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SUBMARINE CAVES OF THE SALENTO PENSINSULA: FAUNAL ASPECTS

SUMMARY

A review has been realized to contribute at the biodiversity assessment of the E.U. habitat "marine submerged caves" in the Salento Peninsula (SE Italy). Information came from the researches explicitly carried out in Salento submarine caves. The number of species recognized (639) is interestingly high notwithstanding the exclusion of plant species (present only at the entrance and not in the dark of the caves) and the limited space available (if compared with neighboring open sea areas). The list includes 385 *taxa* not present in the extended study of Riedel (1966) on 277 Mediterranean submarine caves.

A comparison has also been carried out with the adjacent habitat of the coralligenous assemblage. The high numerical contribution to the species richness of a geographic area is due for sure to the strategy adopted to evaluate species composition of not usual (for caves) assemblages as the plankton or the meiobenthos of rocky walls, but also the inclusion of studies on rarely investigated *taxa* (as Gastrotricha and Facetotecta). The particularity of the environment, or the geographic position of the Salento peninsula, are probably responsible of the presence of uncommon species (55 new for Italian marine fauna, with 18 new for Science).

INTRODUCTION

Submarine caves are a habitat of EU importance (Habitat Directive of the E.U., code 8330, "Submerged or partially submerged sea caves"). This particular coastal habitat is relatively abundant along the Salento Peninsula coastline, with 97 submarine caves censed (Denitto and Belmonte, 2008; Belmonte *et al*., 2011; Guidetti *et al*., 2012), and at least other 10 waiting to be registered (Onorato R., personal communication).

The importance of Salento submarine caves started with the extensive and

eminent study of Riedel (1966) on a Mediterranean scale. From that survey, which comprised 22 submarine caves (completely or partially submerged) in the Salento area, 50 years passed with additional researches carried out by University of Lecce-Salento, Univ. of Modena-Reggio, Univ. of Sassari, and Univ. of Urbino among the others. The work of Riedel (1966) was based on data coming from a total of 277 submarine caves in the Mediterranean Sea (181 in Italy), mostly explored in the frame of the project *Osterreichischen Tyrrhenia Expedition 1952*. The detailed study (committed to many specialists) of the material collected allowed Riedel to list a total of 779 animal species (8 Protista) with 60 of them as new for Science (mostly Porifera, 30 species, and Turbellaria, 15 species). In that study it was described for the first time the cave sponge *Petrobiona incrustans* from a Salento cave.

Pietro Parenzan (1902-1992) was the second eminent naturalist who paid attention to Salento submarine caves. In his extended publication *Puglia Marittima* (Parenzan, 1983) he reported data from a total of 44 submarine caves along the Salento coastline. But he considered the submarine caves as part of the more general karstic phenomenon thus disregarding the specificity of the submerged environment HD 8330. The number of submarine caves in Salento was updated firstly to 53 by Onorato *et al*. (1999) and successively to 77 by Denitto and Belmonte (2008) in the following 25 years. Today the Apulian Regional Register of Karstic morphologies reports 97 censed submarine caves highlighting how their number is still far from to be a final one, thus testifying how much it was still incomplete the knowledge of such a phenomenon, even in a relatively small geographic area as the Salento Peninsula.

As regarding the species list available in literature (those of Riedel and Parenzan, overall), they are not specific of local geographic areas, or of the specific habitat respectively, and consequently we have not any past reference on the precise number of species existing in the Salento submarine caves.

The Salento peninsula occupies a central position in the Mediterranean Sea, and it is known to be a naturalistic bridge with the Balkans showing flora and fauna actually interested by oriental influences more than from the Italian (peninsula) one. For these reasons, the assemblage of animal species is expected to be interesting at least at local (Italian) geographic scale.

MATERIAL AND METHODS

The present work wants to be a contribution in establishing the number of species hosted by Salento submarine caves. The work has been funded on the numerous studies carried out by many scientists in the last years (18 degree thesis of Universities of Lecce-Salento, University of Modena-Reggio, Uni-

versity of Urbino, University of Gent; 3 PhD thesis of University of Salento, University of Siena; and 42 publications on all kinds of scientific journals).

In detail, the cited studies (covering a period of 20 years from 1997 to 2017) interested a total of 80 Km (not contiguous) of Salento rocky coast, in a bathymetric interval of 25 m from the sea surface, which required about 250 visits executed by 34 different divers, always accompanied by professional scuba spelaeo-divers.

Species have been obtained both by lists and simply citations in each publication. In only one case, we used the list (Mollusca) produced by the scuba divers team of P. Mariottini who gave us the permission to publish that for the first time. Lists of species from Riedel (1966) have been used as a comparison to show novelties, and absences, of species from the Salento submarine caves. The species have been listed without the name of the describer because in most of the articles checked this was absent. This means that the species identification is not undoubtedly acceptable but, as regarding the *taxa* new for the geographic area (Italy) or the Science, the identification is reported for sure, even if without the describer name aside the species name.

To obtain a datum to be compared with other submarine coastal habitats of the same geographic area, the number of species has been referred to the substratum area (m^2) corresponding to the walls and the floor of all the caves, being them measured and mapped for census purposes. Each cave has been considered as a triangular pyramid with a face corresponding to the floor and the two remaining faces corresponding to the lateral walls. The pyramid has been assumed to be isosceles, with the basis (where the

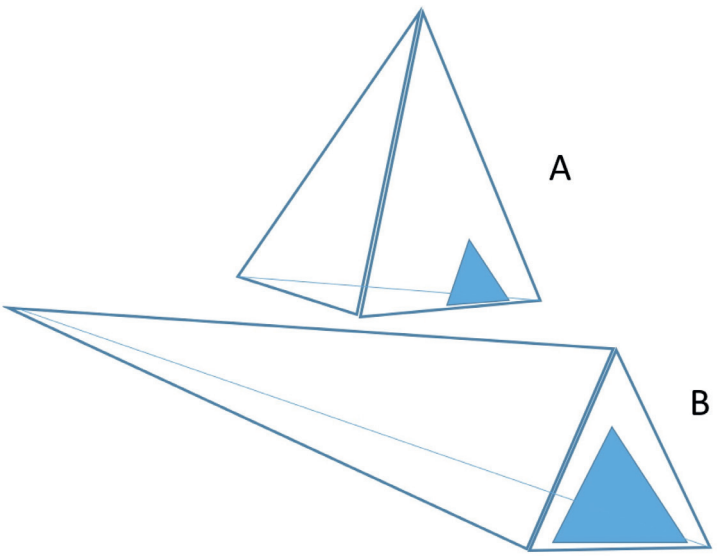

Fig. 1.

entrance of the cave is positioned) and the pyramid height deriving from the true linear measures taken from each cave (see Fig. 1). This approximation of the internal surface of each cave is not far from the reality, otherwise impossible to be reported.

RESULTS AND DISCUSSION

A total of 639 animal *taxa* (mostly species) are listed in the Tab. 1, belonging to 23 high level *taxa* (Phyla or SubPhyla). The number derives by data coming from the whole asset of Salento submarine caves (107 in total), but each single cave has only a portion of this number (maximum 361, in the Ciolo cave) surely due to the abundance of studies and specialists involved there.

The *taxa* most represented (in terms of species) were Crustacea (168 *taxa*), Porifera (87 *taxa*), Mollusca (78 *taxa*), Cnidaria (66 *taxa*), Chordata (65 *taxa* among invertebrates and vertebrates), Annelida (47 *taxa*), Bryozoa (37 *taxa*), Protista (30 *taxa*), Gastrotricha (29 *taxa*), which altogether contains the 95% of the species listed. The Crustacea datum is undoubtedly affected by the analysis of plankton and meiobenthos (both rich of Copepoda). If we exclude this component, we can note how the Salento submarine caves well fit with the definition of "sponge world" which already derived by the Riedel study on the whole assemblage of Mediterranean caves.

If the present list is compared with that of Riedel (1966), it appears that only 254 *taxa* are in common and, consequently, 385 *taxa* can be added to the Riedel's Mediterranean list. This is not only a problem of biogeography but it is also due to the different *taxa* studied in the two timely distant approaches. Gastrotricha and Facetotecta (Todaro *et al*., 2006; Belmonte, 2005) were completely ignored in the Riedel study, together with the *taxa* typical of plankton (Moscatello and Belmonte, 2007) or meiobenthos of rocky walls (Russo *et al*., 2015) which have been studied in the Salento submarine caves for the first time. On the contrary, the whole *phylum* Platyhelminthes has been considered in detail by Riedel (with a totral of 15 species new for Science) and ignored in studies on Salento caves.

The particularity of the habitat, and also the geographic position of the Salento Peninsula, are probably responsible of the faunal novelties found. 55 species were reported from Salento submarine caves for the first time in Italy, with 18 of them new for Science. These numbers are not obvious, even for unexplored *habitats*. In a recent report on Apulian deep sea *habitats* (BIOMAP, 2014) whose naturalistic value has been proposed as deserving protection, only 4 species were new for Italian fauna, and no one of them was new for Science (Tab. 2).

Tab. 1. Species of the submarine caves among the Ionian coast of the Salento Peninsula. Co = Grotta delle Corvine, L = Grotta de *Lu Lampiùne*, Ci = Grotta piccola del Ciolo, P = Galleria della Principessa (Grotta di Porrano), M = Grotta Marinella, O = Others. * Species new for Italian fauna, ** Species new for Science.

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	A
1	PROTISTA	Flagellata	*Noctiluca scintillans*			x			
2		Foraminifera	Cassidulinacea indet.			x			
3			Globigerinacea indet.			x			
4			Miliolina indet.			x			
5			*Miniacina miniacea*	x			x		
6			Rotaliacea indet.			x			
7			Rotaliina indet.			x			
8			Spirillinidae			x			
9			Textulariina indet.			x			
10		Radiolaria	Astrosphaeridae indet.			x			
11			Spumellaridae indet.			x			
12		Ciliophora	*Acanthostomella conicoides* *			x			
13			*Condonella aspera* *			x			
14			*Codonellopsis monacensis* *			x			
15			*Codonellopsis schabii* *			x			
16			*Eutintinnus fraknoi* *			x			
17			*Eutintinnus tubulosus* *			x			
18			*Petalotricha ampulla*			x			
19			*Rhabdonella spiralis*			x			
20			*Salpingella acuminata* *			x			
21			*Stenosemella ventricosa*			x			
22			*Tiarina fusus*			x			
23			*Tintinnopsis beroidea*			x			
24			*Tintinnopsis campanula*			x			
25			*Tintinnopsis cincta* *			x			
26			*Tintinnopsis lieni* *			x			
27			*Tintinnopsis radix*			x			
28			*Undella cleparedei* *			x			
29			*Undella clevei*			x			
30			*Undella subcaudata* *			x			
31	PORIFERA		*Aaptos aaptos*	x			x		x

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
32			*Acanthella acuta*	x	x				x
33			*Agelas oroides*	x	x	x	x	x	x
34			*Alectona millari*	x		x			
35			*Aplysina* sp.						x
36			*Aplysina sulfurea*						x
37			*Axinella cannabina*						x
38			*Axinella damicornis*	x					x
39			*Axinella verrucosa*	x					
40			*Axinella* sp.		x		x		x
41			*Bubaris vermiculata*				x		
42			*Cacospongia* sp.				x		
43			*Calyx nicaensis*						x
44			*Chondrilla nucula*						x
45			*Chondrosia reniformis*				x		x
46			*Clathria toxivaria*			x	x		x
47			*Clathrina clathrus*	x		x	x		x
48			*Clathrina coriacea*						x
49			*Clathrina* sp.				x		
50			*Cliona celata*				x		x
51			*Cliona nigricans*	x			x		
52			*Cliona rhodensis*	x			x		
53			*Cliona schmidtii*	x			x	x	
54			*Cliona* sp.1		x				x
55			*Cliona* sp.2						x
56			*Cliona* sp.3				x		
57			*Cliona viridis*	x					
58			*Corticium candelabrum*	x					x
59			*Crambe crambe*	x			x		x
60			*Delectona madreporica*	x					
61			*Dendroxea lenis*	x		x	x	x	x
62			*Dercitus plicatus*	x					
63			*Dictyonella incisa*	x					
64			*Didiscus styliferus*	x			x		
65			*Diplastrella bistellata*	x					
66			*Diplastrella ornata*	x					
67			*Diplastella* sp.				x		x
68			*Dysidea avara*	x					
69			*Dysidea fragilis*						x
70			*Dysidea incrustans*	x					
71			*Dysidea* sp.	x			x		
72			*Erylus discophorus*	x					

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
73			*Erylus euastrum*				x	x	
74			*Fasciospongia cavernosa*	x					
75			*Geodia conchilega*	x					
76			*Haliclona mucosae*						x
77			*Hemimycale columella*						x
78			*Ircinia* sp.	x					x
79			*Ircinia variabilis*	x			x	x	
80			*Jaspis johnstonii*	x			x		
81			*Leucosolenia* sp.						x
82			*Merlia normani*	x		x	x	x	x
83			*Mycale massa*						x
84			*Myrmekioderma spelaea*	x			x		x
85			*Oscarella lobularis*				x		
86			*Oscarella* sp.1			x	x	x	x
87			*Oscarella* sp.2			x	x	x	
88			*Oscarella* sp.3			x	x	x	
89			*Paraplysilla spinifera*	x					
90			*Penares helleri*	x	x		x		
91			*Petrobiona incrustans* **						x
92			*Petrosia ficiformis*	x	x	x	x	x	x
93			*Phorbas fictitius*	x		x	x		x
94			*Phorbas tenacior*				x	x	
95			*Placospongia decorticans*	x			x		
96			*Placospongia* sp.						x
97			*Plakina bowerbanki*	x					
98			*Plakina dilopha*	x					
99			*Plakina reductum*	x					
100			*Plakina trilopha*	x					
101			*Plakortis simplex*	x					
102			*Pleraplysilla minchini*	x					
103			Porifera indet. sp.1						x
104			Porifera indet. sp.2			x	x	x	
105			Porifera indet. sp.3			x	x	x	
106			Porifera indet. sp.4			x	x	x	
107			*Reniera sarai*	x					
108			*Reniera* sp.	x		x	x		x
109			*Samus anonima*	x					
110			*Sarcotragus foetibus*				x		x
111			*Sarcotragus spinosulus*	x	x		x		x
112			*Spirastrella cunctatrix*	x	x	x	x		x
113			Spirastellidae indet.			x	x	x	

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
114			*Spongia* sp.				x		x
115			*Sycon* sp.	x		x			
116			*Terpios fugax*	x		x	x	x	x
117			*Thoosa mollis*	x					
118	CNIDARIA	Hydrozoa	*Aglantha digitale*			x			
119			*Aglaophenia octodonta*	x		x			x
120			*Aglaophenia* sp.						x
121			*Aglaophenia tubiformis*	x					
122			*Amphinema dinema*						x
123			*Amphimena rugosum*			x			
124			*Amphinema* sp.						x
125			*Anthohebella parasitica*	x					
126			*Antennella secundaria*						x
127			*Bouganvillia messapica* **	x					
128			*Campalecium medusiferum*			x			
129			*Campanularia haevertae* p.			x			x
130			*Campanularia hinksi*			x			
131			*Cladonema radiatum*			x			
132			*Clytia gracilis*	x		x			
133			*Clytia hemisphaerica*	x					x
134			*Clytia linearis*	x		x			
135			*Clytia paulensis*			x			
136			*Clytia viridicans*			x			
137			Corymorfidae indet.			x			
138			*Dipurena ophiogaster*			x			
139			*Dynamena disticha*						x
140			*Ectopleura larynx*			x			
141			*Eudendrium ramosum*	x					x
142			*Eudendrium* sp.						x
143			*Filellum serpens*						x
144			*Garveia grisea*						x
145			*Halecium conicum*			x			
146			*Halecium nanum* p.			x			x
147			*Halecium pusillum*			x			
148			*Halecium* sp.			x			x
149			*Halopteris* sp.						x
150			*Hydractinia (Perarella) sp.*						x
151			*Hydractinia fucicola*						x
152			*Hydranthea margarica*						x
153			*Hydrodendron mirabile*			x			
154			Hydrozoa indet. 1			x			

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
155			Hydrozoa indet. 2			x			
156			*Laodicea* sp.			x			x
157			*Lovenella cirrata*						x
158			*Monotheca obliqua* p.			x			x
159			*Obelia dichotoma*						
160			*Orthopyxis crenata*	x					x
161			*Orthopyxis* sp.			x			
162			*Plumularia setacea*						x
163			*Podocoryne* sp.			x			
164			*Rhizorhagium arenosum*			x			
165			*Scandia gigas*			x			
166			*Sertularella* sp.						x
167			Siphonophora indet.			x			x
168			*Ventromma halecioides*			x			
169			*Zanclea* sp.	x					
170		Anthozoa	Anthozoa indet.			x	x	x	
171			*Arachnanthus oligopodus* *	x		x	x	x	
172			*Astroides calycularis*	x					
173			*Calliactis parasitica*						x
174			*Caryophyllia smithii*		x		x		x
175			*Cereus pedunculatus*			x	x	x	
176			*Cerianthus membranaceus*						x
177			*Cladocora caespitosa*						x
178			Clavulariidae indet.			x			
179			*Leptopsammia pruvoti*	x					x
180			*Madracis pharensis*						x
181			Madreporaria indet.		x	x			x
182			*Parazoanthus axinellae*				x		x
183			*Polycyathus muellere*		x	x	x	x	x
184	PLATYHELMINTHES	PROSERIATA	*Archilina* sspp **	x					
185			*Parotoplana jondelii* **				x		
186	NEMATODA		Desmoscolecidae indet.			x			
187			Epsilonematidae indet.			x			
188			Nematoda indet.			x			
189	NEMERTEA		Nemertea pilidium	x					
190			*Lineus longissimus*	x					
191	ROTIFERA		Rotifera indet.			x			
192	KINORHYNCHA		Kinorhynca indet.			x			
193	PRIAPULIDA		Priapulidae indet.			x			
194			*Tubiluchus troglodytes* *			x			
195	GASTROTRICHA		*Cephalodasys turbanelloides*			x	x		

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
196			*Chaetonotus apolemmus*				x		
197			*Chaetonotus atrox*				x		
198			*Chaetonotus siciliensis*				x		
199			*Chaetonotus* sp.1**			x	x		
200			*Chaetonotus* sp.2**			x	x		
201			Chaetonotus sp.3				x		
202			*Dendrodasys gracilis*				x		
203			*Diplodasys ankeli*				x		
204			*Diplodasys minor*				x		
205			*Draculiciteria tesselata*			x	x		
206			*Halichaetonotus spinosus*				x		
207			*Heteroxenotrichula pygmaea*				x		
208			*Lepidodasys martini*			x	x		
209			*Macrodasys caudatus*			x	x		
210			*Megadasys minor*			x	x		
211			*Mesodasys adenotubulatus*			x	x		
212			*Mesodasys laticaudatus*			x	x		
213			*Musellifer delamarei*				x		
214			*Paradasys* sp.1**			x	x		
215			*Platydasys* sp.2**			x	x		
216			*Pseudostomella cataphracta*			x	x		
217			*Thaumastoderma mediterraneum*				x		
218			*Tetranchyroderma* sp.**			x	x		
219			*Turbanella* sp.**			x	x		
220			*Urodasys acanthostilis*			x	x		
221			*Xenodasys ecnomios***				x		
222			*Xenotrichula intermedia*			x	x		
223			*Xenotrichula* sp.				x		
224	ANNELIDA	Archiannelida	Archiannelida indet.				x		
225		Polychaeta	Alciopidae indet.		x	x			
226			*Autolitus* sp.	x		x			
227			Chaetopteridae indet.			x			
228			*Chrysopetalum debile*			x			
229			Dorvilleidae indet.			x			
230			Eunicidae indet.			x			
231			*Filograna implexa*			x			x
232			Hesionidae indet.			x			
233			*Hermodice carunculata*						x
234			*Hydroides pseudouncinatus*			x			
235			*Hydroides niger*			x			
236			*Hydroides* sp.			x			

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
237			*Janua pagenstecheri*			x			
238			*Janua* sp.			x			
239			*Megalomma vesiculosum*						x
240			*Mixycola infundibulum*						x
241			*Neodexiospira pseudocorrugata*		x	x			
242			Nereididae indet.			x			
243			Opheliidae indet.			x			
244			Orbinidae indet.			x			
245			Phyllodocidae indet.			x			
246			*Pileolaria heteropoma*			x			
247			Polychaeta indet.	x		x			
248			Polynoidae indet.			x			
249			*Pomatoceros triqueter*			x			
250			*Protolaeospira striata*			x			
251			*Protula* sp. **		x	x			x
252			*Protula tubularia*	x					x
253			*Sabella pavonina*						x
254			*Sabella spallanzanii*			x			x
255			*Sabellaria spinulosa*			x			
256			*Salmacina* sp.			x			
257			*Semivermilia cribrata*			x			
258			*Serpula concharum*			x			
259			*Spio filicornis*			x			
260			Spionidae indet.	x		x			
261			*Spirorbis cuneatus*			x			
262			*Spirorbis infundibulum*			x			
263			*Spirorbis* sp.			x			
264			Syllidae indet.			x			
265			Terebellidae indet.						x
266			*Tripanosyllis zebra*			x			
267			*Vermiliopisis* sp.			x			
268			*Vermiliopisis striaticeps*			x			
269			*Vinearia koehleri*			x			
270		Oligochaeta	Oligochaeta indet.			x			
271	SIPUNCULA		*Sipuncula pelagosphaera*			x			
272	ECHIURIDA		*Bonellia viridis*	x					
273	MOLLUSCA	Polyplacophora	indet.			x			x
274			*Acanthochitona crinita*						x
275			*Acanthochitona fascicularis*						x
276			*Ischnochiton rissoi*						x
277			*Callochiton septemvalvis euplaeae*						x

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
278			*Chiton olivaceus*						x
279		Gastropoda	*Aplysia depilans*						x
280			*Aplysia punctata*						x
281			*Bittium lacteum*						x
282			*Bolma rugosa*						x
283			*Calliostoma conulus*						x
284			*Calliostoma laugeri*						x
285			*Clanculus corallinus*						x
286			*Clanculus cruciatus*						x
287			*Clanculus jussieui*						x
288			*Columbella rustica*						x
289			*Cratena peregrina*						x
290			*Conus mediterraneus*						x
291			*Cymathium parthenopeum*						x
292			*Diodora graeca*						x
293			*Emarginula adriatica*						x
294			*Emarginella huzardii*						x
295			*Erosaria spurca*						x
296			*Fasciolaria lignaria*						x
297			*Felimida krohni*						x
298			*Felimare picta*						x
299			*Flabellina affinis*						x
300			*Flabellina babai*						x
301			*Flabellina ischitana*						x
302			*Flabellina pedata*						x
303			Fissurellidae indet.			x			x
304			*Fusinus syracusanus*						x
305			Gastropoda *veliger*	x		x			
306			*Gibbula umbilicaris*						x
307			*Haliotis tuberculata*						x
308			*Hexaplex trunculus*						x
309			*Lepidopleurus cajetanus*						x
310			*Luria lurida*						x
311			*Mitra ebenus*						x
312			*Mitrella scripta*						x
313			*Muricopsis inermis*						x
314			*Nassarius incrassatus*						x
315			*Neodexiospira pseudocorrugata*						x
316			*Ocinebrina aciculata*						x
317			*Patella pellucida*						x
318			*Peltodoris atromaculata*			x			

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
319			*Pisania striata*						x
320			*Pollia d'orbignyi*						x
321			*Pollia scabra*						x
322			*Serpulorbis arenaria*						x
323			Thecosomata indet.			x			x
324			*Trivia pulex*						x
325			*Umbraculum umbraculum*						x
326			*Vermetus* sp.						x
327			*Vexillum savignyi*						x
328			*Vexillum tricolor*						x
329		Bivalvia	*Anomia ephippium*			x			
330			*Arca noeae*		x				x
331			Bivalvia *veliger*	x		x			x
332			*Barbatia barbata*						x
333			*Cardita calyculata*						x
334			*Chama gryphoides*				x		x
335			*Chlamys multistriata*						x
336			*Gastrochaena dubia*						x
337			*Lima lima*				x		x
338			*Limaria tuberculata*						x
339			*Lithophaga lithophaga*		x		x	x	x
340			*Manupecten pesfelis*						x
341			*Mimachlamys varia*						x
342			*Octopus vulgaris*						x
343			*Pinna nobilis*						x
344			*Pygnodonta cochlear*		x		x		
345			*Rocellaria dubia*			x			
346			*Sepia officinalis*						x
347			*Serpulorbis arenaria*			x			x
348			*Spondylus gaederopus*			x	x		
349			*Striarca lactea*						x
350			*Umbraculum mediterraneum*						x
351	CAMPTOZOA		*Barentsia* sp.			x			
352			*Loxosomella* sp.			x			
353	BRYOZOA		*Adeonella calveti*						x
354			*Aetea* sp.			x			
355			*Annectocyma* sp.			x			
356			Bryozoa cyphonautes indet.			x			
357			*Bryozoa* sp.1			x			
358			*Bryozoa* sp.2			x			
359			*Bryozoa* sp.3			x			

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
360			*Bowerbankia* sp.			x	x	x	
361			Celleporide indet.			x	x		
362			Cheilostomata indet.			x			
363			*Chorizopora brongnarti*			x			
364			*Crisia* sp.			x			
365			Ctenosomata indet.			x	x	x	
366			*Diastopora patina*			x			
367			*Disporella* sp.			x			
368			*Escharoides* sp.			x			
369			*Fenestrulina malusii*			x			
370			*Frondipora* sp.			x	x	x	
371			*Hippaliosina depressa*				x	x	
372			*Hornera frondiculata*						x
373			*Lichenopora radiata*				x		
374			*Margaretta cereoides*				x		
375			*Micropora coriacea*			x			
376			*Microporella ciliata*			x			
377			*Myriapora truncata*	x		x	x		x
378			*Patinella* sp.			x			
379			*Pentapora* sp.			x	x	x	
380			*Porella cervicornis*						x
381			*Puellina* sp.			x			
382			*Schizobrachiella sanguinea*			x			
383			*Schizoporella unicornis*			x			
384			Scrupocellaridae indet.			x	x	x	
385			*Sertella septentrionalis*	x		x	x	x	
386			*Smittina cervicornis*						x
387			*Smittinidae* indet.			x			
388			*Tubulipora* sp.			x			
389			*Watersipora cucullata*				x		
390	CHORDATA	Tunicata	*Aplidium conicum*				x		x
391			*Aplidium tabarquensis*						x
392			*Aplidium* sp.						x
393			Ascidiacea (solitario) indet.	x		x			
394			Ascidiacea larvae			x			
395			*Cystodytes dellechiajei*						x
396			*Didemnum lahillei*				x		
397			*Didemnum* sp.						x
398			*Diplosoma listerianum*				x		
399			*Fritillaria* sp.			x			
400			*Holacynthia papillosa*	x					x

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
401			*Oikopleura dioica*			x			
402			*Pyura dura*	x			x		x
403			Thaliacea Doliolinae			x			
404			Thaliacea Salpidae			x			
405	CHORDATA VERTEBRATA	Condrichthyes	*Torpedo* sp.			x			
406		Osteichthyes	*Apogon imberbis*	x		x	x	x	x
407			Aterinidae indet.			x	x		
408			*Boops boops*					x	x
409			*Bothus podas podas*						x
410			*Chromis chromis*			x	x	x	x
411			*Conger conger*			x	x	x	
412			*Corcyrogobius liechtensteini* *	x		x	x	x	
413			*Coris julis*			x	x	x	x
414			*Dicentrarchus labrax*	x					
415			*Diplodus puntazzo*			x			
416			*Diplodus sargus*			x			
417			*Diplodus vulgaris*			x	x	x	x
418			*Enchelicora anatina* *						x
419			*Epinephelus marginatus*			x	x	x	x
420			*Gobius buchicchi*						x
421			*Gobius geniporus*						x
422			*Grammonus ater*			x			
423			*Labrus merula*						x
424			*Lipophrys nigriceps*			x	x	x	x
425			*Lithognathus mormyrus*						x
426			Mugilidae indet.					x	
427			*Mullus surmuletus*	x		x			x
428			*Muraena helena*			x		x	
429			*Oblada melanura*				x		
430			Osteichthyes larvae			x			x
431			*Parablennius gattorugine*				x		
432			*Parablennius rouxi*						x
433			*Phycis phycis*			x	x	x	
434			*Sarpa salpa*						x
435			*Sciaena (Johnius) umbra*	x					x
436			*Scorpaena maderensis*				x		x
437			*Scorpaena notata*			x	x	x	
438			*Scorpaena porcus*			x	x	x	x
439			*Scorpaena scrofa*				x		x
440			*Serranus cabrilla*			x	x	x	x
441			*Serranus scriba*	x		x	x	x	x

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
442			*Solea* sp.						x
443			*Sphyraena notata*			x			
444			*Sphyraena* sp.			x			x
445			*Symphodus doderleini*						x
446			*Symphodus mediterraneus*				x	x	x
447			*Symphodus tinca*				x	x	
448			*Thalassoma pavo*			x	x	x	
449			*Thorogobius ephippiatus*	x		x		x	x
450			*Trachinus draco*						x
451			*Trypterigion tripteronotus*						x
452		MAMMALIA	*Monachus albiventer*			x			
453	CRUSTACEA	Cirripedia	nauplii Balanomorpha indet.			x			
454			Balanidae indet.			x	x	x	
455			Cirripedia cypris indet.			x			
456			nauplii Lepadomorpha indet.			x			
457		Copepoda	*Acartia adriatica*	x					
458			*Acartia clausi*	x		x			
459			*Acartia discaudata*			x			
460			*Acartia negligens*			x			
461			*Alteuthella* sp. *			x			
462			*Ambunguipes rufocincta* *			x			
463			*Ameira listensis* *				x		
464			*Ameira parvula*				x		
465			Ameiridae sp.			x			
466			*Amonardia phyllopus*			x			
467			*Arenosetella* sp.				x		
468			*Bentomysophria* sp.*	x					
469			*Bradya* sp. *	x					
470			Calanidae indet.			x			
471			*Calanus tenuicornis*			x			
472			*Calocalanus contractus*	x					
473			*Calocalanus pavo*	x					
474			*Candacia* sp.	x					
475			Canuellidae indet.			x			
476			Centropagidae indet.			x			
477			*Clausocalanus arcuicornis*	x		x			
478			*Clausocalanus furcatus*	x		x			
479			Cletopsyllidae indet. *			x			
480			*Clytemnestra* sp.			x			
481			*Corycaeus clausi*			x			
482			*Corycaeus latus*			x			

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
483			*Corycaeus* sp.1	x					
484			*Corycaeus* sp.2	x					
485			*Corycaeus* sp.3			x			
486			Cyclopoida indet. sp.1	x		x			
487			Cyclopoida indet. sp.2			x			
488			Cyclopinidae indet.			x			
489			*Cymbasoma malaquini*			x			
490			*Cymbasoma rigidum*			x			
491			Dactylopusiidae indet.			x	x		
492			*Diarthrodella* sp.*			x			
493			*Diarthrodes* sp.			x	x		
494			*Ectinosoma* sp.1			x	x		
495			*Ectinosoma* sp.2				x		
496			*Eucalanus* sp.	x		x			
497			*Euryte longicauda*			x			
498			*Euterpina acutifrons*	x		x			
499			*Halectinosoma sp.*				x		
500			Harpacticoida indet. 1	x		x			
501			Harpacticoida indet. 2	x					
502			Harpacticoida indet. 3 **			x			
503			*Harpacticus* sp.	x		x			
504			*Idomene* sp. *			x			
505			*Isias clavipes*			x			
506			*Kliopsyllus sp.*				x		
507			*Labidocera sp.*	x					
508			*Laophonte elongata*			x			
509			Laophontidae sp.1	x		x			
510			Laophontidae sp.2			x			
511			Laophontidae sp.3			x			
512			Laophontidae sp.4			x			
513			*Laophontodes* sp.			x			
514			Laophontopsidae indet. **			x			
515			*Leptastacus macronyx*				x		
516			*Leptomesochra confluens**				x		
517			*Leptomesochra* sp. *			x			
518			*Longipedia* sp.			x			
519			*Lucicutia* sp.	x		x			
520			*Metis ignea*			x			
521			*Microsetella rosea*			x			
522			*Microsetella* sp.	x					
523			Miraciidae indet.			x			

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
524			*Monstrilla* sp.			x			
525			Novocrinidae sp. *			x			
526			*Oithona helgolandica*	x					
527			*Oithona linearis*			x			
528			*Oithona nana*	x		x			
529			*Oithona plumifera*	x		x			
530			*Oithona similis*			x			
531			*Oncaea borealis*	x					
532			*Oncaea media*			x			
533			*Oncaea venusta*			x			
534			Paracalanidae indet.			x			
535			*Paracalanus parvus*	x					
536			*Paracartia latisetosa*			x			
537			*Paradactylopodia brevicornis*			x			
538			*Paramisophria* sp. *	x					
539			*Parapontella brevicornis*	x					
540			*Parastenhelia* sp.			x			
541			*Parategastes* sp.	x					
542			*Parevansula mediterranea* *				x		
543			Peltididae indet.			x			
544			*Peltidium purpureum*	x		x			
545			*Perissocope* sp. *			x			
546			*Phyllopodopsyllus* sp.			x			
547			*Poecilostomatoida indet.*			x			
548			Pontellidae indet.			x			
549			*Porcellidium* sp.			x			
550			*Pseudocyclops* sp. *	x		x			
551			Pseudotachidiidae indet.	x					
552			*Pteriacartia josephinae*			x			
553			*Ratania flava*	x					
554			*Scottopsyllus (I.) minutus* *				x		
555			*Sicameira gracilis* *				x		
556			*Sicameira langi* *				x		
557			*Stephos* sp.*	x					
558			*Syngastes* sp.			x			
559			*Syrticola mediterraneus*				x		
560			*Tachidius* sp.	x					
561			Thalestridae sp1			x			
562			Thalestridae sp2			x			
563			Thalestridae indet.			x			
564			*Thalestris rufoviolascens* *			x			

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
565			*Tegastes calcaratus*			x			
566			*Tegastes falcatus*			x			
567			*Tegastes longimanus*			x			
568			*Tegastes* sp.			x			
569			*Temora longicornis*			x			
570			*Temora stylifera*	x		x			
571			Tetragonicepsidae indet.			x			
572			Tetragonicipitidae indet.			x			
573			*Tisbe clodiensis*			x			
574			*Tisbe spp.*	x		x			
575		Siphonostomatoida	Artorogidae indet.			x			
576			Asterocheridae indet.			x			
577			*Metapontius* sp.			x			
578		Caligoida	Caligidae indet.			x			
579		Isopoda	*Gnathia vorax*	x		x			
580			Isopoda indet.			x			
581			*Munna* sp.			x			
582		Ostracoda	Ostracoda indet. sp.1	x		x			
583			Ostracoda indet. sp.2			x			
584			Ostracoda indet. sp.3			x			
585		Cladocera	*Evadne spinifera*			x			
586			*Evadne* sp.	x					
587			*Evadne tergestina*			x			
588			*Penilia avirostris*	x		x			
589			*Podon polyphemoides*			x			
590		Cumacea	Cumacea indet.	x		x			
591		Mysidacea	Mysidacea indet.			x			x
592			*Hemimysis margalefi* *	x		x			
593			*Siriella jaltensis*	x		x			
594		Amphipoda	Caprellidea indet.			x			
595			Hyperidea indet.			x			
596		Facetotecta	Cypris Y indet.			x			
597			*Hansenocaris leucadea* **			x			
598			*Hansenocaris mediterranea* **				x		
599			*Hansenocaris salentina* **				x		x
600			*Hansenocaris corvinae* **	x					
601		Anisopoda	Anisopoda indet.			x			
602		Decapoda	*Achaeus cranchii*			x			
603			Anomura zoea indet.			x			
604			Brachyura zoea indet.			x			
605			*Dardanus calicus*						x

				SUBMARINE CAVES					
	PHYLUM/SUBPHYLUM	CLASSES	SPECIES	Co	L	Ci	P	M	O
606			*Dromia personata*			x			x
607			*Gnathophyllum elegans*			x			
608			*Herbstia condyliata*			x			
609			*Herbstia nitida* *			x			
610			*Ilia nucleus*			x			
611			*Lysmata seticaudata*			x			
612			*Macropodia rostrata*			x			
613			*Palaemon elegans*			x			
614			*Palaemon longirostris*			x			
615			*Palaemon serratus*			x			x
616			*Palaemon xiphias*			x			
617			*Palinurus vulgaris*					x	
618			*Scyllarides latus*	x		x	x	x	x
619			*Stenopus spinosus*			x			x
620			*Xantho pilipes*			x			
621	ECHIURIDA		*Bonellia viridis*						x
622	PYCODONIDA		Pycnogonida indet.			x			
623	INSECTA		Chironomidae indet.			x			
624	ACARI		Acarina indet.			x			
625	ECHINODERMATA		Asteroidea brachiolaria						x
626			*Arbacia lixula*						x
627			*Coscinasterias tenuispina*			x			
628			*Echinaster sepositus*			x			
629			Echinodea irregularia			x			x
630			Echinodea pluteus			x			
631			*Hacelia attenuata*			x			
632			*Holothuria polii*			x			
633			*Holothuria tubulosa*						x
634			*Marthasterias glacialis*						x
635			*Ophioderma longicaudum*			x			
636			Ophiuroidea pluteus			x			x
637	CHAETOGNATHA		Chaetognatha bentonici	x					
638			*Sagitta* spp.			x			
639			*Spadella* spp.	x		x			

Tab. 2. Comparison between species richness of different valuable marine habitats of Apulia. LWC, Leuca White Coral Field; BCC, Bari Canyon Coral Field; SSC, Salento Submarine Caves; ACC, Apulian Coralligenic Constructions (from BIOMAP, 2014, modified). In BIOMAP (2014) is available a subdivision of the ACC data in three geographic subareas, one of which is the Ionian part of Apulia, approximately corresponding to the Salento Peninsula.

Taxon group	**LWC**	**BCC**	**SSC**
Protista	1	0	28
Porifera	37	32	87
Cnidaria	34	6	66
Mollusca	43	3	78
Annelida	28	16	47
Crustacea	28	5	168
Bryozoa	19	21	57
Echinodermata	11	6	12
Pisces	51	21	47
Others	5	1	67

If only the Ionian part of the Apulia is considered and, for comparative reasons, the indicator groups of Porifera, Bryozoa, and Decapoda, it can be derived a picture of similarity/differences possibly existing between coralligenous fauna and the submarine caves one, at local geographic scale (Salento Peninsula). Of the 273 species (Porifera, Bryozoa, and Decapoda) listed in Tab. 3, 192 species are reported from coralligenous, and 140 from submarine caves (59 being common to the two environments, corresponding to the 21.7 % of the total). In detail, the percentage of submarine cave species, present also in the neighboring coralligenous, changes with the considered *taxon*:

- Porifera (85 species in submarine caves): 47 species (=55.3% of the total Porifera species) have been found also in the coralligenous;
- Bryozoa (36 species in submarine caves): 6 species (=16.7% of the total Bryozoa species) have been found also in the coralligenous;
- Decapoda (19 species in submarine caves): 6 species (=31.6% of the total Decapoda species) have been found also in the coralligenous.

In total, the percentage of submarine cave species (on 140 belonging to 3 different *phyla*) present also in the coralligenous of the same geographic subarea (the Salento seas) is 42.1%. This datum simply demonstrates that the fauna of submarine caves is different from that living outside, in the close and similar (and biodiverse) coralligenous habitat.

Tab. 3. Comparison between submarine caves and coralligenous formation of the Salento Peninsula, based on the number of species of three main taxa: Porifera, Bryozoa, Decapoda. TOT, total species found in the two environments. CF, number of species living in the coralligenous formation. SC, number of species living into the submarine caves. ECF, number of species exclusive of the coralligenous formation. ESC, number of species exclusive of the submarine caves. C, number of the species in common between the two environments.

Taxon	**TOT**	**CF**	**SC**	**ECF**	**ESC**
PORIFERA	161	123	85	76	38
BRYOZOA	74	44	36	38	30
DECAPODA	38	25	19	19	13

In the study of Parenzan (1983), the two most important habitats of the Apulia coast (namely, the *Posidonia* bed, and the Coralligenous) were presented as extending for 14 Km^2 and 27.6 Km^2 respectively, approximately paralleling the coastline. The same Author made an attempt of species list relative to those habitats (335, and 771 animal species respectively). Even with the due caution in comparing data from distant historical periods, it is evident how the submarine cave habitat appears surprisingly rich of animal diversity. The comparison, in addition, must to take into consideration that the substratum surface analyzed in submarine caves of the Salento is only (!) 0.42 Km^2. When we compare the number of species with substratum extension considered (Salento coralligenous, 27.6 Km^2 and Salento submarine caves, 0.42 Km^2), it can be easily perceived as the concentration of species (just those belonging to the comparable taxa) gives an evident opposite result (2.5 vs 1,521.0 species x Km^{-2}). This particularly high biodiversity is justifiable according following points:

- Biogeography. The Salento is a naturalistic bridge among Italy and Balkans, thus representing a sort of biogeographic ecotone.
- Behavior. Submarine caves are inserted in the most complex environment of the sea (the coast) and offer refuge to many species endangered in the open sea (as ascertained by Bussotti *et al*. 2002, with fish).
- Competition absence. Due to the absence of light, the benthos of submarine caves host only animals which are not excluded by algae in occupying substrates.
- Habitat complexity. The internal of submarine caves is not homogeneous. Apart for the mineral composition, the hydrology of water masses and their hydro-dynamism, or the presence of a really complex network of crevices which offer shelter to organisms, we have to consider that caves contain together the two large categories of submarine bottoms: soft (on the floor) and rocky (on the walls).
- Deep habitats representation. Submarine caves (as already stated by

Riedel, 1966) are islands of deep sea biology with many representatives of that world, completely absent from the neighboring open areas outside.

The non perfect overlapping of species lists in the two *habitats*, in addition, allows us to recognize species not present into the richest coastal *habitat* of the Mediterranean Sea (the Coralligenous), for example 35 species of Porifera and 17 of Osteichthyes. In this last case, it is evident how the presence of soft substratum (on the floor) in submarine caves allows the presence of species as *Solea* sp. or *Trachinus* sp. impossible to be found in rocky habitats. In any cases, other species (as *Grammomus ater*, see Fig. 2) are typical of deep sea situations and testify the role of species attractor which is played by submarine caves for all the surrounding *habitats* even if not contiguous.

Fig. 2. An example of animal species typically present in submarine caves of the Salento Peninsula.

The existence of species new for Science in Salento submarine caves is a proof of the high naturalistic value of this *habitat*. Although some of them (e.g., Facetotecta) have been also found outside (Belmonte, 2005) the majority of the new described species still remain as endemics of single caves.

All these characteristics justify the protection of submarine caves as environments of high concentration of species and biodiversity, with a possible role even in the re-colonization of neighboring open sea bottoms which suffer injuries of any type from human presence.

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