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The ecology and feeding biology of the sponge
Rhopaloeides odorabile

Thesis submitted by

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for the degree of Doctor of Philosophy
in the School of Marine and Tropical Biology
James Cook University

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Abstract

On large coral reef systems like the Great Barrier Reef, with a significant cross shelf component throughout most of its length, sponges inhabit a broad range of benthic habitats, from shallow water turbid coastal reefs to clear water oceanic reef systems. The structure of sponge assemblages differs taxonomically and morphologically across these varied benthic habitats, responding to environmental conditions and reflecting the prevailing biophysical character. Despite these differences sponges as a group constitute a critical component of the benthos across all these habitats, providing structural rigour, and contributing to benthic-pelagic nutrient fluxes. Sponges also provide a substrate for the settlement and refuge of other benthic organisms and are a host to a large diversity and biomass of symbiotic microorganisms. Despite the importance of sponges within these habitats our understanding of population distributions and the key environmental parameters that influence and maintain them is in its infancy. This knowledge is fundamental to conservation and management of marine benthic environments.

The abundance, size and depth distribution of the sponge *Rhopaloeides odorabile* was quantified within inner-, mid- and outer-shelf reef locations across the continental shelf of the central Great Barrier Reef (GBR), Australia using belt transects. There was a clear gradient in the abundance, size and depth distribution of *R. odorabile* across all reefs sampled, with mean abundances on mid- (20.3 ± 2.2 individuals.250 m⁻²) and outer-shelf reefs (22.6 ± 6.4 individuals.250 m⁻²) being more than three times greater than inner-shelf reefs (6.2 ± 2.4 individuals.250 m⁻²). In addition, although not statistically different, the mean size of *R. odorabile* on outer-shelf reef locations (4236.3 ± 941.9 cm³) were larger than *R. odorabile* on inner- (3096.3 ± 1394.2 cm³) and mid-shelf reef locations (2323.8 ± 548.3 cm³), with *R. odorabile* preferring to inhabit deeper habitats on mid- and

outer-shelf reef locations (8 to 12 m) than inner-shelf reef locations (<8 m). These distinct differences between shelf locations may be driven by differences in environmental gradients across shelf locations, in particular light availability, sedimentation and food availability.

Variation in light, sediment and food are key factors structuring the distribution, abundance and physiology of many sessile marine invertebrates in benthic habitats, particularly those harbouring symbiotic (possibly phototrophic) microbial symbionts. Photophysiology results for *R. odorabile* individuals from inner-, mid-, and outer-shelf reef locations, demonstrate that light availability does not physiologically regulate the size and depth distributions of *R. odorabile* across shelf locations. Photophysiology experiments identified that regardless of their origin, *R. odorabile* individuals collected across inner-, mid-, and outer-shelf reef locations did not photosynthesise or possess any photopigments. Therefore, *R. odorabile* does not acquire energy requirements by way of photosynthesis, showing that in terms of energy acquisition light availability does not influence size and/or the depth distribution of *R. odorabile* across shelf locations.

To quantitatively determine the impact of sedimentation and the role of sediment grain size and mineralogy on the ecology and physiology of *R. odorabile*, suspended sediment was sampled monthly across winter (Austral tropical dry season) and summer (Austral tropical wet season) at different locations including Pelorus Island (inner-shelf reef), Rib Reef (mid-shelf reef), and Pith Reef (outer-shelf reef). Regardless of month sampled, up to 32% of the volume of sediment on inner-shelf reefs was dominated by fine clay sediments (mean grain size $24.4 \pm 5.7 \mu\text{m}$), in contrast to mid and outer shelf reefs where less than 3% of the volume of sediments were fine clay sediments and instead sediments are dominated by coarse biogenic materials (mean grain sizes of $126.6 \pm 30.5 \mu\text{m}$ and $214.3 \pm 33.4 \mu\text{m}$, respectively) (carbonate sediments). Decreasing sediment grain size and increasing clay content of suspended sediments towards the coast corresponded with the decreasing abundance, size and reduced depth distribution of *R. odorabile* towards the coast.

Food availability and the retention efficiency of ultraplankton cell types $<3 \mu\text{m}$ were quantified for *R. odorabile* across inner-, mid- and outer-shelf locations. Across these shelf locations, *R. odorabile* was exposed to a broad range of ultraplankton cell types, including heterotrophic bacteria, *Prochlorococcus* spp., *Synechococcus* – type cyanobacteria and picoeukaryotes $<3 \mu\text{m}$. Food availability was more abundant on inner-shelf locations than outer-shelf locations, including picoeukaryotes $<3 \mu\text{m}$, the main planktonic food source for *R. odorabile*. Picoeukaryotes were retained preferentially with high efficiencies and these efficiencies are consistent across shelf locations (inner-shelf, 95%; mid-shelf, 87%; outer-shelf, 92%). Given the higher abundance of picoeukaryotes $<3 \mu\text{m}$ on inner-shelf reefs, *R. odorabile* at these reefs assimilated 1.5 times more carbon ($8.38 \pm 0.10 \mu\text{g C.l}^{-1}$) and nitrogen ($1.34 \pm 0.02 \mu\text{g N.l}^{-1}$) than on mid-shelf reefs ($5.23 \pm 0.84 \mu\text{g C.l}^{-1}$, $0.84 \pm 0.13 \mu\text{g N.l}^{-1}$), and 3 times more carbon and nitrogen than outer-shelf reefs ($2.71 \pm 0.90 \mu\text{g C.l}^{-1}$, $0.44 \pm 0.15 \mu\text{g N.l}^{-1}$). Paradoxically, *R. odorabile* retains significantly more carbon and nitrogen in the form of picoeukaryotes on inner-shelf reefs than mid- and outer-shelf reefs, however, *R. odorabile* are not larger or more abundant on inner-shelf reefs. This may be explained by a metabolic ‘trade-off’ from increased energetic costs for *R.odorabile* living in high sediment inshore environments exposed to fine clay sediments.

Experimental manipulation of sediment grain size and mineralogy on the respiration rate of *R. odorabile* demonstrated unequivocally that fine clay sediments (mean grain size $3.1 \pm 0.1 \mu\text{m}$) increase the respiration activity from baseline respiration rates by 35% during short-term exposure (7 hours) and up to 43% during long-term exposure (4 days). Visual observations also identified that exposure to fine clay sediments induce the production of mucus on the external surfaces of *R. odorabile*, whilst the shutdown of sponge oscula was also evident. Therefore, exposure of *R. odorabile* on inner-shelf reefs to fine clay suspended sediments that are absent on mid- and

outer-shelf reefs increases their metabolic costs, which may be responsible for reduced abundance and sizes of *R. odorabile* on inner-shelf reefs. This suggests that inner-shelf reefs provide sub-optimal habitat conditions for *R. odorabile*. These higher energetic drains in inshore environments may result in energy normally utilised for growth and reproduction being diverted to maintenance and survival, resulting in lower reproductive output, smaller individuals and subsequently lower abundance. These findings highlight the importance of identifying the key environmental parameters linked with anthropogenic change on the dynamics and structure of an important component of the benthic community.

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