Berko Award Application 2018

Are sensitive life stages, reproduction and early development, bottlenecks to the thermal resistance of reef building corals in the Gulf of Aqaba

Student Name: Jessica Bellworthy

Institution: Bar Ilan University and The Interuniversity Institute for Marine Sciences in Eilat (IUI)

Supervisor: Professor Maoz Fine

Additional reference provided by Professor Anders Meibom, EPFL, Lausanne

Research Outline

Introduction

Coral reefs worldwide are degrading at an alarming rate from the effects of anthropogenic activities, including climate change (Hoegh - Guldberg 1999; Hoegh-Guldberg et al. 2017). Release of greenhouse gases into Earth's atmosphere induces a temperature increase leading to warming oceans (IPCC 2014).

Corals typically live in a very delicate environmental window, meaning that a temperature increase of just one or two degrees can cause stress (Liu et al. 2006). Since daily records began 30 years ago, the Gulf of Aqaba (GoA) has already seen this temperature increase (approximately 1.3ºC) and is actually warming at a rate faster than the global average (Osman et al. 2017). It is known that increasing seawater temperatures lead to a stress response process called coral bleaching. Coral bleaching is a loss of the photosynthetic algae or the photosynthetic pigments of the algae that live in symbiosis inside the coral animal (Hoegh - Guldberg 1999). In a healthy coral, these algae provide up to 95% of the coral's nutritional energy (Muscatine 1990), so during bleaching, the coral is effectively starving and this can lead to mortality.

However, despite the increasing temperature of the GoA, mass coral bleaching has never been observed here, whilst in recent years other reefs have suffered mass mortality following bleaching (Hughes et al. 2018).

These observations lead me to formulate the following research questions:

1. Do corals from the GoA have resistance to elevated temperature stress?
2. What are the effects of temperature stress on sensitive life stages?
3. Is there rapid trans-generational acclimation to environmental change?

Methods

The research uses corals from the reefs adjacent to the IUI. The work involves regular SCUBA diving to sample corals in order to run experiments and also to take natural comparative samples from the sea.

Experiments are conducted in the Red Sea Simulator system in the Lab of Prof. Maoz Fine. I recently published a paper describing the performance and technical details of this world class, large scale mesocosm (Bellworthy and Fine 2018). This system is where corals are exposed to simulated future ocean conditions and changes in their physiology are assessed with a range of laboratory techniques. Transgenerational experiments have also been conducted here by me for the first time. Parent corals are subjected to environmental stress and the resulting offspring (called planulae) of those parents are tested for changes in their physiology. These kinds of experiments are particularly important if we are to understand how corals will adapt to climate change in the near future. However they are rarely done in corals; this may be because the handling of coral planulae is difficult but even more so because the reproductive cycle of corals can last an entire year and certainly because inducing reproduction in an aquarium is very challenging.

Following experiments in the Red Sea Simulator, parameters such as protein, lipid, carbohydrate content, number of algal cells, concentration of photosynthetic pigments, as well as photochemical and metabolic performance are all used to assess the health of the corals. Most of the laboratory work is completed in IUI. However, I have also begun collaboration with Prof. Laurent Charlet of Grenoble University where we conduct Nanotomography using the European Synchotron to test for the effects of sunscreen chemicals on coral larvae. I also collaborate with Dr. Jorge Spangenberg from University of Lausanne to very accurately determine the lipid compounds and concentrations in coral larvae. These compounds are vital energy sources and therefore important to development and survival of corals, yet they remain severely understudied.

Results

Long term experiments (up to five weeks) both at the peak of summer and during the vulnerable reproductive period have resulted in no discernible effects of up to 5ºC elevated temperature on adult corals from the Gulf of Aqaba. Corals maintained the expected seasonal changes in terms of photochemistry and reproductive output similar to field colonies.

Planulae from these parents were also highly resistant to future ocean conditions with protein content, symbiont density, photochemistry, survival, and settlement success not significantly different compared to ambient conditions. My results thus indicate that climate change associated transgenerational effects within this population are weak. Furthermore, planulae have highly variable intra-specific physiology which may enhance their environmental resistance similar to adults.

Therefore, the results so far suggest that sensitive stages, reproduction and early development do not represent a future population bottlenecks. Additionally my findings add support to the emerging hypothesis that the Gulf of Aqaba may serve as a climate change coral refugium (Fine et al. 2013) aided by these corals' inherently broad physiological tolerance.

Significance of research

Gathering experimental evidence of the value of the reefs in the GoA is vital if we are to convince management and policy makers to protect these reefs. Through my research I have repeatedly shown that some species here are likely to survive through predicted sea temperature rise. We have also shown that additional nutrients which can come from fish farms or agriculture can lessen coral's thermal resilience and therefore must have strict management to minimize their concentration in the sea. Such decisions to protect the GoA cannot be made without sound scientific background.

Providing answers to the above research questions is not only locally important but adds to our global understanding of coral's response to environmental perturbation. For example studying populations resistant to thermal stress and following how environmental experience is passed between generations can improve the decisions made in assisted evolution projects. Assisted evolution aims to accelerate coral adaption to climate change through selective breeding. Transgenerational effects are expected to occur in all species so the results do not only apply to corals, but many other organisms. Furthermore, knowledge of how a resistant population performs under climate change can aid predictions of how coral reefs will function in the future.

Concluding remarks

The above research has so far contributed to two first author manuscripts published in peer-reviewed journals (Bellworthy and Fine 2017,2018). In addition I have presented the work in poster format at the Weizmann Institute of Science, for which I won the second prize award, and at the prestigious International Coral Reef Symposium in Hawai'i in 2016. In the last year I have also been invited to present my work in oral conference presentations; at the European Coral Reef Symposium 2017, held every four years, I was selected for the *best student presentation* award for my talk. In addition, my achievements in science were recently recognized with the Bar Ilan University Rector Award 2018 and receiving the Women Divers Hall of Fame Advanced training grant allowed me to complete technical dive training last year at the IUI.

Moving from the UK to Israel was and still is a difficult transition with many challenges. I am however passionate about my research here and engage in every outreach opportunity I can by giving public talks, for example, or through my role as the Chair of the International Society for Reef Studies Student Committee. I am grateful for the facilities and proximity to the sea that IUI provides; I feel privileged to work here with all the staff and students who have contributed so greatly to my successes thus far.

Thank you for considering my application,

Jessica Bellworthy, July 2018

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