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Research Article

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Molluscs associated with a Sardinian deep water population of *Corallium rubrum* (Linné, 1758)

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Abstract

Molluscan species living in association with Corallium rubrum colonies are poorly known. Specimens found on the branches of red coral colonies located off Capo Caccia (Alghero – SS, West Sardinia, Mediterranean Sea) were studied by analyzing red coral branches collected at a depth of between 100 and 120 m; their assemblage was made up of 44 species, all belonging to the classes Gastropoda and Bivalvia. Some data on the geographical distribution, ecology, taxonomy and dominance of these species, both alive and dead, are given and the most interesting are commented on. Among the recorded species Trivia multilirata, Simnia purpurea, Coralliophila brevis, Ocinebrina paddeui, Pleurotomella demosia, Palliolum striatum and Pseudamussium sulcatum deserve attention. Moreover, the second finding of living specimens of Asperarca secreta, described only on loose valves, is reported, and finally the prey-predator relationships among several gastropods and Cnidarians are confirmed.

Keywords: Mollusca assemblage; *Corallium rubrum*; Mediterranean Sea; Sardinia; Alghero.

Introduction

The octocoral anthozoan *Corallium rubrum* (Linné, 1758), belonging to the ordo Gorgonacea, is probably the most well-known Cnidaria of the Mediterranean Sea because of its social and economic importance. It is a sciaphilic species, among the longer living inhabitants principally of the circalittoral plane (PÉRÈS & PICARD, 1964; BALLESTEROS, 2006), and can be found throughout the Mediterranean (mainly in the western part and in a few Greek localities) and along the neighbouring Atlantic shores (MARCHETTI, 1965; BARLETTA *et al.,* 1968; ZIBROWIUS *et al.,* 1984; CHINTIROGLOU *et al.,* 1989; VAFIDIS *et al.,* 1994) ranging in depth from a few meters (in submarine caves) to about 200 m (LABOREL & VACELET, 1961; CARPINE & GRASHOFF, 1975; ZIBROWIUS *et al.,* 1984). It is a slow growing species (GARCIA-RODRIGUEZ & MASSÒ,

1986; GARRABOU & HARMELIN, 2002; BRAMANTI *et al.,* 2005) whose polyps form arborescent colonies that rarely reach big sizes: GARRABOU & HARMELIN (2002), however, report 50 cm as maximum height.

Because of its long history of exploitation since the 17th century and the continuous collecting activities by scuba divers (TESCIONE, 1968; SANTANGELO *et al.,* 1993b; SANTANGELO & ABBIATI, 2001) shallow water populations are rarely able to reach a commercial size and are currently dominated by young, small colonies (GARCIA-RODRIGUEZ & MASSÒ, 1986; SANTANGELO & ABBIATI, 1989; CATTANEO-VIETTI *et al.,* 1993; SANTANGELO *et al.,* 1993a, 2003), in contrast with the deeper ones, accessible only to professional coral fishers and situated along the African coasts, from Morocco to Tunisia, in Spain and in western Sardinia (CATTANEO-VIETTI *et al.,* 1992), where the Alghero coast, thanks to this peculiarity, is also known as 'Riviera del corallo'(COLOMO, 2002).

The red coral is also of great biological importance for the large number of sponges (MELONE, 1965; BARLETTA & VIGHI, 1968; CORRIERO *et al.,* 1997; MALDONADO, 1992; BAVESTRELLO *et al.,* 1999; CALCINAI *et al.,* 2000), crustaceans (ZARIQUIEY ALVAREZ, 1968; GARCIA-RASO, 1989; MANCONI & MORI, 1992, 2000), brachiopods (TEMPLADO & LUQUE, 1986; RUGGIERO-TADDEI, 1990), molluscs (SALAS & SERRA, 1986; PEÑAS *et al.,* 2006) and echinoderms (PEREZ-RUZAFA & LOPEZ-IBOR, 1986) that show a tendency to live on or to form strict associations with it. Even so, except for the sponges, which are well studied because of their ability to damage and thus reduce the commercial value of red coral as well as being the main causes of natural mortality (BARLETTA & VIGHI, 1968; CORRIERO *et al.,* 1997), only the papers above and a few others have been written about these biological relationships so far, and only TEMPLADO *et al.* (1986), more than 20 years ago, have given a global vision of the invertebrate fauna found on rocky bottoms in association with *C. rubrum* colonies.

Our paper, taking the previous ones as a starting point and gathering information from short notes published in local collecting reviews, is the first exclusively dedicated to the Mollusca found in association with red coral. It focuses especially on molluscs living on it, contributing in this way to a better understanding of the host-epibiont and prey-predator red coral-molluscs relationships.

Material and Methods

The investigated site of *Corallium rubrum* (Linné, 1758) is located between 12 and 15 nautical miles SW of Capo Caccia (Alghero - SS) at a depth of about 100-120 m. (Fig. 1).

Because red coral is protected under the Barcelona and Bern Conventions and its fishing is restricted to professional coral fishers, we were not able to use standard collecting methods. The red coral branches were all hand-collected, for commercial purposes only, by the scuba-diving coral fisher Tonino Paddeu. Despite this, the data that were obtained were significant, qualitatively valid and partly quantitatively useful. Red coral branches were collected during the coral fishers' season from April to October and first put underwater in a landing net with a stretched mesh measurement of 5 mm,

Fig. 1: Capo Caccia (Alghero) 40°33”39”N 8°09”50”E.

and then, on the boat, were cleaned of the rocky bottom on which they grow and put in a bowl. From 2002 to 2005 about 150 kg of red coral colonies have been analyzed and the molluscs on that coral harvested.

All molluscan specimens, either living or not, were observed using a Baush & Lomb Stereozoom 4 and the exact number of living and dead specimens were reported in a check list. Dominance was calculated as Di = (ni/N) x 100, where Di is the mean dominance index for species i; ni the number of individuals belonging to species i and N the total number of individuals of all species (BELLAN-SANTINI, 1969). For a better understanding two values of Dominance were given, one regarding total specimens (Di†‡%) and one only living specimens (Di‡%) sampled. When interesting, the maximum sampled sizes measured by an electronic digital caliper Vernier Micrometer LCD were specified.

Specimens of *Coralliophila* spp., *Pleurotomella demosia, Fusinus pulchellus* and *Asperarca secreta* respectively were sent to Messrs Carlo Smriglio, Cesare Bogi, Paolo Russo and Rafael La Perna to confirm our identifications.

Regarding systematic arrangement and nomenclature the ‘CLEMAM - Check list of European marine mollusca’ (accessed on 04/2008) was followed.

All the specimens are currently preserved in the private collection of the authors to continue investigations on the topic.

Results and notes on some species

The examined samples harbour a Molluscan assemblage made up of 44 species (Table 1), belonging to the class Gastropoda (33) and Bivalvia (11). Of a total of 984 specimens, 863 were taken

Table 1
Mollusca assemblage, number of living specimens (‡) and dead specimens (†) sampled, Dominance value for the whole assemblage (Di†‡%) and for living specimens only (Di‡%).

	‡	†	Di†‡%	Di‡%	photo
GASTROPODA					
FISSURELLIDAE					
Emarginula adriatica Costa O.G., 1829	2	0	0,20	0,23	3M
Emarginula fissura (Linné, 1758)	16	0	1,63	1,85	3L
Emarginula rosea Bell T., 1824	7	0	0,71	0,81	3I
TROCHIDAE					
Jujubinus exasperatus (Pennant, 1777)	1	0	0,10	0,12	
CALLIOSTOMATIDAE					
Calliostoma conulus (Linné, 1758)	2	5	0,71	0,23	
Calliostoma zizyphinum (Linné, 1758)	19	4	2,34	2,20	
CHILODONTIDAE					
Danilia costellata (Costa O.G., 1861)	37	19	5,69	4,29	3E
TURRITELLIDAE					
Turritella turbona Monterosato, 1877	0	4	0,41		
TRIVIIDAE					
Trivia arctica (Pulteney, 1799)	2	0	0,20	0,23	
Trivia multilirata (Sowerby G.B. II, 1870)	1	0	0,10	0,12	
OVULIDAE					
Aperiovula adriatica (Sowerby G.B. I, 1828)	0	1	0,10		
Pseudosimnia carnea (Poiret, 1789)	432	0	43,90	50,06	
Simnia purpurea Risso, 1826	8	0	0,81	0,93	3C
NATICIDAE					
Euspira pulchella (Risso, 1826)	2	2	0,41	0,23	
MURICIDAE					
Ocinebrina paddeui Bonomolo & Buzzurro, 2006	49	7	5,69	5,68	2A, 2B
Muricopsis aradasii (Poirier, 1883)	28	9	3,76	3,24	2C, 2D
Orania fusulus (Brocchi, 1814)	0	1	0,10		
Coralliophila brevis (de Blainville, 1832)	16	0	1,63	1,85	2F
Coralliophila cf. *sofiae* (Aradas & Benoit, 1876)	0	6	0,61		2G
Coralliophila squamosa (Bivona Ant. In Bivona And., 1838)	0	6	0,61		2H, 2I
Coralliophila panormitana (Monterosato, 1869)	1	2	0,30	0,12	2E
NASSARIIDAE					
Nassarius lima (Dillwyn, 1817)	0	2	0,20		
BUCCINIDAE					
Chauvetia lineolata (Tiberi, 1868)	0	1	0,10		
COLUMBELLIDAE					
Mitrella gervillii (Payraudeau, 1826)	0	1	0,10		
Mitrella minor (Scacchi, 1836)	0	2	0,20		

(continued)

Table 1 (continued)

	‡	†	Di†‡%	Di‡%	photo
FASCIOLARIIDAE					
Fusinus pulchellus (Philippi, 1844)	43	19	6,30	4,98	3F
CONIDAE					
Comarmondia gracilis (Montagu, 1803)	3	0	0,30	0,35	
Bela menkhorsti Van Aartsen, 1988	0	1	0,10		
Raphitoma concinna (Scacchi, 1836)	0	2	0,20		
Pleurotomella demosia (Dautzenberg & Fisher H., 1896)	4	3	0,71	0,46	3A, 3B
DRILLIIDAE					
Crassopleura maravignae (Bivona Ant. In Bivona And., 1838)	4	0	0,41	0,46	
ARCHITECTONICIDAE					
Philippia hybrida (Linné, 1758)	1	0	0,10	0,12	3D
MATHILDIDAE					
Mathilda cochlaeformis Brugnone, 1873	0	2	0,20		3G
BIVALVIA					
ARCIDAE					
Asperarca secreta La Perna, 1998	6	0	0,61	0,70	3H
MYTILIDAE					
Modiolula phaseolina (Philippi, 1844)	1	0	0,10	0,12	
PTERIIDAE					
Pteria hirundo (Linné, 1758)	6	0	0,61	0,70	
PECTINIDAE					
Palliolum striatum (Müller O.F.,1776)	28	0	2,85	3,24	
Palliolum incomparabile (Risso, 1826)	18	0	1,83	2,09	
Pseudamussium sulcatum (Müller O.F., 1776)	15	0	1,52	1,74	
ANOMIIDAE					
Heteranomia squamula (Linné, 1758)	32	4	3,66	3,71	
Pododesmus patelliformis (Linné, 1761)	41	3	4,47	4,75	
GRYPHAEIDAE					
Neopycnodonte cochlear (Poli, 1795)	34	11	4,57	3,94	
TRAPEZIDAE					
Coralliophaga lithophagella (Lamarck, 1819)	2	0	0,20	0,23	
HIATELLIDAE					
Hiatella arctica (Linné, 1767)	2	4	0,61	0,23	

alive, constituting 88% of the specimens found. A list of families, species and specimens found is presented in Table 2.

No specimens of the 6 remaining classes of Mollusca phylum were raised during our studies, as Mediterranean Monoplacophora constitute only one species (CESARI *et al.,* 1987; CECALUPO & GIUSTI, 1989; SMRIGLIO *et al.,* 1989), never found alive (WARÉN &

Table 2
Contribution to the check-list. Specimens found: alive specimens only (‡), both alive and dead (†‡), dead only (†).

	‡	†‡	†	Total
Class GASTROPODA				
FAMILY	5	7	5	17
Species	12	9	12	33
Specimens	678		99	777
Class BIVALVIA				
FAMILY	6	2	0	8
Species	9	2	0	11
Specimens	185		22	207

GOFAS, 1996) and Scaphopoda and Caudophoveata need a soft substratum for burrowing. Also, specimens of the above-mentioned classes could not be collected because of the 5 mm mesh used.

Sampling methods, moreover, did not permit us to find specimens belonging to the Cephalopoda, while no Polyplacophora has ever been reported in association with red coral colonies (DELL'ANGELO & SMRIGLIO, 1999). Finally, no Solenogastres were sampled, although *Nematomenia coralliophila* (Kowalevsky) is indicated as a cnidarivorous species feeding on *Corallium rubrum* only (SALVINI-PLAWEN, 1972). Its distribution, however, seems to be limited to Algiers (SALVINI-PLAWEN, 1986) and the species is known only from its original description and was never found again in the Mediterranean Sea (Salvini-Plawen pers. commun.). Though many specimens belonging to the Solenogastres have been listed from red coral bottoms (TEMPLADO *et al.* 1986), it is specified that Solenogastres have never been found strictly living on *Corallium rubrum,* in agreement with our samples.

Notes about some interesting families and species of the Alghero red coral.

FISSURELLIDAE: *Emarginula adriatica* Costa O.G., 1829 and *E. fissura* (Linné, 1758)

All the species sampled live principally in circalittoral biocoenoses (PIANI, 1984) feeding on Porifera (GRAHAM, 1955), a phylum well represented in red coral bottoms. Both *E. adriatica* and *E. fissura* were previously recorded living on branches and in *Corallium rubrum* bottoms (BRUSINA, 1866; TEMPLADO *et al.,* 1986).

CALLIOSTOMATIDAE: *Calliostoma conulus* (Linné, 1758) and *C. zizyphinum* (Linné, 1758)

Calliostomatidae are carnivorous species that feed upon a wide range of algae and invertebrate phyla, showing preference principally for Cnidarians (BARSOTTI & FRILLI, 1969; SALVINI-PLAWEN, 1972; PERRON, 1975; KEEN, 1975; FRETTER & GRAHAM, 1977; PERRON & TURNER, 1978; FERRO & CRETELLA, 1993). Both species recorded were previously found living on *Corallium rubrum* (GARA-

VELLI & MELONE, 1968; SPADA, 1968; VAFIDIS *et al.,* 1994), off Alghero (GARAVELLI & MELONE, 1968) and sometimes in great numbers (SPADA, 1968), which could suggest that *Corallium rubrum* is considered by both species as a feeding substratum.

Danilia costellata (Costa O.G., 1861)

First separated from its congeneric *Danilia tinei* (Calcara, 1839), although for about a century it was considered either the adult or a depth form of the latter species (GHISOTTI & STEINMANN, 1970). The discussion was reopened by PALAZZI & VILLARI (2001) who –based on shell differences only– reconsidered *D. costellata* as a good species on the basis of shell differences only and usually living at a greater depth, even though Gofas (2005) reported for Lusitanian seamounts *D. tinei* only. The species, as in our samples, was previously found in a great number living on *Corallium rubrum* colonies, also in the area off Alghero, (GARAVELLI & MELONE, 1968; SPADA, 1968, both as *D. tinei*).

Aperiovula adriatica (Sowerby G.B. I, 1828)

Our present knowledge of the ecology of *Aperiovula adriatica* is very poor and only one dead specimen was found during our sampling; this was considered as an accidental occurrence. This species probably does not live or feed on red coral, as cited in the literature (DONNARUMMA, 1968; SABELLI, 1972; OLIVERIO & VILLA, 1995; KABASAKAL *et al.,* 2006).

Pseudosimnia carnea (Poiret, 1789)

Its association with red coral has been known for centuries and this species was already reported living on *Corallium rubrum* during red coral fishing off Montenero Livorno, Central Tyrrhenian Sea (APPELIUS, 1869) and from Dalmatian red coral (BRUSINA, 1866). More recently several papers have reported this relationship (ROGHI, 1966; GARAVELLI & MELONE, 1968; GHISOTTI & MELONE, 1969; SABELLI, 1972; SALVINI-PLAWEN, 1972; SABELLI & SPADA, 1979; TEMPLADO *et al.,* 1986; ABBIATI & SANTANGELO, 1989; FRANCOUR *et al.,* 1992; VAFIDIS *et al.,* 1994; OLIVERIO & VILLA, 1995). The association was recorded for the area off Alghero, too (GARAVELLI & MELONE, 1968) and also by analyzing the branches taken by scuba-diving coral fishers (ROGHI, 1966; GARAVELLI & MELONE, 1968; SABELLI, 1979; FRANCOUR *et al.,* 1992), which sometimes meant the finding of a great number of specimens (FRANCOUR *et al.,* 1992; ROGHI, 1966). A prey-predator relationship was, however, only hypothesized without detailed analysis (SABELLI, 1972; TEMPLADO *et al.,* 1986; SALVINI-PLAWEN, 1972; ABBIATI *et al.,* 1992). Observations in aquarium and presence of spicules of *Corallium rubrum* into fecal pellets of our specimens from the marine environment also confirm this relationship.

P. carnea was the most common species recorded on the Alghero red coral with a Di†‡ of 43,90% and a Di‡ of 50,06%. Its shell chromatism is strong red as previously reported for red coral populations (SANTANGELO *et al.,* 1993a), not agreeing with OLIVERIO & VILLA (1995) about the general rarity of this colour pattern and probably linked to the colour of the gorgonians on which they feed by direct accumulation of pigments from the host (ABBIATI & SANTANGELO, 1989).

The largest specimen sampled in our work is 17,15 mm in height and 9,43 mm in width, while the maximum total length of 26 mm sampled by SANTANGELO *et al.* (1993a) seems improbable.

Simnia purpurea Risso, 1826

Often considered rare, it usually lives as a guest on *Paramuricea clavata* (VAFIDIS *et al.,* 1994; OLIVERIO & VILLA, 1995), although SABELLI & SPADA (1979) reported it living only on *Corallium rubrum,* and OLIVERIO & VILLA (1995) mentioned it also for hard substrata with the presence of red coral. It was previously found on the Alghero red coral (GIANNINI, 1975) and we found 8 living specimens (Di†‡ of 0,81% and Di‡ of 0,93%), the largest of which is 19,05 mm in height and 8,02 mm in width, confirming that *Simnia purpurea* can live on *Corallium rubrum,* too. In agreement with OLIVERIO & VILLA (1995) about the incorrect identification of such species in the past, we believe that both *Simnia patula,* listed by TEMPLADO *et al.* (1986) amongst the molluscs living on the *Corallium rubrum* colonies and no longer reported by PEÑAS *et al.* (2006), and the violaceous pullus of *Simnia spelta,* included by SPADA (1968) among the species found in the material received by coral fishers from Santa Teresa di Gallura (Sardinia), could probably belong to this taxon, even if these discrepancies are not reported in CLEMAM (2008). This leads us to assume that its rarity is probably due to misidentifications and research on the wrong hosts.

Ocinebrina paddeui Bonomolo & Buzzurro, 2006

This species, named after Tonino Paddeu and recently described on the basis of specimens, including some collected during our sampling (BONOMOLO & BUZZURRO, 2006), is to date known only from the area off Alghero in association with *Corallium rubrum,* where it seems to be one of the most common living species (Di†‡ of 5,69% and Di‡ of 5,68%), although more extensive research on the whole Tyrrhenian malacofauna associated with red coral could extend its distribution. The largest specimen is 15.03 mm in height and 8,51 mm in width (Fig. 2), exceeding the previous largest published.

Orania fusulus (Brocchi, 1814)

Only one crabbed specimen of this species was found, previously reported as living on *Corallium rubrum* bottoms by PEÑAS *et al.* (2006).

Coralliophila brevis (de Blainville, 1832)

Coralliophila brevis' known preys belong to Gorgonacea (RICHTER & LUQUE, 2002), and specifically the species *Eunicella singularis, Eunicella cavolinii* and *Paramuricea clavata* are usually listed as its preys (GARAVELLI & MELONE, 1967, 1968; ALBERGONI & SPADA, 1969, 1972; TEMPLADO *et al.,* 1986; OLIVERIO, 1989; RICHTER & LUQUE, 2003). However, in Greece (VAFIDIS *et al.,* 1994) and in Alboran Island (TEMPLADO *et al.,* 1986; PEÑAS *et al.,* 2006) a few live specimens were found living in *Corallium rubrum* bottoms and on *Corallium rubrum* colonies and SABELLI & SPADA (1980) and RICHTER & LUQUE (2003) report the species as living on *Lophogorgia ceratophyta* too. So, *C. brevis* feeds not only on the three species commonly reported by most previous authors, but probably on the majority of the Mediterranean species belonging to the ordo Gorgonacea.

We recorded 16 live specimens, the largest of 13,90 mm in height and 9.00 mm in width, although most were juveniles and did not reach 10 mm total height (Fig. 2F, specimen of 8,37 mm in height and 5,00 mm in width). They resemble in dimension and general shape *Coralliophila alboranensis* (SMRIGLIO & MARIOTTINI, 2003), a new synonym for *Coralliophila brevis* according to PEÑAS

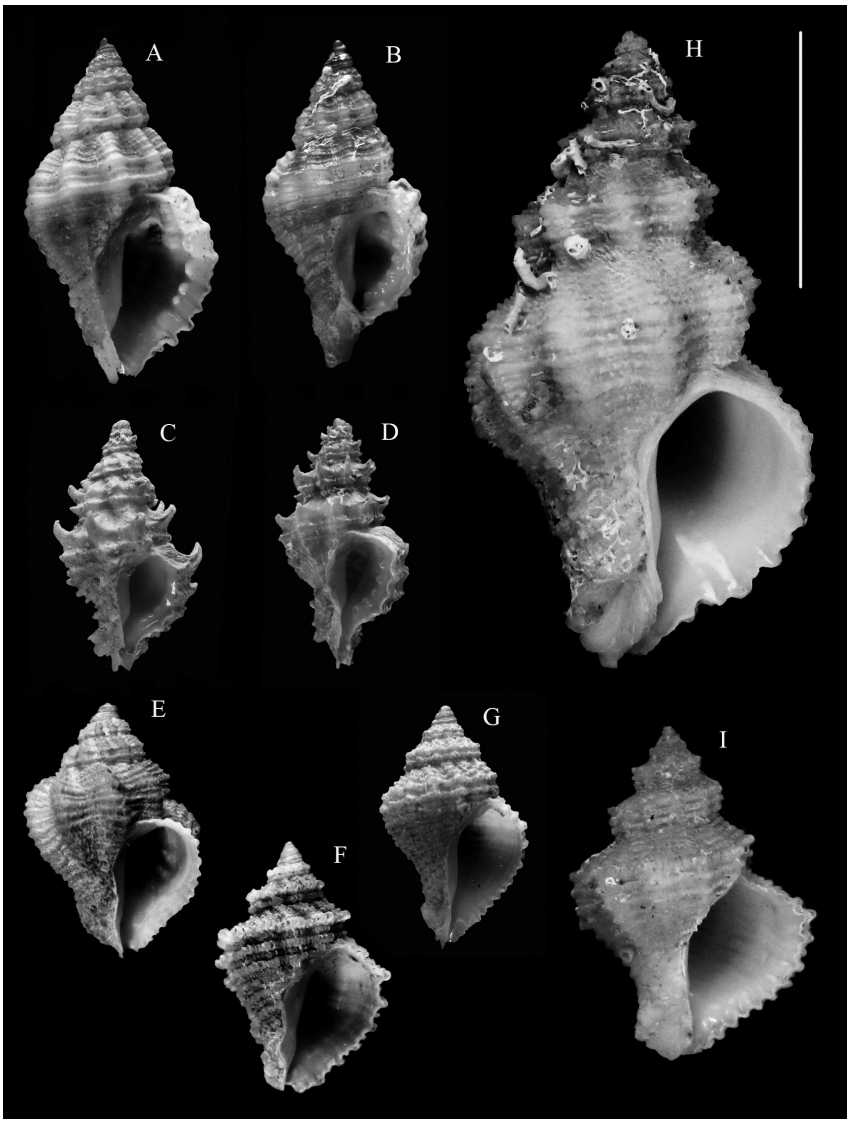

Fig. 2: A-B, *Ocinebrina paddeui* Bonomolo & Buzzurro, 2006; C-D, *Muricopsis aradasii* (Poirier, 1883); E, *Coralliophila panormitana* (Monterosato, 1869); F, *Coralliophila brevis* (de Blainville, 1832); G, *Coralliophila* cf. *sofiae* (Aradas & Benoit, 1876); H-I, *Coralliophila squamosa* (Bivona Ant. in Bivona And., 1838). Scale bar: 10 mm.

et al. (2006), found also itself in association with *Coralliophila panormitana* on coralligenous bottoms at depths between 80 and 150 m, although its host was listed as unknown and the presence of red coral was not mentioned. Different sizes among specimens of a same species, but with different diets, have previously been found in *Coralliophila meyendorfii,* too (OLIVERIO, 1991; OLIVERIO & MARIOTTINI, 2001); the same could be assumed for *Coralliophila brevis.*

Coralliophila cf. *sofiae* (Aradas & Benoit, 1876)

Only 6 juveniles of this species were found (Fig. 2G, the largest one, of 9.01 mm in height and 5,40 mm in width), all without soft parts. We doubt of their determination, even if general shape, spiral cords and siphonal canal lead to *Coralliophila sofiae* (Smriglio pers. commun.), we have no juveniles of this species to compare with our specimens, only further studies and genetic analysis could bring us to a sure identification since a purely conchological approach can be misleading.

Coralliophila squamosa (Bivona Ant. in Bivona And., 1838)

Previously recorded species living in association with *Corallium rubrum* colonies (PEÑAS *et al.,* 2006). We found 6 dead specimens of *Coralliophila squamosa,* 1 with typical form and 5 recalling *Pseudomurex ruderatus* (Sturany, 1896) (Fig. 2H, I), now in synonymy with *C. squamosa* (BOUCHET & WARÉN, 1985).

Coralliophila panormitana (Monterosato, 1869)

Only three specimens, one of them alive (Fig. 2E, specimen of 10.30 mm in height and 6.58 mm in width). It is a deep water species often associated with *Corallium rubrum* (PALMERI, 1986; OLIVERIO, 1989), although no specimens were found in Campaña Coral Rojo (TEMPLADO *et al.,* 1986; PEÑAS *et al.,* 2006).

COLUMBELLIDAE: *Mitrella gervillii* (Payraudeau, 1826) and *M. minor* (Scacchi, 1836)

The two species sampled, belonging both to the genus *Mitrella,* show a wide bathymetric range and could live from a few to more than 100 m depth in very different biocoenoses (LUQUE, 1986; CHIARELLI *et al.,* 2003). Although our specimens were crabbed, *Mitrella gervilli* was already found living on red coral colonies (SPADA, 1968; CHIARELLI *et al.,* 2003), while at great depths *Mitrella minor* prefers muddy and detritical bottoms, present in the immediate vicinity of the analyzed areas. TEMPLADO *et al.* (1986) listed *Mitrella pallaryi* among the species found on red coral bottoms in the Alboran Sea.

Pleurotomella demosia (Dautzenberg & Fisher H., 1896)

This species, first well figured in BOUCHET & WAREN (1980), was described by DAUTZENBERG & FISHER (1896) only for the European Atlantic Sea and the Azores, but recently found in various areas of the Mediterranean Sea (BOGI, 1986), Sardinia (CECALUPO, 1988), the Tuscan archipelago (BOGI *et al.,* 1989) and Spain (GIRIBET & PEÑAS, 1997; PEÑAS *et al.,* 2006). *P. demosia* was previous surveyed living on Corallium rubrum bottoms (PEÑAS *et al.,* 2006). Our largest specimen is 14,76 mm in height and 7,35 mm in width (Fig. 3A).

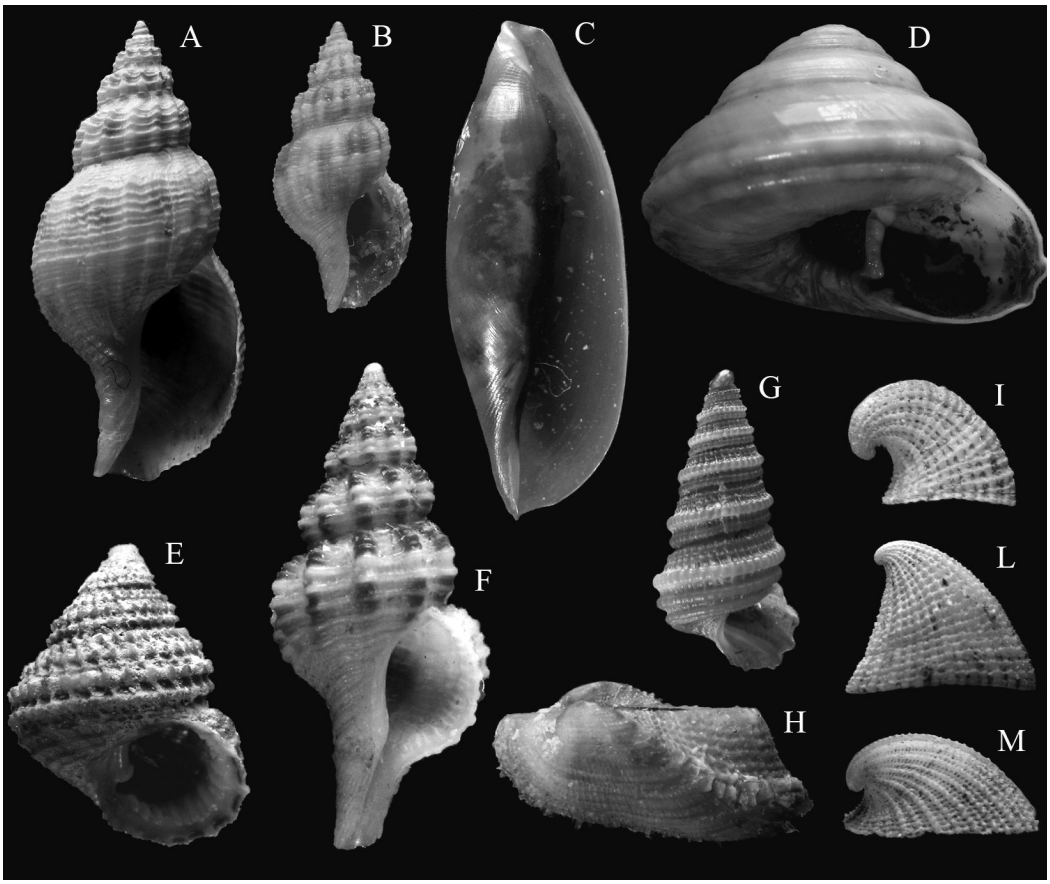

Fig. 3: A-B, *Pleurotomella demosia* (Dautzenberg & Fisher H., 1896); C, *Simnia purpurea* Risso, 1826; D, *Philippia hybrida* (Linné, 1758); E, *Danilia costellata* (Costa O.G., 1861); F, *Fusinus pulchellus* (Philippi, 1844); G, *Mathilda cochlaeformis* Brugnone, 1873; H, *Asperarca secreta* La Perna, 1998; I, *Emarginula rosea* Bell T., 1824; L, *Emarginula fissura* (Linné, 1758); M, *Emarginula adriatica* Costa O.G., 1829. Scale bar: 10 mm.

Philippia hybrida (Linné, 1758)

Species occurring in the Mediterranean and nearby eastern Atlantic (ROBERTSON, 1973) characterized by a wide bathymetric range, living from the first meters of the infralittoral to the circalittoral (BIAGI & CORSELLI, 1978; MELONE & TAVIANI, 1984; MINNITI *et al.,* 1988; PEÑAS *et al.,* 2006), and sometimes found beached too (BIAGI & CORSELLI, 1978; MELONE & TAVIANI, 1984).

Architectonicidae are cnidarivorous and usually feed on zoantharians and scleractinians (ROBERTSON, 1970; ROBERTSON *et al.,* 1970; MELONE & TAVIANI, 1984), but *P. hybrida* has already been found also at about 100 m depth on *Corallium rubrum* off Bocche di Bonifacio, amongst the red coral branches picked up by the coral fisher F. Zoboli (SPADA & GARAVELLI, 1969).

Asperarca secreta La Perna, 1998

The species, recently described for the central Mediterranean Sea at a depth

between 84 and 155 m on about 1000 loose valves from Baie de Calvi (Corsica) and Isola di Ponza (Italy) (LA PERNA, 1998). It was first recorded alive at Centauri (west of Cap Corse), where 4 living specimens and 4 loose valves were found at a depth of 80 m in coralligenous detritus (DELONGUEVILLE & SCAILLET, 2005). We picked up 6 live specimens of *A. secreta;* among them the largest was 3,13 mm in height and 7,05 mm in width (Fig. 3H), sizes until now never reported. For the first time we recorded this species living on hard substrata with the presence of *Corallium rubrum.*

Palliolum striatum (Müller O.F., 1776)

One dead complete specimen of this species, living on muddy, sandy, or rocky bottoms at depths varying from 7 to 800 m (WAGNER, 1988), was previously recorded on red coral bottom by SALAS & SIERRA (1986). It is considered a rare species (LUCAS, 1979b), but in the examined area it is the most common scallop recorded (Di†‡ of 2,85% and Di‡ of 3,24%). Although only one specimen reaches 17.40 mm in height and 16.50 mm in width and most are juveniles or subadult specimens less than 10 mm in size, WAGNER (1988) reported 17,2 mm in height and 16,6 mm in width as maximum sizes measured, DELONGUEVILLE & SCAILLET (1999) 24,4 mm in height and 22,8 mm in width for a specimen taken at 30 m depth off Fuengirola (Spain), and LUCAS (1979b) up to a height of 27 mm for Atlantic specimens.

Palliolum incomparabile (Risso, 1826)

This species usually lives among algae or rubble on muddy and sandy bottoms or is byssally attached on rocky bottoms from littoral to abyssal depths (40 to 2000 m), although it has also been reported from coralligenous zones (LUCAS, 1979A; DIJKSTRA & GOFAS, 2004; WAGNER, 1988). Only a few specimens were previously found living on red coral (SALAS & SIERRA, 1986; TEMPLADO *et al.,* 1986), while we reported 18 live specimens for the Alghero red coral (Di†‡ of 1,83% and Di‡ of 2,09%).

Pseudamussium sulcatum (Müller O.F., 1776)

It is a sublittoral to bathyal depths species, living byssally attached to rocks or among gravel and/or rubble on soft sediments (DIJKSTRA & GOFAS, 2004). Our specimens belong to the morph *bruei* (DIJKSTRA & GOFAS, 2004), considered in the past to be a distinct species (WAGNER, 1988). It is the least common (Di†‡ of 1,52% and Di‡ of 1,74%) of the three species of Pectinidae recorded, previously found living on red coral (BRUSINA, 1866).

ANOMIIDAE: *Heteranomia squamula* (Linné, 1758) and *Pododesmus patelliformis* (Linné, 1761)

Heteranomia squamula and *Pododesmus patelliformis* are among the most common species recorded on the Alghero red coral (Di†‡ respectively of 3,66 and 4,47% and Di‡ of 3,71 and 4,75%). Both species have already been found living on and in association with *Corallium rubrum* (BRUSINA, 1866; SALAS & SIERRA, 1986; TEMPLADO *et al.,* 1986) and we found specimens both living on *Pteria hirundo* and *Neopycnodonte cochlear* and byssed on red coral branches.

Neopycnodonte cochlear (Poli, 1795)

A common sessile species often recorded alive on red coral (BRUSINA,

1866; PARENZAN, 1980; SALAS & SIERRA, 1986; TEMPLADO *et al.,* 1986). Specimens from off Capo Caccia (SS) show the tendency to live attached only to the base of *Corallium rubrum* colonies, in the same way reported both by SALAS & SIERRA (1986) and TEMPLADO *et al.* (1986) suggesting that their larvae could survive with difficulty if they settled on red coral axes. Also specimens assigned to *Ostreola stentina,* reported and illustrated as living on the *Corallium rubrum* of Greece (CHINTIROGLOU *et al.,* 1989) (Chintiroglou pers. communication) definitely belong to this species.

Coralliophaga lithophagella (Lamarck, 1819)

Only one species of Trapeziidae, *Coralliophaga lithophagella,* lives in the Mediterranean, although SALAS, BARRAJON & CARPENA (1988) also reported a dead specimen of *Coralliophaga coralliophaga* (Gmelin, 1791) inside red coral stones from around Alboran Island. This is now considered a misidentification of *C. lithophagella* (CLEMAM, 2008) and no longer reported by PEÑAS *et al.,* (2006). It is an endolithic species living inside cavities mainly in coralligenous habitats (DELONGUEVILLE & SCAILLET, 2005), often recorded as living on *Corallium rubrum* bottoms (SALAS & SIERRA, 1986; TEMPLADO *et al.,* 1986). Two living specimens were obtained during our samples.

Hiatella arctica (Linné, 1767)

This species is often recorded as living in association with *Corallium rubrum* (PARENZAN, 1980; SALAS & SIERRA, 1986; TEMPLADO *et al.,* 1986). Only two adult live specimens were found, both identified by analyzing external conchological characteristic and by the presence of one tooth on each valve, according to MICALI & SOLUSTRI (2004). They were found byssed to red coral branches, as indicated as nestling behaviour by GORDILLO (2001) and typical of this species (BARSOTTI & FRILLI, 1969; HRS-BRENKO & LEGAC, 2006), contrary to the boring behaviour often observed in the other Mediterranean species, *Hiatella rugosa* (VIO & DE MIN, 1996; MICALI & SOLUSTRI, 2004; HRS-BRENKO & LEGAC, 2006).

Conclusions

The Mollusca assemblage found on *Corallium rubrum* colonies between 100 and 120 m of depth is of particular interest for its faunistic, ecologic and taxonomic significance and is quite heterogeneous for the presence of 44 species (33 sampled alive), belonging only to 2 different classes (Gastropoda and Bivalvia), but to 25 different families of Mollusca.

Among the gastropods we only found carnivorous species, with the exception of *Jujubinus exasperatus,* of which only one that it may be considered an occasional specimen accidentally drifted from neihbouring habitats. This species can however live at up to a depth of 200 m (FRETTER & GRAHAM, 1977); the lack of herbivorous species is connected to the poor presence, or sometimes total absence, of algae on red coral bottoms.

The most ecologically important records belong to four families, all live sampled, which include mostly or exclusively corallivorous species (Calliostomatidae, Ovulidae, Muricidae and Architectonicidae).

Calliostoma conulus and *C. zizyphinum* are considered carnovorous species with a preference for Cnidaria, and were found several times in association with red coral.

The relationship between *Pseudosimnia carnea* and *Corallium rubrum* has been known for centuries and is confirmed by the high number of specimens sampled (43,90% of the total abundance), while *Simnia purpurea*'s association with red coral was often hypothesized without conclusive data, probably both due to the rarity of such species and to the difficulty of finding and accessing well developed red coral colonies. In our samples *S. purpurea* accounted for 0,81 of the total specimens. *Aperiovula adriatica*'s host, on the contrary, is still unknown and there is no evidence that it could feed on red coral.

Of the four species of the genus *Coralliophila* found in our samples, *C. brevis* and *C. panormitana,* both found live although usually considered rare to find, could also feed on *Corallium rubrum.* For the latter it is certain, for the former only a few specimens have been found in previous research into red coral associated fauna. The record of 16 specimens in our study living on red coral strongly suggests *Corallium rubrum - Coralliophila brevis* as a prey-predator relationship and adds another example of the lack of species-specificity among *Coralliophila.* This has also been documented for *Coralliophila meyendorfii* that can even feed on different orders of Anthozoa (OLIVERIO, 1991; OLIVERIO & MARIOTTINI, 2001; RICHTER & LUQUE, 2002). Further studies are needed on the taxonomy of Corall *Coralliophila* cf. *sofiae,* whose identification remains questionable, and on the ecology of *C. lamellosa ruderata.* The great number of specimens of this form compared to the typical *C. lamellosa* indicates that it could be strictly related to red coral bottoms, probably eating this octocoral too.

Finally, Architectonicidae are usually known to feed on Zoantharia and Scleractinia only, but at least 3 species (*Philippia hybrida, Solatisonax alleryi* and *Heliacus fallaciosus*) were found living on *Corallium rubrum,* too (BRUSINA, 1866; VAFIDIS *et al.,* 1994). Although it is likely that Architectonicidae feed on living Zoantharia and Scleractinia in strict association with red coral (TEMPLADO *et al.,* 1986), further research into the relationships between the family Architectonicidae and red coral are advisable.

Of the other carnivorous species found, some could be surely considered accidental on red coral branches (but not in red coral bottoms), such as *Emarginula* spp. and *Trivia* spp., that feed on sponges and ascidians respectively (LEBOUR, 1931, 1933) and are well-represented groups in red coral bottoms. The record of *Trivia multilirata* in the Tyrrhenian area deserves attention because it has been so far mostly recorded in the Adriatic Sea, usually at great depths, but we picked up only a sub-adult living specimen. The high presence of *Fusinus pulchellus* could be explained by the presence of polychaetes, often found living principally on *Neopycnodonte cochlear,* at the base of red coral colonies and on the rocks in the nearby red coral bottoms and considered the principal food of *Fusinus* spp. which, however, also feeds on other molluscs (G. Russo, pers. observation).

Turritella turbona and *Nassarius lima* live principally on mobile bottoms around red coral banks, and the present shells were moved onto the colonies by hermit crabs. *Euspira pulchella* could feed on the molluscs surveyed (both gastropods and

bivalves) and for this species red coral is a simple walking and hunting substratum like the neighbouring rocks.

Among Muricidae the most relevant and localized species is *Ocinebrina paddeui,* known only from the area off Alghero in association with *Corallium rubrum,* although further, extensive research into the malacofauna associated with red coral colonies could extend its present known distribution. Maximum sizes known for this species are updated in this paper to 15,03 mm in height x 8,51 mm in width. Another species, live sampled too, also reaches very large sizes: *Pleurotomella demosia,* of 14,76 mm in height and 7,35 mm in width.

Nothing is known about the ecology of *Danilia* spp. but they are among the most common species on the Alghero red coral and are often observed in association with Cnidaria. The taxonomic status of *Danilia costellata* is uncertain; it was considered a good species only by analyzing shell characters, but several intermediates between the two Mediterranean species could be easily found, and as BEU & CLIMO (1974) asserted more than thirty years ago 'without comparative radula and anatomical information it was impossible to shed light on the taxonomy of *Danilia* spp.', we also consider daring to affirm without doubt that *Danilia costellata* is a species different from *Danilia tinei,* exclusively by analyzing shell characters. Anatomic and genetic analysis to determine the taxonomy of *Danilia* in the Mediterranean is strongly suggested.

Among the eleven species of bivalves sampled on red coral, seven (*Asperarca secreta, Modiolula phaseolina, Pteria hirundo, Palliolum striatum, Palliolum incomparabile, Pseudamussium sulcatum* and *Hiatella arctica*) show nestling behaviour and could live byssed both on the neighbouring rocks and on the red coral, with which they share a habitat particularly rich in currents and nutrient. Such behaviour, typical of *Hiatella arctica,* is commonly used as a distinguishing parameter from the other species of *Hiatella* living in the Mediterranean, and is utilized also by us, together with shell characters, to identify the species. However, observations by HUNTER (1949) exclude the possibility of distinguishing the two Hiatella (*H. arctics* and *H. rugosa*) by shell characters and ecology only, and over the centuries the two species have been divided or unified according to the ideas of different authors. Among the seven listed, particularly relevant is *Asperarca secreta,* seen alive for the second time in the Mediterranean and for the first time associated with red coral bottoms. One specimen is much larger than previous records in the Mediterranean Sea (2,83 mm in height and 6,25 mm in width). Also two of the three species of Pectinidae (*Palliolum striatum* and *Pseudamussium sulcatum*) are usually considered rare, but are present in a good number on red coral bottoms.

On the contrary, *Coralliophaga lithophagella,* is an endolithic species, and lives principally inside the holes of rocky red coral bottoms, sometimes not well cleaned from the basis of *Corallium rubrum* axes.

Finally , the three remaining species (*Neopycnodonte cochlear, Heteranomia squamula* and *Pododesmus patelliformis*), live strongly attached to a hard substratum: the former always to the basis of *Corallium rubrum* colonies and never reported living on the branches, suggesting that its larvae could not survive on red coral axes. Sometimes the fore valves of *Neopycnodonte cochlear* can become a

basis of the settlement of new red coral colonies, as observed in our samples. The two species of Anomiidae, moreover, did not show preference for living on *Pteria hirundo* and *Neopycnodonte cochlear* or on red coral branches.

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