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# Alien and cryptogenic Foraminifera in the Mediterranean Sea: A revision of taxa as part of the EU 2020 Marine Strategy Framework Directive

**Ruta STULPINAITE[1], Orit HYAMS-KAPHZAN[2] and Martin R. LANGER[1]**

[1] Institut für Geowissenschaften, Paläontologie, Nussallee 8, 53115 Bonn, Germany
[2] Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

Corresponding author: martin.langer@uni-bonn.de

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## Abstract

The human-mediated translocation of marine alien species beyond their natural ranges started as early as people began navigating the sea and is of growing concern to nature conservation. The Mediterranean Sea is among the most severely affected areas by biological invasions, a phenomenon that has been fostered by the opening and recent extension of the Suez Canal, the transport and release of ballast water, aquaculture and aquarium trade, ichthyochory and other active or passive dispersal mechanisms. The increase of marine invasions has stimulated considerable research, but for some important groups, in particular microorganisms, data are still limited. In this paper we have reviewed the current status of marine alien foraminifera in the Mediterranean Sea. Our survey includes a comrephensive taxonomic revision of previously recognized alien taxa, and new information obtained from the fossil record and from molecular studies. Our survey and reexamination of alien benthic foraminifera yielded a total of 44 validly recognized species and two species of cryptogenic taxa and reduces the number of previous recordings. The revised list includes both larger symbiont-bearing and smaller benthic foraminifera, including 16 hyaline-perforate, 3 agglutinated and 25 porcelaneous taxa. The vast majority of alien foraminifera recorded so far have become established in the Eastern and Central Mediterranean Sea, indicative for translocation and introduction via the Suez Canal pathway. Only one species, *Amphistegina lobifera*, causes significant ecological impacts and fulfills the criteria to be considered as an invasive alien. This species is a prolific carbonate producer, and displays extreme forms of ecosystem invasibility with capabilities to reduce native diversity and species richness. The proliferation and rates of recently observed range extensions, track contemporary sea surface temperature increases, provide strong support for previous species distribution models, and corroborate findings that rising water temperatures, global climate change and the extension of climate belts are major drivers fueling the latitudinal range expansion of larger symbiont-bearing and smaller epiphytic foraminifera. Intensified efforts to study alien foraminifera on a molecular level, in dated cores and in ballast water are required to trace their source of origin, to identify vectors of introduction and to verify their status as true aliens.

**Keywords:** Alien foraminifera; invasive species; taxonomy; biogeography; Mediterranean Sea.

## Introduction

Alien or non-indigenous species (NIS), as defined in the European *Union's* Regulation 1143/2014 (EU, 2014a), are organisms introduced outside their natural range and dispersal potential. While most of them have little impact and are not a cause of concern, others can become invasive and pose a serious threat to biodiversity, ecosystem services, and coastal economies. More than 1400 marine species are currently recognized to be alien, cryptogenic or questionable to European waters, among which the Mediterranean Sea is the most impacted (Tsiamis *et al.*, 2019, 2020; Galil *et al.*, 2015; Zenetos & Galanidi, 2020; Zenetos, 2017). The number of marine alien species introductions continues to grow as global trade, shipping, fishing, travel, commercial mariculture, and aquarium trade allow species to be transported over large distances and to reach regions outside their native range not previously accessible to them.

The transfer of species started as early as shipping trade, and ballast water has been recognized as a major vector for the translocation of aquatic species across biogeographic boundaries. A substantial number of alien species are also translocated as hitchhikers by using floating objects for attachment and dispersal [e.g. ship hulls, marine plastic litter, trash, mollusk veliger shells (Gollasch, 2002; Nessbit, 2005; Rech *et al.*, 2016)]. Today, more than 80% of global trade is transported by commercial shipping (UNCTAD, 2019) and maritime transport will remain the most important transport mode in the foreseeable future. International shipping is responsible for transporting and discharging ~ 3-12 billion tons of ballast water and 100 million tons of sediment each year (UNCTAD, 2019), and Cohen (1998) estimated that up to 10,000 aquatic alien species are transported in ships around the world per day. The rise of alien species around the globe is a consequence of an increasingly connected world and the result of human population growth (Pyšek *et al.*, 2020).

Biological invasions are now recognized as a major driver of biodiversity change across the globe (Vitousek *et al.*, 1996; Ojaveer *et al.*, 2015). The capacity to mitigate potential risks posed by alien species depends on precise, up-to-date and easily accessible information. To increase awareness and to facilitate effective prevention and management activities, comprehensive databases were established through large-scale international collaborations and advances in analytical bioinformatic tools. Comprehensive accounts are now available for plants, bryophytes, terrestrial snails, ants, spiders, amphibians, birds and mammals (Pyšek *et al*., 2020). For some important groups of organisms, in particular microorganisms, data are still limited. Here we provide a comprehensive review of alien and invasive benthic foraminifera from the Mediterranean Sea. Foraminifera are a highly diverse group of single-celled eukaryotes, characterized by granular pseudopodia and a test that can be organic, agglutinated or calcareous. They are among the most abundant testate protists in the world's ocean, have an excellent fossil record and their shells represent a major and globally significant sink for calcium carbonate (Langer, 2008). To assess the current state, we carefully reviewed the presence of NIS benthic forminifera in the Mediterranean Sea.

The Mediterranean is a semi-enclosed sea at the crossroads between Europe, Africa and Asia and a global hotspot of marine alien species (Costello *et al*., 2010; Molnar *et al.;* 2008; Edelist *et al*., 2013; Katsanevakis *et al.*, 2014a). During the 10th meeting of the Conference of the Parties at Nagoya in 2010, a New Strategic Plan for Biodiversity 2011-2020 was adopted in the Convention on Biological Diversity (CBD, 2012, 2014). This included *Aichi Target 9* on alien species, with the requirement that "*By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled and eradicated and measures are in place to manage pathways to prevent their introduction and establishment*". The Marine Strategy Framework Directive (MSFD) of the European Union (Directive 2008/56/EC), initiated to achieve Good Environmental Status (GES) in the EU's marine waters by 2020, included the assessment of Non-Indigineous Species (NIS) as key Descriptor D2 (EU, 2008). In 2014, the EU Regulation 1143/2014 on Invasive Alien Species (IAS) has been implemented to oversee the detection, main pathways and early control or eradication until 2020 (EU, 2014a). To satisfy the need and in partial fulfillment to achieve the goals set by the EU Directive and Aichi Target 9, this survey provides a comprehensive reexamination, status-report and overview of NIS benthic foraminifera morphospecies and molecular types currently recognized in Mediterranean waters.

## Material and Methods

The European Alien Species Information Network (EASIN) was launched with the aim to enable easy access to data and information on alien species in Europe and to assist scientists and policy makers in their efforts to prevent, control and manage alien invasions (Katsanevakis *et al.,* 2012). EASIN is an initiative of the Joint Research Centre (JRC) of the European Commission and has been established as a platform upon the recognition of the increasing serious threat posed by alien species in Europe. The EASIN information system facilitates the implementation of the EU Regulation 1143/2014 on Invasive Alien Species (EU, 2014a), and entered into force to fulfill Action 16 of Target 5 of the EU 2020 Biodiversity Strategy, as well as Aichi Target 9 of the Strategic Plan for Biodiversity 2011-2020 under the Convention of Biological Diversity.

EASIN (2020) currently contains the most complete register of foraminifera considered to be alien to the Mediterranean Sea. Primary data inserted into the EASIN database originate from published resources and contain the scientific name of the species, coordinates where the species was found, notes on the location, the date of observation, and a reference to a scientific publication/data source to allow proper citation and to link data to its original source. To respect high standards, quality assurance of the EASIN catalogue is provided by the EASIN Editorial Board (EB), a group of taxonomic experts responsible for specific groups of species. In an effort to update the existing account on invasive alien foraminifera in the Mediterranean Sea, we have conducted a large-scale survey on the existing literature. This includes a careful revision of the current taxonomic status of species, records and observations from new core material, and recent findings from molecular genetic analysis. The bulk of data have been carefully extracted from literature records published by generations of micropaleontologists. Literature data have been carefully surveyed and with a few exceptions include only adequately illustrated studies to assure taxonomic consistency. Because species-level taxonomy may vary from author to author and affects biogeography, all literature records have been critically reevaluated by the authors. The uniformity of nomenclature thus provides a framework of recognizable species that minimizes human-created taxonomic and identification weaknesses.

According to the Convention on Biological Diversity (CBD, 2012), alien species "*refers to a 'species, subspecies or lower taxon, introduced outside its natural past or present distribution; including any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce*". Because foraminifera are extremely abundant and provide an excellent fossil record, past occurrences can be traced from dated fossil material, a feature potentially masked by recent invasions through the opening of the Suez Canal in 1869, an artificial waterway connecting the Indian Ocean and the Mediterranean Sea. Thus, our survey includes fossil records from dated cores (0.3-120 m) using OSL, $^{14}C$ and $^{210}Pb$ (Toueg, 1996; Avital, 2002; Tapiero, 2002; Tapiero *et al.*, 2003; Avnaim-Katav, 2010; Hyams-Kaphzan, unpublished data) *with a focus on sites from the shallow Mediterranean coast of Israel:* Achziv, Haifa, Dor, Beit-Yanai, Caesarea, Herzliya, Palmachim and Ashkelon. Benthic foraminifera obtained from material of other cores in the Mediterranean Sea apart from Israel (e.g. Koukousioura *et al.,* 2012; Milker & Schmiedl, 2012; Melis *et al.,* 2015) were also examined to verify the presence and identity of species pre-dating the opening of the Suez Canal in 1869. In the following we discuss the foraminifera species listed in the EASIN database together with new additions recently reported in the literature. For each species we provide the first record and locality, original citation, references, a synonymy, occurrence records in Mediterranean subregions, and discuss their status classified as alien, invasive, native, cryptogenic, or absent in respect to previously published studies on alien foraminifera (Table 1, Table 2, Fig. 1). Potential pathways for the introduction (Table 1) are inferred from habitat preferences, live modes (epiphytic, epifauna, infauna), field and laboratory studies (Finger 2017; Langer, 1993; Jorissen, 1987; Hyams *et al.*, 2002; Alve & Goldstein, 2003; Langer *et al.,* 2009; Guy-Haim *et al.*, 2017; Weinmann *et al.*, 2019; McGann *et al.* 2020). Additional information is provided when a species was recorded in fossil or core material and when new molecular genetic data were available. The taxonomy adopted here generally follows Cimerman & Langer (1991), Hottinger *et al.* (1993), and Langer & Schmidt-Sinns (2006), with additional modern revisions provided by Parker (2009), Förderer & Langer (2018, 2019), WORMS (2020), and Fajemila *et al.* (2020).

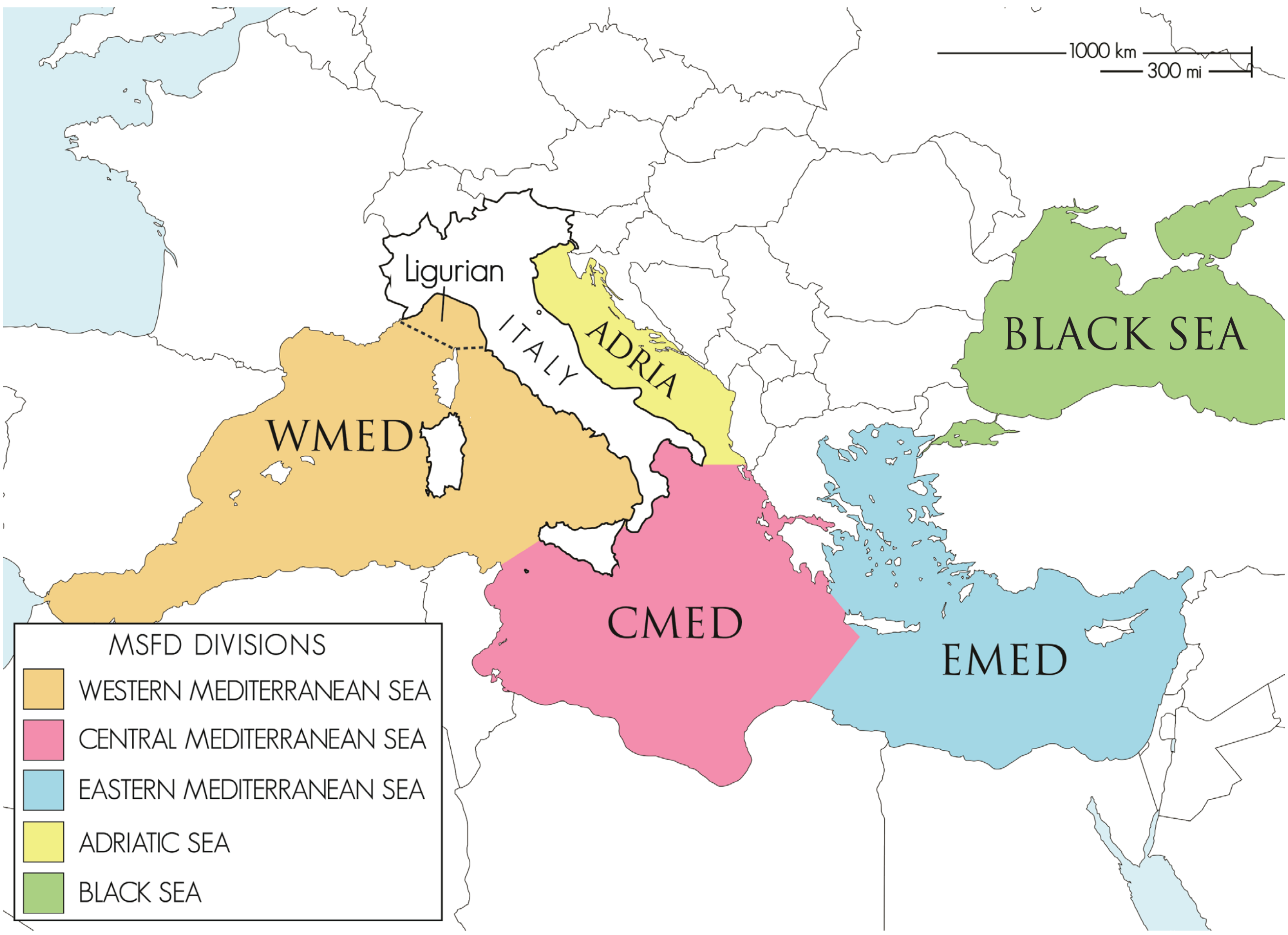


***Fig. 1:*** Mediterranean marine subregions according to the MSFD (Directive 2008/56/EC) as delineated by Article 4 of the MSFD (Jensen *et al.,* 2017; modified after Servello *et al.,* 2019). The border between ADRIA and CMED is defined by a line that runs from Capo Santa Maria di Leuca (Italy) (39.8° N, 18.36666° E) to the west coast of Corfu (Greece) (39.75194° N, 19.62777° E); the border between CMED and WMED is defined by a line that joins Capo Bon (37.08333° N, 11.05° E) (Tunisia) with Capo Lilibeo (37.8° N, 12.43333° E) (Sicily, Italy); between Sicily and the mainland of Italy, the border of WMED is a line that connects Capo Peloro (North-East Sicily, Italy) (38.26666° N, 15.65° E) to Capo Paci (Calabria, Italy) (38.25° N, 15.7° E) on the mainland. The border between the Central Mediterranean Sea and Eastern Mediterranean Sea (=Aegean-Levantine Sea) subregions is based on the reporting of Greece of its marine waters in 2012 under MSFD Article 8, 9 and 1020 and runs from the Greek mainland to the Island of Kithira (Greece), to the western coast of Crete and to Ras Al Hilal (Libya).

**Table 1. Alphabetical list of currently recognized alien foraminifera in the Mediterranean Sea.**
**Abbreviations**: **Year**=Year of first detection in the Mediterranean Sea as reported for the collection of the material in the publication; **REF**=References for the first year of detection in the Mediterranean Sea; **NDR**= Native distribution (Oceanic region from where the holotype was described); **RS=**Red Sea, **IO=**Indian Ocean, **IP=**Indo-Pacific, **PTW=**Pacific Tropical West, **PTE=**Pacific Tropical East, **PT=**Pacific Tropical, **PO=**Pacific Ocean, **PW**=Pacific West, **PN**=Pacific North, **PS**=Pacific South, **PSE**=Pacific Southeast, **PSW=**Pacific Southwest, **PNE=**Pacific Northeast, **PNW=**Pacific Northwest, **ASE**=Atlantic Southeast, **ASW**=Atlantic Southwest, **ANE**=Atlantic Northeast, **ANW=**Atlantic Northwest, **ATW**=Atlantic Tropical West, **ATE=**Atlantic Tropical East, **AT=**Atlantic Tropical, **AO**=Atlantic Ocean, **AW**=Atlantic West, **AN=**Atlantic North, **ArO=**Arctic Ocean, **CoC=**Cosmopolitan Circumtropical, **CoT=**Cosmopolitan Temperate, **UNK=**Unknown; **Success**=population success, **CAS**=casual, **EST**=established, **Inv**=invasive, **UNK**=unkown; **PP**=Potential Pathway; **COR**=Transport via the Suez Canal Corridor; **TC/AN**=Transport Contaminant: Contaminant on animals (species transported by host/vector); **TS**=TRANSPORT STOWAWAY: (Ship/boat ballast water, Ship/boat hull fouling); **TS/AFS**=TRANSPORT STOWAWAY: Attached to floating substrates (wood, seagrass leaves, rhizomes, algae) including plastic waste; Occurrence records of alien foraminifera in MSFD subregions of the Mediterranean Sea (for details see Servello *et al.*, 2019): MSFD subregions: the Adriatic (**ADRIA**), the central Mediterranean (**CMED**), the western Mediterranean (**WMED**), and the eastern Mediterranean (**EMED**).

| ***Species Name*** | **Year** | **REF (* not illustrated or unpublished record)** | **NDR** | **MSFD subregions** | **Success** | **PP** |
|---|---|---|---|---|---|---|
| *Agglutinella compressa* El-Nakhal, 1983 | 1998 | Hyams-Kaphzan *et al*., 2008 | RS | EMED | CAS | COR, TS |
| *Amphistegina lessonii* d'Orbigny, 1826 | 1974 | Hollaus & Hottinger, 1997 | IO | EMED, CMED, WMED | EST | COR, TS, TC/AN, TS/AFS |
| *Amphistegina lobifera* Larsen, 1976 | 1955-1964 | Blanc-Vernet, 1969 | RS | EMED, ADRIA, CMED, WMED | INV | COR, TS, TC/AN, TS/AFS |
| *Amphistegina* cf. *A. papillosa* Said, 1949 | 2005 | Caruso & Cosentino, 2014 | RS?/IO? | CMED, WMED | EST | COR, TS, TC/AN, TS/AFS |
| *Borelis schlumbergeri* (Reichel, 1937) | 1999 | Hyams (2000) | IO | EMED | EST | COR, TS, TS/AFS |
| *Brizalina simpsoni* (Heron-Allen & Earland, 1915) | 2007 | Meriç *et al*., 2010*, Meriç *et al*., 2014 | IO | EMED | CAS | COR, TS, TS/AFS |
| *Cibicides mabahethi* Said, 1949 | 1998 | Hyams (2000) | RS | EMED | CAS | COR, TS, TS/AFS |
| *Clavulina* cf. *C. multicamerata* Chapman, 1907 | 1972-1974 | Blanc-Vernet *et al*., 1979 | PSW/IO | EMED, CMED | EST | COR, TS |
| *Cycloforina* sp. | 2008 | Langer, 2008 | RS | EMED | CAS | COR, TS, TS/AFS |
| *Cyclorbiculina compressa* (d'Orbigny, 1839) | 2002 | Meriç *et al*., 2008a | ATW | EMED | EST | TS, TC/AN, TS/AFS |
| *Elphidium striatopunctatum* (Fichtel & Moll, 1798) | 1998 | Hyams, 2000 | RS | EMED | EST | COR, TS, TS/AFS |
| *Epistomaroides punctulata* (Said, 1949) | 2005 | Almogi-Labin & Hyams-Kaphzan, 2012 | RS | EMED | EST | COR, TS, TS/AFS |
| *Haddonia* sp. | 1996 | Hyams-Kaphzan, unpubl. | RS | EMED | CAS | COR, TS |
| *Hauerina diversa* Cushman, 1946 | 1996 | Hyams, 2000 | PT | EMED | EST | COR, TS, TS/AFS |
| *Heterostegina depressa* d'Orbigny, 1826 | 1965 | Moncharmont Zei, 1968 | ASE | EMED | EST | COR, TS, TS/AFS |
| *Loxostomina* cf. *L. africana* (Smitter, 1955) | 1972-74 | Alavi, 1980 | IO | EMED | EST | COR, TS, TS/AFS |
| *Mimosina affinis* Millett, 1900 | 2012 | Mouanga, 2017 | PTW | ADRIA | CAS | COR, TS, TS/AFS |
| *Neoconorbina clara* (Cushman, 1934) | 1997 | Hyams-Kaphzan *et al.,* 2008 | PTW | EMED | CAS | COR, TS, TS/AFS |

continued

Table 1 continued

| *Species Name* | Year | REF (* not illustrated or unpublished record) | NDR | MSFD subregions | Success | PP |
|---|---|---|---|---|---|---|
| *Nodophthalmidium antillarum* (Cushman, 1922) | 1968 | Moncharmont Zei, 1968 | ATW | EMED | EST | COR, TS, TS/AFS |
| *Operculina ammonoides* (Gronovius, 1781) | 2015 | Merkado, 2016 | IO | EMED | EST | COR, TS, TS/AFS |
| *Pararotalia* cf. *P. socorroensis* (McCulloch, 1977) | 1997 | Hyams-Kaphzan *et al.,* 2008 | PTE | EMED | CAS | COR, TS, TS/AFS |
| *Parasorites orbitolitoides* (Hofker, 1930) | 2016 | Nadal Nebot, 2017 | PTW | WMED | CAS | COR, TS, TS/AFS |
| *Paratrochammina madeirae* Brönnimann, 1979 | 1997 | Hyams, 2000 | ASW | EMED | CAS | TS, TS/AFS |
| *Pegidia lacunata* McCulloch, 1977 | 1994 | Langer, 2008 | PTW | EMED | CAS | COR, TS, TS/AFS |
| *Planispirinella exigua* (Brady, 1879) | 1988-1991 | Oflaz, 2006 | PTW | EMED, ADRIA? | EST | COR, TS, TS/AFS |
| *Planogypsina acervalis* (Brady, 1884) | 1909 | Sidebottom, 1909 | PTW | EMED, ADRIA? | EST | COR, TS, TS/AFS |
| *Procerolagena oceanica* (Albani, 1974) | 2003 | Hyams, 2006 | PW | EMED | CAS | COR, TS, TS/AFS |
| *Pseudohauerinella dissidens* (McCulloch, 1977) | 1998 | Hyams, 2000 | PTE | EMED | CAS | COR, TS, TS/AFS |
| *Pseudomassilina australis* (Cushman, 1932) | 1988-1991 | Oflaz, 2006 | PT | EMED | CAS | COR, TS, TS/AFS |
| *Pseudomassilina reticulata* (Heron-Allen & Earland, 1915) | 1998 | Hyams, 2000 | IO | EMED | EST | COR, TS, TS/AFS |
| *Pyrgo denticulata* (Brady, 1884) | 1994, 1996 | Hyams, 2000, Samir *et al.*, 2003 | PTE | EMED | EST | COR, TS, TS/AFS |
| *Quinqueloculina* cf. *Q. mosharrafai* Said, 1949 | 2002 | Meriç *et al.*, 2008a | RS | EMED | EST | COR, TS, TS/AFS |
| *Quinqueloculina* cf. *Q. multimarginata* Said, 1949 | 1996 | Hyams, 2000 | RS | EMED | CAS | COR, TS, TS/AFS |
| *Schlumbergerina alveoliniformis* (Brady, 1879) | 2008 | Meriç *et al.*, 2008b | PTW | EMED | EST | COR, TS |
| *Sigmamiliolinella australis* (Parr, 1932) | 1977 | Alavi, 1980 | IO | ÈMED, CMED, ADRIA | EST | COR, TS, TS/AFS |
| *Siphonaperta distorqueata* (Cushman, 1954) | 1977 | Alavi, 1980 | PTW | EMED | EST | COR, TS, TS/AFS |
| *Sorites variabilis* Lacroix, 1941 | 1996 | Langer (unpublished) | RS | EMED, WMED | EST | COR, TS, TS/AFS |
| *Spiroloculina angulata* Cushman, 1917 | 1968 | Moncharmont Zei, 1968 | PN | EMED | EST | COR, TS, TS/AFS |
| *Spiroloculina antillarum* d'Orbigny, 1826 | 1913 | Wiesner, 1913 | PN | CMED, ADRIA | EST | COR, TS, TS/AFS |
| *Spiroloculina attenuata* Cushman & Todd, 1944 | 1997 | Hyams, 2000 | PTW | EMED | CAS | COR, TS, TS/AFS |
| *Spiroloculina* aff. *S. communis* Cushman & Todd, 1944 | 1996 | Hyams-Kaphzan *et al.*, 2008 | PTW | EMED | EST | COR, TS, TS/AFS |
| *Spiroloculina nummiformis* Said, 1949 | 1997 | Hyams, 2000 | RS | EMED | CAS | COR, TS, TS/AFS |
| *Triloculina* cf. *T. fichteliana* d'Orbigny, 1839 | 2002 | Meriç *et al.*, 2008a | ATW | EMED, CMED | EST | TS, TS/AFS |
| *Varidentella* cf. *V. neostriatula* (Thalmann, 1950) | 1996 | Hyams, 2000 | PTW | EMED | CAS | COR, TS, TS/AFS |

**Table 2.** Alphabetical list of currently recognized cryptogenic foraminifera in the Mediterranean Sea (for abbreviations see captions in in Table 1).

| ***Species Name*** | **Year** | **REF (* not illustrated)** | **NDR** | **MSFD subregions** | **Suc-cess** | **PP** |
|---|---|---|---|---|---|---|
| *Cymbaloporetta* sp. 1 | 1968 | Moncharmont Zei, 1968 | PTE | EMED, CMED, ADRIA, WMED | CAS | ST/SH-BAL, ST/AFS, UNAI |
| *Euthymonacha polita* (Chapman, 1900) | 2007 | Meriç *et al.,* 2010 | PW | EMED, ADRIA, CMED | EST | ST/SH-BAL, ST/AFS, UNAI |

## Results

### ***Acervulina inhaerens*** Schulze, 1854

1854 *Acervulina inhaerens* Schulze – Schulze, p. 68, pl. 6, fig. 12.
2015 *Acervulina inhaerens* Schulze – Delliou *et al*., p. 570, pl. 1, fig. 5.

*Acervulina inhaerens* was first described by Schulze (1854) from the Adriatic Sea and found to be alive on phytal substrates, on sand and along rocky shores off Ancona (Italy). The species was reported as alien by Delliou *et al.* (2015) from coastal habitats in the Gulf of Kavala (NE Aegea Sea, Greece). The record by Schulze (1854) shows the species to be present in the Mediterranean prior to the opening of the Suez Canal and the taxon must therefore be considered to be native.

### ***Adelosina carinata-striata*** (Wiesner, 1912)

1912 *Miliolina milletti* var. *carinata-striata* Wiesner – Wiesner, p. 221
1923 *Adelosina milletti* var. *carinata-striata* Wiesner – Wiesner, p. 77, figs. 190-191
1970 *Quinqueloculina milletti* var. *carinata-striata* (Wiesner) – von Daniels, p. 74, pl. 2, figs. 17a-c, textfig. 49
1987 *Quinqueloculina poeyana carinata* Albani – Baccaert, p. 97, pl. 47, figs. 5a-c
1991 *Adelosina carinata-striata* (Wiesner) – Cimerman & Langer, p. 28, pl. 20, figs. 1-4
1993 *Cycloforina? carinata* (Albani) – Hottinger *et al.,* p. 49, pl. 32, figs. 1-9
2005 *Adelosina carinata striata* (Wiesner) – Debenay *et al*., pl. 1, figs. 14-15
2007 *Quinqueloculina carinatastriata* (Wiesner) – Bouchet *et al*., pl. 1
2012 *Adelosina carinatastriata* (Wiesner) – Koukousioura *et al*., pl. 10, fig. 18
2013 *Adelosina carinata-striata* (Wiesner) – Bassler-Veit *et al*., pl. 5, figs. 1a-b
2014 *Adelosina carinata-striata* (Wiesner) – Meriç *et al*., pl. 9, figs. 8-9
2017 *Adelosina carinata-striata* (Wiesner) – Mouanga, pl. 3, fig. 11

*Adelosina carinata-striata* was first described by Wiesner (1912) from the Adriatic Sea. The species is present off the European Atlantic coast (Bouchet *et al*., 2007) and in the Red Sea (Hottinger *et al*., 1993). Illustrated Mediterranean Sea records include specimens from the Adriatic Sea (Wiesner, 1923; von Daniels, 1970; Cimerman & Langer, 1991; Mouanga, 2017), Greece (Debenay *et al*., 2005) and Turkey (Bassler-Veit, 2013; Meriç *et al*., 2014). Subfossil specimens from the Aegean Sea were recorded by Koukousioura *et al.* (2012). *Adelosina carinata-striata* is present in the lower part of a borehole from Alykes Kitros, and the illustrated specimen was dated at 7460±40yBP. The species *Adelosina carinata-striata* is therefore native to the Mediterranean Sea. The specimen recorded by Triantaphyllou *et al.* (2005) under the name *Adelosina milletti* var. *carinata* differs from *Adelosina carinata-striata* (Wiesner) and belongs to a different species.

### ***Adelosina milletti*** (Wiesner, 1911)

*non* 1839 *Quinqueloculina bosciana* – d'Orbigny, p. 191, pl. 11, figs. 22-24
1898 *Miliolina bosciana* d'Orbigny – Millett, p. 267, pl. 6, fig. 1
1911b *Miliolina milletti* Wiesner – Wiesner, p. 506
1912 *Miliolina milletti* Wiesner – Wiesner, p. 220
1923 *Adelosina milletti* Wiesner – Wiesner, p. 76
*non* 1980 *Quinqueloculina milletti* (Wiesner) – Alavi, p. 20 (appendix), pl. 17, fig. 5, pl. 18, fig. 6
*non 1990 Massilina milletti (Wiesner)* – Dermitzakis & Triantafillou, pl. 2, fig. 8
*non* 1993 *Quinqueloculina milletti* (Wiesner) – Sgarrella & Moncharmont Zei, p. 172, pl. 7, fig. 7
*non* 2000 *Quinqueloculina milletti* (Wiesner) – Hyams, pl. 7, fig. 8
*non* 2006 *Edentostomina milletti* (Wiesner) – Oflaz, p. 145, pl. 2, figs. 4-6
*non* 2016 *Quinqueloculina milletti* (Wiesner) – Hyams-Kaphzan, pl. 2, fig. 10
*non* 2016a *Quinqueloculina milletti* (Wiesner) – Dimiza *et al*., pl. 2, fig. 2

*Adelosina milletti* was first reported by Wiesner (1911b, as *Miliolina milletti*) from the Adriatic Sea (not illustrated) and a morphological description was provided by Wiesner in 1912. The author (1923) considered the species to be identical with *Miliolina bosciana* of Millett (1898) from the Malay Archipelago and to represent the type species. However, Wiesner (1923) pointed out that *Miliolina bosciana* Millett is not present in the Adriatic Sea and that the species is characterized by rounded chambers, a smooth surface, a short, curved neck and therefore differs from *Miliolina bosciana* d'Orbigny (1839). The species was illustrated by Wiesner in his monograph on miliolids from the eastern Adriatic Sea (1923). Mediterranean records by Alavi (1980), Dermitzakis & Triantafillou (1990), Oflaz (2006) and Dimiza *et al*. (2016a) provide illustrated specimens but they all differ from the original of Millett (1898). The specimens of *Quinqueloculina milletti* (see Sgarrella & Moncharmont Zei, 1993; Hyams, 2000; Hyams-Kaphzan, 2016), a species also considered to be alien to the Mediterranean in EASIN (2020), also differ substantially from Millett's *Miliolina bosciana* and require further study. To date, there is no reliable record of *Adelosina milletti* in the Mediterranean Sea, and we therefore consider the species to be absent from Mediterranean waters.

***Agglutinella compressa*** El-Nakhal, 1983

| | |
|---|---|
| 1983 | *Agglutinella compressa* El-Nakhal – El-Nakhal, p. 129, pl. 1, figs. 1-3, pl. 2, figs. 10-11 |
| 1993 | *Agglutinella compressa* El-Nakhal – Hottinger *et al.*, p. 48, pl. 29, figs. 5-10 |
| *non* 2003 | *Agglutinella compressa* El-Nakhal – Samir *et al.*, pl. 1, figs. 5, 9-10 |
| *non* 2012 | *Agglutinella compressa* El-Nakhal – Aloulou *et al.*, pl. 1, fig. 5 |

*Agglutinella compressa* was first described by El-Nakhal (1983) from the Gulf of Suez. The specimens illustrated are identical with the specimens reported by Hottinger *et al.* (1993) from the Gulf of Aqaba. Rare specimens reported from the Mediterranean Sea (Samir *et al.*, 2003; Aloulou *et al.*, 2012) have more inflated chambers, are less elongate and compressed and have an elliptical aperture. The species was collected off the Mediterranean coast of Israel between the years 1998-1999 (Hyams-Kaphzan *et al.*, 2008). The data currently available indicate that *Agglutinella compressa* is alien to the Mediterranean Sea.

***Agglutinella robusta*** El-Nakhal, 1983

| | |
|---|---|
| 1983 | *Agglutinella robusta* El-Nakhal – El-Nakhal, p. 130, pl. 1, figs. 4-6, pl. 2, figs. 12-15 |
| 1993 | *Agglutinella robusta* El-Nakhal – Hottinger *et al.*, p. 48, pl. 29, figs. 11-14, pl. 2, figs. 12-15 |
| *non* 2003 | *Agglutinella robusta* El-Nakhal – Samir *et al.*, pl. 1, figs. 6-8 |
| *non* 2019 | *Agglutinella robusta* El-Nakhal – Badr-ElDin *et al.*, pl. 1, figs. 5a-c |

The holotype of *Agglutinella robusta* was described and illustrated by El-Nakhal (1983) from the Red Sea. Mediterranean records of this species were provided by Samir *et al.* (2003), but their findings differ from the holotype in having a more elongated shape, less inflated chambers and a coarser agglutination pattern. Specimens illustrated by Badr-ElDin *et al.* (2019) differ substantially from the holotype. Yokeş & Meriç (2009) have reported the species to be present in the Mediterranean Sea, but do not provide an illustration. We therefore consider *Agglutinella robusta* to be absent from the Mediterranean Sea.

***Amphisorus hemprichii*** Ehrenberg, 1839

| | |
|---|---|
| 1839 | *Amphisorus hemprichii* Ehrenberg – Ehrenberg, p. 130, pl. 3, fig. 3 |
| 1993 | *Amphisorus hemprichii* Ehrenberg – Hottinger *et al.*, p. 71, pl. 81, pl. 82 |
| 2013 | *Amphisorus hemprichii* Ehrenberg – Merkado *et al.*, fig. 7.3 |
| 2014 | *Amphisorus hemprichii* Ehrenberg – Meriç *et al.*, pl. 40, figs. 3-6, pl. 41, figs. 1-2 |
| 2015 | *Amphisorus hemprichii* Ehrenberg – Corsini-Foka *et al.*, p. 356, fig. 2 |

The holotype of *Amphisorus hemprichii* has been described by Ehrenberg (1839) from modern sediments off Alexandria, Egypt. Present-day Mediterranean occurrences were reported by Meriç *et al.* (2014) from shallow water sites off Turkey. Living specimens reported as *Amphisorus hemprichii* by Gruber (2007) from Shikmona (Haifa, Israel) were reexamined by us and belong to *Sorites orbiculus*. Only a lateral view is illustrated by Corsini-Foka *et al.* (2015) for a specimen from Rhodes Island (Greece), but the species is described to possess two separate layers of chamberlets and a double row of apertures, and as such fulfills the criteria for *Amphisorus*. No living *A. hemprichii* are currently present along the Mediterranean coast off Israel (Merkado *et al.*, 2013; Hyams-Kaphzan, unpublished data). The lower temperature limit for symbiont-bearing species of *Amphisorus hemprichii* is at around 18°C in the Mediterranean Sea (Langer, unpubl. data). *Amphisorus hemprichii* is widely present in all oceans (Langer & Hottinger, 2000) and shows a circumtropical distribution. The species is native to the Mediterranean Sea.

***Amphistegina lessonii*** d'Orbigny, 1826

| | |
|---|---|
| 1826 | *Amphistegina lessonii* – d'Orbigny, p. 304 |
| 1993 | *Amphistegina lessonii* d'Orbigny – Hottinger *et al.*, p. 132, pl. 184, fig. 1-11; pl. 185, fig. 1-7 |
| 1997 | *Amphistegina lessonii* d'Orbigny – Hollaus & Hottinger, p. 592 |
| 2000 | *Amphistegina lessonii* d'Orbigny – Hyams, pl. 28, figs. 1-4 |
| 2002 | *Amphistegina lessonii* d'Orbigny – Hyams *et al.*, p. 174, pl. 1, fig. 1 |
| 2006 | *Amphistegina lessonii* d'Orbigny – Langer |

& Lipps, p. 349
2009 *Amphistegina lessonii* d'Orbigny – Parker, p. 498, fig. 355a-d
2011 *Amphistegina lessonii* d'Orbigny – Makled & Langer, p. 248, fig. 9: 30, 31
2015 *Amphistegina lessonii* d'Orbigny – Fajemila *et al.*, Moorea, fig. 2: 12
2016 *Amphistegina lessonii* d'Orbigny – Langer *et al.*, p. 76, pl. 2, fig. 28-31
2018 *Amphistegina lessonii* d'Orbigny – Förderer & Langer, p. 124, pl. 51, figs. 4-6
2019 *Amphistegina lessonii* d'Orbigny – Guastella *et al.*, p. 5, figs. 2.7-2.10
2020 *Amphistegina lessonii* d'Orbigny – Fajemila *et al.,* Moorea, p. 79, pl. 29, fig. 24-29.

*Amphistegina lessonii* has first been described by d'Orbingy (1826) from Mauritius (Indian Ocean). The species has a circumtropical distribution and has also been reported from the Pacific and the Atlantic Ocean, and the Red and the Mediterranean Sea (see Förderer and Langer, 2018 and Fajemila *et al.,* 2020 for biogeographic details). The biogeographic range of *A. lessonii* is strongly controlled by water temperature and in the Mediterranean Sea (Hollaus & Hottinger, 1997; material collected in 1974) the species has recently reached the coast of Sicily (Guastella *et al.,* 2019). *Amphistegina lessonii* has established self-maintaining populations, and reaches high abundances in some areas (e.g. Central and eastern Mediterranean; Triantaphyllou *et al.,* 2005; Guastella *et al.,* 2019; Hyams-Kaphzan, unpublished). Whether the species has indeed the capability to cause a negative impact on the diversity of native biotas or to modify local habitats requires further study. The species is considered to be alien to the Mediterranean Sea, but molecular genetic studies are needed to confirm that the species has been introduced from the Atlantic via the Strait of Gibraltar and/or the Red Sea via the Suez Canal.

***Amphistegina lobifera*** Larsen, 1976

1968 *Amphistegina madagascariensis* d'Orbigny – Moncharmont Zei, p. 29, pl. 5, figs. 2a-b
1969 *Amphistegina madagascariensis* d'Orbigny – Blanc-Vernet, p. 214, pl. 10, 2, nr. 30
1976 *Amphistegina lobifera* Larsen – Larsen, p. 4, pl. 3, figs. 1-5, pl. 7, fig. 3, pl. 8, fig. 3
1980 *Amphistegina lobifera* Larsen – Alavi, p. 67 (appendix), pl. 34, fig. 3, pl. 35, figs. 1, 3
1993 *Amphistegina lobifera* Larsen – Hottinger *et al.*, p. 133, pl. 186, figs. 1-11, pl. 187, figs. 1-7, pl. 188, figs. 1-6
1998 *Amphistegina lobifera* Larsen – Yanko *et al.*, p. 193, pl. 3, figs. 14-16
2000 *Amphistegina lobifera* Larsen – Langer & Hottinger, p. 112
2000 *Amphistegina lobifera* Larsen – Hyams, pl. 28, figs. 5-6
2002 *Amphistegina lobifera* Larsen – Hyams *et al.*, p. 174, pl. 1, figs. 2-4
2005 *Amphistegina lessonii* d'Orbigny - Triantaphyllou *et al.,* p. 283, pl. 1, fig. 5
2008 *Amphistegina lobifera* Larsen – Langer, p. 404, fig. 3
2009 *Amphistegina lobifera* Larsen – Triantaphyllou *et al.,* p. 79, pl. 1, figs.1-5
2010 *Amphistegina lobifera* Larsen – Koukousioura *et al.,* p. 159, pl. 1, figs. 1-2
2010 *Amphistegina lobifera* Larsen – Avnaim-Katav, p. 232, pl. 8, figs. 11-12
2013 *Amphistegina lobifera* Larsen – Triantaphyllou & Dimiza in Siokou *et al.*, p. 242, fig. 7
2016 *Amphistegina lobifera* Larsen – Langer & Mouanga, fig. 4
2020 *Amphistegina lobifera* Larsen – Manda *et al.,* pl. 3c

*Amphistegina lobifera* has first been described by Larsen (1976) from the Red Sea. Its biogeographic range is strongly controlled by water temperature and the distributional range is currently delimited by the 13.7°C winter isotherm (Zmiri *et al.,* 1974; Hollaus & Hottinger, 1997; Langer & Hottinger, 2000). The species is widely present in the eastern Mediterranean and the Ionian Sea (Blanc-Vernet, 1969; Langer, 2008; Guy-Haim *et al.*, 2017; Manda *et al.,* 2020; Triantaphyllou *et al*., 2005; Triantaphyllou & Dimiza in Siokou *et al*., 2013), has recently invaded the Adriatic Sea (Langer & Mouanga, 2016), the coast of Sicily (Guastella *et al.,* 2019) and is present along the coast of Libya (Langer unpubl. data) and Tunisia (Blanc-Vernet *et al.*, 1979; Glacon, 1962; Langer, 2008; El Kateb *et al*., 2018; Damak *et al*., 2019; Langer unpubl. data). The species is currently among the 26 most invasive taxa recorded in the Mediterranean (Servello *et al.*, 2019; Tsiamis *et al.*, 2020). Core material recovered from Haifa Bay (Israel) shows *Amphistegina lobifera* to be present at a depth of 1.95 m (Avnaim-Katav, 2010) but dating of this core is not clear cut and requires further studies. A sediment core date prior to the opening of the Suez Canal, would support previous hypothesis (Langer & Hottinger, 2000; Langer, 2008) that Mediterranean populations were restocked from the Atlantic via the Strait of Gibraltar.

***Amphistegina* cf. *A. papillosa*** Said, 1949

2014 *Amphistegina* cf. *A. papillosa* Said – Caruso & Cosentino fig. 5, 8

*Amphistegina* cf. *A. papillosa*, an ecomorphotype of *Amphistegina papillosa* Said, was recently reported by Caruso & Cosentino (2014) from shallow waters off the Pelagian Islands, Central Mediterranean Sea. The ecomorphotype is similar to *A. papillosa*, which is commonly found attached to green algae in the Red Sea at water depth of 112 and 135 m (Hottinger *et al.,* 1993), and is one of the Amphisteginids that occupies the deepest waters (Murray, 2006 and reference therein). The ecomorphotype has not been formally described but was considered to be a putative exotic form (Caruso & Cosentino,

2014) and was listed as an alien species by Servello *et al.* (2019). The holotype of *A. papillosa* was described by Said (1949) from the Red Sea, but neither *A. papillosa* nor a related "eco"-morphotype has been reported prior the finding of Caruso & Cosentino (2014) from the Mediterranean Sea. *Amphistegina* cf. *A. papillosa* and *Amphistegina papillosa* Said are not known from the Mediterranean coast of Israel, and the occurrence at the Pelagian Islands is puzzling. For the time being, *Amphistegina* cf. *A. papillosa* is here considered to be alien to the Mediterranean Sea, but molecular genetic studies are needed to confirm that the species is identical with the Red Sea species.

***Archaias angulatus*** (Fichtel & Moll, 1798)

| | |
|---|---|
| 1798 | *Nautilus angulatus* Fichtel & Moll – Fichtel & Moll, p. 113, pl. 22, figs. a-e |
| 1928 | *Archaias angulatus* Fichtel & Moll – Cushman, p. 220, pl. 31, fig. 9 |

The holotype of *Archaias angulatus* has been described by Fichtel & Moll (1798) from the Red Sea but was not found in present-day assemblages recorded by Said (1949) and Hottinger *et al.* (1993). *Archaias angulatus* has been recorded from the Cape Verde Islands (Rocha & Mateu, 1971). An obscure finding of a single, small, megalospheric test of *A. angulatus* was reported from around the Kornati Islands, Adriatic Sea (Langer & Hottinger, 2000). To date, this represents the only record in the Mediterranean Sea. Cushman (1931) and Smout & Eames (1958) consider the species to be absent from the Mediterranean Sea. Other Mediterranean occurrences of *A. angulatus* have never been reported and we therefore consider the species to be absent from the Mediterranean Sea.

***Articulina alticostata*** Cushman, 1944

| | |
|---|---|
| 1944 | *Articulina alticostata* Cushman – Cushman, p. 16, pl. 4, figs. 10-13 |
| *non* 2004 | *Articulina alticostata* Cushman – Meriç *et al.*, p. 109, pl. 16, fig. 10 |
| *non* 2006 | *Articulina alticostata* Cushman – Oflaz, p. 180, pl. 4, fig. 6 |
| *non* 2009 | *Articulina alticostata* Cushman – Yokeş & Meriç, pl. 2, figs. 10-11 |

Meriç *et al.* (2004) consider *Articulina alticostata* to be present in the Mediterranean Sea but the initial part of the specimen illustrated is lacking. Therefore, the species can not be assigned with certainty to the genus *Articulina*. Specimens illustrated by Yokeş & Meriç (2009) show chambers that are less inflated than in the holotype and are similar to *Nodophthalmidium antillarum*. The specimen identified by Oflaz (2006) as *Articulina alticostata* is an aberrant juvenile variety of *Articulina pacifica* (for further information see remarks on *Articulina pacifica*). To date, convincing evidence for the presence of *Articulina alticostata* in the Mediterranean Sea is lacking and we therefore consider the species to be absent.

***Articulina mayori*** Cushman, 1922

| | |
|---|---|
| 1922 | *Articulina mayori* Cushman – Cushman, p. 71, pl. 13, fig. 5 |
| *non* 2006 | *Articulina mayori* Cushman – Oflaz, pl. 4, fig. 9 |

*Articulina mayori* is a tropical species that was first described from the Tortugas (Florida) by Cushman (1922). The illustration provided by Oflaz (2006) has a very faint striation pattern and is not identical with the distinctly ornamented specimen described and illustrated by Cushman (1922). The specimen depicted by Oflaz (2006) may belong to the genus *Nodophthalmidium* but its true identification requires further study. For the time being, we consider *Articulina mayori* to be absent from the Mediterranean Sea.

***Articulina pacifica*** Cushman, 1944

| | |
|---|---|
| 1904 | *Articulina sulcata* Reuss – Sidebottom, p. 16, pl. 4, figs. 16-17 |
| 1944 | *Articulina pacifica* Cushman – Cushman, p. 17, pl. 4, figs. 14-18 |
| 1993 | *Articulina pacifica* Cushman – Hottinger *et al.*, p. 48, pl. 31, figs. 5-9 |
| 2006 | *Articulina alticostata* Cushman – Oflaz, p. 180, pl. 4, fig. 6 |

The holotype of *Articulina pacifica* was described by Cushman (1944) from Fiji. The species is present in the Red Sea (Hottinger *et al.*, 1993). Mediterranean records include the specimens illustrated by Sidebottom (1904, as *Articulina sulcata* Reuss), Oflaz (2006) and Hyams-Kaphzan *et al.* (2008). As the oldest record of *Articulina pacifica* was provided by Sidebottom (1904) from the island of Delos (Greece), and the species is considered to be native to the Mediterranean Sea.

***Astacolus insolitus*** (Schwager, 1866)

| | |
|---|---|
| 1866 | *Cristellaria insolita* Schwager – Schwager, p. 242, pl. 6, fig. 85 |
| 1980 | *Astacolus insolitus* (Schwager) – Srinivasan & Sharma, p. 28, pl. 5, figs. 12-13 |
| *non* 2009 | *Astacolus insolithus* (Schwager) – Yokeş & Meriç, pl. 4, fig. 1 |
| *non* 2009 | *Astacolus insolitus* (Schwager) – Mojtahid *et al.*, pl. 2, fig. 26 |
| *non* 2014 | *Astacolus insolitus* (Schwager) – Meriç *et al.*, pl. 46, figs. 11a-b |

*Astacolus insolitus* has been described from fossil deposits of Car Nicobar, north-eastern Indian Ocean (Schwager, 1866). A neotype has been illustrated by Srinivasan & Sharma (1980). Records from the Mediterranean Sea were illustrated by Yokeş & Meriç (2009), Mojtahid *et al.* (2009) and Meriç *et al.* (2014) but differ substantially from Schwager's illustrations and the neotype and belong to a different species, most probably to *Astacolus* *crepidulus* (Fichtel & Moll, 1798). To date, there is no record for *Astacolus insolitus* in the Mediterranean Sea and we therefore consider the species to be absent.

***Brizalina simpsoni*** (Heron-Allen & Earland, 1915)

1915 *Bolivina simpsoni* Heron-Allen & Earland – Heron-Allen & Earland, p. 648, pl. 49, figs. 18-35
1993 *Brizalina simpsoni* (Heron-Allen & Earland) – Hottinger *et al.*, p. 92, pl. 111, figs. 8-13, pl. 112, figs. 1-2
1997 *Brizalina simpsoni* (Heron-Allen & Earland) – Haunold *et al.*, fig. 5
2014 *Brizalina simpsoni* (Heron-Allen & Earland) – Meriç *et al.*, pl. 50 fig. 1
2017 *Brizalina simpsoni* (Heron-Allen & Earland) – Thissen & Langer, pl. 13, figs. 6-8

The holotype of *Brizalina simpsoni* has been described by Heron-Allen & Earland (1915) from the Quirimba Islands off northeastern Mozambique. The species has also been reported from the Red Sea (Hottinger *et al.,* 1993; Haunold *et al.,* 1997) and Zanzibar (Thissen & Langer, 2017). The first Mediterranean record was given by Meriç *et al.* (2010) from the Pamuçak Cove (northwest Kuşadasi, Turkey). The species has later been illustrated by Meriç *et al.* (2014) from the Gulf of Kuşadasi, Aegean Sea. For the generic assignment, we follow the concept of Revets (1996). The available records show that the species is alien to the Mediterranean Sea.

***Borelis schlumbergeri*** (Reichel, 1937)

1973 *Neoalveolina pygmaea schlumbergeri* Reichel – Reichel, p. 110, pl. 10, figs. 1-3, pl. 11, fig. 6b
1993 *Borelis schlumbergeri* (Reichel) – Hottinger *et al.*, p. 68, pl. 75, figs. 1-17
? 2000 *Borelis* sp. – Hyams, pl. 14, figs. 9-10
? 2002 *Borelis* sp. – Hyams *et al.*, pl. 1, figs. 5-6
2008 *Borelis* sp. – Langer, fig. 5
? 2017 *Borelis* sp. – Makled *et al.*, pl. 13, figs. 19-20
2019 *Borelis schlumbergeri* (Reichel) – Bassi *et al.*, p. 14, figs. 12-13

The genus *Borelis* has a circumtropical distribution and is represented by two extant species (Langer & Hottinger, 2000): an elongate *Borelis schlumbergeri* and a spherical *Borelis pulchra*. Fossil occurrences of other species of *Borelis* spp. from the Mediterranean region were reported by Reiss & Gvirtzman (1966), Adams (1976), Jones *et al.* (2006), Makled *et al.* (2017) and Bassi *et al.* (2019). Unpublished records of modern *B. schlumbergeri* from northern Israel (Hyams-Kaphzan) show the species to be present in the year 1999 at Akhziv. Later, more *Borelis* were found at Akhziv by Lazar (2007), showing the typical elongate test shape (see also Langer, 2008). Specimens reported by Hyams (2000) and Hyams *et al.* (2002) represent subspherical forms that may represent juvenile stages of *Borelis schlumbergeri* or *Borelis pulchra*. Subspherical forms were also reported from fossil sediments in the Nile Delta (Makled *et al.,* 2017). For the time being, we consider the elongate *Borelis schlumbergeri* to be alien to the Mediterranean Sea.

***Cibicides mabahethi*** Said, 1949

1949 *Cibicides mabahethi* Said – Said, p. 42, pl. 4, figs. 20a-c
1993 *Cibicides mabahethi* Said – Hottinger *et al.*, p. 115, pl. 151, figs. 6-12
2000 *Cibicides mabahethi* Said – Hyams, pl. 22, figs. 1-2

*Cibicides mabahethi* was first described from the Red Sea by Said (1949). Recent material from the eastern Mediterranean Sea has been recorded by Hyams (2000), Hyams *et al.* (2002) and Hyams-Kaphzan *et al.* (2008). This species is considered to be alien to the Mediterranean Sea.

***Clavulina angularis*** d'Orbigny, 1826

1826 *Clavulina angularis* d'Orbigny – d'Orbigny, p. 268, pl. 12, fig. 7
*non* 1979 *Clavulina angularis* d'Orbigny – Blanc-Vernet *et al.,* pl. 21, fig. 3
*non* 1980 *Clavulina angularis* d'Orbigny – Alavi, p. 11 (appendix), pl. 5, fig. 12, pl. 7, fig. 1
1993 *Clavulina angularis* d'Orbigny – Hottinger *et al.*, p. 41, pl. 21, figs. 1-13
*non* 2000 *Clavulina angularis* d'Orbigny – Hyams, pl. 2, fig. 8
*non* 2008a *Clavulina angularis* d'Orbigny – Meriç *et al.*, pl. 1, figs. 7a-b
*non* 2009 *Clavulina angularis* d'Orbigny – Yokeş & Meriç, pl. 1, figs. 6-7
*non* 2014 *Clavulina angularis* d'Orbigny – Meriç *et al.*, pl. 7, figs. 3-4
*non* 2016 *Clavulina angularis* d'Orbigny – Ayadi *et al.*, pl. 2, fig. 6

*Clavulina angularis* has first been reported by d'Orbingy (1826) from Corsica in the western Mediterranean Sea. Jones and Parker (1860) reported it from the Gulf of La Spezia (Italy) and Crete (as *Valvulina angularis,* not illustrated). The specimens reported by Alavi (1980), Hyams (2000), Yokeş & Meriç (2009), Meriç *et al.* (2008a; 2014) and Ayadi *et al.* (2016) show rounded last chambers that are absent in the holotype and belong to *Clavulina* cf. *C. multicamerata.* The first record of *Clavulina angularis* shows the species to be present before the opening of the Suez Canal and therefore native to the Mediterranean Sea.

***Clavulina* cf. *C. multicamerata*** Chapman, 1907

1907 cf. *Clavulina parisiensis* d'Orbigny var.

*multicamerata* Chapman – Chapman, p. 127, pl. 9, fig. 5
1979 *Clavulina angularis* d'Orbigny – Blanc-Vernet *et al.,* pl. 21, fig. 3
1980 *Clavulina angularis* d'Orbigny – Alavi, p. 11 (appendix), pl. 5, fig. 12, pl. 7, fig. 1
1993 *Clavulina* cf. *C. multicamerata* Chapman – Hottinger *et al.*, p. 42, pl. 22, figs. 1-6
2000 *Clavulina angularis* d'Orbigny – Hyams, pl. 2, fig. 8
2008a *Clavulina angularis* d'Orbigny – Meriç *et al.*, pl. 1, fig. 7
2008a *Clavulina* cf. *C. multicamerata* Chapman – Meriç *et al.*, pl. 1, fig. 8
2009 *Clavulina angularis* d'Orbigny – Yokeş & Meriç, pl. 1, figs. 6-7
2009 *Clavulina* cf. *C. multicamerata* Chapman – Yokeş & Meriç, pl. 1, figs. 8-9
2014 *Clavulina angularis* d'Orbigny – Meriç *et al.*, pl. 7, figs. 3-4
2014 *Clavulina* cf. *C. multicamerata* Chapman – Meriç *et al.*, pl. 7, figs. 5-6
2014b *Clavulina* cf. *C. multicamerata* Chapman – Katsanevakis *et al.*, p. 688, fig. 20

The holotype of *Clavulina multicamerata* has been described from Victoria (Australia) by Chapman (1907). A similar but subtriangular to rounded form was reported by Hottinger *et al.* (1993) from the Red Sea and represents a separate species (*Clavulina* cf. *C. multicamerata)*. For morphological details on this variety, see the remarks in Hottinger *et al.* (1993). Specimens of the latter species were also reported from Tunisia (Blanc-Vernet, 1979), Turkey (Alavi, 1980; Meriç *et al.*, 2008a; 2014; Yokeş & Meriç, 2009), Israel (Hyams, 2000; collected in 1996) and Greece (Katsanevakis *et al.*, 2014b). The available illustrated records indicate that this species is alien to the Mediterreanean.

***Coscinospira hemprichii*** Ehrenberg, 1839

? 1791 *Nautilus (Lituus) arietinus* Batsch – Batsch, p. 15, figs. 15d-f
1839 *Coscinospira hemprichii* Ehrenberg – Ehrenberg, p. 143, pl. 2, fig. 2
? 1987 *Peneroplis pertusus* (Forskål) *arietinus* (Batsch) – Baccaert, p. 60, pl. 19, figs. 3a-b, pl. 20, figs. 1-2
1991 *Coscinospira hemprichii* Ehrenberg – Cimerman & Langer, p. 49, pl. 47, figs. 8-11
1993 *Coscinospira hemprichii* Ehrenberg – Hottinger *et al.*, p. 69, pl. 76, figs. 1-12, pl. 77, figs. 1-8
1997 *Coscinospira hemprichii* Ehrenberg – Hollaus & Hottinger, p. 593
2002 *Coscinospira hemprichii* Ehrenberg – Hyams *et al.*, pl.1, figs. 7-8
2008 *Coscinospira hemprichii* Ehrenberg – Langer, fig. 4
2008b *Peneroplis arietinus* (Batsch) – Meriç *et al.*, pl. 4, figs. 17-19, pl. 5, figs. 1-3, 5-6
2010 *Coscinospira hemprichii* Ehrenberg – Koukousioura *et al.*, p. 171, pl. 1, fig. 3

*Coscinospira hemprichii* was originally described from the Red Sea by Ehrenberg (1839). The specimens illustrated by Batsch (1791) are believed to originate from recent sediments in the Adriatic Sea (Cushman, 1931) and were assigned to *Spirolina hemprichii* (Ehrenberg) or *Spirolina cylindracea* (see Cushman, 1931, p. 72). Modern Mediterranean records include material from the Adriatic Sea, Greece, Israel and Turkey (Cimerman & Langer, 1991; Hollaus & Hottinger, 1997; Hyams *et al.*, 2002; Langer, 2008; Meriç *et al.,* 2008b; Koukousioura *et al.*, 2010). Fossil material of *Coscinospira hemprichii* from the Mediterranean was recently reported by Melis *et al.* (2015), Yümün *et al.* (2016) and Hyams-Kaphzan (unpublished) from the Adriatic Sea, Turkey and Israel, respectively. Both the fossil record and the material from Batsch show that *Coscinospira hemprichii* was present in the Mediterranean prior to the opening of the Suez Canal and the species must therefore be considered to be native.

***Cribromiliolinella milletti*** (Cushman, 1954)

1954 *Hauerina milletti* Cushman – Cushman *et al.*, p. 337, pl. 84, fig. 23

*Cribromiliolinella milletti* has been reported to be alien to the Mediterranean Sea (EASIN, 2020). Cushman *et al.* (1954) described the holotype, *Hauerina milletti*, from the Marshall Islands. No published records exist for this species from the Mediterranean Sea and the taxon is therefore considered to be absent.

***Cushmanina striatopunctata*** (Parker & Jones, 1865)

1865 *Lagena sulcata* Walker and Jacob, var. *striatopunctata* Parker & Jones – Parker & Jones, p. 350, pl. 13, figs. 25-27
*non* 1910 *Lagena striatopunctata* Parker & Jones – Sidebottom, p. 17, pl. 2, figs. 5a-b
*non* 1940 *Lagena striatopunctata* Parker & Jones – Buchner, p. 444, pl. 7, fig. 100
1987 *Cushmanina striatopunctata* (Parker & Jones) – Patterson & Richardson, p. 217, pl. 1, figs. 2-6
*non* 2009 *Cushmanina striatopunctata* (Parker & Jones) – Yokeş & Meriç, pl. 4, fig. 5
*non* 2014 *Cushmanina striatopunctata* (Parker & Jones) – Meriç *et al.*, pl. 48, fig. 7

Yokeş & Meriç (2009) consider *C. striatopunctata* (Parker & Jones) to be alien to the Mediterranean Sea. However, the illustrated specimen (see also Meriç *et al.*, 2014) differs significantly from the original by Parker & Jones (1865, number of costae and ornamental pattern on the neck) and belongs to a different species. The specimens reported as *Lagena striatopunctata* by Sidebottom

(1910) and Buchner (1940) also differ from the type specimen. To date, there is no reliable record for *Cushmanina striatopunctata* in the Mediterranean Sea and the species is therefore not alien to the Mediterranean Sea. The status and the taxonomic identification of the species illustrated by Yokeş & Meriç (2009) and Meriç *et al.* (2014) require further study.

***Cycloforina quinquecarinata*** (Collins, 1958)

1958 *Quinqueloculina quinquecarinata* Collins – Collins, p. 360, pl. 2, figs. 8a-c
1993 *Cycloforina quinquecarinata* (Collins, 1958) – Hottinger *et al.*, p. 49, pl. 33, figs. 7-15
2016 *Cycloforina quinquecarinata* (Collins, 1958) – Hyams-Kaphzan, pl. 2, figs. 6-7
*non* 2016 *Cycloforina quinquecarinata* (Collins, 1958) – Martins *et al.*, pl. 2, figs. 3a-b

*Cycloforina quinquecarinata* has an Indopacific origin (Collins, 1958) and is also present in the Red Sea (Hottinger *et al.*, 1993). The species has been recorded along the Mediterranean coast of Israel by Hyams-Kaphzan *et al.* (2008; 2009) and Hyams-Kaphzan (2016). Martins *et al.* (2016) reported the species from off Bizerte (Tunisia) but their specimen lacks the typical short neck, has somewhat inflated chambers and the surface shows microstriae that are not present in the original material. New findings from core records along the coast of Israel (Hyams-Kaphzan, unpublished) show that the species has been present in the Mediterranean Sea for at least 250 years (core depth: 80 cm). The species is therefore native to the Mediterranean Sea.

***Cycloforina* sp.**

1993 *Cycloforina* sp. C – Hottinger *et al.*, p. 50, pl. 35, figs. 7-13
2008 *Cycloforina* sp. – Langer, p. 407, fig. 8

*Cycloforina* sp. has been reported by Hottinger *et al.* (1993) from the Red Sea (as *Cycloforina* sp. C). The species is characterized by its reticulated test surface ornamentation, produced by intersecting costae (Langer, 2008). It resembles *Quinqueloculina pseudoreticulata* but is provided with a neck and a rounded aperture. Rare specimens were found off Haifa, Israel (Langer, 2008). *Cycloforina* sp. is here considered to be alien to the Mediterranean Sea.

***Cyclorbiculina compressa*** (d'Orbigny, 1839)

1839 *Orbiculina compressa* d'Orbigny – d'Orbigny, p. 66, pl. 8, figs. 4-6
1884 *Cyclorbiculina compressa* (d'Orbigny) – Brady, pl. 14, figs. 7-9
2008a *Cyclorbiculina compressa* (d'Orbigny) – Meriç *et al.*, pl. 11, fig. 12 (*non* fig. 11)
2008b *Cyclorbiculina compressa* (d'Orbigny) – Meriç *et al.*, p. 314, pl. 5, fig. 10 (*non* figs. 8, 9)
2009 *Cyclorbiculina compressa* (d'Orbigny) – Yokeş & Meriç, pl. 3, fig. 2 (*non* fig. 1)
2014 *Cyclorbiculina compressa* (d'Orbigny) – Meriç *et al.*, pl. 40, fig. 2 (*non* fig. 1)

The holotype of *Cyclorbiculina compressa* has been described by d'Orbigny from Cuba (1839). Smout & Eames (1958) consider the biogeographic range of *Cyclorbiculina compressa* to be restricted to the Caribbean, the Gulf of Mexico and other parts of the tropical western Atlantic. The species has not yet been recorded from the Red Sea (Said, 1949; Hottinger *et al.*, 1993). Some specimens illustrated by Meriç *et al.* (2008a; 2008b; 2014) and Yokeş & Meriç (2009) from Turkey show similarity to the holotype of d'Orbingy, although no profile views were shown; other specimens closely resemble *Sorites*. For the time being, we consider *Cyclorbiculina compressa* to be alien to the Mediterranean Sea. The species was probably introduced into the Mediterranean Sea via passage through the Strait of Gibraltar. Records by Brady (1884) from the Cape Verde Islands support this conclusion.

***Cymbaloporetta* sp. 1**

? 1924 *Tretomphalus bulloides* var. *plana* Cushman – Cushman, p. 36, pl. 10, fig. 8
? 1968 *Tretomphalus planus* (Cushman) – Moncharmont Zei, pl. 4, figs. 8a-b
? 1979 *Pseudotretomphalus planus* (Cushman) – Hofker, p. 23, figs. 12-13
? 1987 *Cymbaloporetta plana* (Cushman) – Loeblich & Tappan, pl. 649, figs. 1-3
? 1991 *Cymbaloporetta* sp. 1 – Cimerman & Langer, pl. 80, figs. 1-5
? 1993 *Cymbaloporetta* sp. A – Hottinger *et al.*, p. 120, pl. 160, figs. 1-8
? 1994 *Cymbaloporetta plana* (Cushman) – Jones, pl. 102, figs. 7-8, 12
? 2000 *Cymbaloporetta* sp. 1 – Hyams, pl. 23, figs. 6-8
? 2008b *Cymbaloporetta plana* (Cushman) - Meriç *et al.*, pl. 8, figs. 2-7
2010 *Cymbaloporetta plana* (Cushman) – Koukousioura *et al.*, pl. 2, figs. 1-2
2014 *Cymbaloporetta plana* (Cushman) – Meriç *et al.*, pl. 62, figs. 12-13
? 2014 *Cymbaloporetta plana* (Cushman) – Meriç *et al.*, pl. 62, figs. 14-16

The holotype of *Cymbaloporetta plana* Cushman (1924) was described from Samoa (Pacific Ocean). Although the quality of the original illustration is poor, photographs of the holotype provided by the Smithsonian Museum of Natural History (2020) appear to be identical with most specimens illustrated from the Mediterranean Sea. *Cymbaloporetta* sp. 1 has been frequently reported from the Mediterranean Sea (as *C.* sp. 1 and *C. plana*; see synonymie list). The species has been recorded by Hottinger *et al.* (1993) from the Red Sea (as *C.* sp. A). Hofker (1979) recorded the species (as *Pseudotretomphalus planus*) from the Caribbean. Some authors (Rückert-Hilbig,

1983) consider *C. plana* to be a synonym of *C. bulloides* (d'Orbigny, 1839). The complex taxonomic status of the species (e.g. *C. plana, C. bulloides, C.* sp.) has not yet been resolved and requires further studies. The species is widespread and present in most oceans (Pacific, Atlantic, Red Sea, Mediterranean Sea). Until molecular genetic data are available for the specimens from the type locality and other regions, and because of its complex taxonomic status, we consider the status of *Cymbaloporetta* sp. 1 from the Mediterranean Sea as cryptogenic.

***Edentostomina cultrata*** (Brady, 1881)

1881 *Miliolina cultrata* Brady – Brady, p. 45
1884 *Miliolina cultrata* Brady – Brady, p. 161, pl. 5, figs. 1-2
1987 *Edentostomina cultrata* (Brady) – Loeblich & Tappan, pl. 334, figs. 6-8
1980 *Edentostomina cultrata* (Brady) – Alavi, p. 14 (appendix), pl. 10, fig. 11
*non* 2004 *Edentostomina cultrata* (Brady) – Meriç *et al.*, pl. 5, fig. 1
2006 *Edentostomina cultrata* (Brady) – Oflaz, pl. 2, fig. 3
2006 *Edentostomina milletti* (Wiesner) – Oflaz, pl. 2, figs. 4-6
*non* 2008b *Edentostomina cultrata* (Brady) – Meriç *et al.*, pl. 2, figs. 1-5

*Edentostomina cultrata* was first described by Brady (1884) from Papua New Guinea. Mediterranean records from Turkey were given by Alavi (1980) and Oflaz (2006). The specimens identified as *E. cultrata* by Meriç *et al.* (2004; 2008b) do not show the typical thick, everted apertural rim, lack a pronounced neck and therefore belong to a different species of *Edentostomina.* The species *Edentostomina milletti*, originally described by Cushman (1917, as *Biloculina milletti*), looks similar but has a short bifid tooth. Records of *Edentostomina cultrata* in recent surface samples along the Mediterranean coast of Israel as well as findings of this species in core material deposited prior to the opening of the Suez Canal (Hyams-Kaphzan, unpublished) indicate that this species is native to the Mediterranean Sea.

***Elphidium charlottense*** (Vella, 1957)

1957 *Elphidiononion charlottensis* Vella – Vella, p. 38, pl. 9, figs. 187-188
1958 *Elphidium advenum* (Cushman) – Parker, pl. 4, figs. 3-4
1980 *Elphidium advenum* (Cushman) – Alavi, pl. 32, fig. 12
1991 *Elphidium* sp. 1 – Cimerman & Langer, p. 79, pl. 89, fig. 8
1997 *Elphidium charlottense* (Vella) – Hayward *et al.*, p. 72, pl. 6, figs. 15-16
2004 *Elphidium advenum* (Cushman) – Meriç *et al.*, pl. 32, figs. 9-10
2006 *Elphidium* sp. 1 – Langer & Schmidt-Sinns, pl. 15, fig. 5
2008a *Elphidium charlottense* (Vella) – Meriç *et al.*, pl. 16, figs. 1-3
? 2012 *Elphidium advenum* (Cushman) – Debenay, p. 218
2017 *Elphidium namibium/advenum* – Mouanga, pl. 16, fig. 17

The holotype of *Elphidium charlottense* has been described by Vella (1957) from Rellings Bay, Queen Charlotte Sound, Marlborough (New Zealand). The species is characterized by its rounded keel, translucent wall and non-inflated chambers resulting in a comparatively smooth test surface. The species differs from *Elphidium advenum* (Cushman), a species that has more inflated chambers and deeper interlocular septae and spaces. *Elphidium charlottense* has not been recorded from the Red Sea (Hottinger *et al.*, 1993) but is present in shallow waters off the coast of Namibia (Langer, unpublished). *Elphidium charlottense* has been found in core material collected off Greece (Parker, 1958, as *Elphidium advenum*) and is therefore considered to be native to the Mediterranean Sea.

***Elphidium striatopunctatum*** (Fichtel & Moll, 1798)

1798 *Nautilus striatopunctatus* Fichtel & Moll – Fichtel & Moll, p. 61, pl. 9, figs. a-c
*non* 1909 *Polystomella striatopunctata* (Fichtel & Moll) – Sidebottom, pl. 4, fig. 10, pl. 5, figs. 1-2
1993 *Elphidium striatopunctatum* (Fichtel & Moll) – Hottinger *et al.*, p. 149, pl. 213, figs. 1-8, pl. 214, figs. 1-6
2000 *Elphidium striatopunctatum* (Fichtel & Moll) – Hyams, pl. 27, figs. 7-8
2001 *Elphidium striato-punctatum* (Fichtel & Moll) – Avşar *et al.*, pl. 4, figs. 8-11
2009 *Elphidium striatopunctatum* (Fichtel & Moll) – Yokeş & Meriç, pl. 5, figs. 8-10
2014 *Elphidium striatopunctatum* (Fichtel & Moll) – Meriç *et al.*, pl. 83, figs. 16-17

*Elphidium striatopunctatum* has been described from the Red Sea by Fichtel & Moll (1798). Modern Mediterranean records include specimens from Israel (Hyams, 2000) and Turkey (Avşar *et al.*, 2001; Yokeş & Meriç, 2009; Meriç *et al.*, 2014). Not illustrated records include Jones and Parker (1860), Schaudinn (1911) and Wiesner (1911a; 1911b). The illustrations given by Sidebottom (1909) show a different species. *Elphidium striatopunctatum* is therefore considered to be alien to the Mediterranean Sea.

***Epistomaroides punctulata*** (Said, 1949)

1949 *Epistomaria punctata* Said – Said, p. 37, pl. 4, figs. 23a-c
1980 *Anomalina punctulata* d'Orbigny – Hansen & Rögl, pl. 1, figs. 4-8

1993 *Epistomaroides punctatus* (Said) – Hottinger *et al.*, p. 131, pl. 180, figs. 1-11, pl. 181, figs. 1-6
2012 *Epistomaroides punctatus* (Said) – Almogi-Labin & Hyams-Kaphzan, fig. 2
2017 *Epistomaroides punctulatus* (d'Orbigny) – Thissen & Langer, pl. 19, figs. 1-5

The holotype of *Epistomaroides punctulata* was described by Said (1949) from the Red Sea. According to Hottinger *et al.* (1993), the specimens recorded by d'Orbigny (1826) as *Anomalina punctulata* are identical to the specimens described by Hansen & Rögl (1980). The material of d'Orbigny (1826) was collected around the Island of Mauritius, Indian Ocean. The first Mediterranean record of this species along the northern coast of Israel was provided by Almogi-Labin & Hyams-Kaphzan (2012). Today, the species is very abundant and widely distributed along the Mediterranean rocky coast of northern Israel (Hyams-Kaphzan, unpublished). We consider this species to be alien to the Mediterranean Sea.

***Euthymonacha polita*** (Chapman, 1900)

1900 *Peneroplis (Monalysidium) polita* Chapman – Chapman, p. 4, pl. 1, fig. 5
1994 *Monalysidium politum* (Chapman) – Jones, p. 29, pl. 13, figs. 24-25
2010 *Euthymonacha polita* (Chapman) – Meriç *et al.*, p. 192, fig. 2
2013a *Euthymonacha polita* (Chapman) – Langer *et al.,* fig. 7, 23-24
2014 *Euthymonacha polita* (Chapman) – Meriç *et al.*, pl. 35, figs. 8-15
2015 *Euthymonacha polita* (Chapman) – Delliou *et al.*, pl. 1, fig. 3
2016 *Euthymonacha polita* (Chapman) – Huth, p. 31, pl. 1, figs. 10-12
2017 *Euthymonacha polita* (Chapman) – Mouanga, pl. 1, figs. 1a-d
2018 *Euthymonacha polita* (Chapman) – Emter, pl. 21, fig. 6

*Euthymonacha polita* was first described by Chapman (1900) from Funafuti (Pacific Ocean). Mediterranean records include findings from the Gulf of Kuşadasi, Ilica Bay and the Karaburun Peninsula in Turkey (Meriç *et al.*, 2010; 2011), from the Kavala Gulf in Greece (Delliou *et al.*, 2015), from off Otranto, Italy (Huth, 2016), Libya (Emter, 2018) and the Balearic Islands off Spain (Alvira Romero, 2019). Brady (1884) recorded it from the Cape Verde Islands (Atlantic Ocean) as *Peneroplis pertusus* var. *e* (see Jones, 1994), and Langer *et al.* (2013a) recorded it from the Bazaruto Archipelago (Mozambique). So far, the species has not been recorded from the Red Sea or the Mediterranean coast of Israel (Said, 1949; Hottinger *et al.*, 1993; Hyams-Kaphzan *et al.*, 2008). The circumtropical distribution and the widespread occurrence in the Mediterranean Sea suggest that this species may possibly be native to the Mediterranean. However, no record prior to the opening of the Suez Canal exists to date. For the time being we consider the species to be cryptogenic and further evidence is needed to resolve its status.

***Euuvigerina* sp.**

1982 *Uvigerina peregrina* Cushman – Foraminiferi Padani, pl. 34, figs. 1-1bis
2004 *Euuvigerina* sp. – Meriç *et al.*, pl. 22, figs. 2-3

*Euuvigerina* sp. was reported by Meriç *et al.* (2004) from Turkey and claimed to be alien to the Mediterranean Sea. The illustration provided is identical to specimens of *Uvigerina peregrina* reported in Foraminiferi Padani (1982), which, according to the authors, has been present in the Mediterranean Sea since the Pliocene. However, the holotype of *Uvigerina peregrina* Cushman differs from *Euuvigerina* sp. of Meriç *et al.* (2004). The taxonomic status of *Euuvigerina* sp. requires further study, but the species is certainly present in fossil material and therefore native to the Mediterranean Sea.

***Guttulina?* sp.**

2008a *Entosigmomorphina* sp. – Meriç *et al.*, pl. 13, figs. 8a-b
2014 *Entosigmomorphina* sp. – Meriç *et al.*, pl. 49, figs. 8a-b
*non* 2014 *Entosigmomorphina* sp. – Caruso & Cosentino, pl. 4, fig. 12

Meriç *et al.* (2008a) provide the first illustrated record of this species from the Mediterranean Sea. The chambers of the illustrated specimen are rapidly increasing in size and height and successive chambers appear to be 144° apart. The sutures are strongly depressed and the aperture is radiate. This would place the specimen in the genus *Guttulina* d'Orbigny, 1839. As this represents the first record of this taxon, it is considered to be native to the Mediterranean Sea. The specimen illustrated by Caruso & Cosentino (2014) does not belong to the genus *Entosigmomorphina*, differs from Meriç *et al.* (2008a, 2014), and requires further study.

***Haddonia* sp.**

1993 *Haddonia?* sp. C – Hottinger *et al.*, p. 31, pl. 4, figs. 5-9
2008a *Haddonia* sp. – Meriç *et al.*, pl. 1, figs. 1-4
2008b *Haddonia* sp. – Meriç *et al.*, pl. 1, figs. 1-14
2009 *Haddonia* sp. – Yokeş & Meriç, pl. 1, figs. 1-3
2014 *Haddonia* sp. – Meriç *et al.*, pl. 2, figs. 7-17

*Haddonia* is a genus described from coral reefs from the Torres Strait (off northern Australia) by Chapman (1898). Hottinger *et al.* (1993) recorded a total of four different species in the Red Sea. *Haddonia* sp. was reported from Turkey by Meriç *et al.* (2007, see also Meriç *et al.*, 2008b; Yokeş & Meriç, 2009; and Meriç *et al.*, 2014). Poorly preserved specimens of *Haddonia* were also found in surface samples from rocky reefs off the coast of Israel (Hyams-Kaphzan, unpublished; material collected in 1996). The species *Haddonia* sp. is here considered to be alien to the Mediterranean Sea.

***Hauerina diversa*** Cushman, 1946

1932 *Hauerina bradyi* Cushman – Cushman, p. 44, pl. 10, figs. 12-15
1946 *Hauerina diversa* Cushman – Cushman, p. 11, pl. 2, figs. 16-19
1993 *Hauerina diversa* Cushman – Hottinger *et al.*, p. 50, pl. 36, figs. 1-7
1998 *Hauerina diversa* Cushman – Yanko *et al.*, p. 195, pl. 5, figs. 1-3
2000 *Hauerina diversa* Cushman – Hyams, pl. 6, figs. 6-7
2006 *Sigmoihauerina bradyi* (Cushman) – Oflaz, p. 170, pl. 3, fig. 9
2008a *Hauerina diversa* Cushman – Meriç *et al.*, pl. 4, figs. 9-12
2008b *Hauerina diversa* Cushman – Meriç *et al.*, pl. 3, figs. 12-14
2010 *Hauerina diversa* Cushman – Avnaim-Katav, pl. 2, fig. 12
2014 Hauerina diversa Cushman – Meriç et al., pl. 16, figs. 11-15
2017 *Hauerina diversa* Cushman – Guy-Haim *et al.*, pl. 4 fig. 16, pl. 5, figs. 10-11

*Hauerina diversa* was first described by Cushman (1946) from Hereheretue, French Polynesia. Mediterranean records of *Hauerina diversa* include material from the Turkish Aegean coast (Meriç *et al.,* 2008a; 2008b) and from Israel (Yanko *et al.*, 1998; Hyams, 2000; Hyams-Kaphzan *et al.*, 2008; Avnaim-Katav, 2010 core-top). Non-illustrated records from Turkey also include Avşar (1997 and Avşar *et al*. (2001). The species has recently been found in large numbers along the rocky coast of northern Israel (Hyams-Kaphzan, unpublished). The Mediterranean and Red Sea forms do not show internal septulae and are placed into the genus *Hauerina*. We consider *Hauerina diversa* to be alien to the Mediterranean Sea. The species has been recovered from fish guts collected in the the Suez Canal and the Mediterranean Sea (Guy-Haim *et al.*, 2017), indicating that ichthyochory is a potential vector for long-distance transport and species introduction.

***Heterocyclina tuberculata*** (Möbius, 1880)

1880 *Heterostegina tuberculata* Möbius – Möbius, p. 107, pl. 12, figs. 3-7
1977 *Heterocyclina tuberculata* (Möbius) – Reiss *et al.*, p. 104, figs. 35 A-C, 36 A
1993 *Heterocyclina tuberculata* (Möbius) – Hottinger *et al.*, p. 156, pl. 226, figs. 1-7, pl. 227, figs. 1-8, pl. 230, fig. 10

*Hererocyclina tuberculata* has been described by Möbius (1880) from the western Indian Ocean. It has been recorded from the Turkish Mediterranean coast by Avşar *et al.* (2001; 2008) and from Greece (Debenay e*t al.*, 2005) but the specimens are not illustrated. Langer & Hottinger (2000) consider *Heterocyclina tuberculata* to be "restricted to the Indian Ocean and the Red Sea". Illustrations of this species from the Mediterranean Sea were not published and we therefore consider the species to be absent from the Mediterranean Sea.

***Heterostegina depressa*** d'Orbigny, 1826

1826 *Heterostegina depressa* d'Orbigny – d'Orbigny, p. 305, pl. 17, figs. 5-7
*non* 1865 *Heterostegina depressa* d'Orbigny – Parker *et al.*, p. 34, pl. 3, fig. 100
*non* 1907 *Heterostegina depressa* d'Orbigny – Silvestri, p. 43, pl. 2, fig. 5
1968 *Heterostegina antillarum* d'Orbigny – Moncharmont Zei, p. 27, pl. 5, figs. 3-7
1980 *Heterostegina antillarum* d'Orbigny – Alavi, p. 27, pl. 35, figs. 3-7
1993 *Heterostegina depressa* d'Orbigny – Hottinger *et al.*, p. 157, pl. 228, figs. 1-11, pl. 229, figs. 1-8, pl. 230, fig. 9
2000 *Heterostegina depressa* d'Orbigny – Langer & Hottinger., p. 110, text-fig. 4A
2002 *Heterostegina depressa* d'Orbigny – Hyams *et al.*, pl. 1, fig. 9
2008 *Heterostegina depressa* d'Orbigny – Langer, p. 403, fig. 2
2008b *Heterostegina depressa* d'Orbigny – Meriç *et al.*, p. 323, pl. 10, figs. 1-12
2010 *Heterostegina depressa* d'Orbigny – Avnaim-Katav, p. 236, pl. 10, fig. 20

*Heterostegina depressa* has been described by d'Orbigny (1826) from the island of Saint Helena in the South Atlantic. The species is a true circumtropical foraminifer and its distribution encompasses the Caribbean, the North and South Atlantic, the entire Indian and Pacific Oceans and the Red and Arabian Sea (Langer & Hottinger, 2000; Langer, 2008 and references therein). Mediterranean records include specimens from Lebanon (Moncharmont Zei, 1968, as *H. antillarum*), Israel (Yanko *et al.,* 1998, not illustrated; Hyams *et al.*, 2002; Avnaim-Katav, 2010 core-top) and Turkey (Alavi, 1980; Meriç *et al.*, 2008b). Fossil occurrences of this species were reported by Parker *et al.* (1865) from "Middle Tertiary limestones of Malta and Vienna" and by Silvestri (1907) from a cave near Turin, Italy. However, the quality of the illustrations is too poor to assign the species to *H. depressa* and the specimens probably belong to a different species (Hottinger, pers. comm.). *Heterostegina depressa* is therefore considered to be alien to the Mediterranean Sea.

***Loxostomina* cf. *L. africana*** (Smitter, 1955)

1955 cf. *Loxostomum africanum* Smitter –

Smitter, p. 118, fig. 40 (o)
1975 *Brizalina (Parabrizalina)* cf. *B. (P.) africana* (Smitter) – Zweig-Strykowski & Reiss, p. 100, pl. 3, figs. 1-8
1980 *Bolivina africana* (Smitter) – Alavi, p. 42 (appendix), pl. 26, figs. 5, 9-10
1993 *Loxostomina* cf. *L. africana* (Smitter) – Hottinger *et al.*, p. 97, pl. 119, figs. 10-15
2000 *Loxostomina* cf. *L. africana* (Smitter) – Hyams, pl. 18, fig. 1
*non* 2017 *Brizalina africana* (Smitter) – Makled *et al.*, p. 479, pl. 16, fig. 18

*Loxostomina africana* has been described by Smitter (1955). The material was collected from sediments off Mozambique and are "probably Upper Miocene" in age. The holotype has a smooth surface texture. Hottinger *et al.* (1993) illustrated a similar species. However, the Red Sea specimens have distinct longitudinal striae across the entire test surface and were therefore referred to as *Loxostomina* cf. *L. africana*. Striated representatives of this species were also recorded from Turkey by Alavi (1980) and from Israel by Hyams (2000), Hyams (2006), and Hyams-Kaphzan *et al.* (2008). So far, the species has not been recorded in fossil material. The first record of *Loxostomina* cf. *L. africana* from the Mediterranean Sea was provided by Alavi (1980). As the oldest record for this species originates from the Red Sea (Zweig-Strykowski & Reiss, 1975) the species is considered to be alien to the Mediterranean Sea.

***Loxostomina costulata*** (Cushman, 1922)

1922 *Bolivina limbata* var. *costulata* Cushman – Cushman, p. 26, pl. 3, fig. 8
1993 *Loxostomina? limbata* (Brady) *costulata* (Cushman) – Hottinger *et al.*, p. 97, pl. 120, figs. 8-13
? 2000 *Loxostomina? limbata* (Brady) *costulata* (Cushman) – Hyams, pl. 18, fig. 2
2016 *Loxostomina limbata* (Brady) *costulata* (Cushman) – Huth, p. 32, pl. 2, figs. 1-2
2017 *Loxostomina limbata* (Brady) *costulata* (Cushman) – Mouanga, pl. 12, figs. 10a-b

*Loxostomina costulata* has been described by Cushman (1922) from the Tortugas (Florida). Hottinger *et al.* (1993) recorded specimens from the Gulf of Aqaba, Red Sea. The species was also found in the Adriatic Sea off Otranto, Italy (Huth, 2016). Specimens from the coast of Israel provided by Hyams (2000) do not show the strong costate surface as illustrated by Hottinger *et al.* (1993) but may represent a morphological variety of this species. Fossil specimens of *Loxostomina costulata* with faint costate surfaces, were also found in core material from Israel (Hyams-Kaphzan, unpublished). The species is therefore considered to be native to the Mediterranean Sea.

***Mimosina affinis*** Millett, 1900

1900 *Mimosina affinis* Millett – Millett, p. 548, pl. 4, fig. 11
1993 *Mimosina affinis* Millett – Hottinger *et al.*, p. 104, pl. 133, figs. 9-12, pl. 134, figs. 1-3
2017 *Mimosina affinis* Millett – Mouanga, pl. 13, figs. 1a-b

*Mimosina affinis* has been first described by Millett (1900) from the Malay Archipelago. A single Mediterranean record of this species was provided by Mouanga (2017) from the Bay of Vlore, Albania. *Mimosina affinis* is considered to be alien to the Mediterranean Sea.

***Monalysidium acicularis*** (Batsch, 1791)

1791 *Nautilus lituus acicularis* Batsch – Batsch, p. 3, pl. 6, figs. 16a-b
1993 *Monalysidium acicularis* (Batsch) – Hottinger *et al.*, p. 70, pl. 78, figs. 1-14
2011 *Coscinospira acicularis* (Batsch) – Meriç *et al.*, p. 2, fig. 3
2019 *Monalysidium acicularis* (Batsch) – Förderer & Langer, pl. 2, figs. 32-35

*Monalysidium acicularis* was first described by Batsch (1791) but the type locality was not provided. Cushman (1931) considers the specimens to originate "from Rimini or at least the Adriatic Sea". The species is abundant in the Red Sea (Hottinger *et al.*, 1993). Records of *Spirolina acicularis* from the Mediterranean include specimens from Turkey (Alavi, 1980), Israel (Yanko *et al.*, 1998) and Italy (Aiello *et al.*, 2006), but all lack illustrations. A single illustrated record of *M. acicularis* from the Mediterranean Sea was provided by Meriç *et al.* (2011, as *Coscinospira acicularis*). The information provided by Cushman on the type locality from the Adriatic Sea suggests that *Monalysidium acicularis* is native to the Mediterranean Sea.

***Neoconorbina clara*** (Cushman, 1934)

1934 *Tretomphalus clarus* Cushman – Cushman, p. 99, pl. 11, figs. 6 a-c, pl. 12, figs. 16-17
1993 *Tretomphaloides clara* (Cushman) – Hottinger *et al.*, p. 112, pl. 145, figs. 6-11
2008 *Tretomphaloides clara* (Cushman) – Hyams-Kaphzan *et al.,* p. 344

The holotype of *Neoconorbina clara* has been described by Cushman (1934) from Guam Anchorage, Ladrone Islands (western Pacific Ocean). Hottinger *et al.* (1993) recorded this species from the Gulf of Aqaba, Red Sea. The species was reported from the Mediterranean coast of Israel (Hyams-Kaphzan *et al.,* 2008; Hyams-Kaphzan, unpublished). *Neoconorbina clara* is here considered to be alien to the Mediterranean Sea.

***Nodophthalmidium antillarum*** (Cushman, 1922)

1922 *Articulina antillarum* Cushman – Cushman, p. 71, pl. 12, fig. 5
1929 *Nodophthalmidium antillarum* (Cushman) – Cushman, p. 52, pl. 12, fig. 4
1949 *Nodophthalmidium antillarum* (Cushman) – Said, p. 20, pl. 2, fig. 3
1968 *Nodophthalmidium antillarum* (Cushman) – Moncharmont Zei, pl. 3, fig. 3
1980 *Nodophthalmidium antillarum* (Cushman) – Alavi, pl. 20, fig. 9
1993 *Nodophthalmidium antillarum* (Cushman) – Hottinger *et al.*, p. 44, textfig. 2, pl. 23, figs. 4-7
2000 *Nodophthalmidium antillarum* (Cushman) – Hyams, pl. 3, fig. 4
*non* 2008b *Nodophthalmidium antillarum* (Cushman) – Meriç *et al.*, pl. 2, fig. 10 (*non* figs. 11-14)
*non* 2009 *Nodophthalmidium antillarum* (Cushman) – Yokeş & Meriç, pl. 1, figs. 10-11
2013a *Articulina antillarum* Cushman – Langer *et al.*, pl. 7, figs. 6-7
2014 *Nodophthalmidium antillarum* (Cushman) – Meriç *et al.*, pl. 8, figs. 11-12
*non* 2017 *Nodophthalmidium antillarum* (Cushman) – Mouanga, pl. 3, fig. 6

*Nodophthalmidium antillarum* was first described by Cushman (1922) from Tortugas, Florida (Cushman, 1922). The species was also recorded from the Red Sea (Said, 1949; Hottinger *et al.*, 1993) and the Bazaruto Archipelago, Mozambique (Langer *et al.*, 2013a). The first Mediterranean record was provided by Moncharmont Zei (1968) from material collected at Ras Muker Ben and Ras Minet el Hosn (Lebanon) at depth between 75 m and 246 m. Other Mediterranean records include specimens from Turkey (Alavi, 1980; Meriç *et al.*, 2008b) and Israel (Hyams, 2000; Yanko *et al.,* 1998, not illustrated). Specimens illustrated by Meriç *et al.* (2008b) and Yokeş & Meriç (2009) differ substantially from the holotype (chamber shape and striation pattern) and belong to a different species. The juvenile specimen illustrated and recorded by Mouanga (2017) from the coast of Albania is also a different species. *Nodophthalmidium antillarum* is considered to be alien to the Mediterranean Sea.

***Operculina ammonoides*** (Gronovius, 1781)

1781 *Nautilus ammonoides* Gronovius – Gronovius, p. 282 (no. 1220), pl. 19, figs. 5-6
1993 *Assilina ammonoides* (Gronovius) – Hottinger *et al.*, p. 154, pl. 222, figs. 1-8, pl. 223, figs. 1-14, pl. 224, figs. 1-8, pl. 225, figs. 1-9
2016 *Operculina ammonoids* (Gronovius) – Merkado, fig. 2 A, fig. 21, fig. 24, fig. 26

The holotype of *Operculina ammonoides* has been described by Gronovius (1781) from the Bay of Bengal (Indian Ocean). Hottinger *et al.* (1993) recorded this species from the Gulf of Aqaba, Red Sea. The species also has been reported from the Adriatic Sea by Wiesner (1913) and Silvestri (1950) and by Yokeş & Meriç (2009) from Turkey. The latter records, however, lack illustrations. *Operculina ammonoides* was recently reported from the Mediterranean coast of Israel (Merkado, 2016). It is currently also present in rocky reefs of Shikmona, Haifa (Hyams-Kaphzan, unpublished). Populations along the coast of Israel are genetically closely related to specimens from the Red Sea and Japan (Merkado, 2016). The data currently available indicate that *Operculina ammonoides* is alien to the Mediterranean Sea.

***Pararotalia calcariformata*** McCulloch, 1977

1977 *Pararotalia calcariformata* McCulloch – McCulloch, p. 428, pl. 177, figs. 10-11
1980 *Pararotalia* aff. *P. bisaculeata* (d'Orbigny) – Alavi, pl. 30, fig. 8
1994 *Eponides repandus* (Fichtel & Moll) – Yanko *et al.*, pl. 2, figs. 1-9
1994 *Pararotalia spinigera* (Le Calvez) – Reinhardt *et al.*, pl. 2, figs. 11-12
1998 *Pararotalia spinigera* (Le Calvez) – Yanko *et al.*, pl. 1, figs. 6-9
2000 *Pararotalia spinigera* Le Calvez – Hyams, pl. 24, figs. 5-7
2010 *Pararotalia spinigera* Le Calvez – Avnaim-Katav, pl. 9, figs. 7-10
2013 *Pararotalia calcariformata* McCulloch – Meriç *et al.*, figs. 2-3
2015 *Pararotalia calcariformata* McCulloch – Schmidt *et al.*, fig. 1
2016 *Pararotalia calcariformata* McCulloch – Titelboim *et al.*, fig. 5, 3-4
2020 *Pararotalia calcariformata* McCulloch – Avnaim-Katav *et al.*, fig. 4, 18a, b
2020 *Pararotalia calcariformata* McCulloch – Manda *et al.*, fig. 3C

The holotype of *Pararotalia calcariformata* was collected at Colombo Bay, Ceylon, Indian Ocean (McCulloch, 1977). This species has been considered to be alien to the Mediterranean Sea by Meriç *et al.* (2013) and Schmidt *et al.* (2015). *Pararotalia calcariformata* has been frequently reported as *Pararotalia spinigera* (Reinhardt *et al.*, 1994; Yanko *et al.,* 1998; Hyams, 2000; Hyams-Kaphzan *et al.,* 2008). It is currently widely present and increasing in abundance off the coast of Israel from very shallow water depths down to 40 m (Hyams-Kaphzan *et al.*, 2014; Titelboim *et al.*, 2016; Avnaim-Katav *et al.,* 2020; Manda *et al.,* 2020). It has not yet been found in the Red Sea but is present around Bazaruto (Mozambique; Langer *et al.*, 2013a). However, fossil evidence shows *P. calcariformata* (reported as *P. spinigera*) to be present at Caesarea Maritima (Israel, Mediterranean Sea) by 171BC-78AD (Reinhardt *et al.*, 1994) as well as in Haifa Bay (HB30, 5 m), Israel (Avnaim-Katav, 2010). We therefore consider the species to be native to the Mediterranean Sea.

***Pararotalia* cf. *P. socorroensis*** (McCulloch, 1977)

1977 cf. *Praeglobotruncana? socorroensis* McCulloch – McCulloch, p. 424, pl. 178, fig. 4, pl. 179, figs. 1, 3
1993 *Pararotalia* cf. *P. socorroensis* (McCulloch) – Hottinger *et al.*, p. 141, pl. 200, figs. 1-11
2008 *Pararotalia* cf. *P. socorroensis* (McCulloch) – Hyams-Kaphzan *et al.*, p. 344

The holotype of *Pararotalia socorroensis* is from Socorro Island, eastern Pacific Ocean (McCulloch, 1977). The species has been recorded in the Red Sea by Hottinger *et al.* (1993) and from the eastern Mediterranean Sea by Hyams-Kaphzan *et al.* (2008) and Hyams-Kaphzan (unpublished). *Pararotalia* cf. *P. socorroensis* is considered to be alien to the Mediterranean Sea.

***Pararotalia spinigera*** Loeblich & Tappan, 1957 (ex. Le Calvez, 1949)

1987 *Pararotalia spinigera* (Le Calvez) – Loeblich & Tappan, p. 18, pl. 4, figs. 1a-3
*non* 1994 *Pararotalia spinigera* (Le Calvez) – Reinhardt *et al.*, pl. 2, figs. 11-12
*non* 2000 *Pararotalia spinigera* Le Calvez – Hyams, pl. 24, figs. 5-7

*Pararotalia spinigera* was considered to be alien to the Mediterranean Sea (Zenetos *et al.*, 2012). All illustrated Mediterranean records are now considered to be identical with *Pararotalia calcariformata*, a species that is native to the Mediterranean Sea (for further details, see *Pararotalia calcariformata*).

***Parasorites orbitolitoides*** (Hofker, 1930)

1930 *Praesorites orbitolitoides* Hofker – Hofker, p. 149, pl. 55, figs. 8, 10, 11, pl. 58, figs. 1-5, pl. 59, figs. 3, 14
*non* 1977 *Sorites orbitolitoides* (Hofker) – Hottinger *et al.*, figs. 11B, 13, 30A-C, 32A
1994 *Sorites orbitolitoides* (Hofker) – Gudmundsson, figs. 55-58, pl. 7, figs. 1-3
2017 *Parasorites/Broeckina orbitolitoides* (Hofker) – Nadal Nebot, pl. 1, fig. *
2018 *Parasorites* sp. – Mateu-Vicens *et al.*, 2018.
2018 *Parasorites orbitolitoides* (Hofker) – Ferragut Perelló, pl. 1, fig. 6, textfig. 6
2019 *Parasorites orbitoloides* (Hofker) – Alvira Romero, fig. 1

*Parasorites orbitolitoides* has been first described by Hofker (1930) from Indonesia. The species has not been recorded in the Red Sea (Hottinger *et al.,* 1993). Reliable records for *Parasorites orbitolitoides* from the Mediterranean Sea are known from the Balearic Islands, Spain (Nadal Nebot, 2017; Ferragut Perelló, 2018; Mateu-Vicens *et al.*, 2018 (not illustrated, but re-examined); Alvira Romero, 2019). Populations of Mediterranean *P. orbitolitoides* show a genetic similarity of 98% with the Indo-Pacific population analyzed from Guam (Alvira Romero, 2019). For the time being, we consider this species to represent a true alien in the Mediterranean Sea.

***Paratrochammina madeirae*** Brönnimann, 1979

1979 *Paratrochammina madeirae* Brönnimann – Brönnimann, p. 7, pl. 7, figs. a-c, f, h, pl. 10, figs. b, e
1993 *Paratrochammina madeirae* Brönnimann – Hottinger *et al.*, p. 32, pl. 7, figs. 11-15
2000 *Paratrochammina* sp. 1 – Hyams, pl. 1, figs. 9-10
*non* 2004 *Paratrochammina madeirae* Brönnimann – Diz *et al.*, pl. 1, figs. 4a-b
2008 *Paratrochammina madeirae* Brönnimann – Hyams-Kaphzan *et al.*, p. 336 (not illustrated)

*Paratrochammina madeirae* has first been recorded from Brazil (Brönnimann, 1979) and later from the Red Sea (Hottinger *et al.*, 1993). The species has also been found along the coast of Israel (Hyams, 2000; Hyams-Kaphzan *et al.,* 2008) and is considered to be alien to the Mediterranean Sea.

***Pegidia lacunata*** McCulloch, 1977

1977 *Pegidia lacunata* McCulloch – McCulloch, p. 347, pl. 154, fig. 2
1993 *Pegidia lacunata* McCulloch – Hottinger *et al.*, p. 108, pl. 139, figs. 7-9, pl. 140, figs. 1-5
2008 *Pegidia lacunata* McCulloch – Langer, p. 407, fig. 9

*Pegidia lacunata* has been described by McCulloch (1977) from the Philippine Islands, western Pacific. Hottinger *et al.* (1993) have reported the species from the Gulf of Aqaba at depths between 20 and 190 meters. The species has been rarely observed at a single sample site off Haifa, Israel (Langer, 2008, material collected in 1994) and is here considered to be alien to the Mediterranean Sea.

***Peneroplis* cf. *P. antillarum*** (d'Orbigny, 1839)

1826 cf. *Dendritina antillarum* d'Orbigny – d'Orbigny, p. 285
*non* 1839 *Dendritina antillarum* d'Orbigny – d'Orbigny, p. 58, pl. 7, figs. 3-6
*non* 1994 *Peneroplis antillarum* (d'Orbigny) – Gudmundsson, p. 111, textfigs. 19, 20, pl. 3, fig. 4, pl. 4, fig. 4
*non* 2000 *Peneroplis antillarum* (d'Orbigny) – Hohenegger *et al.,* text-fig. 6
2002 *Peneroplis antillarum* (d'Orbigny) – Hyams *et al.*, pl. 1, figs. 10-11
*non* 2019 *Peneroplis antillarum* (d'Orbigny) – Förderer and Langer, pl. 2, figs. 16-18

*Peneroplis antillarum* has been described from the Antilles, Caribbean Sea (d'Orbigny, 1826). Specimens recorded by Hyams *et al.* (2002) from the Mediterranean coast off Israel differ from the specimens illustrated by d'Orbigny (1826, 1839) and Hohenegger *et al.* (2000). The test surface of the Mediterranean specimen is ornamented by costae, has curved sutures and is more rounded in outline. The aperture is characterized by irregular, bilobate, rimmed openings. We consider the Mediterranean species to be a separate taxon, that is tentatively regarded as *P.* cf. *P. antillarum*. As this represents the first record of this species, it is considered to be native to the Mediterranean Sea.

***Peneroplis arietinus*** (Batsch, 1791)

| | |
|---|---|
| 1791 | *Nautilus arietinus* Batsch – Batsch, pl. 6, fig. 15c |
| *non* 1791 | *Nautilus arietinus* Batsch – Batsch, pl. 6, figs. 15a-b, 15d-f |
| ? 1884 | *Peneroplis arietinus* (Batsch) – Brady, p. 204, pl. 13, figs. 18-19 |
| *non* 1884 | *Peneroplis arietinus* (Batsch) – Brady, p. 204, pl. 13, fig. 22 |
| 1923 | *Peneroplis arietinus* (Batsch) – Wiesner, p. 96, fig. 289 |
| 1979 | *Spirolina arietinus* (Batsch) – Blanc-Vernet *et al.*, pl. 24, fig. Sp a |
| 1994 | *Peneroplis arietinus* (Batsch) – Gudmundsson, pl. 2, fig. 3, pl. 3, fig. 2 |
| *non* 2008a | *Peneroplis arietinus* (Batsch) – Meriç *et al.*, pl. 9, figs. 14-16, pl. 10, figs. 1-5 |
| *non* 2017 | *Spirolina arietina* (Batsch) – Lamourou *et al.*, fig. 7g |
| 2019 | *Peneroplis arietinus* (Batsch) – Förderer & Langer, p. 13, pl. 2, figs. 6-12 |

*Peneroplis arietinus* has been described by Batsch (1791). The type locality is not known, but Cushman (1931) states that the collection site of the Batsch species is "from Rimini or at least the Adriatic Sea" based on the faunal content. The species resembles *Peneroplis planatus* and mainly differs from the latter in having fused pit rows that form deep grooves in between the ribs (see also Förderer & Langer, 2019). *Peneroplis arietinus* also resembles *Coscinospira hemprichii*, a species that is native to the Mediterranean Sea (discussed above). Several not illustrated records of *P. arietinus* (Sidebottom, 1904; Wiesner, 1911a; 1911b; 1913; Alavi, 1980; Davaud & Septfontaine, 1995) from the Mediterranean Sea may belong to *C. hemprichii* but the diagnostic features that separate both taxa require further study. Because of lower temperatures in the Mediterranean Sea, *C. hemprichii* masks its prominent morphological features, has lower calcification rates and resembles the sister genus *Peneroplis*. The test ornamentation and the pit row pattern of specimens illustrated by Gudmundsson (1994) resemble *C. hemprichii* as illustrated by Hottinger *et al.* (1993) and Förderer & Langer (2019). The illustrations provided by Meriç *et al.* (2008a) reveal apertural openings centered in the terminal face and distinct pore pits between the longitudinal ribs. Both features are not present in true *Peneroplis arietinus*. The figures provided by Wiesner (1923) and Blanc-Vernet *et al.* (1979) do not provide sufficient resolution to identify the taxon as true *P. arietinus*. *Coscinospira arietina* has previously been reported to be alien to the Mediterranean Sea (Servello *et al.,* 2019), but the latter is in fact *Coscinospira hemprichii*, a species that is native to the Mediterranean (see above). As outlined above, the type locality of *P. arietinus* is believed to be in the Adriatic Sea (Cushman, 1931). We therefore consider *P. arietinus* to be native to the Mediterranean, but further studies are required.

***Planispirinella exigua*** (Brady, 1879)

| | |
|---|---|
| 1884 | *Hauerina exigua* Brady – Brady, p. 196, pl. 12, figs. 1-4 |
| 1954 | *Planispirina exigua* (Brady) – Cushman *et al.*, p. 341, pl. 85, fig. 28 |
| 1994 | *Planispirinella exigua* (Brady) – Loeblich & Tappan, p. 38, pl. 57, figs. 7-8 |
| 2006 | *Planispirinella exigua* (Brady) – Oflaz, p. 141, pl. 1, figs. 10-11, pl. 11, fig. 3 |

The first description of *Planispirinella exigua* was provided by Brady (1879) from the Admiralty Islands and New Guinea. Not illustrated records from the Adriatic Sea include Wiesner (1911a) and Ćosović *et al.* (2011). Oflaz (2006) illustrates *P. exigua* from Turkey. This species is also present off the coast of Israel (Hyams-Kaphzan, unpublished, material collected in 1997). We therefore consider *P. exigua* to be alien to the Mediterranean Sea.

***Planogypsina acervalis*** (Brady, 1884)

| | |
|---|---|
| 1884 | *Planorbulina acervalis* Brady – Brady, p. 657, pl. 92, fig. 4 |
| 1909 | *Planorbulina acervalis* Brady – Sidebottom, p. 2, pl. 1, fig. 4 |
| 1949 | *Planorbulina mediterranensis* d'Orbigny – Said, p. 44, pl. 4, fig. 25 |
| *non* 1949 | *Planorbulina acervalis* Brady – Said, p. 43, pl. 4, fig. 28 |
| 1993 | *Planogypsina acervalis* (Brady) – Hottinger *et al.*, p. 125, pl. 169, figs. 1-9, 170, figs. 1-8 |
| *non* 2006 | *Planorbulina acervalis* (Brady) – Oflaz, pl. 8, fig. 16 |
| 2008b | *Planogypsina acervalis* (Brady) – Meriç *et al.,* pl. 8, fig. 9 (*non* figs. 4-5, 10-11) |
| *non* 2010 | *Planogypsina acervalis* (Brady) – Koukousioura *et al.,* p. 163, pl. 2, figs. 4-5 |
| 2014 | *Planogypsina acervalis* (Brady) – Meriç *et al.,* pl. 63, figs. 4a-b (*non* figs. 5-6) |

*Planogypsina acervalis* has first been described by Brady (1884) from Booby Island, located in the Pacific Ocean (~ 14 m water depth). Said (1949) and Hottinger *et al.* (1993) reported the species from the northern Red

Sea. The first record from the Mediterranean Sea was provided by Sidebottom (1909, Island of Delos, Greece). Records of *P. acervalis* were given by Wiesner (1923) from Rimini (Adria) and by Moncharmont Zei (1968) from off Lebanon, but they all lack illustrations. Other Mediterranean records include Meriç *et al.* (2008b; 2014) and Hyams-Kaphzan (unpublished, material collected in 1998). The currently available evidence indicates that this species is alien to the Mediterranean Sea.

***Planogypsina squamiformis*** (Chapman, 1901)

| | |
|---|---|
| 1901 | *Gypsina vesicularis* (Parker & Jones) var. *squamiformis* Chapman – Chapman, p. 200, pl. 19, fig. 15 |
| 1901 | *Gypsina vesicularis* (Parker & Jones) var. *monticulus* Chapman – Chapman, p. 200, pl. 19, fig. 14 |
| 1949 | *Planorbulina acervalis* Brady – Said p. 43, pl. 4, fig. 28 |
| 1979 | *Planorbulina* aff. *P. acervalis* Brady – Pereira, p. 288, pl. 41, figs. N-Q |
| 1993 | *Plangypsina squamiformis* (Chapman) – Hottinger *et al.*, p. 126, pl. 171, figs. 1-9 |
| *non* 2008a | *Plangypsina squamiformis* (Chapman) – Meriç *et al.*, pl. 15, figs. 1-4 |
| *non* 2008b | *Planogypsina squamiformis* (Chapman) – Meriç *et al.* pl. 8, figs. 12-15 |
| *non* 2009 | *Planogypsina squamiformis* (Chapman) – Yokeş & Meriç pl. 4, figs. 14-15 |
| *non* 2014 | *Planogypsina squamiformis* (Chapman) – Meriç *et al.* pl. 63, figs. 7-10 |

*Planogypsina squamiformis* was described by Chapman (1901) from Funafuti, Pacific Ocean. The species has also been recorded by Said (1949, Red Sea), Pereira (1979, Kenya) and Hottinger *et al.* (1993, Red Sea). The specimens illustrated by Meriç *et al.* (2008a; 2008b; 2014) and Yokeş & Meriç (2009) differ from the specimens recorded from the Pacific and the Indian Oceans and belong to *Planorbulina mediterranensis*. To date, there is no reliable record for *Planogypsina squamiformis* in the Mediterranean Sea, and we therefore consider the species to be absent.

***Procerolagena oceanica*** (Albani, 1974)

| | |
|---|---|
| 1974 | *Lagena oceanica* Albani – Albani, p. 37, pl. 1, figs. 7, 10-11 |
| 1993 | *Lagena oceanica* Albani – Hottinger *et al.*, p. 78, pl. 90, figs. 9-11 |

*Procerolagena oceanica* has first been described from Australia by Albani (1974). Mediterranean records are limited to specimens from the Mediterranean coast off Israel (*Lagena oceanica*: Hyams, 2006; Hyams-Kaphzan, 2016; not illustrated but reexamined). We consider *Procerolagena oceanica* to represent a species that is alien to the Mediterranean Sea.

***Pseudohauerinella dissidens*** (McCulloch, 1977)

| | |
|---|---|
| 1977 | *Pseudohauerina dissidens* McCulloch – McCulloch, p. 237, pl. 102, fig. 7 |
| 1993 | *Pseudohauerinella dissidens* (McCulloch) – Hottinger *et al.*, p. 67, pl. 74, figs. 1-8 |
| 1998 | *Pseudohauerinella dissidens* (McCulloch) – Piller & Haunold, pl. 6, fig. 15 |
| 2000 | *Pseudohauerinella dissidens* (McCulloch) – Hyams, pl. 14, fig. 8 |
| 2017 | *Pseudohauerinella dissidens* (McCulloch) – Thissen & Langer, pl. 9, figs. 15-18 |

The type locality of *Pseudohauerinella dissidens* is Sulphur Bay, Clarion Island (eastern Pacific, 31m depth; McCulloch, 1977). *Pseudohauerinella dissidens* has been recorded from the Red Sea by Hottinger *et al.* (1993) and Piller & Haunold (1998) and from Zanzibar by Thissen & Langer (2017). The first Mediterranean record was provided by Hyams (2000) from the coast off Israel. The Mediterranean representatives of *P. dissidens* are not as strongly plicated as their tropical counterparts. A reduction of test ornamental features is typical for several alien foraminifera that have migrated from warm tropical waters to the colder waters of the Mediterranean Sea. We consider this species to be alien to the Mediterranean Sea.

***Pseudolachlanella slitella*** Langer, 1992

| | |
|---|---|
| 1980 | *Quinqueloculina "laevigata"* d'Orbigny – Alavi, p. 19 (appendix), pl. 10, fig. 5, pl. 11, fig. 5 |
| 1992 | *Pseudolachlanella slitella* Langer – Langer, p. 90, pl. 2, figs. 4-6 |
| 1993 | *"Quinqueloculina" eburnea* d'Orbigny – Hottinger *et al.*, p. 59, pl. 53, figs. 9-11, pl. 54, figs. 1-5 |
| 2003 | *Pseudolachlanella slitella* Langer – Samir *et al.*, pl. 3, figs. 3-5 |
| 2008 | *Pseudolachlanella slitella* Langer – Langer, p. 406, fig. 7 |

*Pseudolachlanella slitella* has first been described by Langer (1992) from the Lagoon at Madang, Papua New Guinea. The species has also been recorded by Loeblich & Tappan (1994) from the Timor Sea, by Debenay (2012) from New Caledonia, and Hottinger *et al.* (1993) from the Red Sea (as *"Quinqueloculina" eburnea*). Mediterranean records include the studies by Alavi (1980, Turkey, as *Quinqueloculina "laevigata"*), Samir *et al.* (2003, Egypt) and Langer (2008, Gulf of Gabes). The species is rarely found along the coast off Israel (Hyams-Kaphzan, unpublished). *Pseudolachlanella slitella* was considered to be alien to the Mediterranean Sea by Langer (2008), but the first documented occurrence by Alavi (1980) shows that it was present in the Mediterranean Sea before its first record from Papua New Guinea, New Caledonia, and the Timor Sea. *Pseudolachlanella slitella* is therefore considered to be native to the Mediterranean Sea.

***Pseudomassilina australis*** (Cushman, 1932)

1932 *Massilina australis* Cushman – Cushman, p. 32, pl. 8, figs. 2 a-b
*non* 1980 *Pseudomassilina* cf. *P. australis* (Cushman) – Alavi, pl. 19 (appendix), fig. 8
1993 *Pseudomassilina australis* (Cushman) – Hottinger *et al.*, p. 53, pl. 41, figs. 3-11
*non* 2000 *Pseudomassilina* cf. *P. australis* (Cushman) – Hyams, pl. 11, fig. 1
2006 *Pseudomassilina australis* (Cushman) – Oflaz, p. 171, pl. 3, fig. 10

The holotype of *Pseudomassilina australis* was described by Cushman (1932) from Rarotonga, Cook Islands. Hottinger *et al.* (1993) recorded *P. australis* from the Gulf of Aqaba, Red Sea. The specimen illustrated by Oflaz (2006) from Turkey shares all morphological features with the holotype but appears to be a semi-adult individual. Similar specimens were recorded by Alavi (1980) from the Cilicia Basin, Turkey, and Hyams (2000) from the coast off Israel, but they show strong transverse ribs and were therefore assigned to *Pseudomassilina* cf. *P. australis*. For the time being we consider the specimen illustrated by Oflaz (2006) to be identical with the holotype and *Pseudomassilina australis* to be alien to the Mediterranean Sea.

***Pseudomassilina reticulata*** (Heron-Allen & Earland, 1915)

1915 *Miliolina (Massilina) secans,* var. *reticulata* Heron-Allen & Earland – Heron-Allen & Earland, p. 582, pl. 45, figs. 1-4
1987 *Pseudomassilina australis* (Cushman) subsp. *reticulata* (Heron-Allen & Earland) – Baccaert, p. 111, pl. 51, fig. 2
1993 *Pseudomassilina reticulata* (Heron-Allen & Earland) – Hottinger *et al.*, p. 54, pl. 42, figs. 5-8, pl. 43, figs. 1-8
2000 *Pseudomassilina reticulata* (Heron-Allen & Earland) – Hyams, pl. 11, figs. 2-3
2008a *Pseudomassilina reticulata* (Heron-Allen & Earland) – Meriç *et al.*, pl. 7, fig. 4
2008b *Pseudomassilina reticulata* (Heron-Allen & Earland) – Meriç *et al.*, pl. 4, fig. 6
2009 *Pseudomassilina reticulata* (Heron-Allen & Earland) – Yokeş & Meriç, pl. 2, fig. 6
2014 *Pseudomassilina reticulata* (Heron-Allen & Earland) – Meriç *et al.*, pl. 27, fig. 16

Heron-Allen & Earland (1915) first described *Pseudomassilina reticulata* from several localities in the Quirimbas Archipelago off northern Mozambique. Their illustrations (figs. 1-2) show a distinct reticulate surface pattern as a characteristic feature of this taxon. The species has been reported from Zanzibar (Thissen & Langer, 2017) and the Red Sea by Hottinger *et al.* (1993). Mediterranean records include Hyams (2000), Avsar *et al.,* 2001 (not illustrated), Meriç *et al.* (2008a; 2008b), Yokeş & Meriç (2009) and Meriç *et al.* (2014). In the Mediterranean Sea, the test reticulation appears to be less pronounced, a morphological feature that is typical for species that have migrated from warm tropical waters to the colder Mediterranean. Hottinger *et al.* (1993) consider test reticulation to be variable. We therefore consider the specimens illustrated by Hyams (2000) and Meriç (2008a) to be identical with the holotype of *Pseudomassilina reticulata* and the species to be alien to the Mediterranean Sea.

***Pseudoschlumbergerina ovata*** (Sidebottom, 1904)

1904 *Sigmoilina ovata* Sidebottom – Sidebottom, p. 6, fig. 1
1968 *Sigmoilina ovata* Sidebottom – Moncharmont Zei, p. 27, pl. 2, fig. 11
1980 *"Sigmoilina" ovata* Sidebottom – Alavi, p. 25 (appendix), pl. 11, fig. 12, pl. 17, fig. 11
1990 *Septloculina rotunda* El-Nakhal – El-Nakhal, p. 91, pl. 1, figs. 8-11, pl. 2, fig. 13
1993 *Pseudoschlumbergerina ovata* (Sidebottom) – Hottinger *et al.*, p. 55, pl. 46, figs. 1-6
2000 *Pseudoschlumbergerina ovata* (Sidebottom) – Hyams, pl. 11, figs. 5-6
2006 *Septloculina rotunda* El-Nakhal – Oflaz, p. 164, pl. 3, fig. 5
2012 *Pseudoschlumbergerina ovata* (Sidebottom) – Milker & Schmiedl, p. 68, pl. 17, figs. 29-30
2017 *Pseudoschlumbergerina ovata* (Sidebottom) – Guy-Haim *et al.*, pl. 4, fig. 19, pl. 2, fig. 15

*Septloculina rotunda* is listed as alien to the Mediterranean in EASIN (2020). The species was described by El-Nakhal (1990) from the Red Sea but is a junior synonym of *Pseudoschlumbergerina ovata* (Sidebottom, 1904), a species that was first recorded from the Mediterranean. *Septloculina rotunda* has been considered to be alien to the Mediterranean Sea by Oflaz (2006). It has been recorded by Hyams-Kaphzan *et al.* (2008, 2014) as *Pseudoschlumbergerina ovata*. Marriner *et al.* (2005), Milker & Schmiedl (2012) and Hyams-Kaphzan (unpublished) recorded fossil occurrences from the Mediterranean Sea. *Pseudoschlumbergerina ovata* is therefore native to the Mediterranean Sea. Guy-Haim *et al.* (2017) found living specimens of *Pseudoschlumbergerina ovata* in fecal pellets of herbivorous rabbitfish collected in the Suez Canal, indicating that present-day species introductions via ichthyochory vectors are ongoing.

***Pseudotriloculina subgranulata*** (Cushman, 1918)

1918 *Triloculina subgranulata* Cushman – Cushman, p. 290, pl. 96, figs. 4a-c
1993 *Pseudotriloculina subgranulata* (Cushman) – Hottinger *et al.*, p. 56, pl. 47, figs. 8-13, pl. 48, figs. 1-8
? 1994 *Triloculina subgranulata* Cushman – Reinhardt *et al.*, pl. 1, figs. 12-13
1998 *Pseudotriloculina subgranulata* (Cushman)

– Yanko *et al.,* pl. 6, figs. 9-11
2000 *Pseudotriloculina subgranulata* (Cushman) – Hyams, pl. 12, fig. 6
*non* 2017 *Pseudotriloculina subgranulata* (Cushman) – Makled *et al.*, pl. 12, fig. 12

*Pseudotriloculina subgranulata* has been described by Cushman (1918, as *Triloculina subgranulata*) from the Tortugas (Florida). The species is characterized by its rough test surface, resulting from distinct microstriae. *Pseudotriloculina subgranulata* was also reported from the coast of Israel by Yanko *et al.* (1998) and Hyams (2000). Other records from the Mediterranean Sea include Moncharmont Zei (1968) and Hyams-Kaphzan *et al.* (2008), but lack illustrations. The fossil specimen reported by Reinhardt *et al.* (1994) requires further study. The species was recently recorded in core material from the Mediterranean coast off Israel (Hyams-Kaphzan, unpublished). *Pseudotriloculina subgranulata* is therefore native to the Mediterranean Sea.

***Pyrgo denticulata*** (Brady, 1884)

1884 *Biloculina ringens* var. *denticulata* Brady – Brady, p. 143, pl. 3, figs. 4-5
1950 *Pyrgo denticulata* (Brady) – Said, p. 7, pl. 1, fig. 15
1993 *Pyrgo denticulata* (Brady) – Hottinger *et al.*, p. 56, pl. 49, figs. 8-12
2000 *Pyrgo denticulata* (Brady) – Hyams, pl. 12, fig. 2
2008a *Pyrgo denticulata* (Brady) – Meriç *et al.*, pl. 7, fig. 10
2010 *Pyrgo denticulata* (Brady) – Avnaim-Katav, p. 224, pl. 4, fig. 7

*Pyrgo denticulata* has been reported from Honolulu and Tongatapu (Tonga) by Brady (1884), from the Malay Archipelago (Millett, 1898), Funafuti (Chapman, 1901), the Kerimba Archipelago (Heron-Allen & Earland, 1915), Jamaica (Cushman, 1929) and the Red Sea (Said, 1950; Hottinger *et al.,* 1993). The first occurrence in the Mediterranean Sea was provided by Hyams (2000) from off Israel. A single figure is provided by Meriç *et al.* (2007; 2008a; 2008b; 2014) and Yokeş & Meriç (2009), a figure that is identical in all four publications. Avnaim-Katav (2010) recorded fossil occurrences from the Mediterranean Sea, Haifa Bay, Israel (HB30, 1.95 m, Israel). However, dating of the core material is not clear-cut and requires further study. For the time being we consider *Pyrgo denticulata* to be alien to the Mediterranean Sea.

***Quinqueloculina* cf. *Q. mosharrafai*** Said, 1949

1949 cf. *Quinqueloculina mosharrafai* Said – Said, p. 10, pl. 1, fig. 23
1993 *Quinqueloculina* cf. *Q. mosharrafai* Said – Hottinger *et al.*, p. 59, pl. 54, figs. 6-9, pl. 55, figs. 1-6
2008a *Quinqueloculina* cf. *Q. mosharrafai* Said – Meriç *et al.*, pl. 6, fig. 12
2009 *Quinqueloculina* cf. *Q. mosharrafai* Said – Yokeş & Meriç, pl. 2, fig. 4
2014 *Quinqueloculina* cf. *Q. mosharrafai* Said – Meriç *et al.*, pl. 24, fig. 8
2014 *Quinqueloculina* cf. *Q. mosharrafai* Said – Hyams-Kaphzan *et al.*, p. 13

*Quinqueloculina mosharrafai* was first described from the Red Sea by Said (1949). Hottinger *et al.* (1993) illustrate a similar species (*Quinqueloculina* cf. *Q. mosharrafai*) from the Red Sea that differs from the holotype in having a bifid tooth and a partially agglutinated test surface. The holotype illustrated by the Smithsonian National Museum of Natural History (2020) shows agglutinated particles on the test surface but lacks the bifid tooth. The specimen described by Meriç *et al.* (2008a; 2014) and Yokeş & Meriç (2009) from Turkey is identical to *Quinqueloculina* cf. *Q. mosharrafai* from the Red Sea (Hottinger *et al.,* 1993). *Quinqueloculina* cf. *Q. mosharrafai* has also been reported from the coast of Israel (Hyams-Kaphzan *et al.*, 2014, material collected in 2013) and is here considered to be alien to the Mediterranean Sea.

***Quinqueloculina* cf. *Q. multimarginata*** Said, 1949

1949 cf. *Quinqueloculina multimarginata* Said – Said, p. 10, pl. 1, fig. 34
1993 *Quinqueloculina* cf. *Q. multimarginata* Said – Hottinger *et al.*, p. 59, pl. 55, figs. 7-10
2000 *Quinqueloculina* cf. *Q. multimarginata* Said – Hyams, pl. 7, fig. 9
2018 *Quinqueloculina* cf. *Q. multimarginata* Said – Förderer & Langer, pl. 23, figs. 28-30

The holotype of *Quinqueloculina multimarginata* described by Said (1949) from the Red Sea has thin keels and irregular costae on parts of the test surface. *Quinqueloculina* cf. *Q. multimarginata* described by Hottinger *et al.* (1993) differs from Said's illustration by having an angular periphery and a rounded carina. In addition, the test surface is covered with distinct anastomosing microstriations. The Mediterranean specimen illustrated by Hyams (2000) represents a morphological variety of *Q.* cf. *Q. multimarginata* and has a slightly smoother surface than the specimens illustrated by Hottinger *et al.* (1993, Gulf of Aqaba) and Förderer & Langer (2018, Indonesia). For the time being, we consider *Quinqueloculina* cf. *Q. multimarginata* to be alien to the Mediterranean Sea.

***Schlumbergerina alveoliniformis*** (Brady, 1879)

1879 *Miliolina alveoliniformis* Brady – Brady, p. 268
1884 *Miliolina alveoliniformis* Brady – Brady, p. 181, pl. 8, figs. 15-20
1987 *Schlumbergerina alveoliniformis* (Brady) – Baccaert, p. 150, pl. 65, figs. 4-5, pl. 66, figs. 1a-c

1993 *Schlumbergerina alveoliniformis* (Brady) – Hottinger *et al.*, p. 61, pl. 58, figs. 11-14, pl. 59, figs. 1-9
2008b *Schlumbergerina alveoliniformis* (Brady) – Meriç *et al.*, p. 331, pl. 3, figs. 8-11
2009 *Schlumbergerina alveoliniformis* (Brady) – Yokeş & Meriç, pl. 1, figs. 16-17
2014 *Schlumbergerina alveoliniformis* (Brady) – Meriç *et al.*, pl. 24, fig. 8

*Schlumbergerina alveoliniformis* has been described by Brady (1879) from the Admiralty Islands in the Pacific Ocean with occurrences in Honolulu and Tongatabu. Mediterranean specimens illustrated by Meriç *et al.* (2008b; 2014) and Yokeş & Meriç (2009) represent the only Mediterranean records. We consider the species to be alien to the Mediterranean Sea.

***Septloculina angulata*** El-Nakhal, 1990

1904 *Sigmoilina ovata* Sidebottom – Sidebottom, p. 6 (pars), text-fig. 1 (*non* pl. 2, figs. 12-13)
1990 *Septloculina angulata* El-Nakhal – El-Nakhal, p. 91, pl. 1, figs. 1-7
*non* 2006 *Septloculina angulata* El-Nakhal – Oflaz, p. 164, pl. 3, fig. 4

The species *Septloculina angulata* was described by El-Nakhal (1990) from the littoral zone off Tartus Town, Syria (Mediterranean Sea). *Septloculina angulata* is a species with seven, externally visible chambers, a subangular thickend periphery, a rough surface, and a semicircular terminal aperture provided with a bifid tooth. The species illustrated by Oflaz has less chambers, lacks the thickend chamber periphery and probably belongs to a different genus. The species was first described from the eastern Mediterranean is therefore native to the Mediterranean Sea.

***Septloculina tortuosa*** El-Nakhal, 1990

1990 *Septloculina tortuosa* El-Nakhal – El-Nakhal, p. 91, pl. 2, fig. 4-9
*non* 2006 *Septloculina tortuosa* El-Nakhal – Oflaz, p. 165, pl. 3, fig. 6

The species *Septloculina tortuosa* has been described by El-Nakhal from Alexandria (1990, Egypt, Mediterranean Sea) and is therefore native to the Mediterranean Sea. The specimen reported by Oflaz (2006) from Iskenderun Bay, Turkey shows a quinqueloculine chamber arrangement and belongs to a different genus.

***Sigmamiliolinella australis*** (Parr, 1932)

1932 *Quinqueloculina australis* Parr – Parr, pl. 1, figs. 8a-c
1987 *Miliolinella australis* (Parr) – Baccaert, p. 138, pl. 60, figs. 6-8
*non* 1990 *Miliolinella subrotunda* (Montagu) – Dermitzakis & Triantafillou, p. 150, pl. 3, fig. 5
2005 *Miliolinella subrotunda* (Montagu) – Triantaphyllou *et al.*, pl. 1, fig. 3
2006 *Miliolinella subrotunda* (Montagu) – Langer & Schmidt-Sinns, pl. 8, figs. 8-9
2010 *Sigmamiliolinella australis* (Parr) – Avnaim-Katav, pl. 4, fig. 18
2011 *Miliolinella subrotunda* (Montagu) – Koukousioura *et al.*, pl. 1, fig. 7
2013a *Miliolinella australis* (Parr) – Langer *et al.,* pl. 5, figs. 40-41
*non* 2014 *Miliolinella australis* (Parr) – Meriç *et al.*, pl. 25, fig. 21
2017 *Miliolinella australis* (Parr) – Fajemila and Langer, figs. 6, 30, 31
2017 *Sigmamiliolinella australis* (Parr) – Mouanga, pl. 8, figs. 15a-b
2018 *Sigmamiliolinella australis* (Parr) – Förderer & Langer, p. 91, pl. 18, figs. 25-30

The type locality for *Sigmamiliolinella australis* is east of Cape Pillar, Tasmania (Parr, 1932). Baccaert (1987) noted that the species is typical for tropical and temperate waters of "Indopacific shallow-water localities exclusively". *Sigmamiliolinella australis* is not known from the northern Red Sea (Said, 1949; Hottinger *et al.*, 1993; Piller & Haunold, 1998). A typical feature of *S. australis* is the partially coarse test surface at the proximal part of the shell. Some specimens of *S. australis* from the Mediterranean have been assigned to *Miliolinella subrotunda*. The first Mediterranean reference of *Miliolinella australis* was provided by Alavi (1980), p. 90. The first illustrated record of *Sigmamiliolinella australis* in the Mediterranean was given by Triantaphyllou *et al.* (2005, identified as *Miliolinella subrotunda*). Other records include material from Greece (Koukousioura *et al.*, 2011), Elba Island, Italy (Langer & Schmidt-Sinns, 2006), Dhermi, Albania (Mouanga, 2017), Corfu (Langer, unpublished; material collected in 2014) and Israel (Avnaim-Katav, 2010 coretop, material collected in 2005; Hyams-Kaphzan *et al.*, 2014, material collected in 2013). The specimen illustrated in Dermitzakis & Triantafillou (1990) has inflated chambers, a smooth surface, lacks the typical thickend apertural rim and thus differs from *Sigmamiliolinella australis* (Parr). Recently re-illustrated material from the same material (Triantaphyllou, unpublished) has a similar test surface but shows a specimen with an oblique middle chamber and small aperture that also lacks the typical thickened apertural rim. To date, the species has not yet been found in core material. *Sigmamiliolinella australis* is currently abundant on macroalgae at sites off Haifa (Hyams-Kaphzan, unpublished) and appears to be a recent arrival in the southeastern Mediterranean Sea. We consider *Sigmamiliolinella australis* to be alien to the Mediterranean Sea.

***Sigmoihauerina bradyi*** (Cushman, 1917)

1884 *Hauerina compressa* d'Orbigny – Brady, pl. 11, figs. 12-13 (*non H. compressa* d'Orbingy)
*non* 1904 *Hauerina compressa* d'Orbigny – Sidebottom, p. 19, no. 20
1917 *Hauerina bradyi* Cushman – Cushman, p, 62, pl. 23, figs. 2a-b
1949 *Hauerina bradyi* Cushman – Said, p. 17, pl. 2, fig. 5
*non* 1968 *Hauerina bradyi* Cushman – Moncharmont Zei, p. 14, pl. 3, fig. 7
1993 *Hauerina bradyi* Cushman – Hottinger *et al.*, p. 62, pl. 60, figs. 1-12
*non* 2006 *Sigmoihauerina bradyi* (Cushman) – Oflaz, p. 170, pl. 3, fig. 9

Brady (1884) provided the original illustrations for *Sigmoihauerina bradyi* (Cushman) from material collected in the Torres Strait and at Booby Island (Pacific Ocean). The species is characterized by its compressed test and thus differs from the more inflated species *Hauerina compressa* of d'Orbingy (1846) from Miocene deposits of the Vienna Basin. The Mediterranean records provided by Sidebottom (1904, as *Hauerina compressa*), Moncharmont Zei (1968), and Oflaz (2006) show the inflated form and that does not match the holotype or the specimens illustrated by Hottinger *et al.* (1993). Specimens with the typical large and compressed test are not yet known from the Mediterranean Sea and we therefore consider *Sigmoihauerina bradyi* to be absent from this region.

***Siphonaperta* cf. *S. pittensis*** (Albani, 1974)

*non* 1957 *Quinqueloculina parvaggluta* Vella – Vella, p. 27, pl. 4, figs. 71-73
1974 cf. *Quinqueloculina pittensis* Albani – Albani, p. 33, pl. 1, figs. 1-3
*non* 1993 *Siphonaperta pittensis* (Albani) – Hottinger *et al.*, p. 63, pl. 64, figs. 1-6
2000 *Siphonaperta* cf. *S. pittensis* (Albani) – Hyams, pl. 9, fig. 6
*non* 2010 *Quinqueloculina parvaggluta* Vella – Hayward *et al.*, p. 154, pl. 5, figs. 1-2
*non* 2012 *Quinqueloculina parvaggluta* Vella – Debenay, p.125
*non* 2012 *Quinqueloculina pittensis* (Albani) – Debenay, p.125
*non* 2013a *Siphonaperta pittensis* (Albani) – Langer *et al.*, pl. 4, figs. 33-34

*Siphonaperta pittensis* was considered to be a Lessepsian invader by Hyams-Kaphzan *et al.* (2008). The Mediterranean records are now considered to constitute a separate species. *Siphonaperta* cf. *S. pittensis* is more elongated than *S. pittensis* and its chambers are less inflated (see also Hyams, 2000). *Siphonaperta* cf. *S. pittensis* also resembles *Quinqueloculina parvaggluta* as described by Vella (1957). The relationship between *Siphonaperta pittensis* and *Quinqueloculina parvaggluta* remains uncertain. Specimens of *Siphonaperta* cf. *S. pittensis*, as illustrated by Hyams (2000), were recorded from the Mediterranean coast off Israel. As this constitutes the only record, we consider the species to be native to the Mediterranean Sea.

***Siphonaperta distorqueata*** (Cushman, 1954)

1954 *Quinqueloculina distorqueata* Cushman – Cushman *et al.*, p. 333, pl. 83, fig. 27
1980 *Quinqueloculina berthelotiana* d'Orbigny – Alavi, pl. 15, fig. 2
1993 *Siphonaperta distorqueata* (Cushman) – Hottinger *et al.*, p. 63, pl. 62, figs. 4-9, pl. 63, figs. 1-6
2000 *Siphonaperta distorqueata* (Cushman) – Hyams, pl. 9, figs. 2-3
2009 *Quinqueloculina distorqueata* Cushman – Parker, p. 195, figs. 138-139
2011 *Siphonaperta distorqueata* (Cushman) – Makled & Langer, fig. 7, 7-9
2017 *Siphonaperta distorqueata* (Cushman) – Thissen & Langer, pl. 7, figs. 24-26
2017 *Quinqueloculina distorqueata* Cushman – Fajemila & Langer, fig. 4, 30-32

*Siphonaperta distorqueata* has been described from the Marshall Islands by Cushman *et al.* (1954). The species has been recorded from the Red Sea by Hottinger *et al.* (1993), from around Australia by Parker (2009, and references therein), from the Chuuk Atoll (western Pacific) by Makled & Langer (2011), from the Atlantic Ocean (Fajemila & Langer, 2017) and from Zanzibar by Thissen & Langer (2017). Mediterranean records include specimens from Turkey (Alavi, 1980, as *Quinqueloculina berthelotiana*) and from shallow waters off Israel (Hyams, 2000; Hyams-Kaphzan *et al.*, 2008; 2014). The species is here considered to be alien to the Mediterranean Sea.

***Sorites variabilis*** Lacroix, 1941

1941 *Sorites variabilis* Lacroix – Lacroix. (pars), p. 14
1941 *Sorites variabilis* Lacroix – Lacroix., p. 11 (pars), figs. 12, 18
? 1979 *Sorites variabilis* Lacroix – Blanc-Vernet *et al.*, pl. 21, fig. 14, pl. 24, fig. S
? 1993 *Sorites variabilis* Lacroix – Hottinger *et al.*, p. 73, pl. 84, figs. 1-15
? 2008a *Sorites variabilis* Lacroix – Meriç *et al.*, pl. 12, figs. 12-15, pl. 13, figs. 1-4
? 2008b *Sorites variabilis* Lacroix – Meriç *et al.*, pl. 7, figs. 1-8
2013 *Sorites variabilis* Lacroix – Merkado *et al.*, pl. 7, figs. 1-2
? 2016 *Sorites variabilis* Lacroix – Ayadi *et al.*, pl. 1, fig. 9, pl. 3, figs. 2-3
*non* 2017 *Sorites variabilis* Lacroix – Lamourou *et al.*, fig. 7(h)

*Sorites variabilis* has been first described by Lacroix (1941) from the Gulf of Aqaba, Red Sea. Lacroix described three types of soritid foraminifera. Only type II has been designated to represent *S. variabilis* (see also Hottinger *et al.*, 1993). The Mediterranean records from Turkey (Meriç *et al.*, 2008a; 2008b) do not provide illustrations of the apertural features and their true identity requires further study. The specimens from Israel (Hyams-Kaphzan *et al.*, 2008, not illustrated) and from Villefranche (Langer, unpublished; material collected in 1996) were reexamined by us, show the typical morphological features of *Sorites variabilis* (particularly thin-shelled, single row of apertures). All *Sorites* specimens described or illustrated from Naxos (Greece, Cherif, 1970) of from along the coast of Tunisia (Glacon, 1962; Blanc-Vernet *et al.*, 1979; Langer, unpublished) are thick-shelled, show the typical features of *Sorites orbiculus*, and do not belong to *Sorites variabilis* (see also Baccaert, 1987). For the time being, this species is considered to be alien to the Mediterranean, but further molecular studies are required.

***Spiroloculina angulata*** Cushman, 1917

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| 1917 | *Spiroloculina grata* Terquem var. *angulata* Cushman – Cushman, p. 36, pl. 7, fig. 5; |
| 1968 | *Spiroloculina grata* Terquem var. *angulata* Cushman – Moncharmont Zei, pl. 3, fig. 10 |
| *non* 2008 | *Spiroloculina angulata* Cushman – Yalçın *et al.*, pl. 1, fig. 8 |
| *non* 2013 | *Spiroloculina angulata* Cushman – Cosentino *et al.*, p. 8786, pl. 1, fig. 18 |

The type species of *Spiroloculina angulata* has been described by Cushman (1917) from the northern Pacific. The species is characterized by its truncated periphery and a characteristic median carina. A single illustrated record of this species exists from the coast of Lebanon (Moncharmont Zei, 1968). Other records of *Spiroloculina angulata* include Alavi (1980), Morhange *et al.* (2000), Basso & Spezzaferri (2000), Samir & El-Din (2001), Avşar *et al.* (2001), Meriç *et al.* (2004), Zaïbi *et al.* (2016), Altınsaçlı *et al.* (2017, Sea of Marmara), but they all lack illustrations. For the time being, *Spiroloculina angulata* is considered to be alien to the Mediterranean Sea.

***Spiroloculina antillarum*** d'Orbigny, 1839

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|---|---|
| 1839 | *Spiroloculina antillarum* d'Orbigny – d'Orbigny, p. 166, pl. 9, figs. 3-4 |
| 1920 | *Spiroloculina antillarum* d'Orbigny – Martinotti, p. 261, figs. 16-17 |
| 1923 | *Spiroloculina antillarum* d'Orbigny – Wiesner, p. 33, pl. 4, fig. 20 |
| non 1970 | *Spiroloculina antillarum* d'Orbigny – Cherif, p. 37, pl. 3, fig. 3 |
| 1977 | *Spiroloculina antillarum* d'Orbigny – Le Calvez, p. 91, pl. 17, figs. 1-6 |
| non 1979 | *Spiroloculina antillarum* d'Orbigny – Blanc-Vernet *et al.*, pl. 24, fig. Sa |
| non 1993 | *Spiroloculina antillarum* d'Orbigny – Hottinger *et al.*, p. 45, pl. 24, figs. 15-17, pl. 25, figs. 1-2 |
| non 2008a | *Spiroloculina antillarum* d'Orbigny – Meriç *et al.*, pl. 3, figs. 5-11 |
| non 2008b | *Spiroloculina antillarum* d'Orbigny – Meriç *et al.*, pl. 2, fig. 19, pl. 3, figs. 1-4, 6-7 (*non* fig. 5) |
| non 2010 | *Spiroloculina antillarum* d'Orbigny – Avnaim-Katav, p. 220, pl. 2, fig. 2 |
| non 2017 | *Spiroloculina antillarum* d'Orbigny – Mouanga, p. 175, pl. 1, figs. 3a-b |
| non 2017 | *Spiroloculina antillarum* d'Orbigny – Thissen & Langer, pl. 3, figs. 7-10 |
| non 2018 | *Spiroloculina antillarum* d'Orbigny – Emter, figs. 19, 21-22 |

*Spiroloculina antillarum* was first recorded from Cuba by d'Orbigny (1839), is elongate fusiform in lateral view and possess a densely costate test surface and long neck (see Le Calvez, 1977). The first record from the Mediterranean was provided by Wiesner (1913, not illustrated). The specimen was later illustrated by Martinotti (1920, Libya), Wiesner (1923, Adriatic Sea). Records without illustrations include Moncharmont-Zei (1968, Lebanon), Samir *et al.* (2003, Egypt), Mkawar *et al.* (2007, Tunisia), and Serandrei-Barbero *et al.* (2011, Adriatic Sea). We consider *Spiroloculina antillarum* to be alien in the Mediterranean Sea. The specimens illustrated by Hottinger *et al.* (1993), Meriç *et al.* (2008 a,b), Avnaim-Katav (2010), Mouanga (2017), Thissen & Langer (2017) and Emter (2018) are coarsely costate, broadly fusiform, and have a short neck and thus differ from the original of d'Orbigny and represent a separate species. The Red Sea/Indian Ocean type (e.g. Hottinger *et al.*, 1993) was also reported from fossil sediments by Mateu (1972), Avnaim-Katav (2010), Melis *et al.* (2015), Yümün *et al.* (2016) and Hyams-Kaphzan (unpublished) and is native to the Mediterranean Sea.

***Spiroloculina attenuata*** Cushman & Todd, 1944

| | |
|---|---|
| 1944 | *Spiroloculina attenuata* Cushman & Todd – Cushman & Todd, p. 54, pl. 9, figs. 23-25 |
| 1987 | *Spiroloculina communis* Cushman & Todd subsp. *attenuata* – Baccaert, p. 118, pl. 53, figs. 4-5 |
| 1993 | *Spiroloculina attenuata* Cushman & Todd – Hottinger *et al.*, p. 45, pl. 25, figs. 3-9 |
| 2000 | *Spiroloculina attenuata* Cushman & Todd – Hyams, pl. 4, fig. 2 |

*Spiroloculina attenuata* was described by Cushman and Todd (1944) with the type locality near Pago Pago Harbor, Samoa (Pacific Ocean). The WoRMS Editorial Board (2020) has recently placed the taxon into *Naxotia* (Al-Zamel & Cherif, 1997), a new genus that was introduced for evolute quinqueloculine forms, with five chambers visible externally, tests with a greasy luster and a necked circular aperture with two teeth. *Spiroloculina attenuata* does not fullfil the range of features required to be placed in *Naxotia*. Hyams (2000) recorded this species from the Mediterranean coast of Israel. We consider *Spiroloculina attenuata* to be alien to the Mediterranean Sea.

***Spiroloculina* aff. *S. communis*** Cushman & Todd, 1944

1944 *Spiroloculina communis* Cushman & Todd – Cushman & Todd, p. 63, pl. 9, figs. 4-5, 7-8
? 1949 *Spiroloculina communis* Cushman & Todd – Said, p. 14, pl. 1, fig. 37
1993 *Spiroloculina* aff. *S. communis* Cushman & Todd – Hottinger *et al.*, p. 45, pl. 25, figs. 10-15

The holotype of *Spiroloculina communis* recorded by Cushman & Todd (1944) originates from the San Andres Island in the Philippines. *Spiroloculina communis* was later illustrated by Said (1949) from the Red Sea. However, the quality of the illustration is poor. *Spiroloculina* aff. *S. communis* was described from the Red Sea by Hottinger *et al.* (1993). This species resembles *S. communis* but possesses only one bifid tooth. Recent material from the Mediterranean Sea for *Spiroloculina* aff. *S. communis* has been recorded by Hyams-Kaphzan *et al.* (2008). We therefore consider the species to be alien to the Mediterranean Sea.

***Spiroloculina nummiformis*** Said, 1949

1949 *Spiroloculina nummiformis* Said – Said, p. 16, pl. 1, fig. 39
1993 *Spiroloculina nummiformis* Said – Hottinger *et al.*, p. 46, pl. 27, figs. 1-9
2000 *Spiroloculina nummiformis* Said – Hyams, pl. 4, fig. 6
*non* 2011 *Spiroloculina nummiformis* Said – Elshanawany *et al.*, pl. 7, fig. 8

*Spiroloculina nummiformis* has been described from the Red Sea by Said (1949). Mediterranean occurrences include two records from the Levantine coast off Israel (Hyams, 2000; Hyams-Kaphzan *et al.,* 2008). The specimen illustrated by Elshanawany *et al.* (2011) from Abu-Qir Bay off Alexandria (Egypt) differs substantially from the holotype and the specimens illustrated by Hottinger *et al.* (1993) from the Red Sea. *Spiroloculina nummiformis* is considered to be alien to the Mediterranean Sea.

***Textularia agglutinans*** d'Orbigny, 1839

1839 *Textularia agglutinans* d'Orbigny – d'Orbigny, pl. 1, figs. 17, 18, 32–34
1884 *Textularia agglutinans* d'Orbigny – Brady, pl. 43 figs. 1–2
1977 *Textularia agglutinans* d'Orbigny – Le Calvez, p. 13–14, fig. 1
1981 *Textularia agglutinans* d'Orbigny – Banner & Pereira, pl. 1, figs. 6–7, pl 2, fig. 1
1990 *Textularia agglutinans* d'Orbigny – Dermitzakis & Triantafillou, p. 161, pl. 3, fig. 6
1991 *Textularia agglutinans* d'Orbigny – Cimerman & Langer, pl. 10, figs. 1–2
1993 *Textularia agglutinans* d'Orbigny – Hottinger *et al.*, pl. 13, figs. 1-9
2012 *Textularia agglutinans* d'Orbigny – Milker & Schmiedl, fig. 10, 15-16
2015 *Textularia agglutinans* d'Orbigny – Merkado *et al.*, fig. 4, 1-4; fig. 5, 1-9
2020 *Textularia agglutinans* d'Orbigny – Manda *et al.*, fig. 3c

*Textularia agglutinans* d'Orbigny is a cosmopolitan agglutinated foraminiferal species, with an elongated biserial test in its adult stage and a low arched aperture. It was first described by d'Orbigny in 1839 from sandy beaches around Cuba and has been reported from numerous locations worldwide: Atlantic Ocean (Culver & Buzas, 1980), Red Sea (Hottinger *et al.*, 1993), Timor Sea (Loeblich & Tappan, 1994), Pacific Ocean (Debenay, 2012), Indian Ocean (Langer *et al.*, 2013a), western and eastern Mediterranean (Cimerman & Langer, 1991; Hyams-Kaphzan *et al.*, 2008, p. 336; Milker & Schmiedl, 2012), Adriatic Sea (Jorissen, 1987), Tyrrhenian Sea (Sgarrella & Moncharmont Zei, 1993) and Marmara Sea (Armynot du Châtelet *et al.*, 2013). Recent molecular analyses (Merkado *et al.*, 2015) indicate that the northern Red Sea and the eastern Mediterranean hard-bottom populations of *T. agglutinans* off Israel belong to the same genetic population, regardless of their large morphological variability. Further molecular studies are required to validate if the Mediterranean species are indeed genetically identical to the material from the Carribian type locality. Fossil *T. agglutinans* material was recorded from Holocene deposits by Milker & Schmiedl (2012) from the western Mediterranean Sea (off Mallorca, Alboran Platform and Oran Bight) and from the Gulf of Corinth (Dermitzakis & Triantafillou, 1990). The species is also abundant in core material (Hyams-Kaphzan, unpublished) collected off Israel. Fossil evidence and the global biogeographic distribution makes it difficult to consider *T. agglutinans* as alien to the Mediterranean Sea. The species is therefore considered to be native.

***Triloculina asymmetrica*** Said, 1949

1949 *Triloculina asymmetrica* Said – Said, p. 18, pl. 2, fig. 11
1993 *Triloculina asymmetrica* Said – Hottinger *et al.*, p. 64, pl. 66, figs. 4-9
*non* 2017 *Triloculina asymmetrica* Said – Mouanga, pl. 9, figs. 14-15

The holotype of *Triloculina asymmetrica* was described by Said (1949) from the Red Sea. Hottinger *et al.* (1993) recorded it from the Gulf of Aqaba, Red Sea. The record by Oflaz (2006) lacks an illustration. The photographs provided by Mouanga (2017) from Albania do not show the typical asymmetrical test shape. *Triloculina asymmetrica* has not yet been found in the Mediterranean Sea, is therefore absent and not alien.

***Triloculina* cf. *T. fichteliana*** d'Orbigny, 1839

| | |
|---|---|
| *non* 1839 | *Triloculina fichteliana* d'Orbigny – d'Orbigny, p. 171, pl. 9, figs. 8, 10 |
| *non* 1929 | *Triloculina fichteliana* d'Orbigny – Cushman, p. 63, pl. 17, figs. 1a-c |
| *non* 1977 | *Triloculina fichteliana* d'Orbigny – Le Calvez, p. 106, fig. 1 |
| 1993 | *Triloculina fichteliana* d'Orbigny – Hottinger *et al.*, p. 65, pl. 66, figs. 10-15 |
| 2008a | *Triloculina* cf. *T. fichteliana* d'Orbigny – Meriç *et al.*, pl. 7, figs. 14-16, pl. 8, figs. 1-2 |
| 2008b | *Triloculina* cf. *T. fichteliana* d'Orbigny – Meriç *et al.*, pl. 4, figs. 9-12 |
| 2010 | *Triloculina fichteliana* d'Orbigny – Koukousioura *et al.*, p. 164, pl. 2, fig. 3 |
| 2015 | *Miliolinella fichteliana* (d'Orbigny) – Delliou *et al.*, pl. 1, fig. 1 |
| 2017 | *Triloculina fichteliana* d'Orbigny – Thissen & Langer, pl. 8, figs. 10-12 |

*Triloculina fichteliana* was originally described by d'Orbigny (1839) from Cuba (see also Le Calvez, 1977). The specimens recorded from the Mediterranean and the Red Sea share a common morphology, that differs from the material described from Caribbean localities (Cushman, 1929). The main differences concern the test ornamentation and the shape of the tooth. We therefore consider specimens from the Red Sea, the Mediterranean Sea (Hottinger *et al.*, 1993; Meriç *et al.*, 2008a; 2008b) and the Indian Ocean (Thissen & Langer, 2017) to represent a species that differs slightly from d'Orbigny (1839), herein referred to as *Triloculina* cf. *T. fichteliana*. As such, we consider it to represent a species alien to the Mediterranean Sea. The specimen illustrated by Cushman (1929) differs from the holotype of d'Orbingy in having a lip instead of a tooth (see also Le Calvez, 1977), belongs to a different genus, but does not have taxonomic priority over *Triloculina fichteliana* of d'Orbigny (1839).

***Vaginulinopsis sublegumen*** Parr, 1950

| | |
|---|---|
| 1950 | *Vaginulinopsis sublegumen* Parr – Parr, p. 325, pl. 11, figs. 18a-b |
| *non* 2004 | *Astacolus sublegumen* (Parr) – Meriç *et al.*, p. 126, pl. 19, fig. 9 |

*Astacolus sublegumen* was reported to be present in Turkey by Meriç *et al.* (2004). The holotype of this species originates from the Antarctic Ocean and is currently referred to as *Vaginulinopsis sublegumen* (see Jones, 1994; and WoRMS Editorial Board, 2020). The specimen illustrated by Meriç *et al.* (2004) significantly differs from the holotype. The same illustration was used in Yokeş & Meriç (2009) and Meriç *et al.* (2014). To date, there is no valid record of *Vaginulinopsis sublegumen* in the Mediterranean Sea and the species is therefore absent and not alien.

***Varidentella* cf. *V. neostriatula*** (Thalmann, 1950)

| | |
|---|---|
| 1932 | cf. *Quinqueloculina striatula* Cushman – Cushman, p. 27, pl. 7, figs. 3-4 |
| 1950 | *Quinqueloculina striatula* Thalmann – Said, p. 5, pl. 1, fig. 9 |
| 1987 | *Quinqueloculina neostriatula* Thalmann – Baccaert, p. 91, pl. 43, figs. 1-6 |
| 1993 | *Varidentella* cf. *V. neostriatula* (Thalmann) – Hottinger *et al.*, p. 66, pl. 70, figs. 5-11, pl. 71, figs. 1-7 |
| 1998 | *Varidentella neostriatula* (Thalmann) – Piller & Haunold, pl. 6, fig. 9 |
| 2000 | *Varidentella* cf. *V. neostriatula* (Thalmann) – Hyams, pl. 14, fig. 4 |

*Quinqueloculina striatula* was described by Cushman (1932) from Mojaukar Anchorage, Fiji (Melanesia). The holotype is characterized by five chambers, a subacute chamber periphery and a test wall that is well ornamented by numerous costae. *Quinqueloculina neostriatula* recorded by Said (1950) and Piller & Haunold (1998) from the northern Red Sea resembles the specimens illustrated by Hottinger *et al.* (1993). However, Said (1950) provides only a single side view illustration. Baccaert (1987) illustrated specimens from Australia with variable morphologies, some of which resemble specimens from the northern Red Sea. A single record of *Varidentella* cf. *V. neostriatula* from the Mediterranean Sea was illustrated by Hyams (2000). It is identical to some of the specimens illustrated by Hottinger *et al.* (1993). The morphotypes of this species are highly variable and further studies are required. For the time being, we consider *Varidentella* cf. *V. neostriatula* to be alien to the Mediterranean Sea.

## Discussion

Our survey and reexamination of alien benthic foraminifera currently present in the Mediterranean Sea yielded a total of 44 validly recognized species and two cryptogenic taxa (Table 1). This reduces the number of previous recordings of alien foraminifera (Hyams-Kaphzan *et al.,* 2008, Zenetos *et al.,* 2012; EASIN, 2020), and is mainly due to new occurrence records, new findings in the fossil record, erroneous identifications, and evidence predating the presence of alien species prior to the opening of the Suez Canal. The revised list of accepted alien species includes both larger symbiont-bearing and smaller benthic foraminifera, including 16 hyaline-perforate, 3 agglutinated and 25 porcelaneous taxa.

The vast majority of alien foraminifera recorded so far have become established in the Eastern Mediterranean Sea (41 species = 93.1 %; Tbl. 1, Fig. 1), primarily along the Levantine coasts (Langer & Hottinger, 2000; Hyams *et al.,* 2002; Hyams-Kaphzan *et al.,* 2008; Langer, 2008;

Almogi-Labin & Hyams-Kaphzan, 2012; Langer *et al.,* 2012; Mouanga & Langer, 2014; Langer & Mouanga, 2016; Guastella *et al.*, 2019; Servello *et al.*, 2019; Katsanevakis *et al*., 2020). The number of alien species decreases rapidly from east to west. Eleven species of alien benthic foraminifera were recorded in the central Mediterranean (27.2 %), 8 species in the Adriatic (20.4 %), and only 5 (11.6 %) in the western Mediterranean Sea. The preferential establishment of NIS of benthic foraminifera within the warmer eastern Mediterranean is indicative for a point source from a tropical location, in particular the Red Sea/Indian Ocean with a pathway through the Suez Canal. In fact, recent molecular phylogenetic analyses have provided evidence that modern populations of a few selected species belong to the same genetic population and were therefore considered Lessepsian migrants (Merkado *et al.,* 2013; 2015; Schmidt *et al.,* 2015). However, the fossil record provides evidence that all of them (*Textularia agglutinans*, *Sorites orbiculus*, *Pararotalia calcariformata*) were present in the Mediterranean prior to the opening of the Suez Canal (see Results). They are therefore native to the Mediterranean Sea and, per definition, can neither be considered alien nor invasive aliens. In addition, fully conclusive evidence to trace the origin of an alien species can only be provided when molecular data are available from the type locality. To trace the origin of a putative alien species via molecular genetic analysis of Mediterranean and Red Sea/Indian/Pacific Ocean material remains therefore inconclusive, if the type locality is located in a different geographic zone (e.g. the Caribbean Sea for *Textularia agglutinans*).

Being located at the crossroads between the Atlantic and the Indo-Pacific Oceans, alien species enter the Mediterranean Sea mainly via the Suez Canal but also via the Strait of Gibraltar and the Dardanelles. Foraminifera entering the Mediterranean via the Suez Canal pathway, generally follow the counterclockwise current pattern and first settle along the eastern shores of the Levantine coast (Langer, 2008). Biological invasions through the Suez Canal have been facilitated as a consequence of expanded connectivity including the extension, broadening and enlargement of the Suez Canal (Galil *et al.*, 2017; Zenetos*,* 2017). This has raised concern over rising propagule pressure and introductions of new NIS with potential consequences on native biotas (Galil *et al.,* 2017). The Red-to-Med invasion of tropical taxa has also been promoted by rising sea surface temperatures (Raitsos *et al.,* 2010; Manda *et al.,* 2020) and the Nile damming (Skliris & Lascaratos, 2004). While rising sea surface temperatures increase thermal habitat suitability (Marras *et al.*, 2015), damming of the Nile has caused drastic modifications in sedimentation patterns, circulation and salinity, diminished pre-existing environmental barriers and provided an additional stimulus for the invasion and establishment of alien species.

The distribution of tropical larger benthic foraminifera (LBF) is strongly constrained by water temperature (Langer & Hottinger, 2000). As they invade the temperate waters of the eastern Mediterranean, they meet a physical border that limits their rapid distribution. The temperature requirements of tropical foraminifera restrict their distributional capacity and migration towards the colder western Mediterranean, which is influenced by cold water currents from the Atlantic Ocean. Some of the larger symbiont-bearing foraminifera have reached Sicily and Tunisia (Langer & Hottinger, 2000, Langer *et al.,* 2012; El Kateb *et al.*, 2018; Damak *et al.*, 2019; Guastella *et al.*, 2019), entered the Adriatic Sea (Langer & Mouanga, 2016), and continue to their range expansion towards the northwestern Mediterranean with more than 10km/yr (Langer *et al.,* 2012; Guastella *et al.*, 2019).

To project future species distributions, species distribution modelling based on ecological niche constraints of current distributions were applied to foraminifera by Langer *et al.* (2012; 2013b) and Weinmann *et al.* (2013). The projection onto the RCP4.5 scenario (Collins *et al.*, 2013) suggests that the overall habitat suitability will increase with potential range expansions into the western area of the Mediterranean along the coast of northern Africa, into the Alboran and Balearic Sea, along the Tyrrhenian coast in Italy, and deep into the Adriatic Sea, following a continuous northwestward dispersal. The range expansions are fueled in response to temperature increases and the extension of climate belts (Tittensor *et al.*, 2010, Langer *et al.* 2012; Guastella *et al.*, 2019). Minimum winter sea surface temperatures (SST) has previously been invoked to be among the main agents controlling the latitudinal distribution of LBF (Zmiri *et al.*, 1974; Langer & Hottinger, 2000) and the observed range extension of thermophilic LBF and endosymbiotic foraminifera were shown to track contemporary SST increase (Langer *et al.,* 2012; Weinmann *et al.,* 2013; Langer & Mouanga, 2016; Schmidt *et al.,* 2015; 2018; Guastella *et al.*, 2019; Manda *et al.,* 2020). In addition, the proliferation and recent range expansion rates of LBF (Langer & Mouanga, 2016; Guastella *et al.*, 2019; Damak *et al.*, 2019) provide strong support for previous species distribution models projecting the northward migration and range shifts and corroborate findings that rising water temperatures and warm currents are the most likely agents controlling the latitudinal extension of larger symbiont-bearing foraminifera. Compared to alien LBF, hardly anything is known about range expansions rates of smaller benthic foraminifera. Previous studies have documented that populations of putative Lessepsian migrants (*Textularia agglutinans* and *Pararotalia calcariformata*) became very dominant along the Israeli Mediterranean coast (Hyams-Kaphzan *et al.,* 2014; Merkado *et al.,* 2015; Schmidt *et al.,* 2015) possibly as a result of rising water temperatures (e.g. Manda *et al.,* 2020).

Almost all alien foraminifera present in the Mediterranean Sea appear to be innocuous and only one fulfills the criteria to be considered as an invasive alien: *Amphistegina lobifera* (Langer *et al.,* 2012; Guastella *et al.,* 2019; Servello *et al.*, 2019). This species is a prolific carbonate producer (Hallock, 1981; Langer *et al.,* 1997; Langer, 2008) and displays extreme forms of ecosystem invasibility (Langer *et al.*, 2012; Mouanga & Langer, 2014; Langer & Mouanga, 2016). This includes mass occurrences, hyperabundances and the appearance in monocultures, with capabilities to reduce native diversity and species richness (Mouanga & Langer, 2014), to transform the composition, grain size and chemistry of sediments from predominantly siliceous to carbonate deposits (Hyams *et al.*, 2002; Samir *et al.,* 2003; Gruber, 2007; Yokeş & Meriç, 2009; Abu Tair & Langer, 2010; Langer *et al.*, 2012; Weinmann *et al.,* 2013; Caruso & Cosentino, 2014; Mouanga & Langer, 2014; Guastella *et al.*, 2019; Meriç *et al.,* 2020), and to trigger changes in ecosystem functioning (Langer *et al.*, 2012). Triantaphyllou *et al.* (2005), Koukousioura *et al.* (2011), and Dimiza *et al.* (2016b) have suggested that their presence and numerical abundance may be used as proxy to assess the degree of environmental disturbance. At some sites extreme abundances of amphisteginid invaders were shown to result in the formation of large amounts of ''living sands'' (Meriç, 2008; Meriç *et al.,* 2008a; Yokeş & Meriç 2009; Abu Tair & Langer 2010; Langer *et al.,* 2012). The invasion and prolific occurrences indicate that the amphisteginid invaders successfully fill an open niche that is obviously providing ideal conditions. While the immediate impact of *Amphistegina lobifera* appears to be obvious, the resilience of native biotas to key invaders remains yet to be determined.

Amphisteginid invasions selectively affect taxa that share the same microhabitat and suggests that competitive exclusion is a major driving force regulating species richness in invaded communities. The displacement of native species may be of local nature and natives may persist in nearby uninvaded areas. Whether *Amphistegina lobifera* displaces any other organisms than foraminifera and what role they play in the food web of metacommunities, is currently not known. Mouanga & Langer (2014) have demonstrated that massive invasions of amphisteginids locally result in the homogenization of the foraminiferal faunas with a clear correlation between the diversity of foraminiferal biotas and percent abundances of amphisteginid invaders (Langer & Mouanga, 2016). *Amphistegina lobifera* was recently included in the list of the top 26 high-priority species that display invasive traits and for which the performance of risk assessments is encouraged (Tsiamis *et al.,* 2019) under Descriptor 2 of the European Union Marine Strategy Framework Directive (EU, 2008) and the Biodiversity Strategy (EU, 2014b).

Means of dispersal of benthic foraminifera are multifold and involve natural and human-mediated sources. Natural means involve transportation by ocean currents, attachment to bodies of birds and fish, the incidental consumption and translocation by macroorganims, and rafting on algae and other objects (Lipps, 1983; Langer, 1993; Langer *et al.,* 1998; Goldbeck *et al.,* 2005; Guy-Haim *et al.*, 2017; Finger, 2017), where the ranges of native species are broadly constrained by limitations on their capacity for dispersal. Knowledge of the processes and mechanisms that govern dispersal and colonization in benthic organisms is crucial for understanding biodiversity patterns and historical development of biogeography. However, the rate at which humans translocate species has substantially intensified with increasing globalization and does not show any signs of saturation (Seebens *et al.,* 2017). Human-mediated introductions of NIS include ballast water, hull fouling and sea chests (water-intake recesses in the hull), intentional and accidental *releases* of aquaculture species, aquarium discards and aquarium trade.

Ballast water is generally invoked to be among of the major pathways for the introduction of nonindigenous marine species (Ruiz *et al.,* 1997; Carlton *et al.,* 1999; Molnar *et al.,* 2008; Seebens *et al.,* 2016), but hardly anything is kown about the potential role of transoceanic ship deballasting as a vector for the introduction of alien foraminifera in the Mediterranean Sea (Galil & Hülsmann 1997; McGann *et al.,* 2020). The release of ballast water and the transport stowaway pathway related to shipping traffic (biofoulers and hitchhikers) have been widely suspected as vectors for the introduction of non-native foraminifera (Hayward, 1997; Hayward *et al.,* 1999; 2004; McGann *et al.,* 2000; Calvo-Marcilese & Langer, 2010; Polovodova Asteman & Schönfeld, 2016; Eichler *et al.,* 2018; Deldicq *et al.,* 2019), has led to a breakdown of classical biogeographic regions and is considered a major vector for Red-to-Med alien species invasions (Zenetos *et al.,* 2012).

Cargo ships and tankers take up and release large volumes of ballast water. The ballast water is used for stability and maneuverability and may also be added to add weight to pass under bridges and other structures. Ballasting and deballasting most frequently occurrs in shallow water, in ports and in estuaries. Ballast water was shown to contain abundant and diverse biotas, is moved accross oceans and constitutes "a conveyor belt of marine organisms wrapping around the world". Together with the ballast water, ships also pump substantial amount of sediment (including foraminifera) into their ballast tanks (Carlton & Geller 1993; Chu *et al.,* 1997; Galil & Hülsmann 1997; Gollasch *et al.,* 1998; Macdonald, 1998; Lavoie *et al.,* 1999; Smith *et al.,* 1999; McGann *et al.,* 2000; 2020; Drake *et al.,* 2005; Johengen *et al.,* 2005). Ballast water may contain both benthic and planktic foraminifera, including all life stages ranging from propagules to adult life-stages. The invasion success of ballast water aliens is highly probabilistic and a game of ecological roulette, where the outcome depends on a myriad of dynamic factors (Ricciardi, 2016), including species traits, available nich space, interactions with native biotas, trade routes, climate change and water temperature (among many others).

Predicting foraminiferal invasions is a challenging task and there is general international consensus that multi-vector pathways-based management is a priority in minimizing marine alien species (Ojaveer *et al.,* 2018). To date, there is no evidence that foraminifera are toxic (Langer & Bell, 1995), they are of no concern to human health, and by virtue of their substantial carbonate production, they may be even beneficial to coastal protection (Hallock, 2002; Hohenegger, 2006; Langer, 2008, Langer *et al.,* 2013b; Doo *et al.,* 2014). Management of invasive alien species has been among the main priorities of the IAS Regulation (Article 4, EU, 2014a), but measures to mitigate the impact of alien foraminifera, or to efficiently control or even eradicate are neither feasible nor costeffective (Tsiamis *et al.,* 2020), and may be even counterproductive. Because of their abundance, high reproduction rates, and ubiquity in virtually all marine environments, however, foraminifera are excellent predictors of rates of global change.

The revision and revised list of alien foraminifera presented here is a dynamic resource and will continue to evolve as the number of alien species is likely to increase. Regular updates, more accurate information and the application of molecular techniques will assist our understanding of climate driven range shifts and the magnitude of alien species impacts in the Mediterranean Sea and in global oceans. In addition, recent molecular genetic studies provide accumulating evidence that traditional morphospecies taxonomy vastly underestimates true diversity in foraminifera and routinely report a higher number of previously unrecognized species (e.g. Pawlowski *et al.,* 2014; Prazeres *et al.,* 2020). On a molecular level, alien foraminifera present in the Mediterranean Sea are currently underresearched and require intensified efforts to trace their source. Rigorous morpho- and molecular species identifications, studies on ballast water, species distribution modeling and new evidence from the fossil record will thus continue to shed new light on the status (native/alien/cryptogenic), pathway, vector and origin of species (Atlantic/Red Sea).


## Summary

A large-scale survey on alien benthic foraminifera in the Mediterranean Sea has been conducted and resulted in a revised list of 44 validly recognized alien and two cryptogenic species, including both larger symbiont-bearing and smaller benthic taxa. The reexamination of previous alien species records is based on a critical and careful revision of the current taxonomic status of each species, new findings in the fossil record, and recently published data obtained through molecular genetic analysis. The vast majority of alien foraminifera recorded so far have established self-sustaining populations in the Eastern and Central Mediterranean Sea. It is anticipated that rising sea surface temperatures and the expansion of climate belts will convey the range expansion and northwestward migration of alien species. To date, only *Amphistegina lobifera* meets the full set of criteria to be considered as an invasive alien. Measures to mitigate its impact on ecosystems and native biotas, to efficiently control, manage or even eradicate are neither feasible nor costeffective and may even be counterproductive. The number of alien foraminifera is likely to evolve as travel, shipping trade, rising temperatures and increasing globalization promote the spread of alien taxa in the Mediterranean Sea. Because of their abundance, ubiquity, and high reproduction rates, foraminifera are excellent proxies for rates of global climate change. Monitoring future range expansions of key alien taxa (e.g. *Amphistegina* spp.) will thus provide a baseline to assess the magnitude, rate and impact of predicted global change.



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