



Bathyal ostracods from the Santa Maria di Leuca deep-water coral province (northern Ionian Sea)

Francesco Sciuto and Antonietta Rosso

ABSTRACT

Living and dead deep-water ostracods from different sites and habitats of the Cold Water Coral Province off Santa Maria di Leuca have been investigated. A total of 42 ostracod taxa were determined, 34 of which at species level and 8 at genus level. The living associations comprise only two species: *Bairdoppilata conformis* and *Bythocypris obtusata*. The same species form dead associations together with *Henryhowella* ex *H. hirta* group, *Macropyxis adriatica*, *Bythocypris bosquetiana*, *Pseudocythere caudata*, *Bathocythere vanstraateni* and *Cytheropteron testudo*. The analysis of dead assemblages, which includes species such as *Bathocythere vanstraateni*, *Cytheropteron testudo*, and *Bythocythere mylaensis* - taxa no longer thriving in the Recent Mediterranean Sea - allowed us to determine that an old component of the ostracod assemblages of the "Santa Maria di Leuca Cold Water Coral Province" seemingly lived during the last cold period of the Late Pleistocene or its transition to the Holocene. Furthermore, the high species richness and specimen abundance, recorded in some samples, might be related to a local increase in the availability of trophic resources at the bottom surface related to the general circulation and to the presence of deep coral bioconstructions. The presence of a few carapaces of species with shallower distributions seems related to post mortem displacement events.

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INTRODUCTION

An area in which deep water corals develop was discovered off Santa Maria di Leuca (northern Ionian Sea, Apulian Margin). The Santa Maria di Leuca Cold Water Coral province (SML CWC province) develops on the continental slope from about

400 to about 1200 m wd, on the Apulian Ridge (Figure 1) (Taviani et al., 2005; Mastrototaro et al., 2010; Rosso et al., 2010). This area has been intensively studied in recent years, and researchers allowed to define seafloor morphology, dominant sedimentary processes as well as the extent

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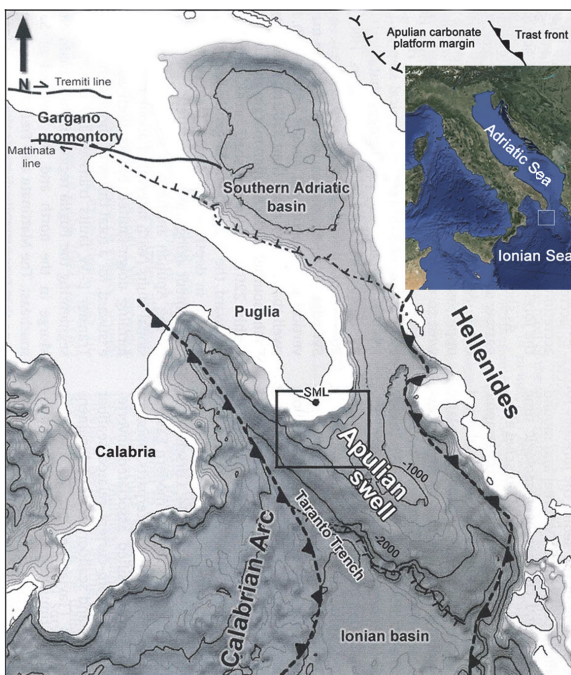


FIGURE 1. Location of the study area and Geological setting of the Apulian swell (after Savini and Corselli, 2010, modified).

and pattern of cold-water coral distribution (Corselli, 2010). In particular, it has been found that deep water coral growth creates patches of colonies settled on the northern flanks and/or near the top of mound structures (Rosso et al., 2010; Vertino et al., 2010). Deep bioconstructions consist of living and dead colonies of *Madrepora oculata* Linnaeus, 1758 associated with *Lophelia pertusa* (Linnaeus, 1758) and *Desmophyllum dianthus* (Esper, 1788). Bioconstruction grow on Pleistocene consolidated sediments and shell lags (Taviani et al., 2005; Malinverno et al., 2010; Rosso et al., 2010; Vertino et al., 2010). Mounds hosting the deep scleractinian or “white corals” community are bounded by several sedimentary facies, mostly bioclastic and coarse-grained, which represent the transition to neighbouring bathyal bottoms characterised by pelagic sedimentation (Rosso et al., 2010).

A few preliminary information on the ostracod fauna from the area was given in Mastrototaro et al. (2010) and in Rosso et al. (2010) concerning present day and dead associations, respectively. However, data acquired at that time and further documentation allow us to present more comprehensive information to shed light on ostracods associated to deep-water coral mounds from the Mediterranean Sea. Although bathyal ostracods

have been studied in several areas from this basin (e.g., Breman, 1975; Bonaduce et al., 1983; Sciuto, 2014) nearly nothing is presently still known about ostracod communities associated with living and Recent CWC from the Mediterranean whereas some information exists about comparable Holocene association from the North Atlantic (Coles et al., 1996; Stalder et al., 2014).

The present paper aims to contribute information to fill, at least partly, this lack of information and particularly to: 1. present a systematic account on living and dead deep-water ostracods from the different sites and habitats of the SML deep water coral mound province; 2. investigate structure and composition of ostracod associations and their distribution in relation to environmental features such as grain size and the availability of food, largely linked to the coral mound proximity and the presence of the scleractinian community.

Geological Setting

The Apulian continental margin (Figure 1), structurally included in the undeformed margin of the African Foreland (Apulian Block), is characterised by a complex topography strongly influenced by gravitative and current-dominated sedimentary processes (Malinverno et al., 2010; Savini and Corselli, 2010). The Continental Shelf is extremely variable in width, from a minimum of 4 km (Taranto) to more than 20 km (off SM Leuca), and is incised by several orders of Holocene terraces, the offshore edges of which have been discovered to host CWC banks (Taviani et al., 2005; Mastrototaro et al., 2010; Rosso et al., 2010).

The continental slope, eroded by canyons, is the site of intense sediment transport towards the Ionian Basin abyssal plain. Slope continuity is interrupted repeatedly by weakly inclined morphological structures where thick sedimentary accumulations form (Savini and Corselli, 2010). The most important of these sites is represented by the Apulian Swell, bounded southwestward by a deep and narrow canyon (the Taranto trench). The Apulian Swell represents a southeastward directed submarine extension of the Apulian peninsula that separates the South Adriatic Basin from the Ionian Basin (Auroux et al., 1985). On the top of the Apulian swell, 9 km south of SM Leuca, the coral mounds are located at depths ranging from about 505 to more than 900 metres (Corselli, 2010). Samples analyzed in the present study came from this area.

TABLE 1. Facies and their sedimentological characters.

Facies		Samples	Depth	Main features
Framework Coral	FC	AP01, AP030	512-747	Biocostruction dominated by <i>Madrepora oculata</i> Linnaeus, 1758 and <i>Lophelia pertusa</i> (Linnaeus, 1758) colonies
Coral Rubble	CR	AP07, AP15, AP17,	525-649	Silt and sandy silt mixed with abundant biogenic detritus mostly derived from the fragmentation of colonial corals
Solitary Coral	SC/HG	AP29, AP04, AP09, AP11	505-790	Fine sediments including cobbles and pebbles and hard ground fragments, both colonized by solitary corals
Gryphus and Isidella	GI	AP08, AP14t, AP14b	525-530	Fine-grained sediments with <i>Gryphus vitreus</i> (Born, 1778) and <i>Isidella elongata</i> (Esper, 1788)
Mollusc Mud	MM	AP19t, AP19b, AP21t, AP21b, AP22b, AP24t, AP24b	638-655	Mud with dispersed mollusc shells mostly colonised by <i>Abra longicallus</i> (Scacchi, 1835) and <i>Ebalia</i>
Foraminifer Mud	FM	AP02, AP03t, AP03b, AP05t, AP05b	506	Silt and bioclastic sand with foraminifers and rare pteropods

MATERIALS AND METHODS

Twenty-five samples of bottom sediments were taken in 2006 in the Ionian Sea during the cruises performed on board of the R/V *Universita-tis*, 9 kilometres south of the S.M. di Leuca. The sampled area is included between the latitudes 39° 28.09'N and 39° 34.84'N and the longitudes 18°24.42' E and 18°23.30' E (Corselli, 2010). This area is located on the top of the northern part of the "Apulian swell" (Figure 1). Samples were collected in the depth range of 506-790 metres, mostly through a 60 litres Van Veen grab and two with a box-corer whereas further three were taken using an epibenthic modified Sanders sledge (Rosso et al., 2010) equipped with a plankton net at its end.

Following Rosso et al. (2010) and Mastro-taro et al. (2010), six different facies have been defined (Table 1, Figure 2): 1) Framework Coral facies (FC), dominated by *Madrepora oculata* and *Lophelia pertusa* colonies; 2) Coral Rubble facies (CR), consisting of silt and sandy silt mixed with abundant biogenic detritus, mostly derived from the fragmentation of colonial corals; 3) Solitary Coral facies and hard grounds (SC/HG), consisting of fine sediments with interspersed pebbles and hard ground fragments and large slabs, colonized by solitary corals; 4) *Gryphus* and *Isidella* facies (GI) mostly consisting of fine-grained sediments and including rare centimetre-sized bioclasts, with *Gryphus vitreus* (Born, 1778) and *Isidella elongata* (Esper, 1788); 5) Mollusc Mud facies (MM) consisting of mud with dispersed mollusc shells, colonised by *Abra longicallus* (Scacchi, 1835); and 6) Foraminifer Mud facies (FM) consisting of silt and bioclastic sand with foraminifers and rare pteropods.

From each sample a sediment volume of 300 cc was used for the analysis of ostracod faunas. Ostracoda were picked from the > 63 microns fraction. Entire carapaces and disarticulated valves were counted. Juveniles were scored separately. The specimens were examined and measured under a stereomicroscope and photographed through a scanning electron microscope LMU Tes-can Vega II. The material is housed in the paleontological section of the Museo di Scienze della Terra of the University of Catania (PMC). Ostracod figured specimens in the Sciuto Collection under the code numbers PMC. FS. I. H. O 16–29.

minifer Mud facies (FM) consisting of silt and bioclastic sand with foraminifers and rare pteropods.

RESULTS

A total of 42 ostracod taxa were detected, of which 34 were determined at species level and 8 at genus level (Appendices 1, 2).

The living community comprises only two species: *Bairdoppilata conformis* (Terquem, 1878) and *Bythocypris obtusata* (Sars, 1866) that are present in one-third of the samples. Their abundance varies from a maximum of four specimens per sample in samples AP29, AP24 and AP19t to one specimen in the sample AP01.

Dead specimens of these two species and the remaining 40 ones form dead assemblages or thanatocoenoses that are present in all the collected samples. Species richness varies greatly from a minimum of one to a maximum of 16 species per sample. In the dead assemblages it is pos-

S W

N E

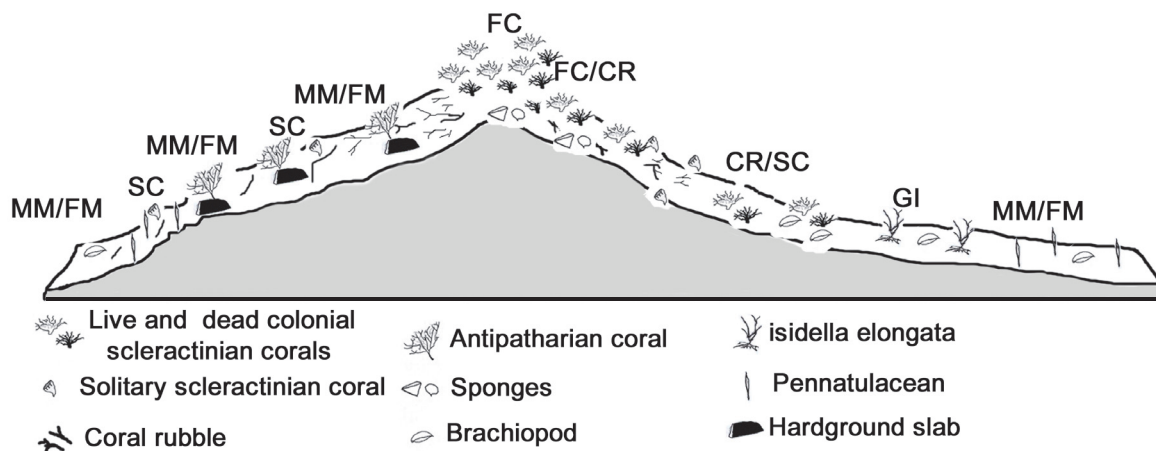


FIGURE 2. Scheme of facies distribution in the Coral mounds (FC=Framework Corals; CR=Coral Rubble; SC=Solitary Corals; GI=*Gryphus* and *Isidella elongata*; MM=Mollusc Mud; FM=Foraminifer Mud; see also Table 1; after Rosso et al., 2010, modified).

sible to distinguish two groups of ostracods on the basis of the conservation status of their carapaces. The first group (f in Appendices 1-3) includes ostracods whose carapaces are fresh-looking and show a rather good preservation state; the second group (w in Appendices 1-3) includes ostracods whose carapaces are opaque and sometimes heavily worn. The most abundant and frequent species are: *Bythocypris obtusata* and *Bairdoppilata conformis*, found in 16 and 17 sites, respectively, out of the 20 sampled ones. These species are followed by few other ones, such as *Henryhowella* ex *H. hirta* (Costa, 1853) group, found in 12 sites, *Macropyxis adriatica* (Breman, 1975) found in 10 sites. Among other species *Bythocypris bosquetiana* (Brady, 1866) and *Pseudocythere caudata* Sars, 1866 are relatively common and frequent. Finally, a third group is constituted by species rare and poorly preserved, such as *Paradoxostoma acuminatum* Müller, 1894 and *Paracytherois flexuosa* (Brady, 1867).

Grouping samples as a function of specimen abundance (Figure 3) it is possible to distinguish: a first group, consisting of the samples AP01, AP29 and AP30, in which ostracod associations are abundant (> 80 specimens per sample) and diversified (16 species); a second group (samples AP02, AP07, AP08, AP09, AP14t, AP14b, AP15, AP17, AP19b, AP21t, AP22t, AP22b, AP24t) with abundances ranging between 20 and 80, and moderate species richness (max 8 species) and a third

group (samples AP03t, AP03b, AP04, AP05t, AP05b, AP19t, AP21b, AP24b) with no more than 4-5 species and less than 20 specimens per sample, with the exception of sample AP5b, which includes 15 species.

From a comparison between samples, and between the community and the dead assemblages in the same sample (Figure 4), it appears that there is a great variability both in terms of species richness and, mostly, of specimens abundance. Living associations are represented by no more than 5 specimens (samples AP19t and AP22t) whereas dead assemblages vary from a maximum of 229 specimens in the sample AP30 to a minimum of 5 specimens in the sample AP03b.

Looking at facies (Figure 5), it can be observed as ostracod associations are always characterized by a low number of species (with a maximum value of 25) and by a significant number of specimens. Furthermore, these facies (Appendices 1-3) show different species compositions.

The Framework Corals facies (FC) shows a living association only represented by *Bythocypris obtusata*. The dead assemblage (Appendix 3) consists of 22 species among which *Bairdoppilata conformis*, *Bythocypris obtusata* and *Paradoxostoma simile* Müller, 1894 are the best represented, followed by *Pseudocythere caudata*, *Henryhowella* ex *H. hirta* group, *Argilloecia acuminata* Müller, 1894 and *Monoceratina mediterranea* Sissingh, 1971.

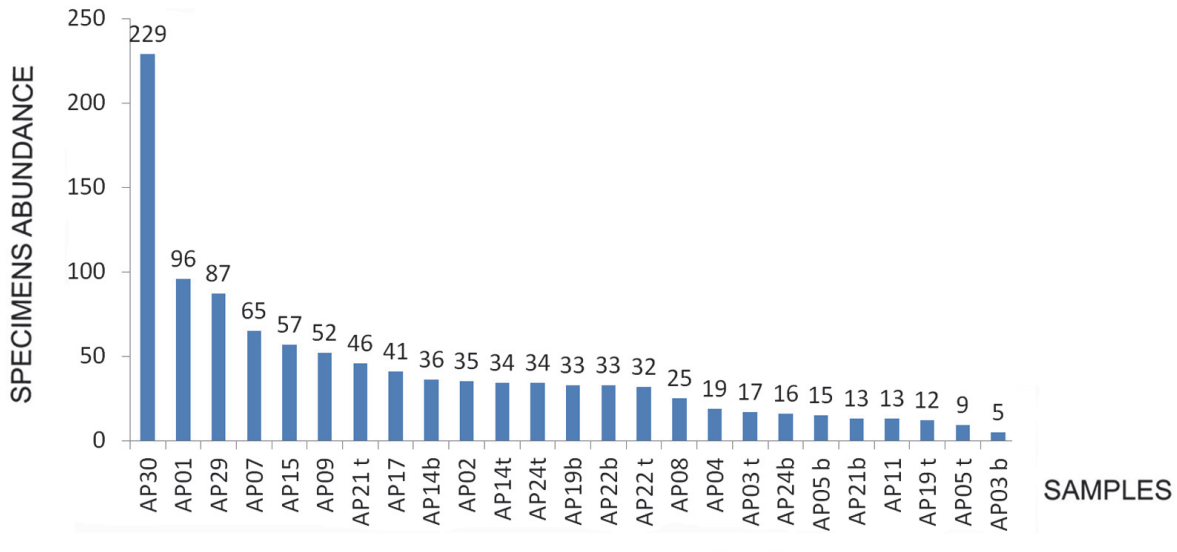


FIGURE 3. Ostracod distribution per samples.

The Coral Rubble facies (CR) includes both species of living ostracods, namely *Bairdoppilata conformis* and *Bythocypris obtusata*, while the dead assemblages are formed by only four species, with *Henryhowella* ex *H. hirta* group and *Macropyxis adriatica*, which add to *Bairdoppilata conformis* and *Bythocypris obtusata*.

The Solitary Coral/ Hard Ground facies (SC/ HG) consists again of living specimens of *Bairdoppilata conformis* and *Bythocypris obtusata*, while the dead assemblages are more diversified than those of the previous facies, including 10 species. *B. conformis* is the dominant species, followed by

B. obtusata, *Henryhowella* ex *H. hirta* group and *Macropyxis adriatica*, while *Bathocythere vans-traateni* Sissingh, 1971, *Echinocythereis echinata* Sars, 1866, *Cytheropteron alatum* Sars, 1866 and *Pterigocythereis jonesii* (Baird, 1850) are less represented (Appendix 3). The *Gryphus* and *Isidella* facies (GI) include 10 species, and the associations are dominated by *B. conformis* followed by *B. obtusata* and *M. adriatica*.

The same species prevail in the Mollusc Mud (MM) facies where 15 species are present including *B. conformis*, *B. obtusata* and *M. adriatica*.

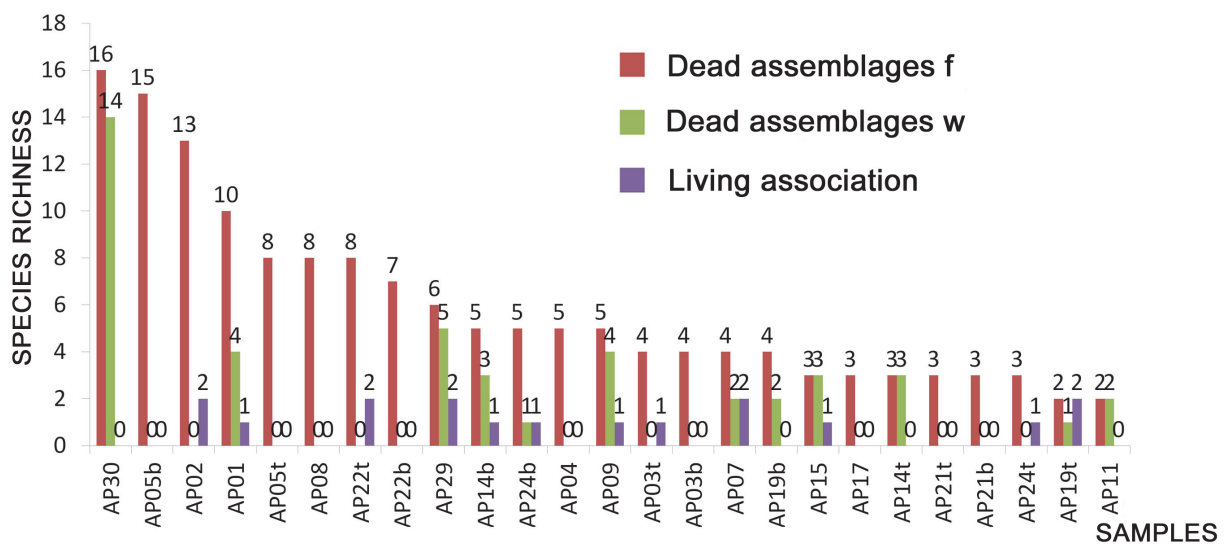


FIGURE 4. Species distribution in dead assemblages “f”, dead assemblages “w”, and biocoenoses, per sample.

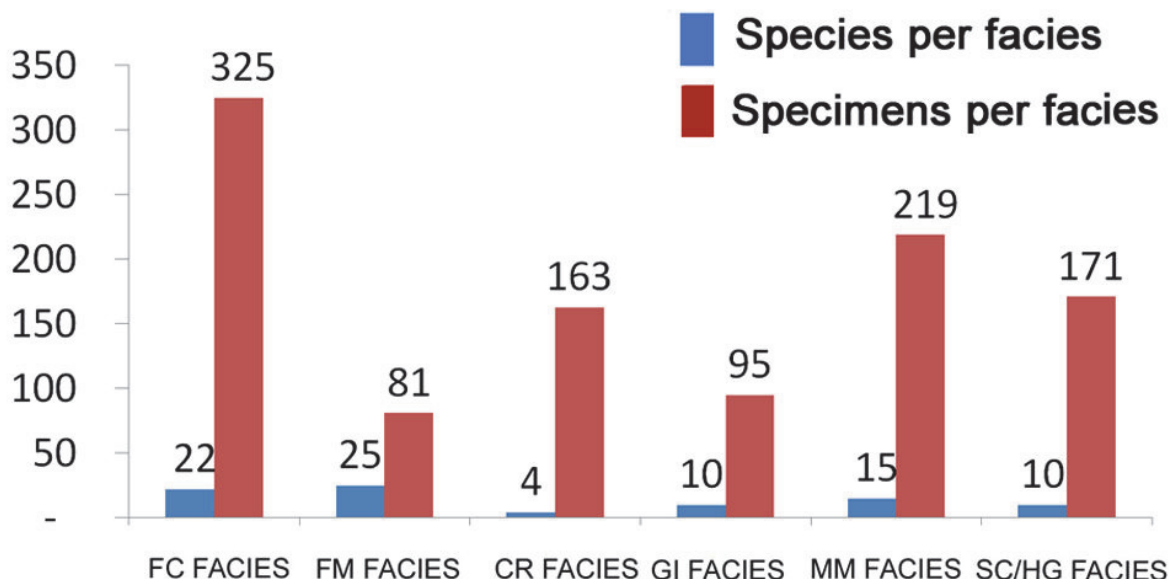


FIGURE 5. Specimens and species abundance per facies. (FC=Framework Coral; CR=Coral Rubble; SC/HG=Solitary Coral; GI=*Gryphus* and *Isidella*; MM=Mollusc Mud; FM=Foraminifer Mud; see also Table 1).

To conclude, the Foraminifer Mud facies (FM) is the best diversified with a total of 25 species. More than half of these species have been detected only in this facies, although several of them have been found in a single sample and with few specimens. *B. conformis*, *Krithe monostera-censis* (Seguenza, 1880) and *H. ex H. hirta* group prevail, followed by *Argilloecia robusta* Bonaduce et al., 1975 and by *Buntonia sublatissima* (Neviani, 1906).

SYSTEMATICS

Among all the ostracod species found, some are particularly significant from the systematic and ecologic viewpoint. They are discussed below.

Class OSTRACODA Latreille, 1806
 Order PODOCOPIDA Sars, 1866
 Family BAIRDIIDAE Sars, 1866
 Genus BAIRDOPPILATA Coryell et al., 1935

Type species. *Bairdoppilata martyni* Coryell et al., 1935

Bairdoppilata conformis (Terquem, 1878)
 Figure 6.1

1878 *Bairdia subdeltoidea* Münster var. *conformis* Terquem, p. 93, pl. 10, figs. 17 a-c.

1883a *Bairdia subdeltoidea* Münster; Seguenza, p. 58.

1883b *Bairdia subdeltoidea* Münster; Seguenza, p. 124, pl. 1, fig. 8.

1975 *Bairdia conformis* (Terquem); Bonaduce et al., p. 22, pl. 6, figs. 5-10.

1980 *Bairdia conformis* (Terquem); Colalongo and Pasini, p. 52, pl. 1, fig. 5.

2000 *Bairdoppilata conformis* (Terquem); Aiello et al., p. 85, pl. 1, fig. 2.

2008 *Bairdia conformis* (Terquem); Sciuto and Rosso, p. 35, pl. 1, fig. 2.

Remarks. According to Maddocks (1969), the specimens have been referred to the genus *Bairdoppilata* Coryell et al., 1935 on the basis of the carapace lateral outline, that is rounded and sub hexagonal, and the muscle scar pattern which is shown in Maddocks (1969, figure 3g).

Among the ostracods found in the SML samples, *B. conformis* is by far the most abundant species, one of two found alive. Both adult and juvenile specimens are present. It is particularly abundant in the MM facies, while it is rare in the FM facies.

B. conformis shows a present-day very wide bathymetrical distribution that includes the whole Circalittoral and the Bathyal Zone in both the Atlantic Ocean and the Mediterranean Sea (Bonaduce et al., 1983; Whatley and Coles, 1987; Guernet and Lethiers, 1989; Montenegro et al., 1998).

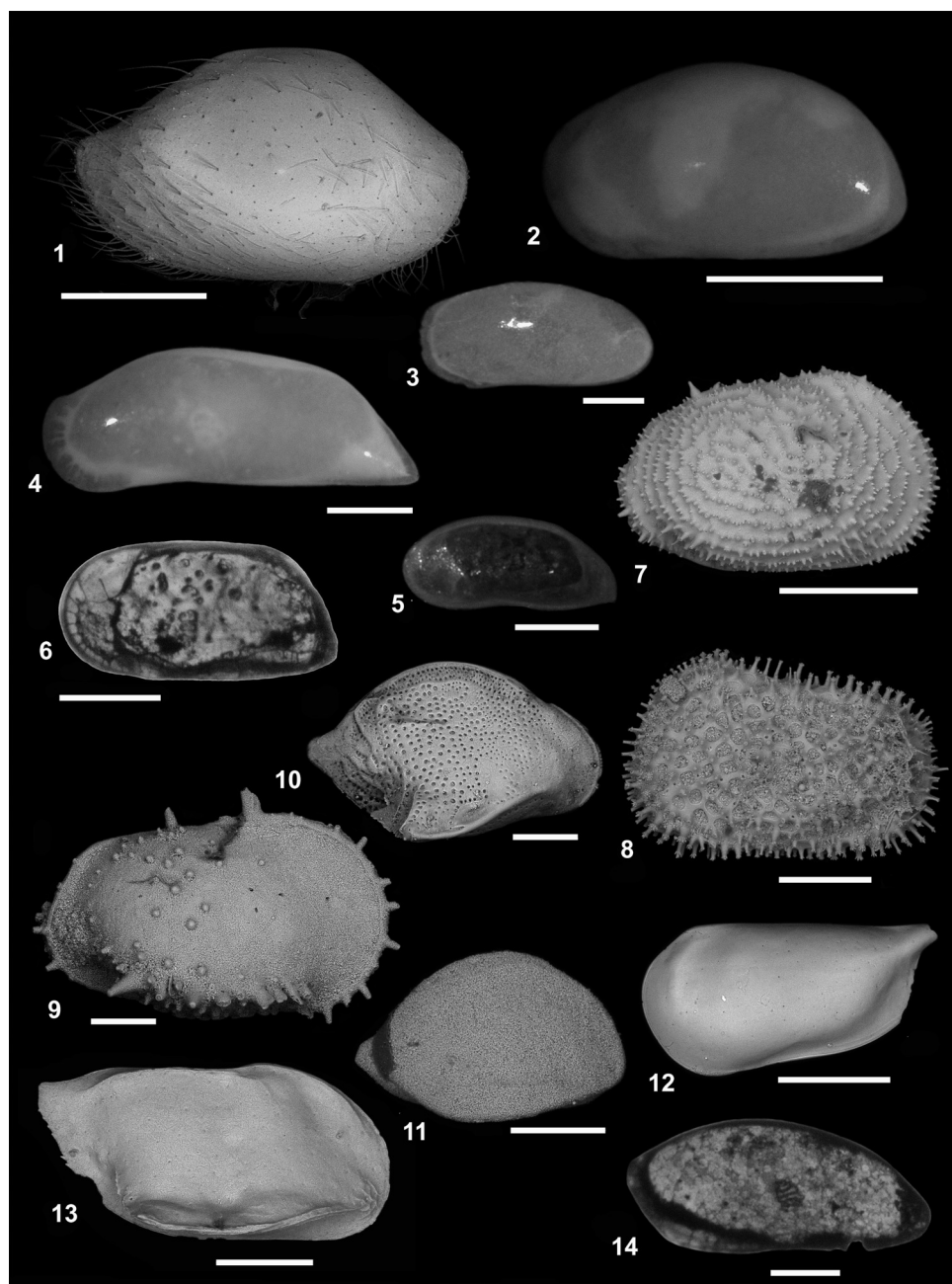


FIGURE 6. 1, *Bairdoppilata conformis* (Terquem, 1878). PMC. O FS 16. RV, external lateral view (scale bar equals 500 μ m); 2, *Bythocypris obtusata* (Sars, 1866). PMC. O FS 17. LV, external lateral view (scale bar equals 500 μ m); 3, *Anchistrocheles tenera* (Breman, 1975). PMC. O FS 18. LV, external lateral view (scale bar equals 200 μ m); 4, *Macropyxis adriatica* (Breman, 1975). PMC. O FS 19. LV, external lateral view (scale bar equals 500 μ m); 5, *Argilloecia acuminata* Müller, 1894. PMC. O FS 20. RV, internal lateral view (scale bar equals 100 μ m); 6, *Krithe monosteracensis* (Seguenza, 1880). PMC. O FS 21. RV, internal lateral view (trasparency, scale bar equals 250 μ m); 7, *Echinocythereis echinata* Sars, 1866. PMC. O FS 22. RV, external lateral view (scale bar equals 500 μ m); 8, *Henryhowella ex H. hirta* (Costa, 1853) group. PMC. O FS 23. LV, external lateral view (scale bar equals 200 μ m); 9, *Bathycythere vanstraateni* Sissingh, 1971. PMC. O FS 24. RV, external lateral view (scale bar equals 200 μ m); 10, *Cytheropteron hadriaricum* Bonaduce et al., 1975. PMC. O FS 25. RV, external lateral view (scale bar equals 100 μ m); 11, *Cytheropteron testudo* Sars, 1869. PMC. O FS 26. RV, external lateral view (scale bar equals 200 μ m); 12, *Pseudocythere caudata* Sars, 1866. PMC. O FS 27. LV, external lateral view (scale bar equals 200 μ m); 13, *Monoceratina mediterranea* Sissingh, 1971. PMC. O FS 28. RV, external lateral view (scale equals bar 200 μ m); 14, *Paradoxostoma simile* Müller, 1894. PMC. O FS 29. LV, internal lateral view (trasparency, scale bar equals 200 μ m). (PMC. O FS 16–29 = Paleontological Museum Catania. Ostracoda Figured Specimens number 16 to 29. RV = right valve; LV = left valve).

B. conformis has been reported in Plio-Pleistocene sediments deposited in deep environments (Aiello et al., 2000; Sciuto and Rosso, 2008).

Family BYTHOCYPRIDIDAE Maddocks, 1969
Genus ANCHISTROCHELES Brady and Norman, 1889

Type species. *Anchistrocheles fumata* Brady, 1890

Anchistrocheles tenera (Breman, 1975)
Figure 6.3

1975 *Bythocypris tenera* Breman, p. 208, pl. 2, figs. 8; pl. 3, fig. 16.

1996 *Anchistrocheles tenera* (Breman); Aiello et al., p. 272, Text-fig. 1 (f-h).

Remarks. *A. tenera* is the only species of the genus currently living in the Mediterranean. It has been reported from bathyal environments in western Mediterranean (Bonaduce et al., 1983), including the Gulf of Naples (Aiello et al., 1996). It is also known from the Adriatic Sea, in Pleistocene bathyal sediments referred to cold environments (Breman, 1975).

In the SML CWCP it is present only in the Mollusc Mud facies (MM) and in the *Gryphus* and *Isidella* facies (IGI).

Genus BYTHOCYPRIS Brady, 1880

Type species. *Bythocypris reniformis* Brady, 1880

Bythocypris bosquetiana (Brady, 1866)

1866 *Bairdia bosquetiana* Brady; p. 364, p. 57, fig. 5.

1880 *Cytheridea lucida* Seguenza; p. 290, pl. 16, figs. 51, 51a.

1894 *Bythocypris bosquetiana* (Brady); Müller, p. 275, pl. 14, figs. 16-18, 20, 31.

1900 *Bythocypris bosquetiana* (Brady); Namias, p. 88, pl. 14, fig. 8.

1964 *Bythocypris lucida* (Seguenza); Ascoli, p. 218, pl. 4, fig. 3.

1972 *Bythocypris bosquetiana* (Brady); Sissingh, p. 78, pl. 3, fig. 7.

1979 *Bythocypris bosquetiana* (Brady); Yassini, p. 375.

1980 *Bythocypris lucida* (Seguenza); Colalongo and Pasini, p. 52, pl. 2, fig. 7, 8.

2000 *Bythocypris bosquetiana* (Brady); Aiello et al., p. 88, pl. 1, fig. 10, pl. 6, fig. 2.

2008 *Bythocypris bosquetiana* (Brady); Sciuto and Rosso, p. 35, pl. 1, fig. 4.

Remarks. *B. bosquetiana* is rare in the SML samples, and it has been found only in the CF and FM facies dead assemblages. In the Recent Atlantic–Mediterranean region this species occurs in the depth range 150–3381 m (Aiello et al., 2000) and as fossil it has been found in sediments referable to deep environments (Sciuto, 2003, 2005; Sciuto and Rosso, 2008).

Bythocypris obtusata (Sars, 1866)
Figure 6.2

1866 *Bairdia obtusata* Sars, p. 24.

1880 *Bairdia obtusata* Sars var. *producta*, Seguenza, p. 191.

1880 *Cytheridea lucida* Seguenza, p. 290, pl. 16, fig. 51.

1987 *Bythocypris lucida* (Seguenza); Aranki, p. 48, pl. 2, fig. 6.

1972 *Bythocypris obtusata* (Sars); Sissingh, p. 79, pl. 3, figs. 10, 11.

1972 *Bythocypris lucida* (Seguenza); Sissingh, p. 78, pl. 3, figs. 8, 9.

1975 *Bairdia obtusata* Sars; Breman, p. 205, pl. 2, fig. 9.

1980 *Bythocypris obtusata* (Sars); Colalongo and Pasini, p. 52, pl. 2, figs. 9, 10.

1981 *Bythocypris obtusata* (Sars); Tsapralis, p. 83, pl. 4, figs. 1-3.

2008 *Bythocypris obtusata* (Sars); Sciuto and Rosso, p. 35, pl. 1, fig. 3.

Remarks. The species is widespread in the SML samples. It is one of two species found alive. *B. obtusata* is currently reported at 300 m WD in the Gulf of Naples (Bonaduce and Pugliese, 1979), between 600 and 2669 m WD in the Atlantic–Mediterranean Region (Bonaduce et al., 1983), at 145–165 m water depth along the Norwegian and British coasts (Sars, 1928) and in the Recent Mediterranean Sea between 150 and 2905 m (Puri et al., 1964). Also the fossil record of this species points to bathyal palaeoenvironments (Tyrrhenian Sea: Colalongo et al., 1988, 1990; Le Castella: Colalongo, 1965; Capo Milazzo: Sciuto, 2003, 2005; Furnari: Sciuto and Rosso, 2008; Vrica: Colalongo and Pasini, 1980).

Family BYTHOCYPRIDAE Sars, 1866
Genus BYTHOCYPRIS Sars, 1866

Type species. *Bythocypris turgida* Sars, 1866

Bythocypris mylaensis Sciuto, 2009

2005 *Bythocypris* sp. 1. Sciuto, p. 222.

2009 *Bythocythere mylaensis*, Sciuto, pl. 1, figs. 1-12.

Remarks. This species was found only in the Framework Corals facies (CF). *B. mylaensis* can be considered as a bathyal taxon because it is always found in typically deep water associations, with ecological requirements seemingly unchanged throughout the Pleistocene. Presently, *B. mylaensis* seems to have restricted both stratigraphical and geographical distributions, known only from Pleistocene sediments of the central Mediterranean area, including north-eastern Sicily (Lower Pleistocene outcrops) and the northern Ionian Sea (Upper Pleistocene underwater cores).

Genus PSEUDOCY THERE Sars, 1866

Type species. *Pseudocythere caudata* Sars, 1866

Pseudocythere caudata Sars, 1866
Figure 6.12

1894 *Pseudocythere caudata* Sars; Müller, p. 284, pl. 16, figs. 5, 10.

1980 *Pseudocythere caudata* Sars; Colalongo and Pasini, p. 64, pl. 26, fig. 5.

1992 *Pseudocythere caudata* Sars; Ciampo, p. 227.

2005 *Pseudocythere caudata* Sars; Sciuto, p. 222.

2014 *Pseudocythere caudata* Sars; Sciuto, p. 4.

2014 *Pseudocythere caudata* Sars; Yasuhara and Okahashi, p. 774, figs. 2.9, 2.10.

2014 *Pseudocythere caudata* Sars; Yasuhara et al., p. 348, figs. 5.1, 5.2.

Remarks. The subspecies *Pseudocythere caudata mediterranea* Bonaduce et al., 1980 was created on the basis of slight differences in the soft part and in the carapace. The SML specimens do not show these features. They were, therefore, attributed to the Sars species.

P. caudata was found mostly in the Framework Corals facies (CF). In the Recent Mediterranean, this species seems to have a very wide ecological distribution from shallow continental shelf to abyssal environments. However, it is known throughout the Pliocene and the Pleistocene always from sediments presumably deposited in deep water environments. In the Pleistocene sediments of Scoppo (ME) several complete specimens of *P. caudata* were found in proximity of coral rudstones (Sciuto, unpublished data), in environmental condition, which may be considered very similar to those currently found at SML.

Such an abundance of *P. caudata* specimens in deep environments might be explained with the

abundance of food due to the presence of coral colonies, as suggested for species belonging to *Paradoxostoma*, *Paracytherois* and *Sclerochilus* (Coles et al., 1996).

Family CYTHERURIDAE Müller, 1894

Genus CYTHEROPTERON Sars, 1866

Type species. *Cythere latissima* Norman, 1865

Cytheropteron testudo Sars, 1869
Figure 6.11

1869 *Cytheropteron testudo* Sars, p.173, pl. 173, fig. 1.

1889 *Cytheropteron testudo* Sars; Brady and Norman, p. 219, pl. 21, figs. 1, 2.

1985 *Cytheropteron testudo* Sars; Montcharmont-Zei et al., p. 30, pl. 1, fig. 6.

1999 *Cytheropteron testudo* Sars; Swanson and Ayress, p. 157, pl. 4, figs. 1-12, pl. 5, figs.1-13, pl. 6, figs. 10-12.

2003 *Cytheropteron testudo* Sars; Stepanova et al., p. 31, pl. 11, figs. 5, 6.

2011 *Cytheropteron testudo* Sars; Faranda and Gliozzi, p. 82, fig. 12.

2012 *Cytheropteron testudo* Sars; Sciuto, p. 122, fig. 3a.

Remarks. *C. testudo* Sars, 1869 is presently restricted to the area between the Norwegian coasts and the Arctic bioprovince. Consequently, it is considered as one of the northern guests widespread in the Mediterranean during the Quaternary (Faranda and Gliozzi, 2011). This species has been found in western Laptev Sea, at 68 m water depth by Stepanova et al. (2003); along the Norwegian coast, at depths of 80 to 240 m, and in the Recent Atlantic, between 1380 and 3526 m water depth by Dingle and Lord (1990); in the Queensland Plateau (SW Pacific) in Holocene to Recent sediments deeper than 500 m by Swanson and Ayress (1999). As fossils, the species has been reported from the Early Pliocene to the Quaternary from bathyal sediments of the Atlantic Ocean (Whatley and Coles, 1987) and from to Early Pleistocene in bathyal sediments of the Mount S. Nicola section (Aiello et al., 2000). In the Mediterranean Sea its last occurrence corresponds to the Last Glacial (Montcharmont-Zei et al., 1985). Therefore *C. testudo* could be considered as a stenothermic species restricted to very cold waters independently of depth.

This species was found only in the Framework Corals facies (CF).

Family MACROCYPRIDIDAE Müller, 1912
Genus MACROPYXIS Maddocks, 1990

Type species. *Macropyxis sapeloensis* Darby, 1965

Macropyxis adriatica (Breman, 1975)
Figure 6.4

1975 *Macrocypris adriatica* Breman, p. 210, pl. 2, figs. 6 a-c, pl. 4, figs. 17 a-d.

1980 *Macrocypris ligustica* Bonaduce et al.; Colalongo and Pasini, p. 62, pl. 23, fig. 7.

1985 *Macrocypris adriatica* Breman; Moncharmont-Zei et al., pl. 1, fig. 2.

1990 *Macropyxis adriatica* (Breman); Maddocks, p. 60, figs. 8 (9, 10), 9 (9, 10), 19 (10), 22 (20), 24 (6), 16 (9-12), 17(9-12), 78 (30).

2010 *Macrocypris adriatica* Masoli (sic!); Rosso et al., p. 365, fig. 11, l.

Remarks. This species has been found in all the facies identified in the sampled area but it is not abundant (Table 1, Figure 2). *M. adriatica* has been reported from the Pleistocene of the Mediterranean and Aegean areas but it seems to be extinct in the Recent Mediterranean. Interestingly, Breman (1975) found *M. adriatica* in levels dated to the Upper Pleistocene including the Allerød and Younger Dryas climatic stage (cores 353 in the Adriatic Sea), and considered this species as a cold water indicator.

Family TRACHILEBERIDAE Sylvester-Bradley, 1948

Genus BATHYCYTHERE Sissingh, 1971

Type species. *Bathycythere vanstraateni* Sissingh, 1971

Bathycythere vanstraateni Sissingh, 1971
Figure 6.9

1971 *Bathycythere vanstraateni* Sissingh, p. 410, pl. 1, 2, figs. 2-4.

1971 *Xandarosina n. nudum*, Benson and Sylvester-Bradley, p. 68, figs. 3 a, b.

1975 *Bathycythere vanstraateni* Sissingh; Breman, p. 213, pl. 4, fig. 20.

1980 *Bathycythere vanstraateni* Sissingh; Colalongo and Pasini, p. 52, plate 4, figs. 7, 8.

1983 *Bathycythere vanstraateni* Sissingh; Bonaduce et al., p. 463.

1985 *Bathycythere vanstraateni* Sissingh; Moncharmont-Zei et al., pl. 1, fig. 7.

1988 *Bathycythere vanstraateni* Sissingh; Colalongo and Pasini, p. 283.

1988 *Bathycythere vanstraateni* Sissingh; van Harten and Droste, p. 732, pl. 1, fig. 1.

1990 *Bathycythere vanstraateni* Sissingh; Colalongo et al., p. 483.

1997 *Bathycythere vanstraateni* Sissingh; Pasini and Colalongo, p. 18.

2004 *Bathycythere vanstraateni* Sissingh; Mazzini, p. 48, figs. 25 K-N.

Remarks. This species is poorly represented in the SML area and is restricted to the Framework Coral facies (FC) and the Hardground fragments colonized by the Solitary Coral facies (SC).

B. vanstraateni is listed among the abyssal ostracods living in the Atlantic Ocean, and Pasini and Colalongo (1997) considered it as a psychrospheric species. It seems to be extinct in the Recent Mediterranean, from where it has been recorded from depths shallower than the SML ones (van Harten, 1990).

Breman (1975) found this species in sediments from the Adriatic Sea dated to the basal Holocene including the Allerød and the Younger Dryas climatic stages. van Harten and Droste (1988) stated that this species disappeared from the eastern Mediterranean about 9 Ka ago together with *K. monosteracensis* and *M. adriatica*, following an anoxic event related to sapropel deposition. A comparable distribution can be desumed from Colalongo et al. (1990, figure 3) for cores from the Tyrrhenian Sea.

Genus BUNTONIA Howe, 1935 in Howe and Chambers, 1935

Type species. *Buntonia shubutaensis* Howe, 1935 in Howe and Chambers, 1935

Buntonia sublatissima (Neviani, 1906)

1906 *Cythere sublatissima* Neviani, p. 198, fig. 8.

1954 *Buntonia sublatissima* (Neviani); Ruggieri, p. 564, figs. 22, 24, 27, 29, 31.

1960 *Buntonia sublatissima sublatissima* (Neviani); Medioli, p. 215, text-fig. 1.

1964 *Buntonia sublatissima* (Neviani); Puri et al. p. 118, fig. 23.

1972 *Buntonia (Buntonia) sublatissima sublatissima* (Neviani); Sissingh, p. 95, pl. 6, fig. 7.

1975 *Buntonia sublatissima* (Neviani); Bonaduce et al., p. 55, pl. 33, figs. 6-11.

1979 *Buntonia sublatissima* (Neviani); Yassini, p. 106, pl. 2, figs. 16, 23, 24.

1984 *Buntonia sublatissima* (Neviani); Malz and Jellinek, p. 124, pl. 1, fig. 2.

1993 *Buntonia sublatissima* (Neviani); Nachite et al., p. 33, pl. 4, fig. 11.

2000 *Buntonia sublatissima* (Neviani); Ruiz et al., p. 237.

2000 *Buntonia sublatissima* (Neviani); Aiello et al., p. 98, pl. 4, fig. 10.

2008 *Buntonia sublatissima* (Neviani); Ruiz et al., p. 850.

Remarks. This species is present only in the Foraminifer Mud facies (FM) with few specimens.

B. sublatissima is known from the Upper Miocene (Carbonel, 1985) to nowadays (Ruiz et al., 2000). In the Mediterranean Sea its presence seems to be restricted to the continental shelf (Puri et al., 1964; Bonaduce et al., 1976, 1988).

Genus ECHINOCYHEREIS Puri, 1954

Type species. *Cythereis garretti* Howe and McGuirt, 1935 in Howe and graduate students, 1935

Echinocythereis echinata (Sars, 1866)
Figure 6.7

1866 *Cythere echinata* Sars, p. 44.

1975 *Echinocythereis echinata* (Sars); Breman, p.213, pl. 4 fig. 21.

1983 *Echinocythereis echinata* (Sars); Bonaduce et al., pl. 3, Figure 4.

1984 *Echinocythereis echinata* (Sars); Peypouchet and Nachite, pl. 2, figs. 3, 4.

1985 *Echinocythereis* sp.1; Moncharmont-Zei et al., pl. 1, fig. 10.

1990 *Echinocythereis echinata* (Sars); van Harten, p. 325, fig. 21.

1990 *Echinocythereis echinata* (Sars); Dingle and Lord, p. 225, fig. 2.3.

2009 *Echinocythereis echinata* (Sars); Alvarez-Zarikian, p. 6, pl. 9, figs. 3, 4.

2014 *Echinocythereis echinata* (Sars); Yasuhara et al., p. 354, fig. 7.5.

2014 *Echinocythereis echinata* (Sars); Yasuhara and Okahashi, p. 782, fig. 8.2.

Remarks. This species has been detected in almost all the facies sampled in the SML CWC. *E. echinata* seems to be absent from the Recent Mediterranean but it has been reported from layers deposited during the cold phases of the Pleistocene (Breman, 1975; Peypouchet and Nachite, 1984; Moncharmont-Zei et al., 1985). According to Barra and Bonaduce (2000), this species can be considered as a cold water indicator.

Genus HENRYHOWELLA Puri, 1957

Type species. *Henryhowella evax* Ulrich and Basler, 1904

Henryhowella ex *H. hirta* (Costa, 1853) group
Figure 6.8

1853 *Cypridina hirta* Costa, p. 174, pl. 15, figs. 2 a, c.

1894 *Cythereis sarsii* Müller, p. 370, pl. 8, fig. 8.

1950 *Cythereis hirta* (Costa); Ruggieri, p. 25.

1980 *Henryhowella asperrima* (Reuss); Yassini, p. 102, pl. 6, figs. 6, 8, 10.

1999 *Henryhowella sarsii sarsii* (Müller); Bonaduce et al., p. 64, pl. 2, figs. 1-10, pl. 3, fig. 12, pl. 4, figs. 9, 10, pl. 5, figs. 1, 2, 6, 8, 11.

1999 *Henryhowella parthenopea* Bonaduce et al., p. 61, pl. 3, figs. 1-11, 13, 14, pl. 4, figs. 11, 12, pl. 5, figs. 3-5, 9, 10, 12.

2003 *Henryhowella hirta* (Costa); Guernet et al., p. 84.

2008 *Henryhowella parthenopea* Bonaduce et al.; Faranda and Giozzi, pl. 6, figs. 2, 5, 8, 11.

2014 *Henryhowella* ex *H. hirta* (Costa, 1853) group; Sciuto, p. 6, pl. 1.H.

Remarks. Following Sciuto (2014), some specimens have been ascribed to *Henryhowella* ex *H. hirta* (Costa, 1853) group, which is present in nearly all the facies in the studied area.

DISCUSSION AND CONCLUSION

The ostracod fauna found in the SML CWC province consists of 42 taxa. Only two species, *Bairdoppilata conformis* and *Bythocypris obtusata*, were found alive in nearly all the facies detected. Both of them are already known as common in deep-water environments. Looking at dead assemblages, most of the ostracod species detected can be considered as in equilibrium with present-day bathymetry at each site. Consequently they are mostly considered as preserved in situ. Noteworthy, several taxa can be considered as stenothermic and rather ecologically restricted to cold waters independently from depth. This is the case for *Cytheropteron testudo*, and probably for *B. obtusata*, *Macropyxis adriatica* and *Echinocythereis echinata* (Breman, 1975; Sciuto, 2009). Further species, such as *Bathocythere vanstraateni* (Breman, 1975) and *Bythocythere mylaensis* (Sciuto, 2009), are typical of bathyal environments or have wide bathymetric distributions, which include preferentially the bathyal zone, such as *Pseudocythere caudata*, *Bythocypris bosquetiana*, *Henryhowella*

ex *H. hirta* group and *Cytherella vulgatella* (Montenegro et al., 1998).

Significantly, the composition of the ostracod fauna from SML shows some similarities with those found in the core 353 located at 1200 m WD in the southern Adriatic Basin (Breman, 1975) as well as in cores from the Gulf of Taranto (Montchamont-Zei et al., 1985). Compositional similarity is particularly evident for levels A and B of the 353 core, dated to the Upper Pleistocene, also including the climatic stages Allerød and Younger Dryas. In the Gulf of Taranto, levels which delivered *Cytherop-teron testudo*, *Macropyxix adriatica* and *Bathycythere vanstraateni* were attributed to a cold period, at the end of the last glaciation. The disappearance of *M. adriatica*, *B. vanstraateni* and *Krithe monosteracensis* has been documented in the Eastern Mediterranean Basin at the base of the early Holocene in correspondence to the sapropel S1 deposited approximately between 9000 and 7000 YBP (van Harten and Droste, 1988). Therefore, data collected so far seems to confirm that the ostracod fauna of SML CWC province also include species no longer found in the Recent Mediterranean Sea, but they partly document an association which lived during a cold phase of the Late Pleistocene (Allerød) or during the transition to the Holocene (Younger Dryas) when low temperatures still allowed their presence in this area, approximately between 11.800 and 10.000 YBP (sensu Hoek, 2008). These species, particularly *C. testudo* and *Bythocythere mylaensis*, include opaque, sometimes heavily worn carapaces, and have been reported in the columns "W" in Appendices 1 and 2.

Some scarce species belonging to *Callistocythere*, *Loxoconcha*, *Neocytherideis* and *Cytheridea*, typical of shallow water shelf habitat, were considered as displaced. The fauna displacement phenomenon, indeed, may be due to frequent downslope mass movement due to the steep morphology of the seafloor and the intense tectonic activity in the area (Savini and Corselli, 2010).

Interestingly, some species, such as *Paradoxostoma simile*, *Paradoxostoma acuminatum* and *Paracytherois flexuosa*, have been found mainly in the Framework Corals facies (CF) usually with a high number of specimens. Their presence could be related to the existence of favourable environmental parameters in this habitat. The abovementioned taxa have been reported especially from shelf environments rich in plants and/or biodetritus (e.g., Whatley and Wall, 1975; Athersuch et al., 1989; Coles et al., 1996), as well as from deep bio-

topes. On the basis of current knowledge, despite the scarcity of autoecological data and some concerns about taxonomical determinations, already remarked by Maddocks and Steineck (1987) and Athersuch et al. (1989), it is presumable that the extension of their distribution to deep environments is related to favourable trophic conditions, as suggested for comparable environments by Passlow (1997). This has been proven by Maddocks and Steineck (1987) who report the discovery of a living specimen, probably referable to the species *Schlerochilus contortus*, at 1830 m water depth on artificial wood panels anchored to the bottom of the Caribbean Sea. These panels formed "wood islands", where a significant increase of food resources potentially exploitable by ostracods (film of bacteria and fungi, mucus secreted by echinoderms, fecal pellets, decaying tissues) was observed. The ostracod populations are characterized by the simultaneous presence of purely xilophilous ostracods, as well as by epiphytic or scavenging taxa, or by parasites on other organisms, all typical of shallow environments, usually as abundant as those typical of the bathyal environments.

A considerable availability of trophic resources exploitable by bathyal ostracods as well as by associated typical "shallow marine, phytal taxa", such as *Paradoxostoma*, *Paracytherois* and *Schlerochilus* species, has been reported by Coles et al. (1996) from bathyal coral bioconstructions from the Porcupine Basin at 750 m water depth. It is worth noting that in the SML CWC province, as well as in the Porcupine Basin, the abundance of these taxa rises to a maximum in the Framework corals facies and progressively lowers moving away from areas colonized by corals, possibly in relation to a decrease of available resources. Therefore, the presence of abundant trophic resources may have caused the extension toward deeper areas of taxa, such as *Paradoxostoma* and *Paracytherois*. Species of such genera can be interpreted as in situ rather than displaced from shallow environments, as already noted in North Atlantic Holocene bathyal associations by Coles et al. (1996).

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APPENDIX 1.

List of the ostracod species found in the samples belonging to the FC, FM, CR, and GI facies from the Santa Maria di Leuca coral province. For each species the total number of specimens found, separated for living association (bio), fresh-looking specimens constituting the recent association (f) and old-looking specimens constituting the oldest Holocene assemblage (w) are reported, together with their relative percentages (%).

File available as spreadsheet at palaeo-electronica.org/content/2015/1164-deep-water-ostracods

APPENDIX 2.

List of the ostracod species found in the samples belonging to the MM and SC/HG facies from the Santa Maria di Leuca coral province. For each species the total number of specimens found, separated for living association (bio), fresh-looking specimens constituting the recent association (f) and old-looking specimens constituting the oldest Holocene assemblage (w) are reported, together with their relative percentages (%).

File available as spreadsheet at palaeo-electronica.org/content/2015/1164-deep-water-ostracods

APPENDIX 3.

List of the ostracod species found in the six facies detected in the Santa Maria di Leuca coral province. For each species and for each facies (including living associations: bio, fresh-looking specimens of the recent association: f, and old-looking specimens from the oldest Holocene assemblage: w), the frequency (i.e., the number of samples where that species has been found out of the total number of samples examined) and the total number of specimens found are reported in the first line. Numbers in brackets in the second line indicate the range of relative percentages.

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