AUTHOR QUERIES

DATE 8/17/2009
JOB NAME NAUTI
ARTICLE 0917
QUERIES FOR AUTHOR Marco Taviani et al.

THIS QUERY FORM MUST BE RETURNED WITH ALL PROOFS FOR CORRECTIONS
Coralliophilinae (Gastropoda: Muricidae) associated with deep-water coral banks in the Mediterranean

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.

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 callieti (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
(Figures 2–6) were trawled from CORTI CORSICATUSCORNUTUS Malta 35-13.505 06.320 18.850 51.800
MARCOS MS43 Malta 35-13.505 06.320 18.850 51.800
EM85 G19 Malta 35-13.505 06.320 18.850 51.800
CORTI CS73 CS73 7 NamelessUrania Bank 36°53.600' 13°06.300' 695 36°51.800' 13°06.300' 410 C. richardi
ET95 ET95 D21 Tuscan Archip. 43°18.840' 09°48.920' 582 43°19.710' 09°49.000' 515 B. sentix
GRUND2003 MARCAS MARCAS MS44 Malta 35°30.506' 14°06.230' 632 35°31.228' 14°05.698' 457 B. sentix
End Long. E
End Depth (m)
Species
Coralliophila richardi
Coralliophila squamosa (morphotype ruderatus)
C. richardi
B. sentix
C. squamosa (morphotype ruderatus)
C. richardi
B. sentix
C. squamosa (morphotype ruderatus)

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: Bouche 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 Eminia 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 lithothem (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.

<table>
<thead>
<tr>
<th>Cruise</th>
<th>Sample no.</th>
<th>Area</th>
<th>Start Long. N</th>
<th>Start Lat. E</th>
<th>Start Depth (m)</th>
<th>End Long. N</th>
<th>End Lat. E</th>
<th>End Depth (m)</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS73</td>
<td>7</td>
<td>Nameless URNA Bank</td>
<td>36°53.600'</td>
<td>13°06.300'</td>
<td>695</td>
<td>36°51.800'</td>
<td>13°06.300'</td>
<td>410</td>
<td>Coralliophila richardi</td>
</tr>
<tr>
<td>ET95</td>
<td>D21</td>
<td>Tuscan Archip.</td>
<td>43°18.840'</td>
<td>09°48.920'</td>
<td>582</td>
<td>43°19.710'</td>
<td>09°49.000'</td>
<td>515</td>
<td>B. sentix</td>
</tr>
<tr>
<td>GRUND2003</td>
<td>G19</td>
<td>Malta</td>
<td>35°30.47'</td>
<td>14°06.27'</td>
<td>617</td>
<td>35°30.830'</td>
<td>14°06.020'</td>
<td>420</td>
<td>C. richardi</td>
</tr>
<tr>
<td>MARCAS</td>
<td>MS44</td>
<td>Malta</td>
<td>35°30.720'</td>
<td>14°06.561'</td>
<td>607</td>
<td>35°30.903'</td>
<td>14°06.511'</td>
<td>457</td>
<td>B. sentix</td>
</tr>
<tr>
<td>CORTI</td>
<td>CORT171</td>
<td>Tuscan Archipelago</td>
<td>43°13.505'</td>
<td>09°36.326'</td>
<td>369</td>
<td>43°13.682'</td>
<td>09°36.260'</td>
<td>399</td>
<td>C. squamosa (morphotype ruderatus)</td>
</tr>
<tr>
<td>M70-1</td>
<td>677</td>
<td>Nameless URNA Bank</td>
<td>36°50.340'</td>
<td>13°09.300'</td>
<td>544</td>
<td>36°50.340'</td>
<td>13°09.390'</td>
<td>388</td>
<td>C. squamosa (morphotype ruderatus)</td>
</tr>
</tbody>
</table>
**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)

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

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

**Remarks:** *Babelomurex sentix* (originally described from east of St. Vincent, Lesser Antilles) is a rare Atlantic 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 Angioly, 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 alucoides* Blainville, 1829: 128; pl. 5B fig. 1 (non *Murex alucoides* Olivi 1792)

*Fusus lamellosus* Philippi, 1836 [ex de Cristofori and Jamnitz: 204–205, pl. 11 fig. 30 (non *Fusus lamellosus* Born 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.

---

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

ACKNOWLEDGMENTS

For their cooperation, we are grateful to Captains, crew, and scientific staff of R/V URANIA during the MARCOS cruise, of R/V VICTOR HENSEN cruise VH-97, and R/V MÉTEOR cruise M70/1 for their cooperation. Lydia Beuck, GZN-Erlangen, assisted with GIS positioning and archiving of M70/1 data. Gianluca Bini and Alessandro Ceregato helped with samples and bibliography. Partial funding provided by FP-VI Integrated Project HERMES (GOCE-CT-2005-511234-1) and HERMIONE of the European Commission and by BIOCORAL grant (Ministry of Environment of Italy). This is ISMAR-CNR scientific contribution no. 1633.

LITERATURE CITED

Bayer, F. M. 1971. Biological results of the University of Miami Deep-Sea expeditions. 79. New and unusual mollusks collected by R/V JOHN ELLIOTT PILLSBURY and R/V Gerda in


