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# Coralliophilinae (Gastropoda: Muricidae) associated with deep-water coral banks in the Mediterranean

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## ABSTRACT

Fisheries and scientific investigations of the recently discovered deep-water coral province south of Malta sampled living specimens of two deep-water Coralliophilinae intimately associated with *Lophelia-Madrepora* coral banks. The species are '*Coralliophila richardi*' (Fischer P., 1882) and *Babelomurex sentix* (Bayer, 1971). A third coralliophilinid '*Coralliophila squamosa*' (Bivona Ant. in Bivona And., 1838: deep-water morphotype) has been also observed alive close to deep-water corals at the Nameless-Urania Bank.

*Additional keywords:*, Neogastropoda, XXXXX

## INTRODUCTION

Deep-water coral ecosystems are receiving increasing attention from the scientific community as biodiversity hotspots (Freiwald et al., 2004; Roberts et al., 2006). The Mediterranean Sea hosts a variety of deep-water corals inhabiting soft and hard substrates. Some skeletonized cnidarians (mostly the scleractinians *Lophelia pertusa* (Linnaeus, 1758), *Madrepora oculata* Linnaeus, 1758, *Desmophyllum dianthus* (Esper, 1794), *Javania cailleti* (Duchassaing and Michelotti, 1864), *Caryophyllia* spp., *Dendrophyllia* spp., the gorgoniacean *Corallium rubrum* (Linnaeus, 1758), and several others) may contribute to the formation of considerable bioconstructions at depths in excess of 300 m (Taviani et al., 2005; Freiwald et al., 2009). Such living deep-water coral assemblages are widespread in the Mediterranean basin as are still-submerged taphocoenoses and outcrops (Taviani et al., 2005).

Unravelling the interactions between cnidarians and their predators is essential for a better understanding of the ecology of deep-water coral banks. Top predators of cnidarians include gastropods belonging to the families Ovulidae, Epitoniidae, Janthinidae, Muricidae-Coralliophilinae, and Architectonicidae (Graham, 1985; Oliverio, 1989; Bieler & Petit, 2005; Schiaparelli et al., 2005; Gittenberger, 2006, with references). However, there are few documented reports of gastropod predation on Mediterranean deep-water corals due to: (1) the relative paucity of deep-water corals living in this basin, (2) the rarity of most coral-associated gastropod taxa, and (3) the inherent difficulties in imaging or sampling these deep-water habitats.

Maltese, Italian, and German oceanographic cruises (Figure 1), sampled three rare deep-water Coralliophilinae at deep-water coral (**dwc**) sites in the Strait of Sicily: '*Coralliophila richardi*' (Fischer P., 1882), *Babelomurex sentix* (Bayer, 1971), and '*Coralliophila squamosa*' (Bivona Ant. in Bivona And., 1838: morphotype better known as *Pseudomurex ruderatus* Sturany, 1896) respectively. The present report documents these findings (Table 1).

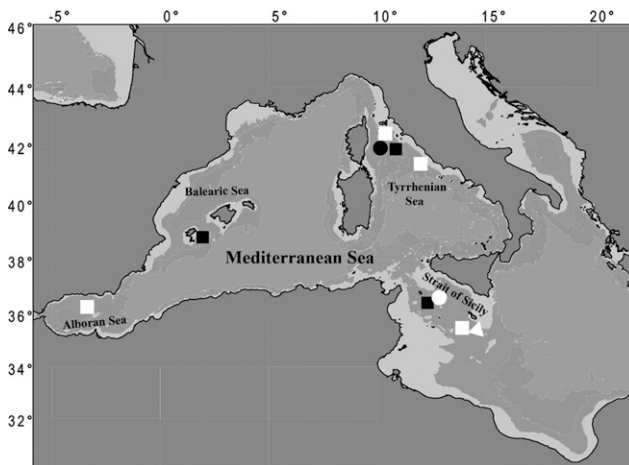
## CORALLIOPHILINES FROM MEDITERRANEAN DEEP-WATER CORAL SITES

'*Coralliophila richardi*' (Fischer P., 1882)

*Murex richardi* Fischer P., 1882: 49

*Coralliophila lactuca* Dall, 1889: 220, pl. 16, fig. 6

*Coralliophila richardi*.—Bouchet and Warén, 1985: 152, fig. 368



**Figure 1.** Map showing station localities discussed in this report. Symbols: □, live *Coralliophila richardi* (from literature and this paper); ■, subfossil *C. richardi* (from literature and this paper); △, *Babelomurex sentix*; ○, *Coralliophila squamosa* (morphotype *runderatus*); ●, subfossil *Coralliophila* cf. *squamosa* (morphotype *runderatus*).

**Remarks:** Two living specimens of *Coralliophila richardi* (Figures 2–6) were trawled from *Lophelia-Madrepora* coral banks off Malta during the GRUND 2003 mission (see Schembri et al., 2007). Additional pre-modern material (Figures 7–9; most likely glacial Pleistocene fossils) was collected over many decades of sampling during the CNR-Bologna oceanographic missions of the research vessels BANNOCK (see Bouchet and Warén, 1985; Taviani and Taviani, 1986) and URANIA (this study).

*Coralliophila richardi* (described from the Bay of Biscay) is the senior synonym of *Coralliophila lactuca* Dall, 1889 (from off Cuba and Fernandina, Florida in the Western Atlantic; Bouchet and Warén, 1985; Taviani and Taviani, 1986). This amphi-Atlantic species is now known from various sites in the eastern Atlantic Ocean (Rolan and Pedrosa, 1981; Oliverio and Gofas, 2006) and has been reported living in the Tyrrhenian and

Alboran Seas (Cecalupo, 1984; Oliverio, 1989; Giusti, 1996; Giannuzzi-Savelli et al., 2003). It also occurs as an Early Pleistocene fossil in deep-water deposits of presumed Sicilian age in southern Italy (Vazzana, 1996).

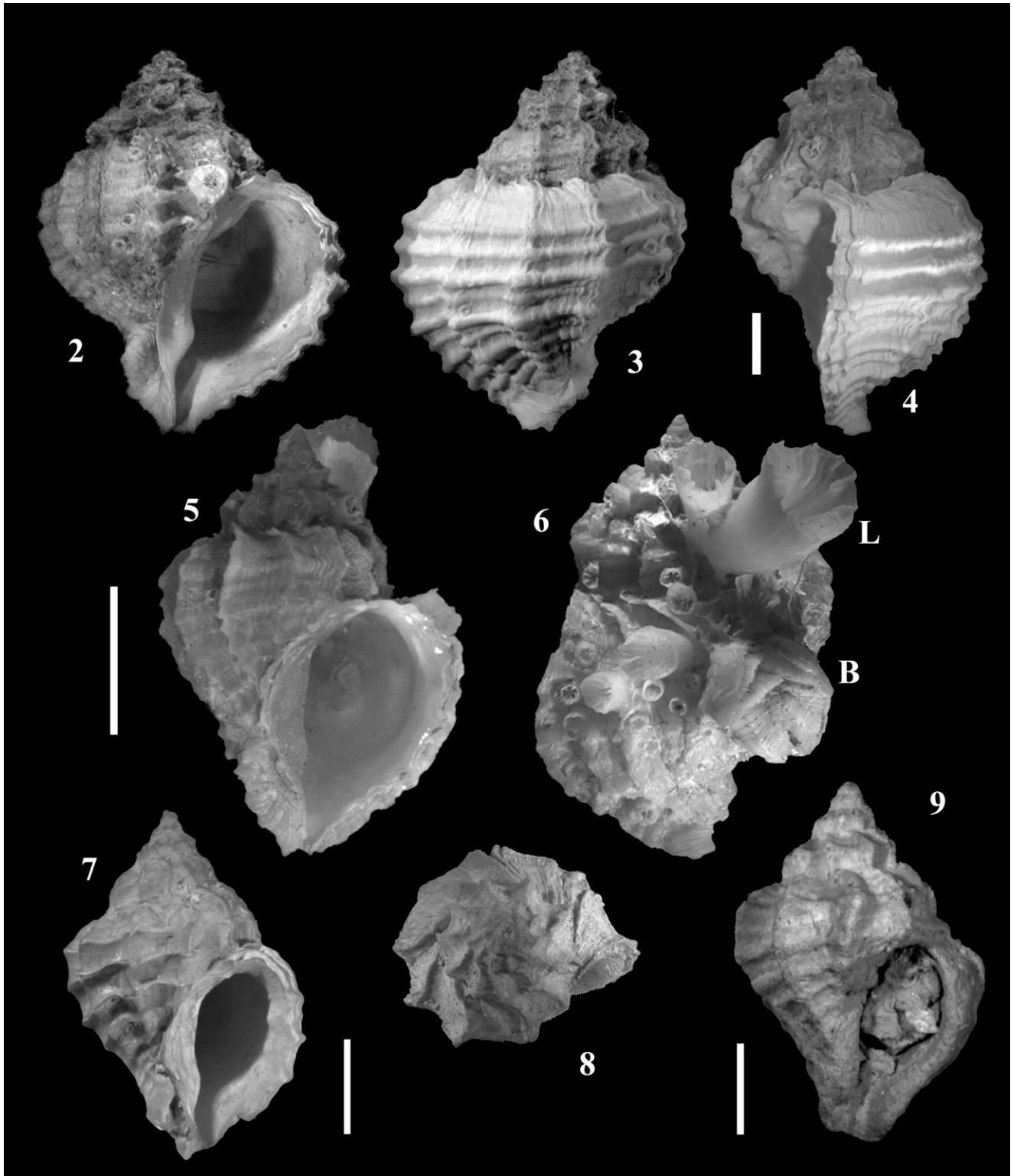
The taxonomic affinities of *Coralliophila richardi* are obscure. The shell morphology of this species is unusual within the subfamily Coralliophilinae, and is shared only with *Emozamia licinus* (Hedley and Petterd, 1906), a deep-water, western Pacific species. Genetic studies of Mediterranean (this material) and Atlantic specimens will certainly elucidate the taxonomy of this group.

The consistent co-occurrence of *Coralliophila richardi* with the scleractinians *Lophelia* and *Madrepora* in Recent and pre-modern assemblages has led to the suggestion that this taxon is likely a predator of one or both corals (e.g., Taviani and Colantoni, 1979). The regularly arched shape and dimension of the shell aperture of *C. richardi* seem well adapted for a sedentary position on a branching stony coral colony such as those of *Madrepora* or *Lophelia*.

This hypothesis is supported by the co-occurrence of live *Lophelia*, *Madrepora*, and *C. richardi* off Malta, the latter fouled by juvenile *Lophelia* corals (Figures 5–6). Information from Atlantic Ocean specimens further supports the hypothesis of a strict relationship between *C. richardi* and branching deep-water corals. A specimen was photographed still adhering to the surface of living *Lophelia* on the Galicia Bank (Figure 19) (42°48.37' N, 11°47.47' W, 880 m depth). *Coralliophila richardi* has also been reported from various seamounts in the eastern Atlantic (Oliverio and Gofas, 2006), where it co-occurs with living or dead coral (mostly *Madrepora*: Gofas, unpublished notes, and M.T., unpublished notes). In the western Atlantic, three live specimens of *C. richardi* were collected with living corals on a *Lophelia* lithoherm (peak # 160) off St. Augustine, Florida (29°50.9726' N, 79°37.5976' W, in 871–746 m, bottom temperature 7.96°C; salinity 35.1) during dive JSL-I-4912 (Chief Scientist J. Reed), 11 Nov. 2005.

**Table 1.** Main attributes of stations yielding the Mediterranean coralliophilines discussed in the text.

Cruise	Sample no.	Area	Start Long. N	Start Lat. E	Start Depth (m)	End Long N	End Lat E	End Depth (m)	Species
CS73	7	Nameless Urania Bank	36°53.600'	13°06.300'	695	36°51.800'	13°06.300'	410	<i>Coralliophila richardi</i>
ET95	D21	Tuscan Archip.	43°18.850'	09°48.920'	582	43°19.450'	09°49.080'	515	<i>C. richardi</i>
GRUND2003	G19	Malta	35°30.47'	14°06.27'	617	35°30.830'	14°06.020'	420	<i>C. richardi</i>
MARCOS	MS43	Malta	35°30.720'	14°06.561'	607	35°30.803'	14°06.511'	452	<i>Babelomurex sentix</i>
MARCOS	MS44	Malta	35°30.506'	14°06.230'	632	35°31.228'	14°05.698'	467	<i>B. sentix</i>
CORTI	CORTI71	Tuscan Archipelago	43°13.505'	09°36.326'	369	43°13.682'	09°36.260'	399	<i>Coralliophila squamosa</i> (morphotype <i>runderatus</i> )
M70-1	677	Nameless Urania Bank	36°50.340'	13°09.300'	544	36°50.340'	13°09.390'	388	<i>C. squamosa</i> (morphotype <i>runderatus</i> )



**Figures 2–9.** *Coralliophila richardi*. **2–6.** Living *Coralliophila richardi* from Malta coral banks (st. GRUND 2003-G19). **2–4.** Sinuous outer lip accommodates settlement on coral branch. Scale bar = 1 cm. **5–6.** Fouling by scleractinian corals (e.g., *Lophelia pertusa*: A, Vertino, pers. comm., 2008) and barnacles. Scale bar = 1 cm. **7–9.** Specimens from Pleistocene submerged assemblages. **7–8.** Strait of Sicily (Station CS73-7). Scale bar = 1 cm. **9.** Tuscan Archipelago (Station ET95-D21). Scale bar = 1 cm.

*Coralliophila richardi* also occurs in the Gulf of Mexico on live deep-water coral banks. Norem et al. (2008: pl. 27B) illustrated two specimens of *C. richardi* (identified as the shallow-water *C. abbreviata* (Lamarck, 1816)), on live coral from the *Lophelia* banks of the Viosca Knoll in circa 315 m depth (dive JSL 4747).

*Babelomurex sentix* (Bayer, 1971)

*Coralliophila sentix* Bayer, 1971: 189, fig. 49

*Latiaxis sentix carcassii* Nicolay and Angioy, 1985: 16–18

**Remarks:** *Babelomurex sentix* (originally described from east of St. Vincent, Lesser Antilles) is a rare amphiatlantic species seldom found alive (Bayer, 1971; Oliverio and Gofas, 2006). There are a few scattered records from the western basin of the Mediterranean Sea off Sardinia, Melilla, and Alboran. Within this basin, fresh shells, including some with operculum, document that this species has been found alive in the Mediterranean more than once (Nikolay and Angioy, 1985: as *Latiaxis sentix carcassii*; Oliverio, 1989; Giannuzzi-Savelli et al., 2003).

Two living specimens (Figures 10–12) and one shell of *Babelomurex sentix* were trawled from south of Malta from coral banks dominated by adult *Lophelia*, *Madrepora*, and *Desmophyllum* and small colonies of *Coralium* in 2007 during the MARCOS cruise (Chief Scientist Marco Taviani). The animals were kept alive in the aquarium onboard the ship for a week and were quite active, thus permitting a full documentation of

their expanded soft parts (Figures 18–20). Its presumed association with white corals (Oliverio, 1989) is only based on indirect evidence.

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

*Fusus squamosus* Bivona Ant. in Bivona And., 1838: 14; fig. 22

*Murex aluoides* Blainville, 1829: 128; pl. 5B fig. 1 (non *Murex aluoides* Olivi 1792)

*Fusus lamellosus* Philippi, 1836 [ex de Cristofori and Jan ms.]; 204–205, pl. 11 fig. 30 (non *Fusus lamellosus* Borsson 1821)

*Fusus squamulosus* Philippi, 1836: 204, pl. 11 fig. 31 (non *Fusus squamulosus* Deshayes, 1835)

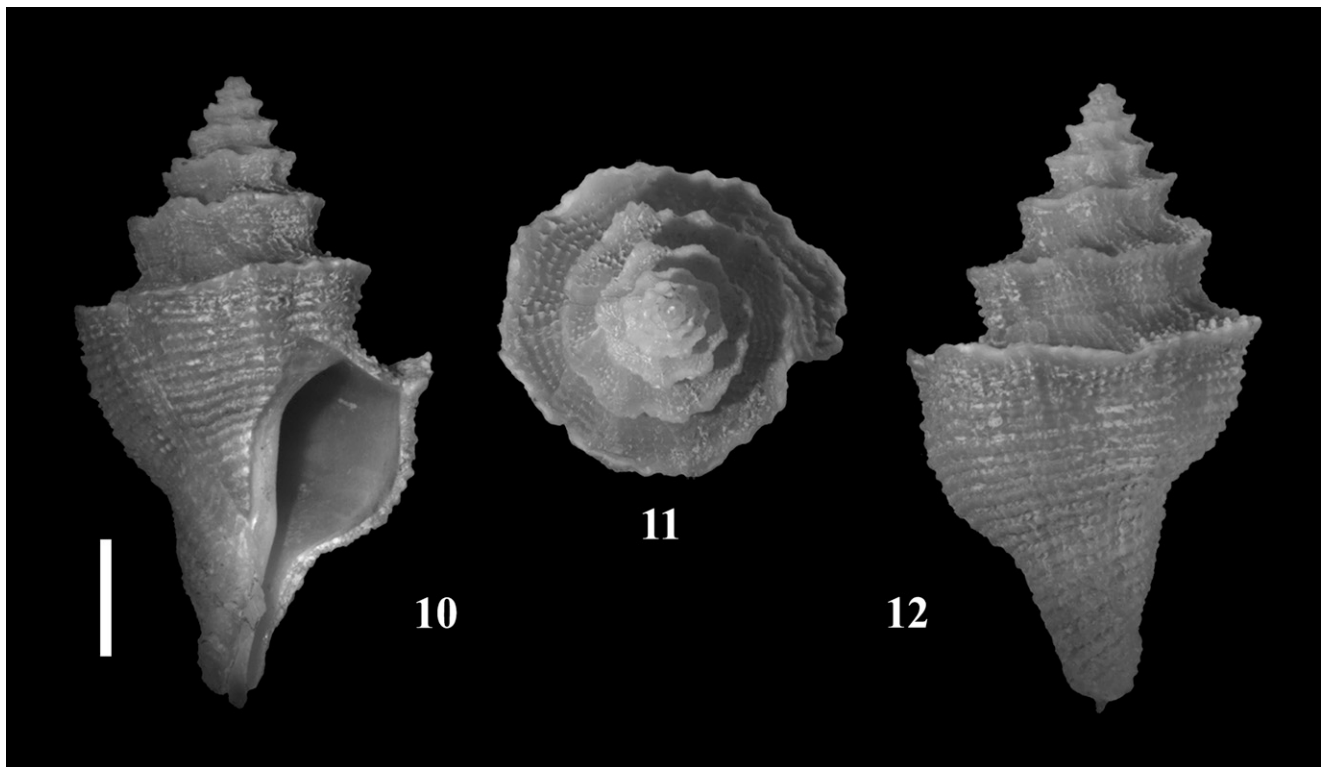
? *Pseudomurex perfectus* Fischer P., 1883: 274

? *Pseudomurex ruderatus* Sturany, 1896 [ex Monterosato ms.]; 26, pl. 2 fig. 42–43

? *Pseudomurex monterosatoi* Locard, 1897: 315, pl. 15 fig. 21–23

**Remarks:** ‘*Coralliophila*’ *squamosa* (originally described from Sicily, but currently with a neotype from Corsica: Bouchet and Waren, 1985), is a relatively common and widespread taxon known throughout the Mediterranean Sea. It is presumed to be associated with gorgonians, and, on the deeper continental shelf, with scleractinians (Oliverio, 1989), although there is no direct evidence for this.

F10–12



**Figures 10–12.** Living specimens of *Babelomurex sentix* collected from Malta deep-water coral banks during the MARCOS cruise (Station MS43). Scale bar = 1 cm.

A plausible association of *C. squamosa*, recorded as larger and smoother morphotypes of *Coralliophila lamellosa* (de Cristofori and Jan, 1832), with Mediterranean deep-water corals was reported by Taviani and Colantoni (1979). These shells are included in *Pseudomurex ruderatus* (Sturany, 1896). *Pseudomurex ruderatus* may represent a deep-water morphotype of the variable Atlantic-Mediterranean '*Coralliophila*' *squamosa* and their mutual relationships will be elucidated by an on-going genetic study.

A single live individual of '*Coralliophila*' *squamosa* (morphotype *ruderatus*: Figures 13–14) has been photographed and then collected using the MARUM ROV QUEST 4000 M during cruise M70-1 of R/V METEOR (Chief Scientist A. Freiwald). A single living specimen (Figure 17) was found on the volcanic bedrock at circa 500 m off the Nameless-Urania Bank, Strait of Sicily. The ROV images document a variety of co-occurring cnidarians at this site including *Lophelia*, *Madrepora*, *Desmophyllum*, *Corallium*, as well as antipatharians and gorgonians. Other empty shells collected from various deep-water sites in the Mediterranean basin may also belong to this elusive taxon (Figure 15).

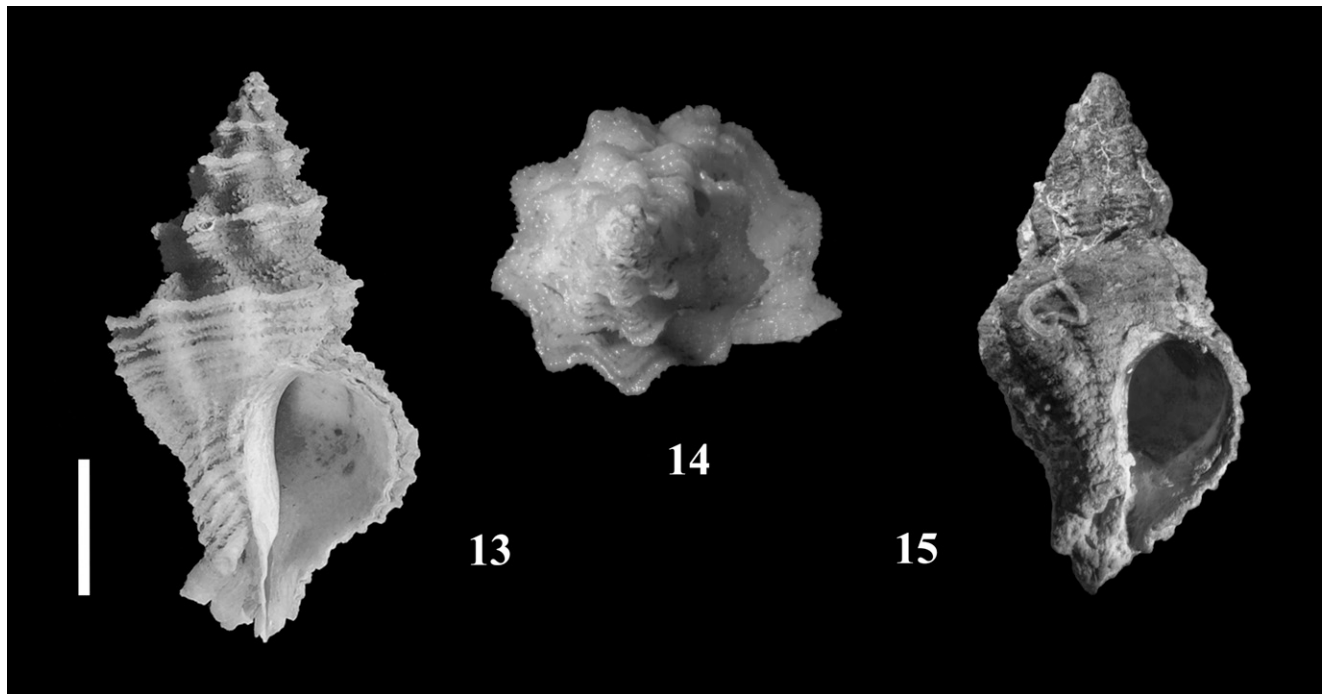
## CONCLUSIONS

Of the coralliophilines associated with deep-water coral banks, *Coralliophila richardi* is strictly associated with *Lophelia* and very likely with *Madrepora*. *Babelomurex*

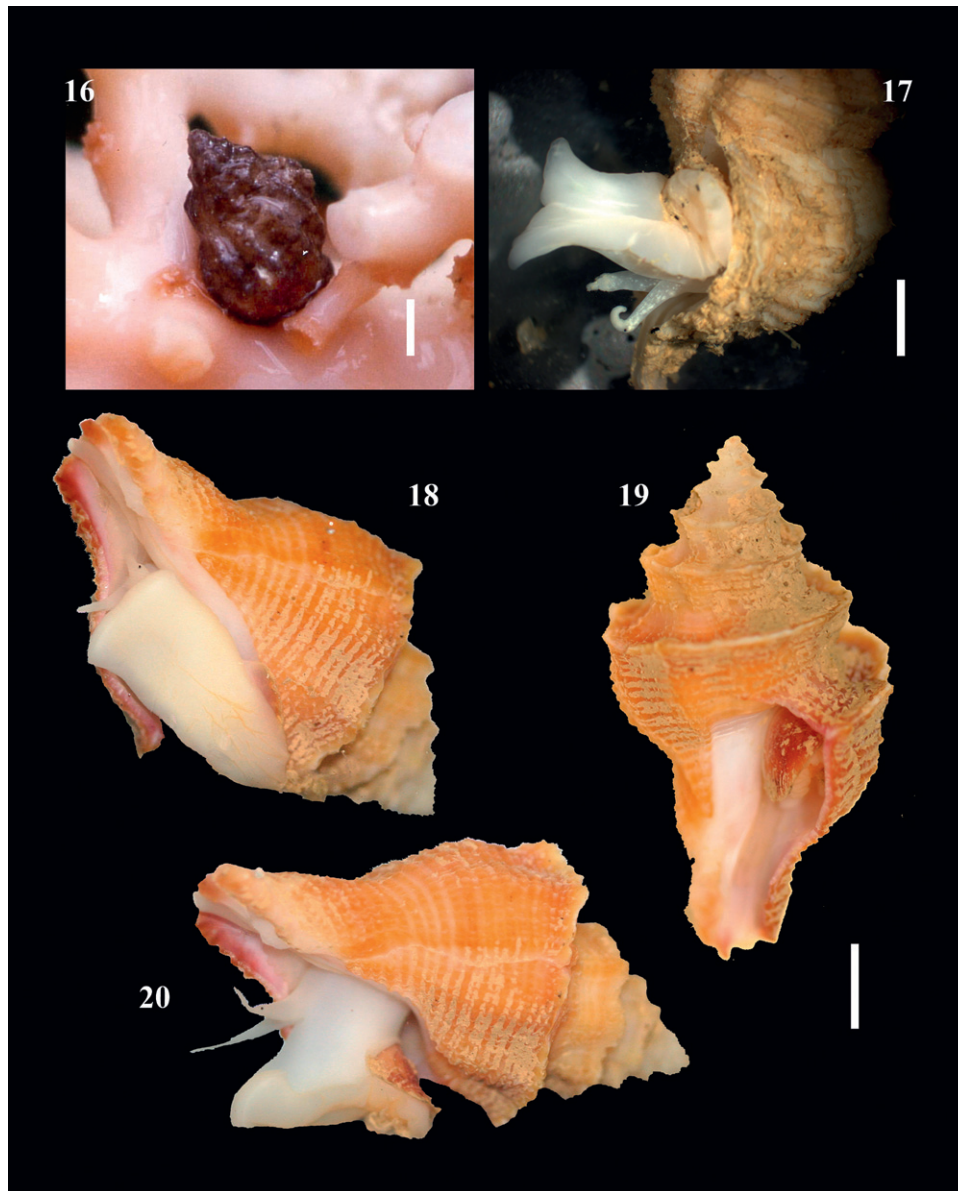
*sentix* and *C. squamosa* (morphotype *ruderatus*) seem confined to deep water coral banks, but their precise hosts have yet to be identified. The supraspecific position of these three bathyal coralliophilines is still unclear.

Recent collections of living specimens of these rare Coralliophilinae have provided material for molecular systematic studies, as well as for determination of their host cnidarians through DNA barcoding of their gut contents (Oliverio and Mariottini, 2001; Oliverio *et al.*, 2009).

The biogeography of these very rare coralliophilines merits attention. For all three species, connections between Mediterranean and Atlantic populations may be linked to their supposedly teleplanic larvae. All three species (*C. squamosa*, *C. richardi*, and *B. sentix*) have established populations in the Atlantic Ocean. Their planktotrophic larvae may have been passively dispersed into the Mediterranean by currents. This may have led to the establishment of viable populations in this basin (as it is certainly the case for *C. squamosa*) although the possibility of non-reproductive pseudo-populations (Bouchet and Taviani, 1992) can not be ruled out. However, *Coralliophila squamosa* is not uncommon (with its typical morphotypes) in shallower waters throughout its range, and the rarity of its putative deep-water morphotype *ruderatus* may be related to sampling difficulties. *Coralliophila richardi* is known from multiple sites in the western Mediterranean and this suggests a status of permanent resident in the basin, also supported by its prolonged, albeit not necessarily continuous, presence in this basin since the Early Pleistocene. Records of



**Figures 13–15.** *Coralliophila*' *squamosa* (morphotype *ruderatus*). **13–14.** Live-collected specimen from the Nameless-Urania bank, Strait of Sicily, Station M70/1-677. **15.** Shell from a Pleistocene submerged assemblage, Tuscan Archipelago, Station CORTI-71. Scale bar = 1 cm.



**Figures 16–20.** Living *Coralliophila richardi*. **16.** Live specimen on living *Lophelia pertusa*, Galicia Bank. Scale bar = 3 mm. **17.** *In situ* photograph of '*Coralliophila squamosa*' (morphotype *ruderatus*) recovered from the Nameless-Urania Bank (Station. M70/1-677). Scale bar = 5 mm. **18–20.** *Babelomurex sentix* with extended soft parts, collected during the MARCOS cruise. **18, 20.** Adult specimen from StationMS44. **19.** Immature specimen from Station MS43. Scale bar = 1cm.

*B. sentix* in the Mediterranean Sea are scanty. Further evidence is needed for us to demonstrate the presence of permanent populations in the region.

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