UNIVERSITY OF PISA

DEPARTMENT OF BIOLOGY

Ph.D in Biology

TUBE-WORM BIOCONSTRUCTIONS: EXPLORING NOVEL ECOLOGICAL ASPECTS AND BIOTECHNOLOGICAL APPLICATIONS

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ABSTRACT

Biogenic reefs built by tube-forming polychaetes, mainly belonging to the *Sabellaria* genus, provide habitat to diverse associated assemblages and support a range of ecosystem services due to their ability to filter large volumes of water, stabilize sediments and host a wide array of organisms. They are, however, exposed to natural and anthropogenic threats, and are listed among habitats to be protected in EU Directives. Moreover, especially in the Mediterranean Sea, such reefs are poorly studied as little experimental information is available on their stability and ecological processes, and possible biotechnological applications of sabellariid cement proteins. Therefore, they are classified as Data Deficient by the Joint Nature Conservation Committee.

This PhD research aims to fill some of these knowledge gaps through four objectives. The first objective focused on assessing the sensitivity of *Sabellaria alveolata* reefs to multiple disturbances (Chapter 2). A manipulative experiment was carried out to examine the effects of multiple disturbances on the resistance and resilience of the reefs. Specifically, it was tested the different resistance and ability to recover of the bioconstruction after events of physical disturbance depending on their occurrence on intact biogenic patches or patches that were previously subject to increasing levels of damaging. Surprisingly, intermediate levels of disturbance were associated with increased patch sizes, while other structural characteristics remained unchanged. These findings indicate that Mediterranean *S. alveolata* reefs are highly resilient to physical disturbances.

Another concern is about the space competition with other sessile organisms (Chapter 3). Mussels, encrusting algae, and other sessile organisms dominate patches in the study area at the edge of sabellariid bioconstructions. The potential ability of these sessile organisms to limit the expansion of the reef is assessed through a field experiment involving their selective removal at the edge of the bioconstruction and monitoring the subsequent development of the reef in terms of percentage cover and spread rate. Results showed that the most pronounced competitive effects occurred when free space was made available at the start of the *S. alveolata* growth phase, emphasizing the significance of seasonal timing in the interaction between species.

In order to better understand the relationship between patch size and community structure, the third objective explored species-area relationships within *S. alveolata* patches (Chapter 4). Contrary to classical ecological theory, larger patches exhibited lower species richness. Detailed multivariate analyses revealed that larger patches hosted distinct assemblages compared to smaller ones, suggesting that scale-dependent ecological processes are at play in structuring the infaunal communities associated with these biogenic reefs.

Finally, the fourth objective addressed the biotechnological potential of *S. alveolata* mucus, with a particular focus on its capacity to enhance melanin production (Chapter 5). Methanolic extracts from the mucus were tested on murine melanoma cells, where they significantly increased melanin synthesis by upregulating key genes involved in the melanogenesis pathway. These results point to the potential for sabellariid mucus to be applied in dermatological and cosmetic industries, opening new avenues for research into its biotechnological applications.

In summary, this thesis advances our understanding of the ecological dynamics of *S. alveolata* reefs, their resilience to disturbances, and their potential biotechnological value. The findings have important implications for both the conservation of these reefs and the exploration of new medical and cosmetic applications, contributing to broader efforts to protect and restore these valuable marine habitats in the face of increasing environmental pressures.