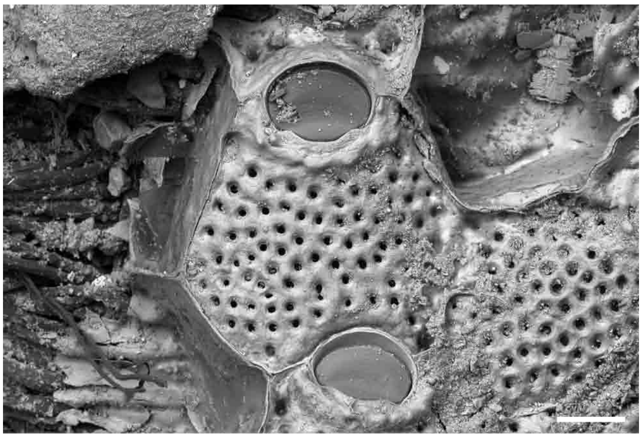

Fig. 9: *Hippoporina persuta.,* unbleached colony showing zooids with in-situ opercula (TAU-BR25069). Scale bar: 500 μm.

Material. TAU-BR25069, Ashkelon, 30 m, on a piece of cloth.

Description. Colony **e**ncrusting. Autozooids polygonal, separated by thin, raised walls; frontal shield flat or slightly convex, finely granular, evenly perforated with closely spaced round pores, developing a wide median umbo proximal to orifice; orifice slightly wider than long; sinus very shallow; condyles rounded; ovicells not observed. Avicularia not observed.

Remarks. The colony recorded from Israel is very small and because of the substratum type (cloth) bleaching was not attempted as it may have led to disintegration of the specimen. The opercula are intact in the unbleached specimen and consequently the shape of the condyles is obscured. The species is known from Europe (Bock, 2015) and the Aegean Sea in the Eastern Mediterranean (Kocak & Onen, 2014) but there are no previous records from the Levant basin.

Family Schizoporellidae Jullien, 1883
Genus ***Schizoporella*** Hincks, 1877
Schizoporella unicornis Johnston, 1847
(Fig. 10)

Material. TAU-BR25072, Achziv, 2 m.

Description. Colony encrusting, multiserial. Autozooids generally hexagonal to subrectangular with wide, squared distal end, broadening significantly prior to row bifurcations; frontal shield convex, covered with numerous irregularly arranged pseudopores and deep marginal areolar pores; umbo stout, proximal but not adjacent to orifice; primary orifice with broad U-shaped sinus and wide semielliptical anter; condyles robust, round; ovicell prominent, round and globular, recumbent on the fron-

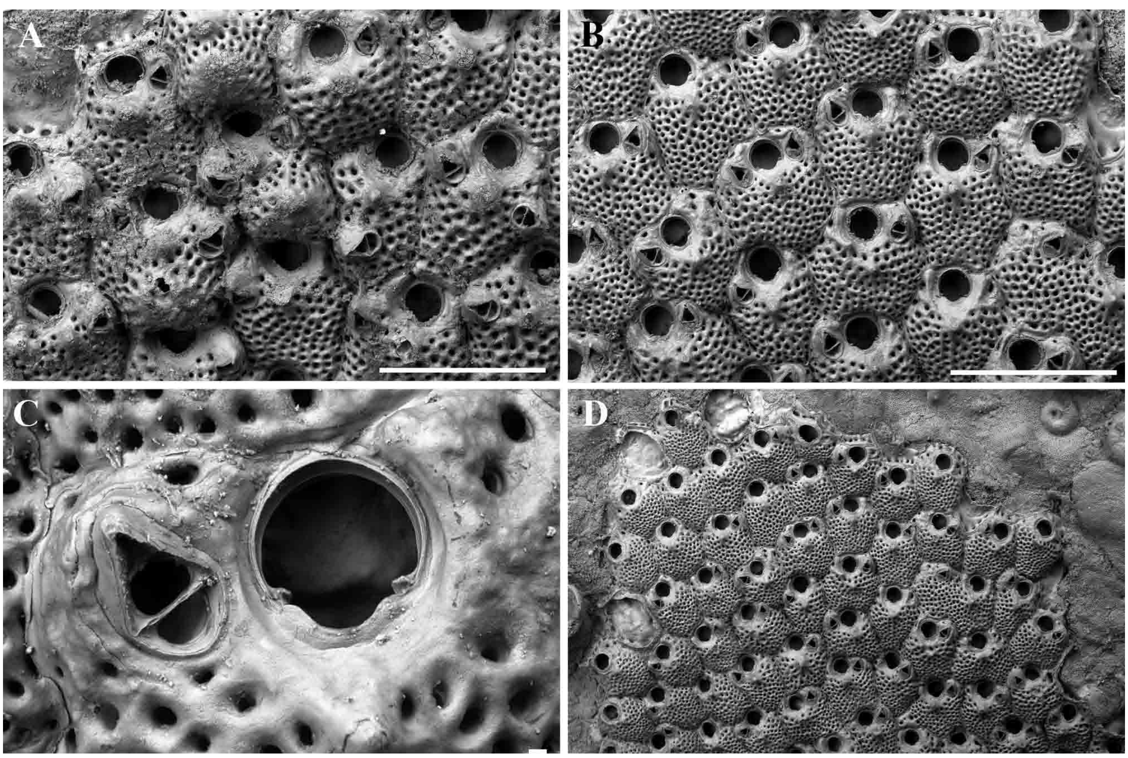

Fig. 10: *Schizoporella unicornis* (TAU-BR25072). A. Autozooids with well-developed umbos. B. Zooids and ovicells. C. Orifice and avicularia. D. Part of colony view with growing edge. Scale bars: 500 μm (A, B,D); 10 μm (C).

tal shield of distal zooid, distolaterally porous. Adventitious avicularia single or paired, directed distolaterally; rostrum acutely triangular with concave sides; opesia rounded, semicircular.

Remarks. The genus *Schizoporella* has 60 nominal species at the present day and distinguishing between them can be difficult. The umbo and paired avicularia are the main characters that identify the Israeli specimen as *S. unicornis*, a species comprehensively redescribed by Tompsett *et al.* (2009) based on a study of type and other material. This species is considered widespread, known from northeast Atlantic region to the western Mediterranean and the Adriatic (Hayward & Ryland, 2002). In the Eastern Mediterranean it was reported from the Sea of Marmara, Turkey (Kocak & Onen, 2014), but not previously from the Basin.

Family Escharinidae Tilbrook, 2006
Genus ***Therenia*** David and Pouyet, 1978
Therenia rosei Berning, Tilbrook and Rosso, 2008
(Fig. 11)

Material. TAU-BR25073, Achziv Canyon, 25 m. TAU-BR25074, on an ancient anchor found off Rosh Carmel at 60 m.

Description. Colony encrusting, unilaminar multiserial. Autozooids polygonal, broad and flat, closely contiguous with only a fine separating line visible in bleached colonies; frontal shield perforated by numerous small pseudopores, with a few larger areolar pores at corners; orifice approximately semicircular, distal edge curved, proximal edge almost straight with narrow, slit-like sinus and two lateral condyles giving it a notched appearance. Avicularia large, located proximolaterally of each autozooidal orifice; rostrum rounded; pivotal bar thick; mandible vibraculoid, very long, reaching almost 2 mm in length.

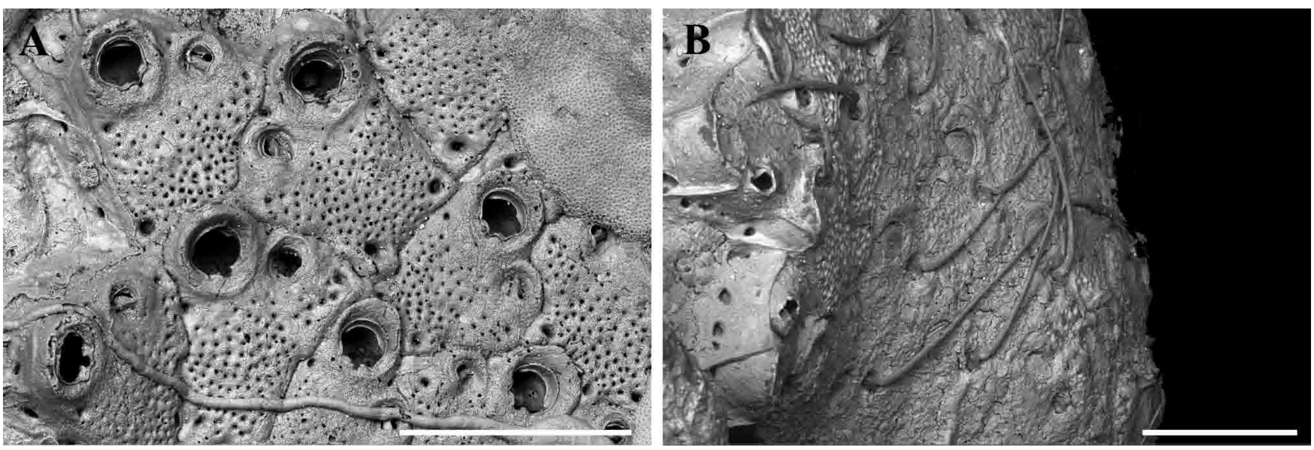

Fig. 11: *Therenia rosei.* A. Group of autozooids and avicularia (TAU-BR25073). B. Oblique view of unbleached colony with long setae (TAU-BR25074). Scale bars: 500 µm.

Remarks. *Therenia rosei* was recently erected by Berning *et al.* (2008) based on a holotype described by Hayward (1974) from the Aegean Sea and other material from the Ionian Sea (Rosso, 1996), both previously identified as *Escharina porosa*. This is a first record from the Levant Basin.

Family Gigantoporidae Bassler, 1934
Genus ***Cosciniopsis*** Canu & Bassler, 1927
Cosciniopsis ambita Hayward, 1974
(Fig. 12)

Material. TAU-BR25076, Achziv Canyon, 25 m.

Description. Colony encrusting, unilaminar, multiserial. Autozooids large, oval; frontal shield strongly convex, coarsely tuberculate, porous; orifice elliptical with prominent lateral condyles, enclosed by a low, slightly flared peristome. Avicularium placed laterally of orifice, enclosed within the peristome, rostrum directed proximally and curving around the orifice.

Fig. 12: *Cosciniopsis ambita* (TAU-BR25076), oblique view of zooids and growing edge. Scale bar: 500 µm.

Remarks. This species was first described from the Greek island of Chios by Hayward (1974) and was also recorded as *Cosiniopsis* sp. by Harmelin (1969) from other locations in the southern Aegean Sea. Recent records have been published from Sicily and the Ionian Sea (Rosso *et al*., 2013; Sanfilippo *et al*., 2015). Although small and infertile, the colony collected in Israel represents a first record in the Basin.

Family HippoporidridaeVigneaux, 1949
Genus ***Trematooecia*** Osburn, 1940
***Trematooecia mikeli* sp. nov.**
(Fig. 13)

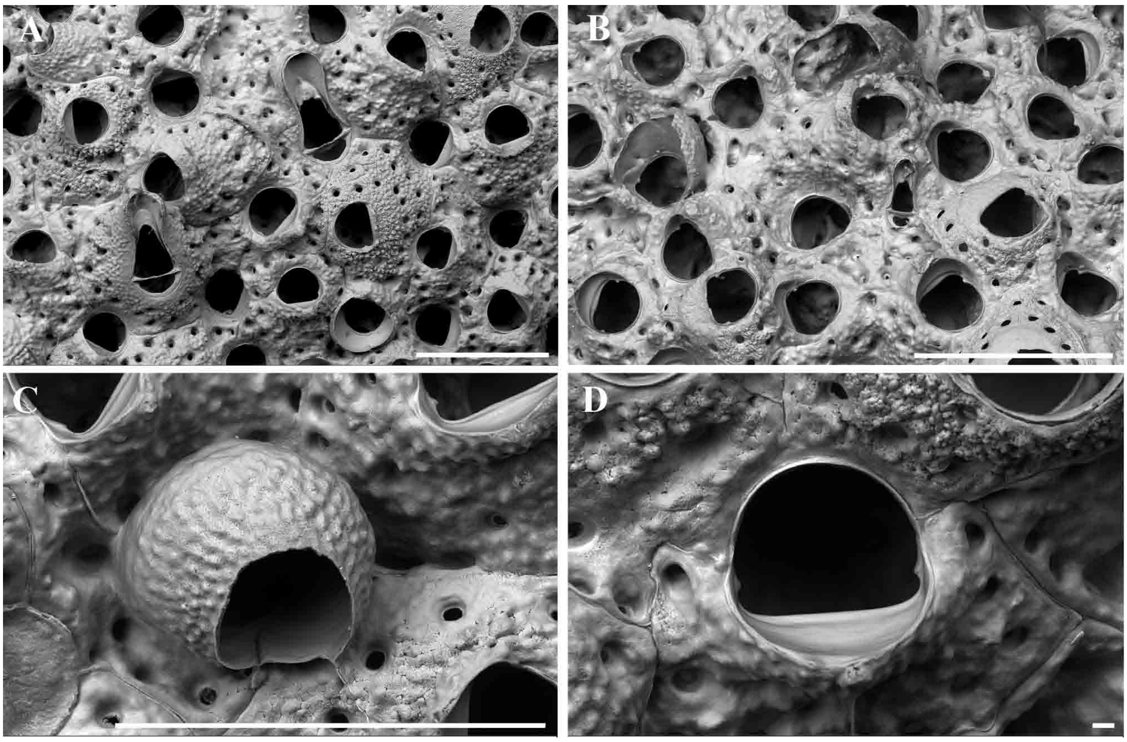

Fig. 13: *Trematooecia mikeli.* sp. nov. A. Part of a colony with two large interzooidal avicularia (TAU-BR25029). B. Colony with smaller interzooidal avicularia (TAU-BR25080). C. Ovicell (TAU-BR25029) D. Primary orifice with condyles (TAU-BR25029). Scale bars: 500 µm (A, B, C); 20 µm (D).

Material. Holotype: TAU-BR25029, Paratype: TAU-BR25080, Haifa Bay, 20 m, on the *Shelly* wreck.

Derivation of name. In recognition of the bryozoological research of the Spanish marine biologist Mikel Zabala.

Description. Colony encrusting, multilaminar, multiserial, large; grey-blue in colour. Autozooids irregularly polygonal (frontally budded), mean length 368 µm (r = 250–426 µm; CV = 11; n = 15), mean width 334 µm (r = 242–471 µm; CV = 19; n = 15); frontal shield granulated, porous with pores located mostly around edges of zooids, surface raised into mounds especially close to orifice; orifice sunken, semicircular with wide, straight-edged poster separated from semicircular anter by prominent condyles, mean length 145 µm (r = 111–163 µm; CV = 9; n = 15), mean width 154 µm (r = 135–172 µm; CV = 7; n = 15); peristome raised as a suboral tubercle or umbo in some zooids. Ovicell cap-shaped, bulbous, imperforate, granulated. Interzooidal avicularium spatulate, variable in size, mean length 381 µm (r = 198–510 µm; CV = 32; n = 9), mean width 124 µm (r = 71–158 µm; CV = 26; n = 9); rostrum rounded with concave edges; pivotal bar calcified; opesia crescent-shaped.

Remarks. Species of the genus *Trematooecia* are distributed predominantly in the warm waters of the tropics and subtropics, including the Caribbean, southwestern Pacific and West Africa. Eleven extant species have been assigned to the genus (Bock, 2015). Specimens here described most closely resemble *T. aviculifera* (Canu & Bassler, 1923), but differences include the lack of peristomial avicularia, the presence of condyles, and the shape of the interzooidal avicularia. Compared with *T. ligulata*, the only species of the genus known from the Mediterranean, *T. mikeli* shows greater differences, such as in orifice shape (egg shaped vs. D shaped) and ovicell morphology (immersed with long median foramen vs. cap-shaped).

Family Phidoloporidae Gabb & Horn, 1862

***Crenulatella* gen. nov.**

Type species: *Crenulatella levantinensis* sp. nov.

Derivation of name. In reference to the crenulated peristome.

Diagnosis. Encrusting Phidoloporidae; heavily calcified, few (3-5) marginal areolar pores; orifice without beading; peristome crenulated, broken examples revealing internal compartments; avicularia uncommon, small, suboral, directed laterally; Ovicells hyperstomial, enveloped by secondary calcification.

Remarks. The crenulated peristome is a distinctive feature of this new genus. Unlike most genera of phidoloporids, *Crenulatella* has an encrusting rather than an erect, reticulate colony. *Crenulatella* differs from the encrusting phidoloporid *Rhynchozoon* in lacking: (1) beading along the distal edge of the primary orifice; (2) a peristomoal pseudosinus; and (3) adventitious avicularia (Zabala & Maluquer, 1988) . The phidoloporid genus *Lifuella* Gordon & d'Hondt, 1997 shares some characters with *Crenulatella*, such as the shape of the autozooids and areolar pores as well as the orifice and ovicells. However, species of *Lifuella* have oral spines that are missing from the new genus described here. The new genus also resembles *Calvipelta* Tilbrook, 2006 (monospecific for *C. calvifrons* Tilbrook, 2006). However, marginal areolar pores and peristomial avicularia are not visible in *C. calvifrons*. In addition, salient zooidal boundary walls are present in *Calvipelta* but not in *Crenulatella*, and the peristome of *Calvipelta* is developed only along the lateral and distal sides of the orifice, not circumferentially as in *Crenulatella*.

Assignment of the new genus to Phidoloporidae is based on the frontal shield with areolar pores only and the morphology of the ovicell, as well as the general character of the calcification. However, it should be emphasized that the family-level classification of the new genus is somewhat equivocal in the absence of some typical phidoloporid features such as a beaded orifice.

***Crenulatella levantinensis* sp. nov.**
(Fig. 14)

Derivation of name. In reference to its occurrence in the Levant (eastern Mediterranean).

Material. Holotype: TAU-BR25002, Tel-Aviv Gordon, 6 m. Paratypes: TAU-BR25003, TAU-BR25004, TAU-BR25005, Achziv Canyon, 25 m. NHMUK 2015.5.5.6, Achziv Canyon, 25 m, encrusting an erect phidoloporid bryozoan.

Description. Colony encrusting, multiserial, unilamellar, small, 0.6–3.5 mm in diameter, containing between 6 and 84 zooids in the seven studied examples. Ancestrula

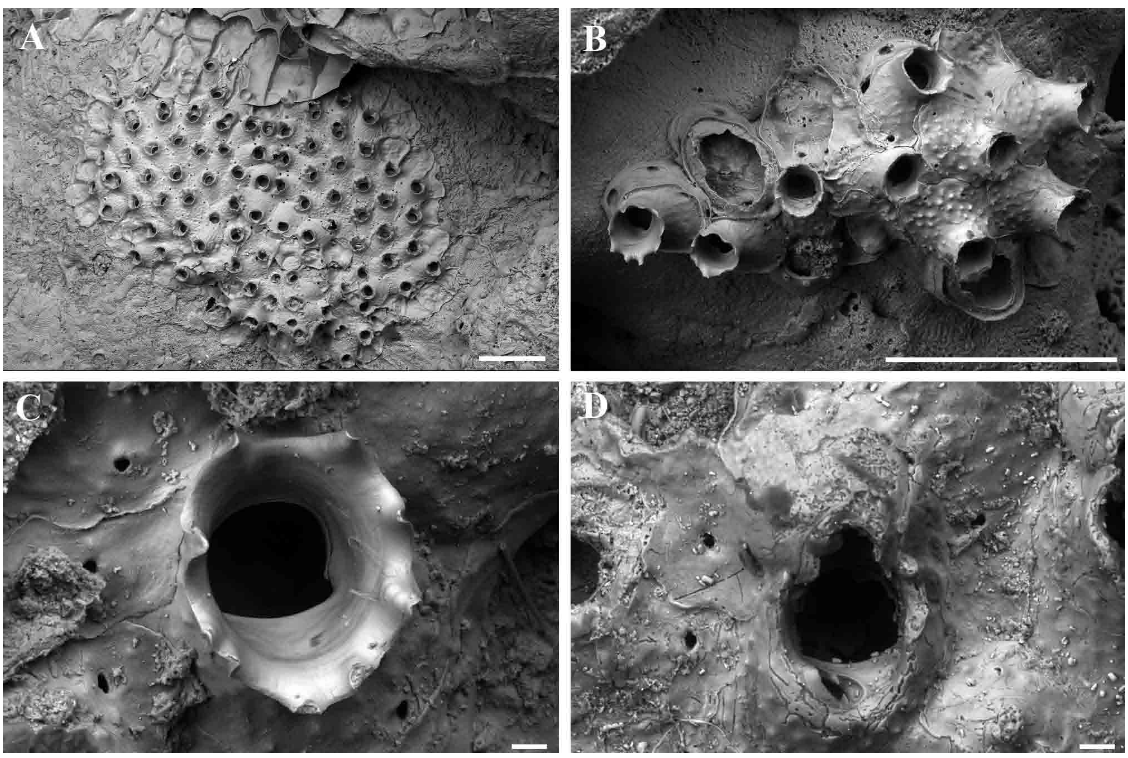

Fig. 14: *Crenulatella levantinenis gen.* et. sp. nov. A. Part of colony containing ovicellate zooids (TAU-BR25002). B. Young ancestrulate colony (NHMUK 2015.5.5.6.). C. Bell shaped orifice surrounded by crenulate peristome. (TAU-BR25003). D. Fertile zooid with ovicell covered by secondary calcification, and peristomial avicularium (TAU-BR25005). Scale bars: 500 µm (A, B); 20 µm (C); 30 µm (D).

tatiform, budding three periancestrular zooids, one distal and two distolateral. Autozooids oval, longer than wide: mean length = 260 µm (r = 220–310 µm; CV = 12; n = 14), mean width = 190 µm (r = 130–270 µm; CV = 20; n = 14) separated by thin sutures in young colonies, their boundaries becoming obscured in older colonies due to secondary calcification; frontal shield convex, imperforate centrally, a few (about 4) small, round areolar pores present marginally, nodular in young colonies becoming smoother in older colonies; primary orifice more or less bell-shaped: mean length = 76 µm (r = 60–90 µm; CV = 10; n = 8). mean width = 77 µm (r = 60–90 µm; CV = 17; n = 8), with small lateral condyles, proximal edge slightly convex, poster shallow, almost as broad as the larger anter; peristome crenulate, flared distally, sometimes with 6–8 spine-like processes, internal compartments evident in broken peristomes. Ovicell prominent, globular, enveloped by secondary calcification, a semicircular notch developed along proximal edge above orifice. Avicularia infrequent, possibly associated only with ovicellate zooids, single, adventitious, hidden inside peristome along proximal edge of the orifice, directed laterally parallel to the proximal edge of the orifice.

Remarks. Seven colonies of this new species from five samples were studied using SEM and a few more colonies were observed using a stereomicroscope only. According to J.-G. Harmelin (personal communication, May 2013), this species has not previously been described from the Mediterranean. While it could be a cryptic, long-term Mediterranean resident, it is equally possible that it is an invasive species.

Genus ***Reteporella*** Busk, 1884
***Reteporella* sp.**
(Fig. 15)

Material. TAU-BR25081, on a sponge collected using an ROV at 100 m.

Description. Colony erect, fan shaped, reticulate, with irregular, elongate fenestrules; colour pale pink when live. Autozooids elongate polygonal, arranged in alternating longitudinal series along branch frontal surfaces, separated by sutures in early ontogeny; frontal shield smooth with few marginal areolar pores; peristome obscuring proximal part of primary orifice; ovicell observed only in an incompletely developed state. Avicularia adventitous, suboral, small, incorporated in the peristome, directed proximally, inclined to frontal surface. Abfrontal surface composed of kenozooids bearing single oval adventitious avicularia.

Remarks. Thirteen species of *Reteporella* have been recorded in the Mediterranean (Rosso, 2003). The species reported here has some similarity to *R. beaniana*, particularly the smooth frontal shield with few marginal areolar pores and the presence of a suboral avicularia. However, the stout spines present on each side of the orifice are missing from the Israeli species. As this feature apparently typifies late ontogeny (Hayward & Ryland, 1996),

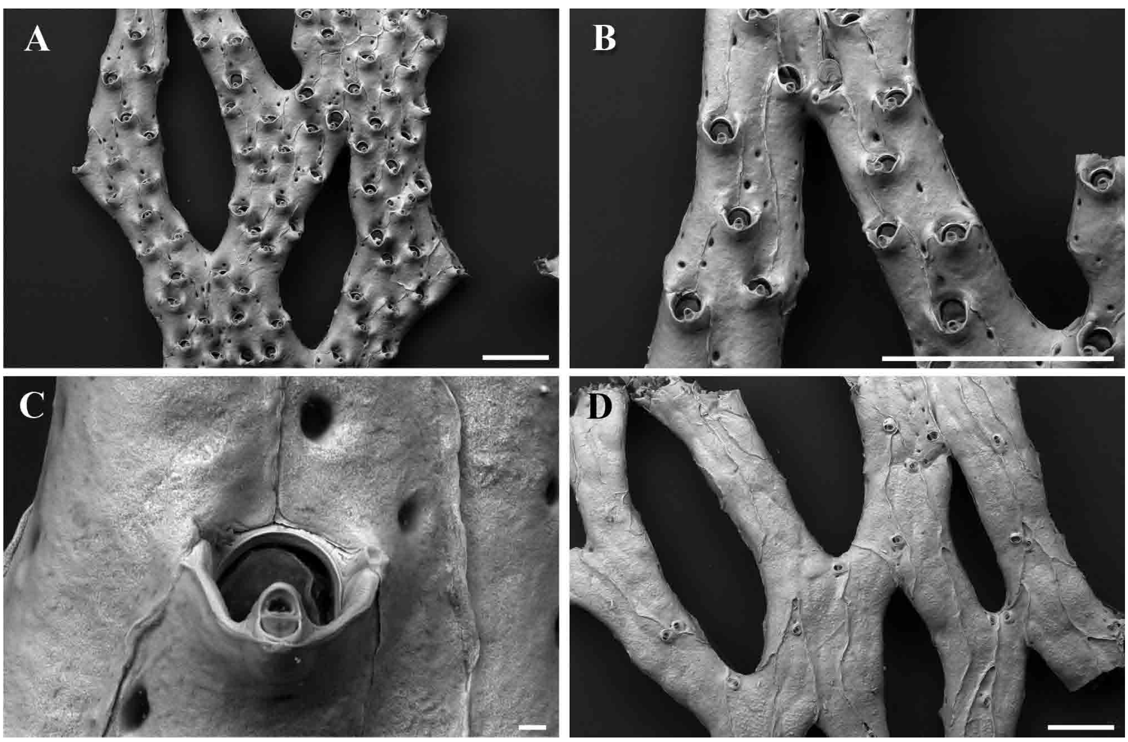

Fig. 15: *Reteporella* sp. (TAU-BR25081). A. Part of a colony. B. Two branches. C. Orifice and suboral avicularium. D. Abfrontal view. Scale bars: 500 µm (A, B, D); 20 µm (C).

it may be lacking in the material reported here which has no ovicells and may be too immature.

Estimation of sampling effort

A total of 47 species were identified among 132 bryozoan specimens all collected from shallow water (down to 30 m depth), except for one sample of *Reteporella* sp. collected at 100 m. The rarefaction curve based on these findings asymptotes at ~60 expected species and predicts that sampling 177 individuals would reveal 95% of the species present along the Mediterranean coast of Israel in shallow water, based on the point where the asymptote crosses the upper 95% confidence interval (Figure 17). Therefore, the species identified in this study can be inferred to represent 80% of the expected species for the shallow water bryozoan fauna in the Israeli Mediterranean.

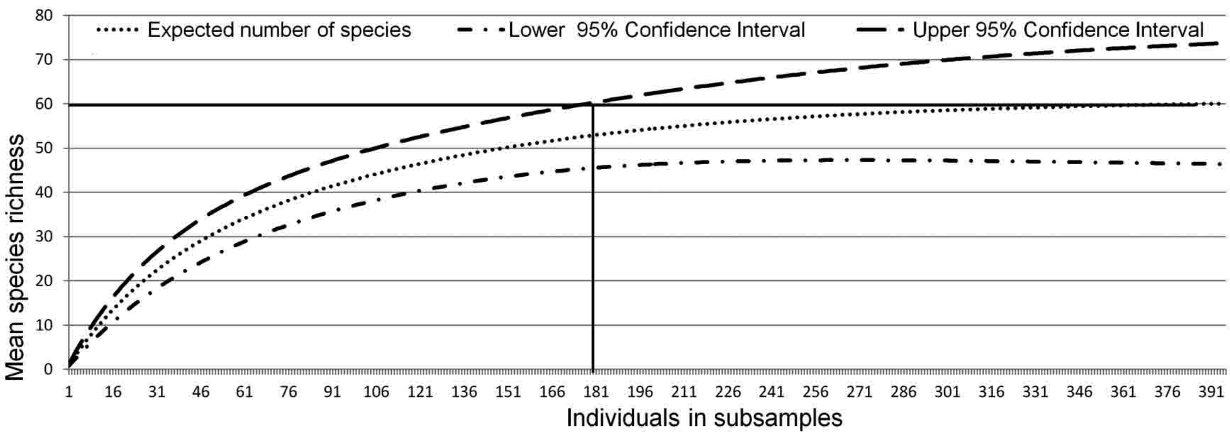

Fig. 16: Number of bryozoan species expected in shallow waters (down to 30 m) in the Israeli Mediterranean predicted using rarefaction. A random sample was repeated 100 times for each subsample. The black lines indicate the point where the asymptote crosses the upper 95% confidence line.

Discussion

The correct identification of bryozoan species is critical for mapping the biodiversity of the phylum. This, in turn, is important in the areas of: (1) ecological change (e.g., to detect temporal and spatial changes in community composition, or in the distribution of given species); (2) marine biotechnology (e.g., to be able to repeat studies in which a chemical with desired properties was isolated from a particular species); and (3) broader research projects which involve bryozoan species (e.g., molecular evolutionary studies that aim to reconstruct the metazoan tree of life, or environmental management).

The current study is the first attempt in over 40 years to study the Israeli Mediterranean bryozoan fauna from shallow waters. The 47 species found here do not represent the full richness, which rarefaction suggests is about 60 species, and provides only preliminary information about the local species composition of this phylum due to the limited number of sample sites. The methods applied for this study – collecting conspicuous colonies in shallow water (down to 30 m) and finding small colonies as a 'by-catch' in the laboratory while looking at pieces of rock using a binocular microscope – may create a biases. The finding of three species new to the Levant basin – *Crenulatella levantinensis* gen. et. sp. nov., *Licornia vieirai* sp. nov. and *Trematooecia mikeli* sp. nov., plus the first record for the Mediterranean Sea of *Conopeum ponticum* – strengthen the need for a broader study in this region. This should incorporate different sampling methods, such as benthic sledges and grabs, as well as further sampling using conventional methods of scuba and shore collecting etc.

Comparing the results of the current study with those published by d'Hondt (1988), while the total number of species is very similar, the number of species in common between the two studies is very low (Table 3), equivalent to less than one-third of the total number of species described in each study (overlapping species were estimated in a conservative manner, excluding potential synonyms and making the assumption that bryozoans identified only at genus level were conspecific). While all but two of the samples in the current study were collected by means of scuba diving in less than 30 m water depth, the majority of samples (81%) studied by d'Hondt were from greater depths. This reveals the potential to discover a much greater number of species in the Israeli Mediterranean.

It is also probable that the Israeli Mediterranean bryozoan fauna has changed due to the invasion of alien species during the last 40–50 years since the time that of collection of the material studied by d'Hondt (1988).

Table 3. Comparison of species diversity between the current study and that of d'Hondt (1988).

Species in common	d'Hondt (1988)	This study	
1?	7	1	Ctenostomata
1?	4	2	Cyclostomata
~14	40	44	Cheilostomata
16	51	47	Total

Reports from the region show an increasing number of alien species. Harmelin (2014) reported fourteen non-indigenous cheilostome bryozoans from Lebanon (a northern neighbour of Israel), including four genera new to the Mediterranean (two of which *Drepanophora* and *Mucropetraliella* are reported here as well). A comparison by Fishelson (2000) of faunal studies of different littoral phyla from the Israeli Mediterranean between the 1970s and the end of the 1990s showed an increase in Red Sea immigrant species (almost doubling in number), and a drastic decline of biodiversity and species richness at several polluted sites. Species of Red Sea origin comprised 15% of some of the studied communities (Fishelson, 2000). A similar phenomenon has been observed in fouling communities in the eastern harbour of Alexandria, Egypt, where variation in fouling communities through the last four decades was evident, including a shift not only in diversity but also in the dominant groups (Ramadan *et al.*, 2006).

The paucity of cyclostome bryozoans in Israel and the Eastern Mediterranean contrasts with their richness in the Western Mediterranean: Harmelin (1976) recorded 32 species of tubuliporine cyclostomes alone from Marseille, France. This pattern is consistent the more tropical character of the bryozoan fauna from the Eastern Mediterranean given the apparent decrease in the proportion of cyclostomes in bryozoan faunas at low latitudes (Taylor, 2001).

Bryozoa have been ranked as the eighth phylum in terms of their contribution to alien taxa invading the Mediterranean Sea, with 31 non-indigenous species (Zenetos *et al.*, 2012). The current study adds a further alien species (*Conopeum ponticum*). Eight additional species reported here are considered alien species in the Mediterranean (*Electra tenella*, *Licornia jolloisii* , *Celleporaria aperta, Drepanophora birbira, Parasmittina egyptiaca*, *P. protecta, Microporella harmeri, Mucropetraliella thenardii*), while two (*Thalamoporella harmelini* and *Schizoretepora hassi*) are suspected as being aliens as they are known only from the Levant basin (Harmelin *et al.*, 2007, 2009, 2011; Harmelin, 2014 a; Rosso, 1994; Zenetos *et al.*, 2010, 2012). All of the alien species reported above are considered to be warm-water species, known from tropical and sub-tropical regions, which makes them potentially Lessepsian migrants. These records mean that of the 47 species reported in this study 19% or 23% (depending on whether *T. harmelini* and *S. hassi* that known only from the Levant are included) are non-indigenous. This number may increase when the species that were determined here only to genus level are identified to species level, as they too may be alien to the Mediterranean. More alien species may be found in other habitats not sampled in this study (e.g. deeper water). It is worth noting that *Celleporaria fusca*, reported by d'Hondt (1988) but not found in the current study, is also considered alien (Zenetos et al., 2012). *Hippopodina iririkiensis*, which is not included in the Tel Aviv collection (and has no museum reference) but was studied by Eitan (1972) (as *Hippopodina feegeensis*), is another species considered as alien to the Mediterranean (Tilbrook, 1999; Zenetos *et al.*, 2012).

The strong fouling ability of bryozoans suggests that transport on the hulls of ships may be an important dispersal mechanism (Watts *et al.*, 1998). Along with the fact that bryozoan larvae are usually lecithotrophic and have a short duration (a few minutes to hours) (McKinney & McKinney, 2002), this makes it probable that most bryozoan introductions are ship-mediated. With the continuing rise in seawater temperatures, further changes in species composition in the Levant basin from one typical of the temperate Atlantic/Mediterranean, towards a warm, tropical fauna are likely. The Eastern Mediterranean is particularly prone to colonization by subtropical species because of its climate, low nutritional content, and proximity to the Suez Canal (Occhipinti-Ambrogi, 2007; Coll *et al.*, 2010; Lejeusne *et al.*, 2010; Katsanevakis *et al.*, 2014). Consequently, the Israeli Mediterranean bryozoan fauna should continue to be monitored through time as further changes in species composition are to be expected and may have economic consequences if levels of fouling increase or if native species are adversely impacted by the invaders.

Acknowledgements

For taxonomic advice, we would like to thank J.-G. Harmelin (Marseille), D. P. Gordon (NIWA, Wellington), L.M. Vieira (Sao-Paulo), A. Ostrovsky (Vienna) and J. Souto (Santiago de Compostela). We would like to thank one anonymous reviewer for insightful comments. N.S was supported by the Israel Taxonomy Initiative (ITI) Fund for Doctoral studies and travel fund. The Steinhardt Museum of Natural History and National Research Center, for Post Doctoral studies, a Costantiner travel

fellowship, a Kenneth Lindsday scholarship trust of the The Anglo-Israel Association, and a Lev Fishelson travel fellowship.

Supplementary material

SEM images of species found in this study known from the region, but have scarce detailed images in the literature.

References

Audouin, J. V., 1826. Explication sommaire desplanchesde polypes de l'Egypte et de la Syrie, publiees par Jules-Cesar Savigny. Imprimerie Impériale, Paris, 225-244.

Ayari, R., Taylor, P.D., Afli, A., Aissa, P., 2008. A new species of the cheilostome bryozoan *Trematooecia* Osburn, 1940 from the Mediterranean Sea. *Cahiers de Biologie Marine,* 49 (3), 261-267.

Bassler, R.S., 1934. Notes on Fossil and Recent Bryozoa. *Journal of the Washington Academy of Science,* 24, 404-408.

Bassler, R.S., 1935. *Bryozoa. Generum et Genotyporum. Index et Bibliographica*. W. Junk, s'Gravenhage, 229.

Berning, B., Tilbrook, K.J., Rosso, A., 2008. Revision of the north-eastern Atlantic and Mediterranean species of the genera *Herentia* and *Therenia* (Bryozoa: Cheilostomata). *Journal of Natural History,* 42 (21-22), 1509-1547Bock, P. 2015. *Bryozoa Homepage* (Accessed 12 June 2015).

Busk, G., 1852. An account of the Polyzoa, and sertularian zoophytes, collected in the Voyage of the Rattlesnake, on the coasts of Australia and the Louisiade Archipelago. Vol. 1. p. 343-402. In: *Narrative of the Voyage of the H.M.S. Rattlesnake.* MacGillivray, J. (Ed.). T. & W. Boone, London.

Busk, G., 1854. *Catalogue of marine Polyzoa in the collection of the British Museum, II. Cheilostomata (part)*. 1-55-120 pp. Trustees of the British Museum, London.

Busk, G., 1884. Report on the Polyzoa collected by H.M.S. Challenger during the years 1873-1876. Part 1. The Cheilostomata. Report on the Scientific Results of the Voyage of the H.M.S. "Challenger"*, Zoology,* 10, 1-216.

Canu, F., Bassler, R.S., 1923. North American later Tertiary and Quaternary Bryozoa. *Bulletin of the United States National Museum,* 125, 1-302.

Canu, F., Bassler, R.S., 1927. Classification of the cheilostomatous Bryozoa. p. 69: 1-42. In: *Proceedings of the United States National Museum*.

Coll, M., Piroddi, C., Kaschner, K., Ben Rais Lasram, F., Steenbeek, J. *et al*., 2010. The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats. *PLoS ONE* 5 (8), e11842.

Colwell, R.K. 2013. *EstimateS: Statistical estimation of species richness and shared species from samples. Version 9.*

David, L., Pouyet, S,. 1978. Le genre *Herentia* Gray, 1848 (Bryozoa, Cheilostomata). Systematique et phylogenese, biostratigraphie et biogeographie. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon*. H.S. 4, 167-193.

Duvergier, J., 1924. Deuxième note sur les Bryozoaires du Néogène de l'Aquitaine. *Actes de la Société linnéenne Bordeaux,* 75, 145-190.

Eitan, G., 1972. Types of metamorphosis and early astogeny in *Hippopodina feegeensis* Busk (Bryozoa: Ascophora). *Journal of Experimental Marine Biology and Ecology,* 8 (1), 27-30.

Ellis, J., Solander, D.C., 1786. *The Natural History of Many Curious and Uncommon Zoophytes, Collected from Various Parts of the Globe by the Late John Ellis... Systematically Arranged and Described by the Late Daniel Solander. With Sixty-two Plates*. White & Elmsly, London, 206 pp.

Esper, E.J.C., 1796. *Forsetzungen der Pflanzenthiere in Abbildungen nach der Natur mit Farbenerleuchtet hebst Beschreibungen. Theil 1*. Nürnberg, 230 pp.

Fernandez Pulpeiro, E., Reverter Gil, O., 1993. Le genre *Ellisina* (Bryozoa, Cheilostomida) sur les côtes européennes: description d'*Ellisina gautieri* sp. nov. *Cahiers de Biologie Marine,* 34 (1), 93-101.

Fishelson, L., 2000. Marine animal assemblages along the littoral of the Israeli Mediterranean seashore: the Red-Mediterranean Seas communities of species. *Italian Journal of Zoology,* 67 (4), 393-415.

Gabb, W.M., Horn, G.H., 1862. The fossil Polyzoa of the Secondary and Tertiary Formations of North America. *Journal of the Academy of Natural Sciences of Philadelphia,* 5: 111–179.

Galil, B.S., 2007. Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. *Marine Pollution Bulletin,* 55 (7-9), 314-322.

Galil, B.S., 2009. Taking stock: inventory of alien species in the Mediterranean Sea. *Biological Invasions,* 11 (2), 359-372.

Gordon, D.P., d'Hondt, J.L., 1997. Bryozoa: Lepraliomorpha and other Ascophorina, mainly from New Caledonian waters. *Mémoires du Muséum National d'histoire Naturelle,* 176, 9-124.

Gordon, D.P., Hosie, A.M., Carter, M.C., 2008. Post-2000 detection of warm-water alien bryozoan species in New Zealand – the significance of recreational vessels. *Virginia Museum of Natural History Special Publication,* 15, 37-48.

Gordon, D.P., Hossain, M.M., Wood, T., 2007. The known and anticipated bryozoan diversity of Bangladesh. *Journal of Taxonomy and Biodiversity Research,* 1, 45-58.

Gray, J.E., 1848. *List of the specimens of British animals in the collections of the British Museum. Part 1. Centrionae or radiated animals*. Trustees of the British Museum, London, 173 pp.

Harmelin, J.-G., 1976. Le sous-ordre des Tubuliporina (Bryozoaires Cyclostomes) en Méditerranée: écologie et systématique. *Mémoires de l'Institut Océanographique, Monaco* 10, 1-326.

Harmelin, J.-G., 2014a. Alien bryozoans in the eastern Mediterranean Sea-new records from the coast of Lebanon. *Zootaxa,* 3893 (3), 301-338.

Harmelin, J.-G., 2014b. *Monoporella bouchardii* (Audouin & Savigny, 1826) (Bryozoa, Cheilostomata): A forgotten taxon redescribed from Eastern Mediterranean material. *Cahiers de Biologie Marine,* (55), 91-99.

Harmelin, J.-G., Bitar, G., Zibrowius, H., 2007. *Schizoretepora hassi* sp. nov. (Bryozoa: Phidoloporidae) from Lebanon (Eastern Mediterranean) and reappraisal of *Schizotheca serratimargo* (Hincks, 1886). *Cahiers de Biologie Marine,* 48 (2), 179-186.

Harmelin, J.-G., Bitar, G., Zibrowius, H., 2009. Smittinidae (Bryozoa, Cheilostomata) from coastal habitats of Lebanon (Mediterranean Sea), including new and non-indigenous species. *Zoosystema*, 31 (1), 163-187.

Harmelin, J.–G., Ostrovsky, A.N., Caceres-Chamizo, J.P., Sanner, J., 2011. Bryodiversity in the tropics: taxonomy of *Microporella* species (Bryozoa, Cheilostomata) with personate maternal zooids from Indian Ocean, Red Sea and Southeast Mediterranean. *Zootaxa,* 2798, 1-30.

Harmer, S.F., 1926. *Polyzoa of the Siboga Expedition. Part II*. E. J. Brill, Leiden.

Harmer, S.F., 1957. *The Polyzoa of the Siboga Expedition. Part IV*. E. J. Brill, Leiden.

Hayward, P.J., 1974. Studies on the cheilostome bryozoan fauna of the Aegean island of Chios. *Journal of Natural History,* 8, 369-402.

Hayward, P.J., 1985. *Ctenostome bryozoans*. Synopses of the British Fauna, New Series. Brill, London, 169 pp.

Hayward, P.J., 1988. Mauritian cheilostome Bryozoa. *Journal of Zoology,* 215, 269-356.

Hayward, P.J., 2001. The identity of two species of cyphonautes larvae (Bryozoa: Cheilostomata) from Lizard Island, Great Barrier Reef, Australia. *Journal of the Marine Biological Association of the United Kingdom,* 81 (6), 995-1000.

Hayward, P.J., Ryland, J.S., 1985. Systematic notes on some British Cyclostomata (Bryozoa). *Journal of Natural History,* 19 (6), 1073-1078.

Hayward, P.J., Ryland, J.S., 1998. *Cheilostomatous Bryozoa. Part 1 Aeteoidea-Cribrilinoidea*. Field Studies Council, Shrewsbury.

Hincks, T., 1877. On British Polyzoa. Part 2. *Annals and Magazine of Natural History*, Series 4, 520-532.

Hincks, T., 1880a. *A history of the British Marine Polyzoa*. Van Voorst, London, 601 pp.

Hincks, T., 1880b. Contributions towards a general history of the marine Polyzoa. Part II. Foreign Membraniporina. *Annals and Magazine of Natural History*, Series 5, 6, 81-92.

Hincks, T., 1887. Critical notes on the Polyzoa. *Annals and Magazine of Natural History* Series 5, 19, 150-164.

Hondt, J.L., d’ 1985. Contribution à la systématique des Bryozoaires Eurystomes. Apport récents et nouvelles propositions.1-12. in: *Annales des sciences naturelles. Zoologie et biologie animale*, Elsevier.

Hondt, J.L., d’ 1988. Bryozoa from the Coast of Israel. *Bollettino di Zoologia*, 55 (3), 191-203.

Johnston, G., 1840. Miscellanea Zoologica. Description of a new genus of British Zoophyte. *Annals and Magazine of Natural History*, Series 1, (5), 272-274.

Johnston, G., 1847. *A history of British Zoophytes*. Van Voorst, London, 499 pp.

Jullien, J., 1883. Dragages du ‘Travailleur’. Bryozoaires, Espèces draguées dans l’Océan Atlantique en 1881. *Bulletin de la Société zoologique de France,* 7, 497-529.

Katsanevakis, S., Coll, M., Piroddi, C., Steenbeek, J., Ben Rais Lasram, F. *et al*., 2014. Invading the Mediterranean Sea: biodiversity patterns shaped by human activities. *Frontiers in Marine Science,* 1, 11.

Kocak, F., Balduzzi, A., Benli, H.A., 2002. Epiphytic bryozoan community of *Posidonia oceanica* (L.) Delile meadow in the northern Cyprus (Eastern Mediterranean). *Indian Journal of Marine Sciences,* 31 (3), 235-238.

Kocak, F., Onen, A.S., 2014. Checklist of Bryozoa on the coasts of Turkey. *Turkish Journal of Zoology,* 38 (6), 880-891.

Kress, N., Tom, M., Spanier, E., 2002. The use of coal fly ash in concrete for marine artificial reefs in the Southeastern Mediterranean: compressive strength, sessile biota, and chemical composition. *ICES Journal of Marine Science,* 59, S231-S237.

Lamouroux, J.V.F., 1812. Extrait d’un mémoire sur la classification des Polypiers coralligènes non entièrement pierreux. *Nouveau Bulletin Scientifique de la Societe Philosophique,* 3, 181-188.

Lamouroux, J.V.F., 1816. *Histoire des polypiers Coralligènes Flexibles, vulgairement nommés Zoophytes*. F.Poisson, Caen, 559 pp.

Lejeusne, C., Chevaldonne, P., Pergent-Martini, C., Boudouresque, C.F., Perez, T., 2010. Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea. *Trends in Ecology & Evolution,* 25 (4), 250-260.

Levinsen, G.M.R., 1902. Studies on Bryozoa. *Videnskabelige Meddelelser fra den naturhistoriske Foreningi København,* 54, 1-31.

Levinsen, G.M.R., 1909. *Morphological and systematic studies on the cheilostomatous Bryozoa*. Nationale Forfatterers Forlag, Copenhagen.

Manzoni, A., 1870. Bryozoi fossili Italiani. Quarta contribuzione. *Sitzungsberichte der Akademie der Wissenschaften in Wien (Abt. 1),* 61, 323-349.

McCann, L.D., Hitchcock, N.G., Winston, J.E., Ruiz, G.M., 2007. Non-native bryozoans in coastal embayments of the Southern United States: New records for the Western Atlantic. *Bulletin of Marine Science,* 80 (2), 319-342.

McKinney, F.K., McKinney, M.J., 2002. Contrasting marine larval settlement patterns imply habitat-seeking behaviours in a fouling and a cryptic species (phylum Bryozoa). *Journal of Natural History,* 36 (4), 487-500.

Neviani, A., 1895. Briozoi neozoici di alcune localitá d’Italia. Part 1. *Bolletino della Societá Romana per gli studi Zoologici,* 4, 109-123.

Norman, A., 1864. On undescribed British Hydrozoa, Actinozoa and Polyzoa. *Annals and Magazine of Natural History*, Series, 3, 13, 82-90.

Norman, A., 1903. Notes on the natural history of East Finmark, Polyzoa. *Annals and Magazine of Natural History*, Series 7, 11, 567-598.

Occhipinti-Ambrogi, A., 2007. Global change and marine communities: alien species and climate change. *Marine Pollution Bulletin,* 55 (7), 342-352.

Osburn, R.C., 1927. Bryozoa of Curaçao. *Bijdragen tot de Dierkunde,* 25, 123-132.

Osburn, R.C., 1940. Bryozoa of Porto Rico with a resume of West Indian Bryozoan fauna. *Scientific Survey of Porto Rico and the Virgin Islands,* 16, 321-486.

Orbigny, A., d’, 1851–4. *Paléontologie française. Description des Mollusques et Rayonne´s fossiles. Terrains Crétacés, V, Bryozoaires [1]*. Victor Masson, Paris.

Pallas, P.S., 1766. *Elenchus zoophytorum sistens generum adumbrationes generaliores et speciarum cognitarum succintas descriptiones cum selectis auctorus synonymis* Petrum van Cleef, Hagae-Comitum, 451 pp.

Powell, N.A., 1967. Bryozoa (Polyzoa) from South Red Sea. *Cahiers de Biologie Marine,* 8 (2), 161-183.

Powell, N.A., 1969. Indo-Pacific Bryozoa new to Mediterranean Coast of Israel. *Israel Journal of Zoology,* 18 (2-3), 157-168.

Ramadan, S.E., Kheirallah, A.M., Abdel-Salam, K.M., 2006. Marine fouling community in the Eastern harbour of Alexandria, Egypt compared with four decades of previous studies. *Mediterranean Marine Science,* 7 (2), 19-29.

Rasband, W.S., 1997–2014. ImageJ. U. S. National Institutes of Health, Bethesda, Maryland, USA, published at: http://imagej.nih.gov/ij/.

Rosso, A., 1994. Segnalazione di *Electra tenella* (HINCKS) (Bryozoa) lungo il versante sud-orientale della Sicilia. *Accademia Gioenia di Scienze Naturali Catania*, 27 (346), 241-251.

Rosso, A., 2003. Bryozoan diversity in the Mediterranean Sea. *Biogeographia,* 24, 219–238.

Rosso A., Chimenz Gusso C., Balduzzi A., 2010. Bryozoa. p. 17 (suppl.) 589-615. In: *Checklist della flora e della fauna dei mari italiani (parte II). Biologia Marina Mediterranea.* Relini G. (Ed.).

Rosso, A., Sanfilippo, R., Taddei Ruggiero, E, Di Martino, E., 2013. Faunas and ecological groups of Serpuloidea, Bryozoa and Brachiopoda from submarine caves in Sicily (Mediterranean Sea). *Bollettino Società Paleontologia Italiana,* 52 (3), 167-176.

Ryland, J.S., De Blauwe, H., Lord, R., Mackie, J.A., 2009. Recent discoveries of alien *Watersipora* (Bryozoa) in Western Europe, with redescriptions of species. *Zootaxa,* 2093, 43-59.

Sanfilippo, R., Rosso, A., Guido, A., Mastandrea, A., Russo, F. *et al*., 2015. Metazoan/microbial biostalactites from present day submarine caves in the Mediterranean Sea. *Marine Ecology,* 36, 1277-1293.

Soule, D.F., Soule, J.D., Chaney, H.W., 1999. New species of *Thalamoporella* (Bryozoa) with acute or subacute avicularium mandibles and review of known species worldwide. *Irene McCulloch Foundation Monograph Series,* 4, 1-57.

Taylor, P.D., 2001. Preliminary systematics and diversity patterns of cyclostome bryozoans from the neogene of the Central American Isthmus. *Journal of Paleontology,* 75 (3), 578–589.

Thessalou-Legaki, M. , Aydogan, O., Bekas, P., Bilge, G., Boyaci, Y.O. *et al*., 2012. New Mediterranean Biodiversity Records (December 2012). *Mediterranean Marine Science,* 13 (2), 312-327.

Tilbrook, K.J., 1999. Description of *Hippopodina feegeensis* and three other species of *Hippopodina* Levinsen, 1909 (Bryozoa : Cheilostomatida). *Journal of Zoology,* 247, 449-456.

Tilbrook, K.J., 2006. Cheilostomatous Bryozoa of the Solomon Islands. *Santa Barbara Museum of Natural History Monographs 4 (Studies in Biodiversity Number 3)*, 1-386.

Tilbrook, K.J., Vieira, L.M., 2012. *Scrupocellaria* (Bryozoa: Cheilostomata) from the Queensland coast, with the description of three new species. *Zootaxa,* 3528, 29-48.

Tompsett, S., Porter, J.S., Taylor, P.D., 2009. Taxonomy of the fouling cheilostome bryozoans *Schizoporella unicornis* (Johnston) and *Schizoporella errata* (Waters). *Journal of Natural History,* 43, 2227-2243.

van Beneden, P.J., 1850. Récherches sur les polypes bryozoaires de la Mer du Nord, et projet d'une classification des animaux de ce groupe. *Bulletin de l'Academie Royale de Belgique. Classes des Sciences,* 16, 644-658.

Vieira, L.M., Spencer Jones, M.E., Winston, J.E., 2013. Resurrection of the genus *Licornia* for *Scrupocellaria jolloisii* (Bryozoa) and related species, with documentation of *L. jolloisii* as a non-indigenous species in the Western Atlantic. *Journal of the Marine Biological Association of the United Kingdom,* 93 (7), 1911-1921.

Vigneaux, M., 1949. Révision des Bryozoaires néogènes du Bassin d'Aquitaine et essai de classification. *Mémoires de la Société Géologique de France, n.s.* 28, 1-153.

Waeschenbach, A., Vieira, L.M., Reverter-Gil, O., Souto-Derungs, J., Nascimento, K.B. *et al*., 2015. A phylogeny of Vesiculariidae (Bryozoa, Ctenostomata) supports synonymization of three genera and reveals possible cryptic diversity. *Zoologica Scripta,* 44, 667-683.

Watts, P.C., Thorpe, J.P., Taylor, P.D., 1998. Natural and anthropogenic dispersal mechanisms in the marine environment: a study using cheilostome Bryozoa. *Philosophical Transactions of the Royal Society, Series B* 353 (1367), 453-464.

Winston, J.E., 1982. Drift plastic – an expanding niche for a marine invetebrate. *Marine Pollution Bulletin,* 13 (10), 348-351.

Zabala, M., Maluquer, P., 1988. *Illustrated keys for the classification of Mediterranean Bryozoa*. *Treballs del Museu de Zoologia, Barcelona,* 4, 294 pp.

Zenetos, A., Gofas, S., Verlaque, M., Cinar, M., Garcia Raso, J.E. *et al*., 2010. Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. *Mediterranean Marine Science,* 11 (2), 381-493.

Zenetos, A., Gofas, S., Morri, C., Rosso, A., Violanti, D. *et al*., 2012. Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Patterns in introduction trends and pathways. *Mediterranean Marine Science,* 13 (2), 328-352.