Gas Powered Reefs: Exploring the Nature and Variability of the Coral Volatilome

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Certificate of original authorship

I, Caitlin Alinya Lawson declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctorate of Philosophy, in the Faculty of Science at the University of Technology Sydney.

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Figure S5.2 Schematic of volatile sampling set up. Coral nubbins were placed in gas tight chambers and maintained under growth conditions while undergoing a 30 minute purge of instrument grade air (BOC Gases, Linde Group, Australia). The outlet of this purge was passed over Markes thermal desorption tubes (Tenax TA).

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Thesis Abstract

Biogenic volatile organic compounds (BVOCs) are a diverse class of chemicals well studied in terrestrial ecosystems, where they play important ecological and physiological roles, while influencing atmospheric processes and climate. As the health of tropical coral reefs rapidly deteriorates, BVOCs can potentially mitigate stress events directly by functioning as antioxidants and indirectly through atmospheric chemistry. Yet, the composition of the coral volatilome (total BVOCs) and its potential importance for coral reef functioning is understudied.

I investigated the BVOC capacity of corals systematically – from microbial symbiont to coral holobiont. I examined Symbiodiniaceae, the photosynthetic microbes that provide nutrients to corals. Across six species, I detected 82 BVOCs and using a targeted thermal stress experiment on two key species, *Cladocopium goreaui* and *Durusdinium trenchii*, I identified significant changes in specific BVOCs, with the majority of these significantly increasing following stress.

Given that Symbiodiniaceae are associated with complex and abundant bacterial communities, I described the microbiome of 18 species of Symbiodiniaceae. Three bacterial genera were consistently present across all Symbiodiniaceae species: *Labrenzia*, *Marinobacter* and an unclassified Chromatiaceae. I then characterised the volatilome of *Labrenzia* sp. 21p and *Marinobacter adhaerens* HP15 and detected 35 BVOCs between them. The composition of the *Labrenzia* sp. volatilome significantly changed following incubation in Symbiodiniaceae exudate and additional changes were detected in the quantities of individual BVOCs in both bacterial species. This indicates the ability of Symbiodiniaceae-associated bacteria to alter their BVOC production in the presence of Symbiodiniaceae-derived chemicals.

I finally characterised the volatilomes of two common, heat-sensitive, reef-building corals (*Acropora intermedia* and *Pocillopora damicornis*) during a simulated heat stress event. I detected 88 BVOCs from these holobionts however, the BVOC richness of both

species decreased following stress (by 41% in *A. intermedia* and 62% in *P. damicornis*) and the abundance of multiple BVOCs significantly decreased. As such, this study revealed that thermal stress influences the coral holobiont by decreasing the richness and abundance of the volatilome.

From microbe to holobiont, I consistently detected a wide range of BVOCs, many of which are implicated in stress response, signalling, antimicrobial defence or potentially impacting local climate. I demonstrated that corals and therefore potentially coral reefs, are significant sources of numerous BVOCs that should receive increased attention to determine their biological functions. This work highlights the diversity of BVOCs produced by corals and their constituents, and provides important new knowledge for the successful management and conservation of these threatened ecosystems.

Thesis Structure

This thesis is comprised of four data chapters (Chapters 2 to 5), each constructed around an independent experiment, in the form of a journal manuscript for peer-review. At the time of thesis submission, all chapters have been either published, are under peer-review, or in final draft for submission. Because the introduction of each data chapter is exhaustive, the general introduction (Chapter 1) is written as a brief but focussed overview to develop and outline the over-arching aims of this thesis.

Chapter 2: Lawson, C.A., Possell, M., Seymour, J.R., Raina, J.B. and Suggett, D.J., 2019. Coral endosymbionts (Symbiodiniaceae) emit species-specific volatilomes that shift when exposed to thermal stress. *Scientific Reports*, 9(1), pp.1-11.

Chapter 3: Lawson, C.A., Raina, J.B., Kahlke, T., Seymour, J.R. and Suggett, D.J., 2018. Defining the core microbiome of the symbiotic dinoflagellate, *Symbiodinium*. Environmental Microbiology Reports, 10(1), pp.7-11.

Chapter 4: Lawson, C.A., Seymour, J.R., Possell, M., Suggett, D.J. and Raina, J.B., In Review. The volatilomes of Symbiodiniaceae-associated bacteria are influenced by chemicals derived from their algal partners. Frontiers in Microbiology, submitted on 8th October 2019.

Chapter 5: *Lawson, C.A., Seymour, J.R., Deschaseaux, E., Hreiben, V., Possell, M., Raina, J.B. and Suggett, D.J., Final Draft. Volatile trade-offs amongst reef-building corals: thermal stress negatively affects the diversity of the coral volatilome. Intended Journal, Global Change Biology.–*Author list to be finalised.