Bollettino della Società Paleontologica Italiana, 52 (3), 2013, 167-176. Modena

Faunas and ecological groups of Serpuloidea, Bryozoa and Brachiopoda from submarine caves in Sicily (Mediterranean Sea)

Antonietta Rosso, Rossana Sanfilippo, Emma Taddei Ruggiero & Emanuela Di Martino

A. Rosso, Università di Catania, Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Sezione di Scienze della Terra, Corso Italia 57, I-95129 Catania, Italy; rosso@unict.it
R. Sanfilippo, Università di Catania, Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Sezione di Scienze della Terra, Corso Italia 57, I-95129 Catania, Italy; sanfiros@unict.it
E. Taddei Ruggiero, formerly at the Università di Napoli Federico II, Dipartimento di Scienze della Terra, Largo San Marcellino 10, I-80100 Napoli, Italy; ruggiem@unina.it
E. Di Martino, Università di Catania, Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Sezione di Scienze della Terra, Corso Italia 57, I-95129 Catania, Italy; Department of Earth Sciences, Natural History Museum, Cromwell Road, SW7 5BD London, United Kingdom; e.di-martino@nhm.ac.uk

KEY WORDS - Serpuloideans, bryozoans, brachiopods, submarine caves, Sicily, Ionian Sea, Tyrrhenian Sea, Holocene.

ABSTRACT - Serpuloideans, bryozoans and brachiopods, which are among the most representative sessile skeletonised invertebrates in marine caves, are examined herein from four selected submerged marine caves: the Ficarella Cave (NW Sicily, Tyrrhenian Sea), and the Gymnasium, Mazzere and Granchi Caves (SE Sicily, Ionian Sea).

A large number of the identified species are already known as typical representatives of cave communities or, at least, have been already found in submarine caves. In order to better understand the composition of these communities, a categorisation of cave species into ecological groups is proposed herein, based mainly on literature data: 1) Cave species; 2) Sciaphilic and/or "coralligenous" species; 3) Deep-water species; 4) Shelf species; 5) Shallow shelf species; 6) Unplaced species.

The use of these different ecological groups is proposed as a tool for the analysis and interpretation of thanatocoenoses and fossil communities from caves.

RIASSUNTO - [Faune a serpuloidei, briozoi e brachiopodi, e gruppi ecologici in grotte marine sommerse della Sicilia (Mar Mediterraneo)] *- Sono stati studiati serpuloidei, briozoi e brachiopodi di quattro grotte sottomarine ubicate a circa 20 metri di profondità nella Sicilia NO (Grotta Ficarella) e SE (Grotte Gymnasium, Mazzere e Granchi). I gruppi sessili studiati sono tra i più rappresentativi negli ambienti di grotta e comprendono esemplari viventi e resti scheletrici campionati lungo le pareti e le volte, e nei sedimenti di fondo. Tutte le specie individuate (in totale 162) sono state inserite in sei raggruppamenti ecologici principalmente in base a dati di letteratura: 1) Specie di grotta; 2) Specie sciafile e/o "coralligene"; 3) Specie di profondità; 4) Specie di piattaforma; 5) Specie di piattaforma superiore; 6) Specie senza preciso significato.*

Le grotte di entrambe le aree sono colonizzate in prevalenza da specie del gruppo 2, spesso presenti con un elevato numero di esemplari, e subordinatamente da specie dei gruppi 1 e 3, che nell'insieme sono indicativi di associazioni di grotta. La differente incidenza delle specie superficiali fotofile (gruppo 5) nelle varie grotte è indicativa di input esterni di differente entità provenienti da habitat antistanti le cavità, soggette a differenti gradi di esposizione.

L'analisi dei differenti gruppi ecologici si propone come uno strumento investigativo utile nello studio delle tanatocenosi e delle associazioni fossili di grotta.

INTRODUCTION

Benthic ecosystems from shallow water submarine caves are unique in representing enclaves similar in composition to deeper environments but located only a few metres below the sea level (Vacelet et al., 1994). Consequently, habitats and life within caves differ markedly from those of neighbouring systems. Reduction in light and water motion, and exchange with external environments are claimed as the most important factors that strongly shape cave communities (Harmelin, 1986, 2000; Bianchi & Morri, 1994; Bussotti et al., 2006 inter alias). These factors usually show a distinct negative gradient inward the caves. Water inflow and hydrodynamic energy control oxygen and food availability, maintaining existing populations, and favouring the diffusion of larvae coming from the outside. Specifically, colonisation of karstic coastal submarine caves is initially produced by larvae from neighbouring shelf and adjacent slope entering the caves after their flooding caused by land/sea interactions, during the post Würmian sea-level rising in the Mediterranean area. The communities reflect the geographical location, morphology and history of the cave and the local pool of species, as well as the timing and succession of larval inflows, causing in turn, biotic complexity and competition (Harmelin, 1980, 1985, 1997, 2000; Bianchi & Morri, 1994; Martì et al., 2004). Hence, each cave has its peculiar species composition, even though caves of the same geographical area share a certain number of species. Even for the relatively well-investigated Mediterranean Sea, knowledge mostly relates to caves of the western European coasts (Harmelin, 1969, 1985, 1986, 1997, 2000; Harmelin et al., 1985; Balduzzi et al., 1989; Di Geronimo et al., 1993; Taddei Ruggiero, 1994; Taddei Ruggiero et al., 1996; Martì et al., 2004 inter alias), while data on central and eastern sectors is still fragmentary and some studies deal with single taxonomic groups (Di Geronimo et al., 2000; Sanfilippo & Mòllica, 2000; Bussotti et al., 2006; Denitto et al., 2007; Pitruzzello & Russo, 2008; Rosso et al., 2012). Nearly nothing is known about thanatocoenoses and their relationships with communities (Monteiro-Marquez, 1981; Di Geronimo et

ISSN 0375-7633 doi:10.4435/BSPI.2013.18

al., 1993, 1997, 2000; Rosso et al., 2012), though they are informative about cave's colonisation history.

In this context, and taking into account that Sicily is a region rich in submarine caves still poorly known, the present paper aims to: 1) contribute to the knowledge of cave communities from W and E Sicily employing the main skeletonised sessile invertebrates (and therefore the most adequate taxa for a comparison with the thanatocoenoses); 2) explore hard surfaces (walls and vaults) as well as soft sediments for both living and dead communities; 3) categorise all species found into ecological groups; 4) test the proposed species categories as a possible tool to interpret fossil cave communities and compare present day caves using thanatocoenoses.

MATERIALS AND METHODS

Materials come from four selected submerged marine caves (Fig. 1): the Ficarella Cave (FI) located on the E coast of the Capo S. Vito headland, W of Palermo (NW Sicily, Tyrrhenian Sea), and the Gymnasium (GM), Mazzere (MZ) and Granchi (GR) Caves, located in different settings along the Maddalena Peninsula, in the Plemmirio Marine Protected Area (PMPA), S of Syracuse (SE Sicily, Ionian Sea). The PMPA caves open in a Tertiary carbonate succession and develop sub-horizontally, following the rock layering. Caves are elongated, with length ranging from 35 m to 65 m. They share blind ends and a unique entrance, located at about 20 m in depth, 3-8 m wide and 1.5-3 m high. The cave vaults do not exceed 3.5 m in height; the floors are nearly flat and largely covered by muddy deposits with an abundant coarser bioclastic fraction. The FI Cave is 130 m long with a 10 m wide entrance opening between 17 and 30 m in depth. The floor rises inward roughly following the stratification, ending in a partly subaerial chamber. Collapsed blocks, accumulated at places on the floor, partly obstruct the entrance. Coarse sediments cover the floor, and their rippled surfaces in the outer zones point to bottom currents.

Living and dead specimens (thanatocoenoses) were examined from 14 selected sites (Fig. 1), two sites from both the FI and the MZ Caves and five sites from both the GM and the GR Caves. Generally, from each site, rocky substrates from the vault and the walls plus bottom sediments were collected, except at the entrances where the sampling concerned only hard surfaces. Conversely, only sediment samples were taken from the "old" site at the GM Cave and from the FI Cave. Further details on the examined caves, sampling methods and associated faunas can be found in Di Geronimo et al. (2000), Pitruzzello & Russo (2008) and Rosso et al. (2012).

Analysis was focused on three main taxonomic groups: serpuloideans, bryozoans and brachiopods.

Low magnification images were taken through a Zeiss Discovery V8A stereomicroscope equipped with an Axiocam MRC and Axiovision acquisition system; SEM images were performed with a LMU Tescan Vega Scanning Electron Microscope at the Università di Catania and a Jeol JSM5310 at the CISAG of the Università di Napoli "Federico II".

Materials belong to the Rosso (bryozoans) and Sanfilippo (serpuloideans) collections, deposited at the Sezione Paleontologica of the Museo di Scienze della Terra of the Università di Catania (PMC). Brachiopods are housed at the Università di Napoli "Federico II", Taddei collection (NPMT.R).

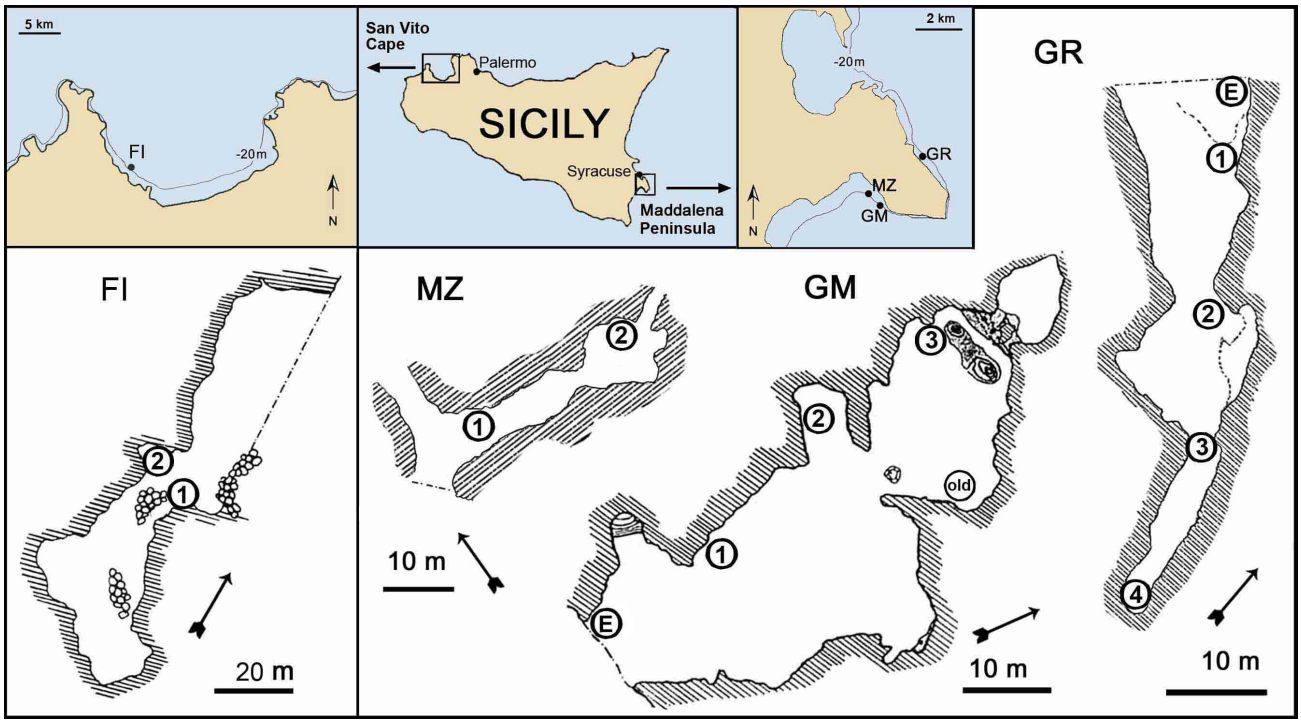


Fig. 1 - Studied submarine caves and their location in northwestern and southeastern coasts of Sicily. FI = Ficarella Cave (38°05'.72N, 12°48'.10E), MZ = Mazzere Cave (37°00'.18N, 15°18'.35E), GM = Gymnasium Cave (37°00'.12N, 15°18'.48E), GR = Granchi Cave (37°01'.13N, 15°19'.40E). Coordinates are in WGS84.

GROUPS	SERPULOIDEA	BRYOZOA	BRACHIOPODA
1 Cave species	(Serpula cavernicola), ***Spiraserpula massiliensis, (Filogranula annulata)***	***Annectocyma indistincta***, (Crassimarginatella crassimarginata), ***C. solidula***, Crisia sigmoidea, De smeplagioecia violacea, (Escharoides coccinea), Gregarinidra gregaria, Herentia hyndmanni, Hippomenella mucronelliformis, ***(Hippopleurifera pulchra)***, ***(Microecia occulta), M. "suborbicularis"*** sensu Harmelin, 1976, Onychocella marioni, (Plagioecia platydiscus), Puellina (G.) pedunculata, ***P. (C.) venusta***, P. (P.) setosa, Schizomavella discoidea, ***Stephanollona armata, Tubulipora hemifragmata***	(Tethyrhynchia mediterranea)
2 Sciaphilic and/or "coralligenous" species	***(Serpula concharum), Janita fimbriata, Josephella marenzelleri, Semivermilia crenata, S. pomatostegoides, Pileoolaria pseudomilitaris, Vinearia koehleri***	(Adeonella calveti), Aetea spp., Caberea boryi, ***Celleporina caminata***, C. canariensis, ***Chorizopora brongniartii***, ***(Copidozoum planum)***, ***(C. tenuirostre)***, Crassimarginatella maderensis, Crisia pyrula, (Dentiporella sardonica), ***Entalophoroecia deflexa***, ***E. gracilis***, Esharina vulgaris, Escharoides mamillata, (Hippellozoon mediterraneum), (Idmidronea triforis), ***(Mecynoecia delicatula)***, ***Metroperiella leprolioides***, ***(Myriapora truncata)***, (Parasmittina raigii), P. rouvillei, (Platonea stoechas), (Puellina hincksi), P. (C.) innominata, ***P. (C.) radiata***, (Reteporella couchii), ***R. elegans***, ***R. grimaldi***, ***(Schizomavella linearis linearis)***, (S. hastata), ***Schizotheca fissa***, Schizoretepora serratimargo, ***S. solanderia***, Scrupocellaria scrupea, S. scruposa, ***(Smittina cervicornis)***, Synnotum aegyptiacum	***Novocrania anomala, Megathiris detruncata, Argyrotheca cuneata, Joania cordata,*** (A. cistellula)
3 Deep-water species	***S. concharum*** (deep form), ***(Serpula israelitica),*** (S. lobiancoi), (Vermiliopsis monodiscus), Filogranula gracilis, ***Placostegus tridentatus, Protula tubularia,*** (Protis sp.)	(Arthropoma cecilii), Haplopoma sciaphylum, (Homera frondiculata), (Plagioecia inoedificata), Puellina (C.) setiformis romana, (Reteporella couchii biaviculata), Setosella cavernicola, (Tervia irregularis)	
4 Shelf species	***(Filograna sp.),*** (Semivermilia cribrata), ***Pileolaria militaris, (Placostegus crystallinus),*** (Spirorbis cuneatus), (S. marioni)	***Annectocyma major***, Beania magellanica, (Calpensia nobilis), ***(Cellaria salicornioides)***, Celleporina hassalli, Crisia fistulosa, ***C. ramosa***, Diplosolen obelia, ***Disporella hispida***, ***Fenestrulina malusii***, Hippothoa flagellum, ***(Patinella radiata)***, Pentapora fascialis, Plagioecia patina, (Reteporella feuerbornii), ***Schizomavella cornuta***, (Schizoporella magnifica), ***Scrupocellaria delilii***	
5 Shallow-shelf species	Hydroides p. pseudouncinatus, (H. stoichadon), ***(Spirobranchus polytrema), (Pomatoceros triqueter), (Janua pagenstecheri)***	(***Chaperiopsis annulus***), (Crisia occidentalis), ***(Hagiosynodos latus)***, (Haplopoma bimucronatum occiduum), ***(Margaretta cereoides)***, ***Mollia patellaria***, ***Pentapora ottomuelleriana***, Reptadeonella violacea, ***Schizobrachiella sanguinea***, (***Schizoporella dunckeri***), (Turbicellepora coronopusoida), (***Umbonula ovicellata***), ***(Watersipora subovoidea)***	
6 Other unplaced species	***(Serpula vermicularis),*** (Metavermilia cf. teniae)	Bugula cf. fulva, B. cf. flabellata, Celleporina caliciformis, (C. cf. caminata), C. syphuncula, (Cheiloporina circumcincta), Chlidonia pyriformis, ***Cosciniopsis ambita***, (Disporella sp. A), Hippaliosina depressa, (Lagenipora lepralioides), (Microporella sp. A), Microporella sp. B, (Microporella sp. C), (Onychocella vibraculifera) (Patinella mediterranea), (Plesiocleidochasma mediterraneum), ***Puellina (G.) corbula***, Reteporella cf. complanata, R. cf. mediterranea, (Rhynchozoon revelatus), Scrupocellaria sp. A, S. cf. aegeensis, ? Synnotum sp. A, ***Therenia rosei***, Trematoecia ligulata, Turbicellepora cf. magnicostata	

Tab. 1 - List of serpuloidean, bryozoan and brachiopod species found in the studied submarine caves of Ficarella (NW Sicily), and Mazzere, Gymnasium and Granchi (SE Sicily), grouped taking into account their distribution and ecological requirements (see text for further explanation). Bold italic: species shared by both geographical areas; underlined italic: species restricted to the Ficarella (FI) Cave; Italic: species restricted to the caves of the Plemmirio Marine Protected Area; in brackets: species found with exclusively dead specimens.

RESULTS

Focusing on serpuloideans, bryozoans and brachiopods, a total of 162 species was detected (Tab. 1, Figs 2-3). Serpuloideans include 32 species (26 serpulids and 6 spirorbids). Bryozoans are present with a total of 124 species, including 99 cheilostomes and 25 cyclostomes, whereas brachiopods consist of six species. Partly as a consequence of the sampling design and effort in the two areas, the total number of species from the FI Cave is lower (87 species: 21 serpuloideans, 60 bryozoans and 6 brachiopods) than that from the PMPA caves (141 species: 32 serpuloideans, 105 bryozoans and four brachiopods). Furthermore, in the FI cave no living specimens were found, while sediments from the PMPA caves yielded communities, although significantly poorer than the hard bottoms from the same sites.

Most species are represented by both living and dead individuals or colonies. As expected, several species are restricted only to one of the two geographical sectors, or even to single caves. This figure is more obvious for bryozoans than it is for serpuloideans and even more for brachiopods.

For each cave, only a relatively small number of species constitutes the bulk of the communities, including the serpulids *Filogranula annulata*, *Semivermilia crenata* and *Josephella marenzelleri* and the bryozoans *Annectocyma* spp., *Disporella hispida*, *Diplosolen obelia*, *Aetea* spp., *Onychocella marioni, Puellina* spp. mostly *P. (G.) pedunculata, Cosciniopsis ambita*, *Escharina vulgaris, Reteporella* spp. and *Celleporina caminata*.

Some taxa, such as the serpuloideans *Spiraserpula massiliensis*, *Protula tubularia*, *F. annulata*, *S. crenata* and *J. marenzelleri,* the bryozoans *Annectocyma indistincta, Crassimarginatella maderensis, C. solidula, O. marioni, Reteporella elegans, Schizoretepora solanderia, Haplopoma sciaphilum, Plagioecia inoedificata, Setosella cavernicola* and *Stephanollona armata* and the brachiopod *Novocrania anomala*, have been observed forming, at places, very dense populations with individuals or colonies, often of different size/age, living close to each other. Some of them, specially the serpuloideans *S. massiliensis* and *P. tubularia* and the bryozoans *O. marioni* and *S. armata*, construct raised nodular to mammellonar biogenic structures centimetre to decimetre sized (Figs 2c, e). Brachiopods are present with six species including the cemented, centimetre-sized *N. anomala,* and other even more diminutive pedunculate species, which usually do not exceed 4-5 mm in shell length, such as the Megathyrididae *Megathiris detruncata, Argyrotheca cuneata, A. cistellula, Joania cordata* and the Rhynchonellidae *Tethyrhynchia mediterranea*.

Some species (indicated in brackets in Tab. 1) are represented exclusively by dead individuals (serpulids and brachiopods) or colonies (bryozoans). Most of them have been collected still attached to their encrusted substratum but some others are present as isolated-to-common, sometimes worn, fragments. These last species, including the serpuloideans *Serpula vermicularis, Spirobranchus polytrema* and *Pomatoceros triqueter*, and several bryozoans, such as *Chaperiopsis annulus, Hagiosynodos latus, Haplopoma bimucronatum occiduum, Margaretta cereoides* and *Watersipora subovoidea*, are usually represented by single specimens in the PMPA caves while are comparably more numerous in the FI Cave.

DISCUSSION

The species identified in the studied caves from Sicily represent a variable percentage of the total number of species known for each taxonomic group from cave environments and from Italian seas and the Mediterranean as a whole. Particularly, serpuloideans represent about 1/2

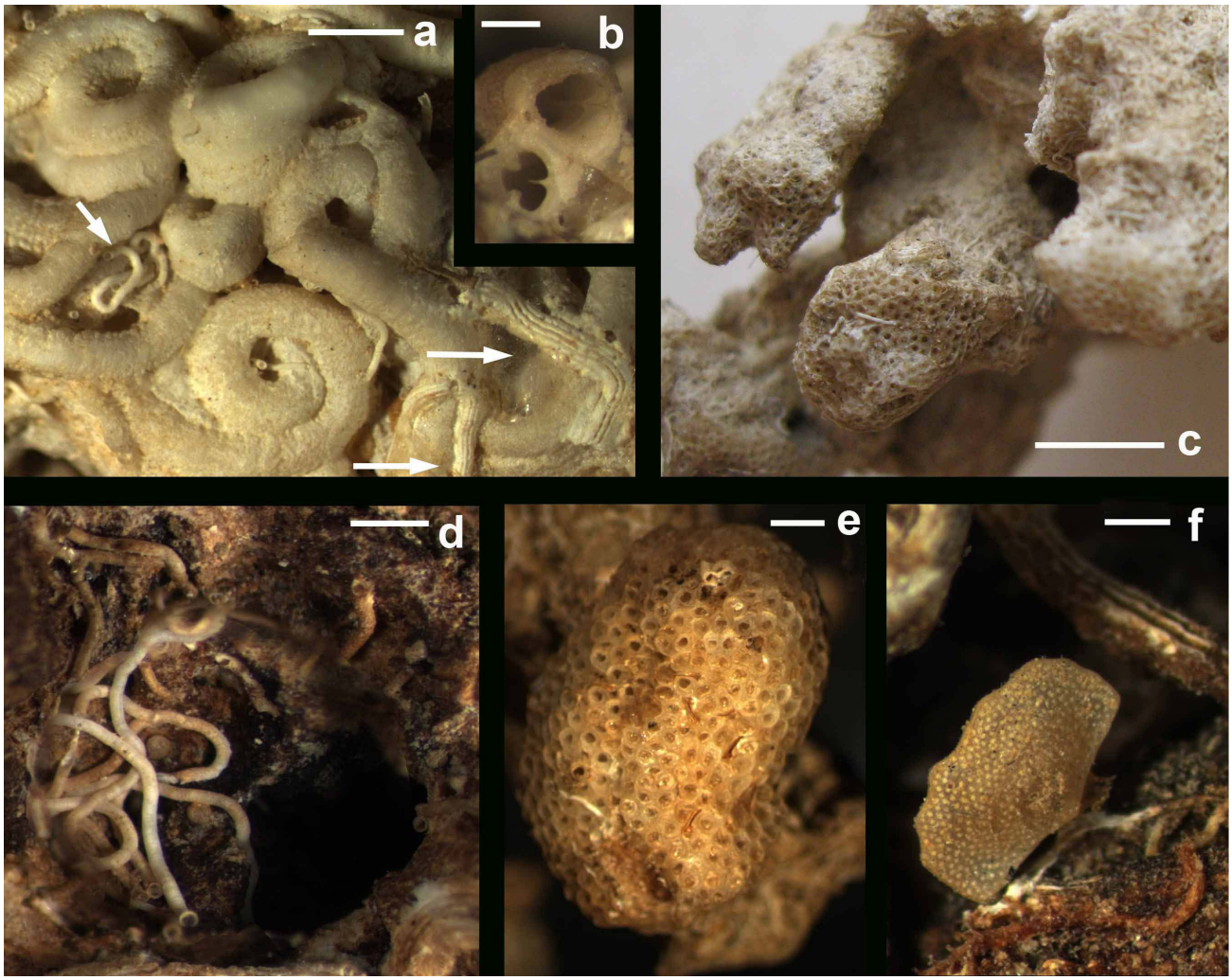


Fig. 2 - a) Tubes of the gregarious serpulid *Spiraserpula massiliensis* (Zibrowius, 1968) closely intertwined and exposing the granular sculpture of their outer surface. The small serpulids *Josephella marenzelleri* Caullery & Mesnil, 1896 (short arrow) and *Semivermilia crenata* (O.G. Costa, 1861) (long arrow) are also visible (PMC.S.I.H.S-1a); b) lumina of tubes of *S. massiliensis* showing their typical internal longitudinal ridges (PMC.S.I.H.S-2a); c) "micro-biohermes" constructed by the bryozoan *Onychocella marioni* Jullien, 1882, whose colonies form pillars through the superimposition of several encrusting sheets; d) tubes of the microserpulid *J. marenzelleri*, colonizing a small crevice, as usual for this species (PMC.S.I.H.S-2a); e) close-up of *O. marioni* from a pillar tip. Note the still in place, winged chitinous mandibles of some avicularia (PMC.R.I.H.B-11a); f) specimen of the brachiopod *Argyrotheca cuneata* (Risso, 1826) (NPMT.R-1). All figures from the sample collected along the wall of the Mazzere Cave, at site 2. Scale bars: a, d, e: 1 mm; b, f: 500 µm; c: 1 cm.

of the species recorded from Italian caves to date (Bianchi & Sanfilippo, 2003) and 2/3 of the total number of Italian species (Castelli et al., 2008). Bryozoans represent less than 1/5 of the total cave bryozoan diversity, as reported by Harmelin (2000), although they account for 1/3 of the Italian water bryozoans (Rosso et al., 2010) and only about 1/4 of the total known bryozoan diversity for the Mediterranean Sea (Rosso, 2003). Interestingly, though the PMPA bryozoan species represent only a relatively low percentage of the whole submarine cave biodiversity, several species, such as *R. elegans, S. solanderia, C. ambita, Trematoecia ligulata* (Fig. 3d) and *Therenia rosei* (Fig. 3e), have been recorded from these caves for the first time (Rosso et al., 2012). Likely further taxa, presently determined only at generic level, will be added. This result further confirms the idea that communities are peculiar to each cave (see introduction). Overall, the listed brachiopod fauna represents half of the total brachiopods of Italy (as speciose as the Mediterranean fauna). Brachiopods include up to 6/7 of all the known Mediterranean cave species (Logan, 1979) but it is somewhat surprising the absence of *Megerlia truncata.* In Italy, this species was found at the Scaletta cave (Palinuro, Campania), at 27 and 41 m depth (Taddei Ruggiero, 2003). Its absence from presently studied caves probably relates to its preference for deeper waters.

A large number of the identified species were already known as typical representatives of cave communities or, at least, had been already found in submarine caves (Harmelin, 1969, 1980, 1985, 1986, 1997, 2000; Zabala & Gili, 1985; Balduzzi et al., 1989; Zabala et al., 1989; Di Geronimo et al., 1993; Taddei Ruggiero et al., 1996; Sanfilippo & Mòllica, 2000; Balduzzi & Rosso, 2003; Bianchi & Sanfilippo, 2003; Taddei Ruggiero, 2003; Martì et al., 2004; Rosso et al., 2012).

In order to better understand the bryozoan component of cave communities, Harmelin (1969) first introduced a categorisation of cave species into ecological groups,

later also suggesting a depth-range grouping (Harmelin, 1997). However, not all bryozoan species found in the studied caves have been categorised so far, as well as most serpuloideans and brachiopods. The present tentative grouping (Tab. 1) follows mostly the above-cited literature and Di Geronimo et al. (1997, 2000) as well as unpublished authors' data.

1. Cave species

This group includes particularly sciaphilic species, which thrive in caves as well as in other cryptic microenvironments (cavities, crevices).

All these species are typical representatives of submarine cave communities though they also colonise other very sheltered microenvironments often associated with species of the group 2. Only a few of them, such as the serpulids *Serpula cavernicola* (Fig. 3h) and *S. massiliensis,* and the brachiopod *T. mediterranea* could be considered as exclusive of cave environments (Logan & Zibrovius, 1994; Pillai & Ten Hove, 1994; Sanfilippo & Mòllica, 2000). Among bryozoans, *A. indistincta*, *Crassimarginatella* spp. and *O. marioni* have been considered typical of this group following Harmelin (1969). Some species, such as the bryozoans *Tubulipora hemiphragmata, Puellina (G.) pedunculata* and *Herentia hyndmanni* and the unique brachiopod *T. mediterranea* (Fig. 3j), are miniaturised. Furthermore, the last-mentioned species, first described by Logan & Zibrowius (1994), has been so far recorded in Italy only from the FI Cave and the Accademia Cave (Ustica). Miniaturised bryozoan species have been typically observed in the more obscure and quiet recesses of caves where they are able to exploit the scarce resources available, in absence of more competitive taxa (Harmelin, 1986, 2000; Berning et al., 2008).

In contrast, some comparably large-sized species constitute at places dense populations, as for example the serpulid *S. massiliensis*, forming tangles locally up to some centimetres high (Figs 2a-b, 3g), comparable but smaller than those formed in a Pleistocene cave (Rosso & Sanfilippo, unpublished data). Analogously, the bryozoans *O. marioni* (Figs 2c, e) and *S. armata* build small nodular biogenic structures. Areas covered by such structures have been described by Harmelin (1985) as transitional between the Obscure and the Semi-Obscure sectors in caves from the Marseille region. Consequently, the finding of similar areas, albeit relatively close to the entrances, points out the presence of the dark cave (GO) aspect in large sectors of at least some of the PMPA caves. However, generality of the occurrence of this transitional zone has been questioned by Balduzzi et al. (1989).

The presence of species represented only by dead individuals or colonies might be indicative of species replacement during time, sometimes at local scale.

2. Sciaphilic and/or "coralligenous" species

All these species show preference for shadowed and sheltered biotopes such as caves, overhangs, "coralligenous" concretions, and the underside of small substrata lying on soft bottoms, even at shallow depths.

This group is by far the richest in species, including about one third of all the identified taxa. Typical representatives are the serpulids *S. crenata* (Fig. 2a), *Vermiliopsis labiata*, *J. marenzelleri* (Figs 2a, d, 3a), the spirorbid *Vinearia koehleri* (Fig. 3i), the encrusting bryozoans *Crassimarginatella maderensis*, *Copidozoum planum* and *C. tenuirostre*, some species of *Puellina*, *Escharoides mamillata*, *Escharina vulgaris* and *C. caminata*, and some erect bryozoans either small sized taxa, such as *Entalophoroecia* spp. and *Idmidronea triforis*, or large sized taxa, mostly *Reteporella* spp. and *S. solanderia* (Fig. 3c). Most large erect species are restricted to the near-entrance zones, characteristically associated with corallinales.

Finally, almost all brachiopods found, namely *N. anomala*, *M. detruncata* (Fig. 3k), *A.cuneata* (Figs 2f, 3l), *A. cistellula* (Fig. 3n) and *J. cordata* (Fig. 3m) can be ascribed to this group. *N. anomala* occurs in clusters, as usual for this species able to reach up to 469 individuals per square metre (Taddei Ruggiero, 1996, 2001).

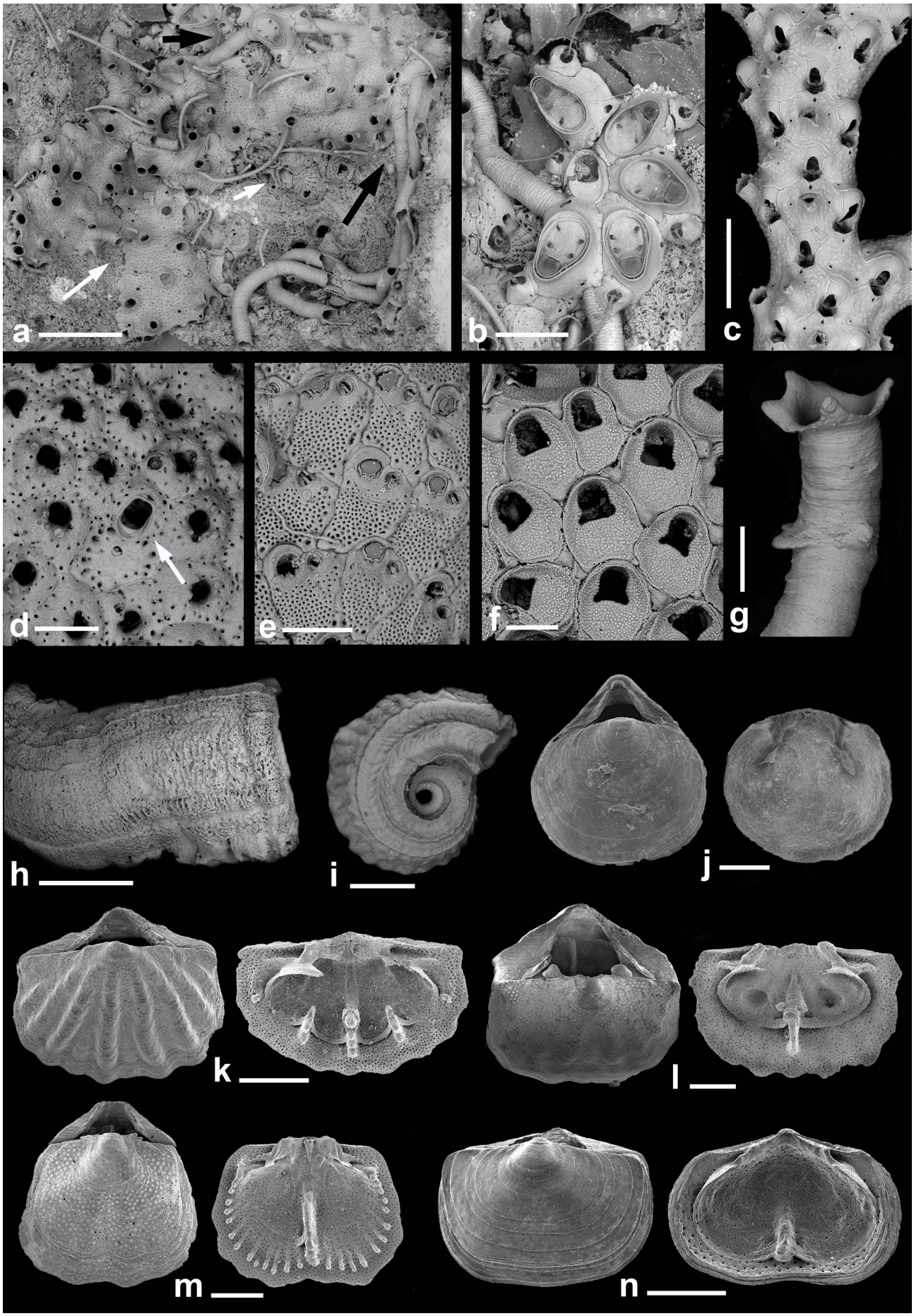
Most of the species show living representatives in the PMPA caves pointing to the presence of more or less extensive sectors hosting "coralligenous" to the semi-dark caves (GSO) communities. The finding of several of them dead or in fragments only, mostly in the FI Cave (Tab. 1), could indicate the action of frequent disturbances. Possible sources might be: 1) hydrodynamic energy, presumably more active in the FI Cave, relatively shallower than the PMPA caves and opening along a relatively more exposed coastline; 2) the organism activity, including human recreational diving. The absence or exclusive presence of some of these species from vault and wall samples, even as dead individuals or colonies, could result from mere sampling biases (Rosso et al., 2012) and/or patchiness.

3. Deep-water species

These species generally live in the outer shelf and the upper slope (lower circalittoral and upper bathyal) and a few of them colonise also shallower habitats. Nevertheless, real "stenobathic deep-water species" sensu Harmelin (1997) are lacking from the examined caves.

Numerous serpuloideans and few bryozoans have been included in this group. Particularly, the bryozoan *Hornera frondiculata* and the serpulids *Serpula israelitica* and *Filogranula calyculata* are able to live at depths as shallow as 50-60 m (Harmelin, 1976; Sanfilippo, 2009). Finally, the bryozoan *S. cavernicola* has been temporarily maintained in this group (Di Geronimo et al., 2000), notwithstanding its single collection at shallower depths in a strongly different setting in the Atlantic (Reverter Gil et al., 2012).

The serpulids *Placostegus tridentatus*, *Filogranula gracilis* and *Protula tubularia*, which are very frequent and common in the studied caves, are typical representatives of the present group. In the PMPA caves, during the recent past, *P. tubularia,* with its large-sized tubes, formed build-ups up to 10-15 cm high. These complex biogenic structures (Guido et al., 2013) are comparable to those reported from Apulian caves by Belmonte et al. (2009). Among bryozoans, *S. cavernicola* and *H. sciaphylum* form spot-like colonies (Fig. 3b), or miniaturized species (see above), usually not exceeding a dozen zooids. Colonies of *S. cavernicola* are often clustered with some closely spaced small colonies surrounding a relatively larger one, thus pointing to a local provenance of recruits and also to a small distance diffusion of larvae.


a
b
c
d
e
f
g
h
i
j
k
l
m
n

The presence of the group 3 species in shallow-water blind caves is due to the strong similarity between cave and deep-water habitats forcing, in turn, a marked faunal affinity (Zibrowius, 1971; Harmelin et al., 1985; Bianchi & Morri, 1994; Vacelet et al., 1994; Harmelin, 2000).

Species belonging to this group are few compared to the previous 1 and 2 groups and are usually represented by few specimens/colonies. Noteworthy, none of the bryozoan species from this group and a relatively low number of serpuloidean species (compared to other ecological groups) is shared by both areas. This difference could result from the colonisation history of each cave, but it is also probably complicated by the special "step by step" diffusion of deep-water species towards shallow submarine caves (Harmelin, 1986), especially due to the different physiographic setting in the two areas.

4. Shelf species

This group includes more or less euriecious species widely distributed in shelf environments.

Some serpulids, such as *Placostegus crystallinus* sensu Zibrowius and *Filograna* sp., as well as the spirorbids *Spirorbis cuneatus*, *S. marioni* and *Pileolaria militaris* have been placed in this group. Bryozoans are relatively numerous but only a few species, such as *Annectocyma major, Fenestrulina malusii* and *Plagioecia patina,* are relatively frequent and common.

Noteworthy, all these species are usually sporadic, often detected in a single cave and even in a single sample; several are represented only by dead fragments. This suggests that these euriecious species are occasional colonisers.

5. Shallow shelf species

These species are particularly tolerant to light and, consequently, able to colonise infralittoral to upper circalittoral habitats, often associated with plant communities.

Several serpuloideans and some bryozoans, but no brachiopods, may be included in this group. The serpulids *S. polytrema* and the spirorbid *Janua pagenstecheri* are typical taxa, as well as some relatively common bryozoans among which *Mollia patellaria, Pentapora ottomuelleriana, Reptadeonella violacea, Schizobrachiella sanguinea* and *Umbonula ovicellata*, that have been often recorded from seagrass (e.g., *Posidonia*) meadows (Gautier, 1962; Zabala, 1986).

These species appear clearly not congruent with the cave habitat. Indeed, only few of them are represented by living individuals or colonies and nearly all are restricted to cave entrances. This is the case for all the bryozoans collected alive in the PMPA caves (Rosso et al., 2012). The abundance of dead specimens and small, often worn, fragments scattered in the sediments clearly results from post mortem transport inside the caves. The incidence of this group is particularly heavy for the FI Cave due to its particular morphology, location and exposition (see above). This relatively shallow cave is subject to strong water motion, probably also responsible of the breakage of erect colonies living in the outermost sectors. Although relatively less important, the input of organogenic material from the outside is proved also for the PMPA caves, through "bioimmuration" moulds of algal thalli and *Posidonia* leaves/fibres produced on the underside of some skeletal fragments.

6. Unplaced species

Several bryozoans and two serpulids cannot be placed in any of the previous groups because they belong to: 1) species for which no particular distributional preference has been highlighted and/or that have been recorded only a few times; 2) species that have been not determined at specific level, as they show a certain difference from the nominal species; 3) species that are probably new to science.

CONCLUSIONS

Communities from all the investigated caves in both areas are characterised by a relevant amount of species typical of cave environments. These species are commonly represented by a large number of individuals or colonies (Fig. 4). They belong mostly to the group 2, which means particularly sciaphilous species generally associated to coralligenous communities, and subordinately to the groups 1 and 3, i.e., species restricted to, and/or indicative of caves, together with deep-water taxa with a second pole of distribution at shallow depths, where caves offer environmental conditions similar to those of the bathyal zone. Similarly, euriecious species widespread on the shelf but present also in cave habitats (group 4), are subordinate in both areas, although relatively numerous and represented by a fair number of specimens. The

Fig. 3 - a) Wall surface colonized by a lobate colony of the cyclostome bryozoan *Diplosolen obelia* (Johnston, 1838) (white long arrow), overgrowing a *Puellina species* (white short arrow), and partly the serpulid *Josephella marenzelleri* Caullery Mesnil, 1896 (black long arrow) (PMC.R.I.H.B-12a), also covered by the bryozoan *Setosella cavernicola* Harmelin, 1977 (black short arrow); b) a *J. marenzelleri* tube partly covered by a colony of the miniaturized bryozoan *S. cavernicola*, with only five autozooids and related vibraculoid avicularia, besides the centrally placed ancestrula (PMC.R.I.H.B-13a); c) fertile branch of the erect rigid bryozoan *Schizoretepora solanderia* (Risso, 1826) (PMC.R.I.H.B-14a); d) zooids and an interzooidal avicularium (arrow) of the encrusting bryozoan *Trematoecia ligulata* Ayari & Taylor, 2008 (PMC.R.I.H.B-15a); e) zooids of the encrusting bryozoan *Therenia rosei* Berning, Tilbrook & Rosso, 2008 (PMC.R.I.H.B-4b); f) zooids of the encrusting bryozoan *Onychocella vibraculifera* Neviani, 1895 (PMC.R.I.H.B-16a); g) distal part of *Spiraserpula massiliensis* (Zibrowius, 1968) tube with typically lobed peristomes (PMC.S.I.H.S-3a); h) tube of *Serpula cavernicola* Fassari & Mòllica, 1991 with the outer rough surface (PMC.S.I.H.S-4a); i) tube of the spirorbid *Vinearia koehleri* (Caullery & Mesnil, 1897) (PMC.S.I.H.S-5a); j-n) brachiopod external views (left) and internal surfaces of the dorsal valve (right): j) *Tethyrhynchia mediterranea* Logan & Zibrowius, 1994 (NPM.T.R-2); k) *Megathiris detruncata* (Gmelin, 1788) (NPM.T.R-3); l) *Argyrotheca cuneata* (Risso, 1826) (NPM.T.R-4); m) *Joania cordata* (Risso, 1826) (NPM.T.R-5); n) *Argyrotheca cistellula* (Searles-Wood, 1841) (NPM.T.R-6). a, b: samples from the wall of the Granchi Cave, at site 1; c, d, g-n: samples from the bottom sediment, at site "old" in the Gymnasium Cave; e: sample from the entrance of the Gymnasium Cave; f: sample from the sediment at site 2 in the Gymnasium Cave. Scale bars: a, c-g, n: 500 µm; b, h: 5 mm; i, l-m: 1 mm; j: 200 µm; k: 2 mm.

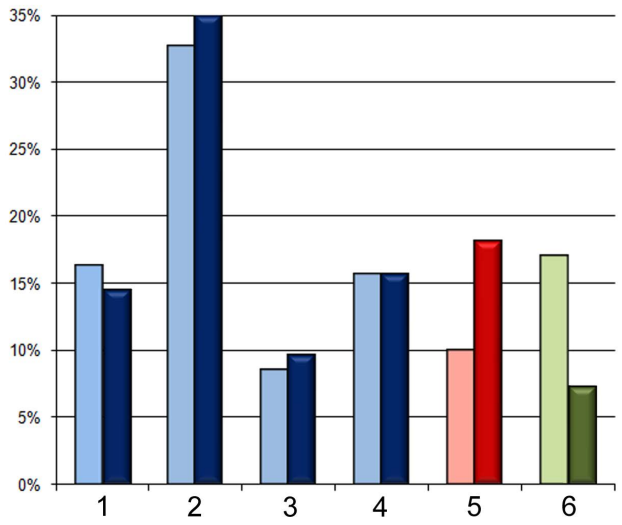


Fig. 4 - Histogram illustrating the contribution of the different groups of species categorised taking into account their ecological requirements in the two investigated areas. 1: Cave species; 2: Sciaphilic and/or "coralligenous" species; 3: Deep-water species; 4: Shelf species; 5: Shallow shelf species; 6: Unplaced species. For each group, light coloured bars on the left refer to caves from the Plemmirio Marine Protected Area and dark coloured bars on the right to the Ficarella Cave. See text for further information. Bleu coloured bars (1-4) are for groups congruent with the cave habitat; red coloured bars (5) represent the group not congruent with the cave habitat; green coloured bars (6) represent the group of unplaced species (see text).

presence of all these groups of species as colonisers inside the Ficarella Cave is documented by thanatocoenoses from bottom sediments. Their incidence, and particularly that of the group 2, is relevant, also in comparison with the caves of the Plemmirio Marine Protected Area. It can be argued that, although having a wide entrance located at shallow depth, the FI Cave hosts typical cave communities, including decidedly sciaphilous species, at least in its inner sectors and that specimens/colony fragments detached from hard surfaces accumulate in cave sediments, although possibly slightly redistributed.

In contrast, the different incidence of shallow shelf (group 5) species, usually present in photophilous habitats associated to infralittoral plant communities, can be used as a positive clue to document inputs from habitats located outside the caves. The present study records that species of the group 5 are represented by very rare living individuals or colonies restricted to the entrances, and by relatively rare-to-common dead ones in the PMPA caves. However, they are present with a relatively high number of species, and above all of individuals or colonies, and even fragments in thanatocoenoses of the FI Cave. Consequently, a heavy post mortem bioclastic input can be hypothesised for the FI Cave, consistent with its location and exposition to water energy. This hypothesis is further confirmed by taphonomic evidences of transport for some species. In contrast all the PMPA caves appear relatively more sheltered even though some of them show clear evidences of an external input.

This kind of analysis, grouping species following the categorisation here proposed, can be usefully employed for the interpretation of cave fossil communities.

ACKNOWLEDGMENTS

The following people are acknowledged: V. Incontro, Director of the Plemmirio MPA, for having made possible sampling activities; V. Di Martino, M. Catra and R. Leonardi for underwater sampling; A. Viola for SEM assistance. The paper has been financially supported by the CoNISMa Project "Study of the submarine cave environments - CODICE HABITAT 8330 - in the Marine Protected Areas of Pelagie, Plemmirio and Capo Caccia" and partly by grants of the Università di Catania to A. Rosso and R. Sanfilippo. Catania Paleoecological Research Group: contribution n. 379.

REFERENCES

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

Balduzzi A., Bianchi C.N., Boero F., Cattaneo Vietti R., Pansini M. & Sarà M. (1989). The suspension-feeder communities of a Mediterranean sea cave. *In* Ros J.D. (ed.), Topics in Marine Biology. *Scientia Marina*, 53: 387-395.

Balduzzi A. & Rosso A. (2003). Briozoi. *In* Cicogna F., Bianchi N.C., Ferrari G. & Forti P. (eds), Grotte marine: cinquant'anni di ricerca in Italia. Ministero dell'Ambiente e della Tutela del Territorio:195-202.

Belmonte G., Ingrosso G., Poto M., Quarta G., D'Elia M., Onorato R. & Calcagnile L. (2009). Biogenic stalactites in submarine caves at the Cape of Otranto (SE Italy): dating and hypothesis on their formation. *Marine Ecology*, 30: 376-382.

Berning B., Tilbrook K.J. & Rosso A. (2008). Revision of the north-eastern Atlantic and Mediterranean species of the genera *Herentia* and *Therenia* (Bryozoa: Cheilostomata). *Journal of Natural History*, 42: 1509-1547.

Bianchi C.N. & Morri C. (1994). Studio biologico comparativo di alcune grotte marine sommerse: definizione di una scala di confinamento. *Memorie Istituto Italiano di Speleologia,* ser. 2, 6*:* 107-123.

Bianchi C.N. & Sanfilippo R. (2003). Policheti Serpuloidei. *In* Cicogna F., Bianchi C.N., Ferrari G. & Forti P. (eds), Grotte marine: cinquant'anni di ricerca in Italia. Ministero dell'Ambiente e della Tutela del Territorio: 175-185.

Bussotti S., Terlizzi A., Fraschetti S., Belmonte G. & Boero F. (2006). Spatial and temporal variability of sessile benthos in shallow Mediterranean marine caves. *Marine Ecology Progress Series,* 325: 109-119.

Castelli A., Bianchi C.N., Cantone G., Çinar M.E., Gambi M.C., Giangrande A., Iraci Sareri D., Lanera P., Licciano M., Musco L., Sanfilippo R. & Simonini R. (2008). Annelida Polychaeta. *In* Relini G. (ed.), Checklist of the flora and fauna of the Italian Seas (part I). *Biologia Marina Mediterranea,* 15 (suppl.): 323-373.

Caullery M. & Mesnil F. (1896). Note sur deux serpuliens nouveaux (*Oriopsis metchnikowi* n.g., n.sp. et *Josephella marenzelleri* n.g., n.sp.). *Zoologischer Anzeiger*, 10: 482-486.

Caullery M. & Mesnil F. (1897). Etudes sur la morphologie comparee et la phylogenie des especes chez les Spirorbes. *Bulletin scientifique de la France et de la Belgique*, 30: 185-233.

Costa O.G. (1861). Microdoride Mediterranea, o descrizione de' poco ben conosciuti od affatto ignoti viventi minuti e microscopici del Mediterraneo. *Stamperia dell'Iride. Naples*, Part 1: 1-80.

Denitto F., Terlizzi A. & Belmonte G. (2007). Settlement and primary succession in a shallow submarine cave: spatial and temporal benthic assemblage distinctness. *Marine Ecology,* 28 (suppl. 1): 35-46.

Di Geronimo I., Allegri L., Improta S., La Perna R., Rosso A. & Sanfilippo R. (1997). Spatial and temporal aspects of benthic thanatocoenoses in a Mediterranean infralittoral cave. *Rivista Italiana di Paleontologia e Stratigrafia,* 103: 15-28.

Di Geronimo I., La Perna R., Rosso A. & Sanfilippo R. (1993). Popolamento e tanatocenosi bentonica della Grotta dell'Accademia (Ustica, Mar Tirreno meridionale). *Il Naturalista Siciliano*, s. 4, 17: 45-63.

Di Geronimo I., La Perna R., Rosso A., Sanfilippo R. & Taddei-Ruggiero E. (2000). Associazioni bentoniche da sedimenti di grotte carsiche in Sicilia. *Speleologia Iblea*, 8: 97-102.

Fassari G. & Mòllica E. (1991). Una nuova specie di Serpulidae (Annelida Polychaeta) di grotta. *Animalia*, 18: 261-267.

Gautier Y.V. (1962). Recherches ecologiques sur les Bryozoaires Chilostomes en Méditerranée occidentale. *Recueil des travaux de la Station marine d'Endoume*, 38: 1-435.

Gmelin J.F. (1788). Caroli a Linné systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio decima tertia, aucta, reformata. 500 pp. Leipzig.

Guido A., Heindel K., Birgel D., Rosso A., Mastandrea A., Sanfilippo R., Russo F., Peckmann J. (2013). Pendant bioconstructions cemented by microbial carbonate in submerged marine caves (Holocene, SE Sicily). *Palaeogeography, Palaeoclimatology, Palaeoecology,* 388: 166-180.

Harmelin J.-G. (1969). Bryozoaires des grottes sous-marines obscures de la région Marseillaise: faunistique et écologie. *Téthys,* 1: 793-806.

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

Harmelin J.-G. (1977). Bryozoaires du banc de la Conception (nord des Canaries). Campagne Cineca I du Jean Charcot. *Bulletin du Muséum national d'Histoire naturelle*, 3: 1057-1076.

Harmelin J.-G. (1980). Etablissement des communautés de substrats durs en milieu obscur. Résultats préliminaires d'une expérience à long terme en Méditerranée. *Memorie di Biologia Marina e Oceanografia*, 10 (suppl.): 29-52.

Harmelin J.-G. (1985). Bryozoan dominated assemblages in Mediterranean cryptic environments. *In* Nielsen C. & Larwood G.P. (eds), Bryozoan: Ordovician to Recent, Olsen & Olsen Fredensborg, Denmark: 135-143.

Harmelin J.-G. (1986). Patterns in the distribution of bryozoans in the Mediterranean marine caves. *Stygologia*, 2: 10-25.

Harmelin J.-G. (1997). Diversity of bryozoans in a Mediterranean sublittoral cave with bathyal-like conditions: role of dispersal processes and local factors. *Marine Ecology Progress Series*, 153: 139-152.

Harmelin J.-G. (2000). Ecology of cave and cavity dwelling bryozoans. *In* Herrera Cubilla A. & Jackson J.B.C. (eds), Proceedings of the 11th International Bryozoology Association Conference, Smithsonian Tropical Research Institute, Panama: 38-55.

Harmelin J.-G., Vacelet J. & Vasseur P. (1985). Les grottes sous-marines obscures: un milieu extrême et un remarquable biotope refuge. *Téthys*, 11: 214-229.

Johnston G. (1838). Miscellanea Zoologica Arcidae. *Magazine of Zoology and Botany, Edinburgh*, 2: 63-73.

Jullien J. (1882). Note sur une nouvelle division des Bryozoaires Cheilostomiens. *Bulletin de la Société Zoologique de France*, 6: 271-285.

Logan A. (1979). The Recent Brachiopoda of the Mediterranean Sea. *Bulletin de l'Institut océanographique, Monaco,* 72: 1-112.

Logan A. & Zibrowius H. (1994). A new genus and species of Rhynchonellid (Brachiopoda, Recent) from submarine caves in the Mediterranean Sea. *Marine Ecology,* 15: 77-88.

Martí R., Uriz M.J., Ballesteros E. & Turon X. (2004). Benthic assemblages in two Mediterranean caves: species diversity and coverage as a function of abiotic parameters and geographic distance. *Journal of the Marine Biological Association of the United Kingdom*, 84: 557-572.

Monteiro-Marques V. (1981). Peuplements des planchers envasés de trois grottes sous-marines obscures de la région de Marseille. Etude préliminaire. *Téthys,* 10: 89-96.

Neviani A. (1895). Briozoi fossili della Farnesina e di Monte Mario presso Roma. *Palaeontographia Italica*, 1: 77-140.

Pillai T.G. & Hove H.A. ten (1994). On recent species of *Spiraserpula* Regenhardt, 1961, a serpulid polychaete genus hitherto known only from Cretaceous and Tertiary fossils. *Bulletin of the British Museum (Natural History), Zoology, London*, 60: 39-104.

Pitruzzello P. & Russo G.F. (2008). Particolarità ambientali di due grotte sottomarine dell'area marina protetta del Plemmirio (Siracusa, Sicilia). *Biologi Italiani*, 11: 41-57.

Reverter-Gil O., Souto J. & Fernández-Pulpeiro E. (2012). New and little known species of Bryozoa from Iberian Atlantic waters. *Zoosystema,* 34: 157-170.

Risso A. (1826). Histoire naturelle des principales productions de l'Europe méridionale et principalement de celles des environs de Nice et des Alpes maritimes: tome cinquième. 402 pp. F-G. Levrault, Paris.

Rosso A. (2003). Bryozoan diversity in the Mediterranean Sea. *Biogeographia*, 24: 219-238.

Rosso A., Chimenz Gusso C. & Balduzzi A. (2010). Bryozoa. *In* Relini G. (ed.), Checklist of the flora and fauna of the Italian Seas (part II). *Biologia Marina Mediterranea*, 17 (suppl.): 589-615.

Rosso A., Di Martino E., Sanfilippo R. & Di Martino V. (2012). Bryozoan Communities and Thanatocoenoses from submarine caves in the Plemmirio Marine Protected Area (SE Sicily). *In* Ernst A., Schäfer P. & Scholz J. (eds), Bryozoan Studies 2010, Proceedings of the 15th IBA Conference, Kiel, Germany. *Lecture Notes in Earth System Sciences*, Springer, Berlin, Heidelberg, 143: 251-269.

Sanfilippo R. (2009). Systematics and life habit in *Serpula israelitica* Amoureux, 1976 (Polychaeta Serpulidae) from the Mediterranean with remarks on other soft-bottom serpulids. *Journal of Natural History*, 43: 2009-2025.

Sanfilippo R. & Mòllica E. (2000). *Serpula cavernicola* Fassari & Mòllica, 1991 (Annelida Polychaeta): diagnostic features of the tubes and new Mediterranean records. *Marine Life*, 10: 27-32.

Searles-Wood (1841). Catalogue of Shells from the Crag. *The Annals and Magazine of Natural History*, 6: 243-253.

Taddei Ruggiero E. (1994). Brachiopods from bio- and thanatocoenoses of the Isca submarine cave (Sorrento Peninsula). *In* Matteucci R., Carboni M.G. & Pignatti J.S. (eds), Studies on Ecology and Palaeoecology of Benthic Communities. *Bollettino della Società Paleontologica Italiana*, spec. vol. 2: 313-323.

Taddei Ruggiero E. (1996). Notes on living brachiopod ecology in a submarine cave off the Campania coast, Italy. *In* Copper P. & Jisuo J. (eds), Brachiopods. Proceedings of the III International Brachiopod Congress, Balkema, Rotterdam: 227-231.

Taddei Ruggiero E. (2001). Brachiopods of the Isca submarine cave: observations during ten years. *In* Brunton C.H., Cocks L.R.M. & Long S.L. (eds), Brachiopods Past and Present, Taylor & Francis, London, 27: 261-267.

Taddei Ruggiero E. (2003). Brachiopodi. *In* Cicogna F., Bianchi N.C., Ferrari G. & Forti P. (eds), Grotte marine: cinquant'anni di ricerca in Italia. Ministero dell'Ambiente e della Tutela del Territorio: 203-209.

Taddei Ruggiero E., Annunziata G., Rosso A. & Sanfilippo R. (1996). Il benthos della Grotta sottomarina dell'Isca (Penisola Sorrentina): evidenze faunistiche della sua evoluzione recente. *VII Congresso Nazionale della Società Italiana di Ecologia*, 17: 329-332.

Vacelet J., Boury-Esnault N. & Harmelin J.-G. (1994). Hexactinellid cave, a unique deep-sea habitat in the scuba zone. *Deep-Sea Research I*, 41: 965-973.

Zabala M. (1986). Fauna dels bryozous dels Països Catalans. Institut Estudis Catalans, Secció de Ciènces, Barcelona, 84: 1-833.

Zabala M. & Gili J.M. (1985). Distribution des Bryozoaires le long d'un gradient sédimentaire dans deux grottes sous-marines du

littoral de Majorque. *Rapports Commission Internationale mer Méditerranéenne,* 29: 137-140.

Zabala M., Rieira T., Gili J.M., Barange M., Lobo A. & Peñuelas J. (1989). Water Flow, Trophic Depletion, and Benthic Macrofauna Impoverishment in a Submarine Cave from the Western Mediterranean. PSZNI *Marine Ecology*, 10: 271-287.

Zibrowius H. (1968). Etude morphologique, systématique et écologique des Serpulidae (Annelida Polychaeta) de la région de Marseille. *Recueil des travaux de la Station marine d'Endoume*, 43: 81-252.

Zibrowius H. (1971). Remarques sur la faune sessile des grottes sous-marines et de l'étage bathyal en Méditerranée. *Rapports Commission Internationale mer Méditerranéenne*, 20: 243-245.

Manuscript received 9 January 2013
Revised manuscript accepted 14 August 2013
Published online 30 October 2013