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**MONOGRAPH**

# First assessment of the vermetid reefs along the coasts of Favignana Island (Southern Tyrrhenian Sea)

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**ABSTRACT** Intertidal vermetid reefs, particularly vulnerable to environmental changes and human activities, are now experiencing high mortality in several areas of the Mediterranean Sea. Since the increase of knowledge on this habitat is important for conservation purposes, we provide a first baseline assessment of the vermetid reefs along the coasts of the Favignana Island (Marine Protected Area "Egadi Islands"). Preliminary results showed the presence of a true reef, similar to a fringing reef, displaying at least three local patterns, distinguishable for width (from 2.3 to 15.5 m), height of the outer and of the inner margin (from 5.6 to 18 cm and from 8.3 to 26 cm, respectively) and number, width and depth of cuvettes. Moreover, significant differences in topographic complexity among the areas were evidenced whereas no correlation between coastal exposure and topographic complexity was found.

**KEY WORDS** Bioconstruction; Favignana Island; habitat and topographic complexity; vermetid reef.

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## INTRODUCTION

Vermetid reefs are bioconstructions built up by the gastropod mollusc *Dendropoma petraeum* (Monterosato, 1884) in association with some coralline algae such as *Neogoniolithon brassica-florida* (Harvey) Setchell & Mason. These bioconstructions are unique and highly diverse systems that play a fundamental structural role, as they protect coasts from erosion, regulate sediment transport and accumulation, serve as carbon sinks, make the habitat more complex and heterogeneous and provide numerous habitats for animal and vegetal species thus increasing intertidal biodiversity (Pandolfo et al., 1992; Pandolfo et al., 1996; Badalamenti et al., 1998). In the Mediterranean Sea their distribution is restricted to the warmest part of the basin with the largest formations generally found off the coasts of Israel and Lebanon, but they have also been reported in Turkey, Crete, continental Spain and Baleari Islands, Algeria, Morocco, along Maltese and Italian shores (Pérès & Picard, 1952; Molinier & Picard, 1953; Molinier, 1955; Safriel, 1975; Boudouresque & Cinelli, 1976; Dalongeville, 1977; Kelletat, 1979; Richards, 1983; Laborel, 1987; Azzopardi, 1992; Garcia-Raso et al., 1992; Templado et al., 1992; Bitar & Bitar-Kouli, 1995a, 1955b; Azzopardi & Schembri, 1997).

In Sicily, large and more or less continuous vermetid reefs are present along the north/northwestern

coasts between Zafferano Cape and Trapani and within the Marine Protected Area (MPA) "Egadi Islands" (Chemello, 1989; Chemello et al., 1990a, 1990b; Badalamenti et al., 1992a, 1992b; Chemello et al., 2000; Dieli et al., 2001; Chemello, 2009). Isolated reefs are found at Milazzo Cape and only small reefs are found around Taormina and Syracuse, on the eastern coast of Sicily, and on the Islands of Lampedusa and Ustica, that represent the limit of distribution respectively on the south and on the north of the Sicilian coasts (Chemello et al., 1990a; Chemello et al., 2000; Dieli et al., 2001; Consoli et al., 2008; Chemello, 2009). These biogenic constructions, enclosed in the SPA/BIO Protocol (Barcelona Convention) are now threatened by environmental changes and human activities (e.g. pollution, climate change, ocean acidification) thus experiencing high mortality in several areas of the Mediterranean Sea (Di Franco et al., 2011; Galil, 2013; Milazzo et al., 2014).

Due to the high vulnerability of these habitats, action plans for their conservation should be a priority. We know that the increase of knowledge is essential for the conservation and protection of this highly valuable habitat. Since only a low percentage of Sicilian vermetid reefs are subjected to conservation and many of them are not yet investigated (Chemello, 2009; Chemello & Silenzi, 2011), with this study we provide a first baseline assessment of the vermetid reefs present along the coasts of Favignana Island (MPA "Egadi Islands").

The aims of the present study were: i) to provide a first description of the reef typology and ii) to test the effect of the coastal exposure on the topographic complexity of the reefs.

## MATERIAL AND METHODS

### *Study area*

The study was carried out at Favignana Island (MPA "Egadi Islands"), located approximately five kilometers from the west coast of Sicily. The Island, part of the Aegadian Archipelago, represent an example of a lower Pleistocene bioclastic calcarenite, characterized by a typic association known as foramol (Kil, 2010). The west side is characterized by the presence of the calcareous Monte Santa Caterina (300 metres high), flanked by areas with lower relief. The mechanical and chemical erosion

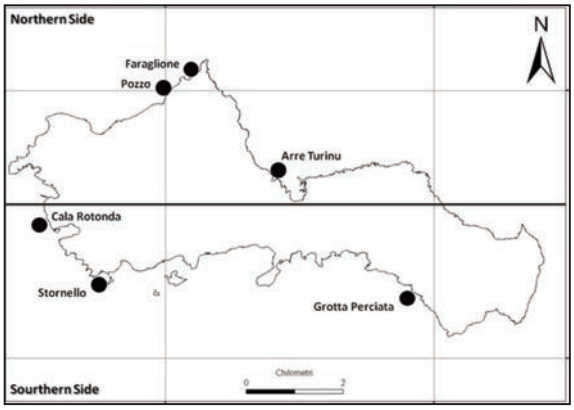



Figure 1. Location of the study areas: Favignana Island.

produced detritic deposits that partially mask the abrasion platform. The eastern side of the mountain shows a high cliff in the northern part, that gradually dips to the south. The coastline is highly rugged and not very high. The south dipping surface might be the result of either depositional or erosional processes. From a geological point of view, two main tectonic units can be recognized: the Monte Santa Caterina and the Punta Faraglione.

### *Vermetid reef analysis*

A preliminary survey allowed us to locate six study areas characterized by the presence of a vermetid reef: Faraglione, Pozzo, Arre Turinu, Grotta Perciata, Cala Rotonda and Stornello (Fig. 1).

The areas were chosen in such a way to also test the effects of the coastal exposure on the vermetid reef topographic complexity. Three along the northern side: Faraglione, Pozzo and Arre Turinu, and three along the southern side: Grotta Perciata, Cala Rotonda and Stornello. In each area the reef topographic complexity was measured using a 1m x 1m quadrat (three random replicates). The 4 sides and the 2 diagonals of the quadrat were measured using a meter with a resolution of 0.01m. Topographic complexity was calculated as the ratio between the registered measures (real measure, Xi) and the known measures of the used quadrat (Xn): Xi/Xn (Graziano et al., 2009 ).

The more the ratio is far from 1, the more complex is the substrate. To describe the reef typology the following variables were considered: the reef width from the inshore towards the open sea (measured using a meter with a resolution of 0.01m), the height of the inner and the outer margin and the slopes of the margins (measured using a goniometer).

### *Data analysis*

Differences in reef topographic complexity were analysed using permutational multivariate analysis of variance (PERMANOVA, Anderson, 2001). For the topographic complexity, the design consisted of three factors: Coastal exposure (Sd; two levels, fixed factor), Area (Ar; three levels, random, nested in Sd) and Site (St; three levels, random, nested in ArxSd). All multivariate analyses were based on Bray-Curtis dissimilarities of log(x + 1) transformed data and each term in the analyses was tested using 9999 random permutations of the appropriate units. The analyses were performed using the software package PRIMER 6 (Clarke & Gorley, 2006).

## RESULTS

### *Reef typology*

All the vermetid reefs are consistent with a true reef (according to Antonioli et al., 1999), displaying at least three local patterns, distinguishable for width, height of the outer and of the inner margin and number, width and depth of cuvettes. A description of the different patterns are reported below.

Pattern 1: Pozzo and Faraglione (northern side, Figs. 2–5).

OUTER MARGIN: wide, flattened and irregular. In the inner side, crevices were also present. Sometimes at Faraglione are present two outer margins. INNER MARGIN: *Dendropoma petraeum* is absent. CUVETTES: not many, not deep and with a variable width. At Faraglione they are mainly present near the outer margin. At Pozzo some of them are fullfilled of sediment.

| Study Areas | Width (m) | Height of the inner margin (cm) | Height of the outer margin (cm) | Slope of the inner margin (°) | Slope of the outer margin (°) |
|---|---|---|---|---|---|
| **Faraglione** | 7.03 ± 0.23 | 8.66 ± 0.23 | 18 ± 0.23 | 38.3 ± 0.23 | 45 ± 0.23 |
| **Pozzo** | 15.46 ± 0.23 | 17.33 ± 0.23 | 15.33 ± 0.23 | 45 ± 0.23 | 45 ± 0.23 |

Pattern 2: Grotta Perciata and Stornello (southern side, Figs. 6–9).

OUTER MARGIN: thin and not continuously arranged. INNER MARGIN: *Dendropoma petraeum* is absent. CUVETTES: not many and not deep.

| Study Areas | Width (m) | Height of the inner margin (cm) | Height of the outer margin (cm) | Slope of the inner margin (°) | Slope of the outer margin (°) |
|---|---|---|---|---|---|
| **Grotta Perciata** | 7.31 ± 0.23 | 10.33 ± 0.23 | 15.66 ± 0.23 | 27.5 ± 0.23 | 42.5 ± 0.23 |
| **Stornello** | 5.10 ± 0.23 | 8.33 ± 0.23 | 8 ± 0.23 | 33.3 ± 0.23 | 29.16 ± 0.23 |

Pattern 3: Arre Turinu (northern side) and Cala Rotonda (southern side, Figs. 10–13).

The reef is damaged. OUTER MARGIN: it has a variable height and sometimes it is absent. Some crevices can also be present together with regrowth areas. INNER MARGIN: *Dendropoma petraeum* is absent. CUVETTES: many and sometimes very deep.

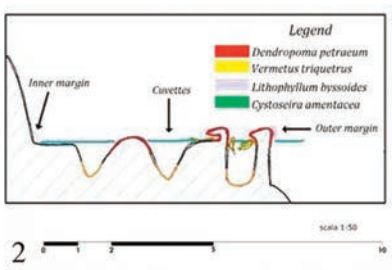
| Study Areas | Width (m) | Height of the inner margin (cm) | Height of the outer margin (cm) | Slope of the inner margin (°) | Slope of the outer margin (°) |
|---|---|---|---|---|---|
| **Arre Turinu** | 6.38 ± 0.23 | 26 ± 0.23 | 17 ± 0.23 | 26.6 ± 0.23 | 45 ± 0.23 |
| **Cala Rotonda** | 2.30 ± 0.23 | 12 ± 0.23 | 7.6 ± 0.23 | 41.6 ± 0.23 | 38.3 ± 0.23 |

### *Reef topographic complexity*

The PERMANOVA on the reef topographic complexity provided an evidence of significant differences in topographic complexity among the areas whereas no differences were recorded between the two coastal exposures (Fig. 14; Table 1).

| Source | df | SS | MS | Pseudo-F | P(MC) |
|---|---|---|---|---|---|
| **Sd** | 1 | 8627 | 8627 | 0.349 | 0.771 |
| **Ar(Sd)** | 4 | 98876 | 24719 | 9.1486 | 0.0001 |
| **St [Ar (Sd)]** | 12 | 32423 | 2701.9 | 1.8084 | 0.0098 |
| **Res** | 36 | 53789 | 1494.1 | | |
| **Total** | 53 | 1.9372E5 | | | |

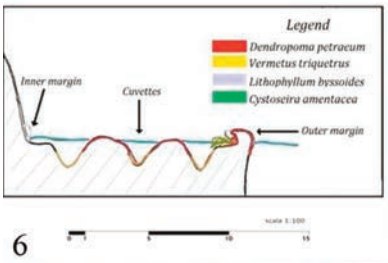
Table 1. PERMANOVA on the topographic complexity data.







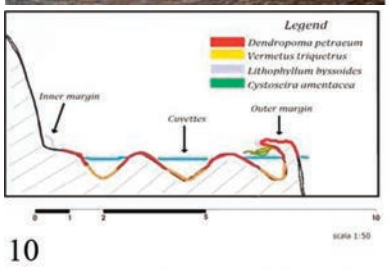
Figures 2–5. Scheme of the pattern 1 (Fig. 2), Faraglione (Fig. 3), Pozzo (Fig. 4), Pozzo: outer margin (Fig. 5).







Figures 6–9. Scheme of the pattern 2 (Fig. 6), Grotta Perciata (Fig. 7), Stornello (Fig. 8), Grotta Perciata: outer margin (Fig. 9).







Figures 10–13. Scheme of the pattern 3 (Fig. 10), Arre Turinu (Fig. 11), Cala Rotonda (Fig. 12), Arre Turinu: outer margin (Fig. 13).

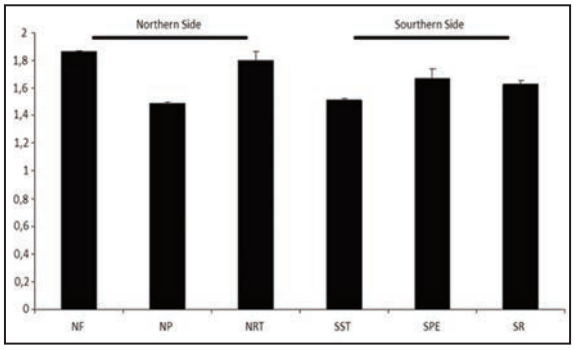



Figure 14. Topographic complexity in the studied areas.

## DISCUSSION AND CONCLUSION

The vermetid reefs along the coasts of Favignana are consistent with a true reef described along the north-western Sicilian coasts (Antonioli et al., 1999). The reef distribution around Favignana confirms the need of carbonatic substrates and of an abrasion platform for the formation of true reefs (Dieli et al., 2001). All the reefs are characterized, along a transect from the inshore towards the open sea, by the tipical patches recognized for other Sicilian reefs (Chemello et al., 2000; Dieli et al., 2001). The reefs width were in agreement with the values reported for other Sicilian reefs whereas the height values were lower (Dieli et al., 2001). Some differences were highlighted locally in the considered variables, in particular in the margins, in the depth and in the number of cuvettes. Data on topographic complexity showed significant differences among the areas (small scale) but no relationship between the coastal exposure (large scale) and the reef topographic complexity was evidenced.

Vermetid reefs play an important role as modulators of morphological coastal processes and as ecological “engineers”, making the habitat more complex and tridimensional and promoting marine biodiversity (Pandolfo et al., 1996; Chemello et al., 2000; Bressan et al., 2009). Therefore, much more attention should be paid to the study of the reef morphology and distribution together with the associated communities and the trophic processes within associated species.

Moreover, since the easy accessibility of vermetid reef makes it highly vulnerable to coastal human activity (Franzitta et al., 2006; Graziano et al., 2007), a correct planning in the areas where reefs are present, in order to minimize all potential environmental threats, should be a priority.

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