THE ECOLOGY OF BIOERODING SPONGES ON CARIBBEAN CORAL REEFS

Submitted by ***Manuel Alejandro González Rivero*** to the University of Exeter

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature:

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others, to jointly-authored works, statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original research work used or reported in my thesis.

Statement of Contributions by Others to the Thesis as a Whole

Peter J. Mumby provided supervision, support and funding for the project. Christine Schönberg supervised and supported discussions over the progress in Chapters 2,3 and 5.

Renata Ferrari provided funding and support over fieldwork and contributed to the discussions of Chapters 2, 3 and 5.

Alexander V. Ereskovsky and Jane Fromont contributing with methodological guidance, interpretation and discussion of histological images (Chapter 2).

Laith Yacob, contributed, as a jointed author in Chapter 4, with analytical model development and discussions.

Published Works by the Author Incorporated into the Thesis

González-Rivero, M., L. Yakob, and P. J. Mumby. 2011. The role of sponge competition on coral reef alternative steady states. Ecological Modelling 222:1847-1853.

González-Rivero, M., R. Ferrari, C. H. L. Schönberg, and P. J. Mumby. 2012. Impacts of macroalgal competition and parrotfish predation on the growth of a common bioeroding sponge. Marine Ecology Progress Series 444:133-142.

Additional Published Works by the Author Relevant to the Thesis but not Forming Part of it

Ferrari, R., M. Gonzalez-Rivero, J. C. Ortiz, and P. J. Mumby. 2012. Interaction of herbivory and seasonality on the dynamics of Caribbean macroalgae. Coral Reefs:1-10. DOI: 10.1007/s00338-012-0889-9

ABSTRACT

Sponges contribute to large number of functions in coral reef ecosystems. Among these, bioerosion is perhaps one of the most widely studied, largely due to the important contribution of excavating sponges to the carbonate budget on coral reefs (up to 95 % of the total internal bioerosion). Despite our current knowledge, much of the literature is centred on individual-based observations, and little is known about their ecological role and interactions with other reef taxa in complex coral reef systems. The aim of this thesis was to quantify the ecological interactions of bioeroding sponges with major reef taxa by scaling up individual observations to population and ecosystem-based approaches. A cosmopolitan, abundant and highly competitive bioeroding sponge from Glover's Atoll, Belize (*Cliona tenuis*) was used as model species. Monitoring of *C. tenuis* populations throughout 2009 indicated a trade-off between reproduction and growth, with the highest growth rates (31.4 ± 5.6 mm.y–1) occurring in summer, and a peak in reproductive output during winter. Populations typically show strong left-skewed size frequency distributions, mostly represented by juvenile-size individuals (46%), suggesting that regulating mechanisms (e.g. competition and predation) may be acting in constraining the transition of juveniles to adult sizes. Long-term in situ manipulations showed no effect of predation, yet competition with macroalgae significantly reduced the size of the sponge by 38% ± 11% (SE). While *C. tenuis* exhibit high growth and recruitment rates that could theoretically result in rapid population growth, the likelihood of sponges forming an alternative stable state as reefs sustain greater levels of disturbance is unclear. An analytical modelling approach of the interplay between macroalgae, coral and sponge was used to explore the likelihood of alternate stable states. The results show that irrespective of successful sponge invasion, inclusion of this third antagonist (in the interplay between coral and macroalgae) can qualitatively affect the likelihood of alternative stable state. The model exhibits emergent properties suggestive of intransitivity between the three competing taxa. Despite the potential of *C. tenuis* to benefit from disturbance, there are few cases in the literature reporting increases in bioeroding sponge

abundance followed disturbance. Therefore, regulating mechanisms such as competition with other taxa, recruitment limitation or mortality are expected to exert demographic control on the populations of bioeroding sponges when space limitation is relaxed due to coral mortality. To determine processes regulating sponge populations, an individual-based spatial modelling approach was used to simulate the population dynamics of *C. tenuis* in a dynamic ecosystem environment. Using an orthogonal hypothesis testing approach, it was found that competition, and to a lesser extend partial mortality of the sponge tissue, largely regulate the population structure of *C. tenuis*. While reductions in coral cover may temporarily favour the rapid colonization by sponges, the competitive superiority of macroalgae may steal the opportunity from the opportunists.

Keywords: Porifera, *Cliona tenuis*, coral reefs, Caribbean, ecology

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