THE "HIDDEN" BIODIVERSITY: MEDITERRANEAN SPONGES AS UNIQUE HABITATS FOR SYMBIOTIC MICROBIAL COMMUNITIES

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Abstract
Mediterranean sponges are important components of benthic ecosystems in terms of biodiversity, function (i.e. nutrient cycles) and service (e.g., as sources of bioactive compounds). Most of these functions are mediated by ways of symbiosis with complex microbial communities. Sponges and their microbes are vulnerable to environmental as well as climate-related perturbations and have recently experienced episodes of mass mortalities in the Mediterranean Sea. Assessing the natural variability in microbial diversity within and between Mediterranean sponge species and understanding whether the microbiota affects the susceptibility/resistance of the animals to abnormal environmental conditions are key aspects for protecting these interactions.

Keywords: Porifera, Microbiota, Symbiosis, North-Western Mediterranean, Warming

Marine sponges establish symbiosis with a complex consortium of microbes [1,2]. Recent and on-going international efforts to characterize the microbiota of sponges haverevealed a core microbiota in phylogenetically and geographically distant sponges. Furthermore, a sponge-host specific microbial signature was identified, indicating that each sponge species harbors its own distinct microbiome (Fig. 1). To date, few studies have assessed the dynamics of the microbiota in Mediterranean sponges over spatial and temporal scales or how the symbionts respond to stressful environmental conditions.

The results discussed here derive mainly from studies on the sympatric Mediterranean sponges of the genus *Ircinia*: *I. oros*, *I. variabilis* and *I. fasciculata* [3-5]. The host species signature of the symbiotic community is present also in these sympatric closely-related species. Host species specificity of *Ircinia* microbiota is maintained at different locations in the Western Mediterranean Sea (up to 600 km apart) and temporally stable despite seasonality in sea water conditions, as characterized by T-RFLP and Sanger sequencing of 16S rRNA gene. Within the same species, some intraspecific variability was detected, particularly within *I. variabilis* [2]. However, this variation did not mask the species signature.

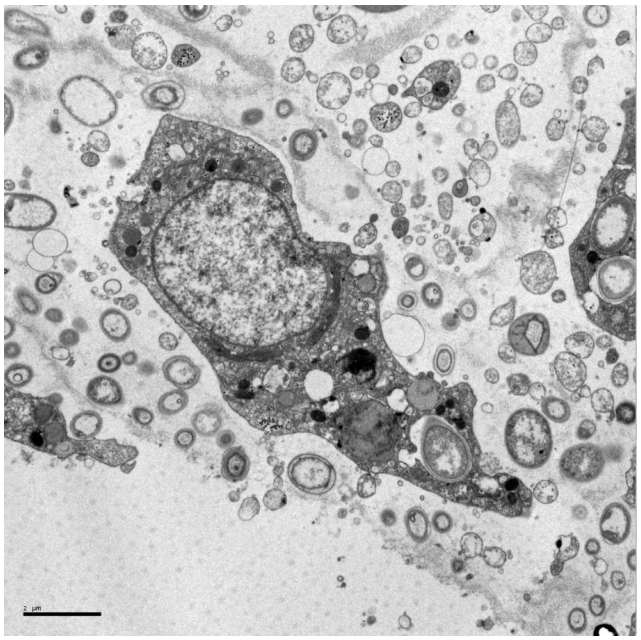

Fig. 1. Electron micrograph of *I. fasciculata* microbiota. Numerous and diverse morphotypes of microbial cells appear in the vicinity of animal host cells.

The recent episodes of mass mortalities in Mediterranean sponges, coinciding withat periods of abnormally warm and long summers (i.e., high temperatures during several weeks and longer period of stratification of seawater column), had different incidences among sympatric species [5]. It can be hypothesized that shifts in symbiotic communities may allow more plasticity and better response of the animals to changing environmental conditions [6], and also serve as early alarm of stress in the sponges. However, experiments in aquaria have shown that under stress-induced conditions in *I. fasciculata* (affected by episodic mortalities) and *I. oros* (unaffected) specimens a significant turnover of sponge microbiota was not detected over one month at the sponge individual level [4]. Symbiotic communities in sponges may thus endure under climate-related perturbations unless sponge health host is already compromised.

With respect to the high microbial diversity in Mediterranean Sea sponges, high-throughput sequencing has shown that each sponge species harbors a host-specific community and constitutes a unique microbial habitat [1]. The host-specificity as well as temporal/geographic stability of microbial communities within sponges may be favored by host mechanisms to prevent cheating by the symbionts. Whether the low individual flexibility in symbiotic dynamics is counter balanced at the population level by certain intraspecific variability in microbial composition is a hypothesis that needs to be tested. More extensive sampling efforts and long-term experiments under controlled conditions are needed towards this goal. A better understanding of sponge population connectivity and symbiosis establishment will help to assess the vulnerability of particular species and their populations in the Mediterranean Sea and allow the development of strategies to conserve the biodiversity and function provided by these organisms and their intimately associated microbes.

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