2015 REPORT – Lizard Island Reef Research Foundation Doctoral Fellowship

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Project title: **Influence of climate change on schooling behaviour in coral reef fish**

Project Summary and Results:

For this project, I had two overarching goals: 1) to establish an important base knowledge on the execution of schooling behaviour on coral reefs and 2) to determine how projected climate change may modulate the tradeoffs of schooling behaviour. To date, I have completed studies toward both of these goals, through which a range of exciting results have been found.

In the last year, I also completed analyses for two chapters towards my PhD thesis based on research completed at the Lizard Island Research Station during my fellowship, whose results I will summarise here. The first chapter links the fields of coral reef ecology, collective behaviour and conservation physiology, so that we can better understand the mechanisms underpinning behaviours on the reef. Theory suggests that group-living animals may experience a "calming effect" through a variety of mechanisms, reducing the physiological stress experienced by group members and, potentially, reducing individuals' total metabolic demand. However, this effect has proven difficult to quantify due to the difficulty in isolating individuals for testing. Here, I examined the impact of schooling on metabolism and body condition in the gregarious damselfish species *Chromis viridis*. Using a novel respirometry methodology for social species, I found that the presence of school-mate cues led to a reduction in the estimated standard metabolic rate of individuals (Figure 1a). Fish held in isolation for one week also exhibited a reduction in body condition when compared to those held in schools (Figure 1b). These results indicate that social isolation due to environmental disturbance could have physiological consequences for gregarious species. The manuscript resulting from this study has been submitted to *Biology Letters*.

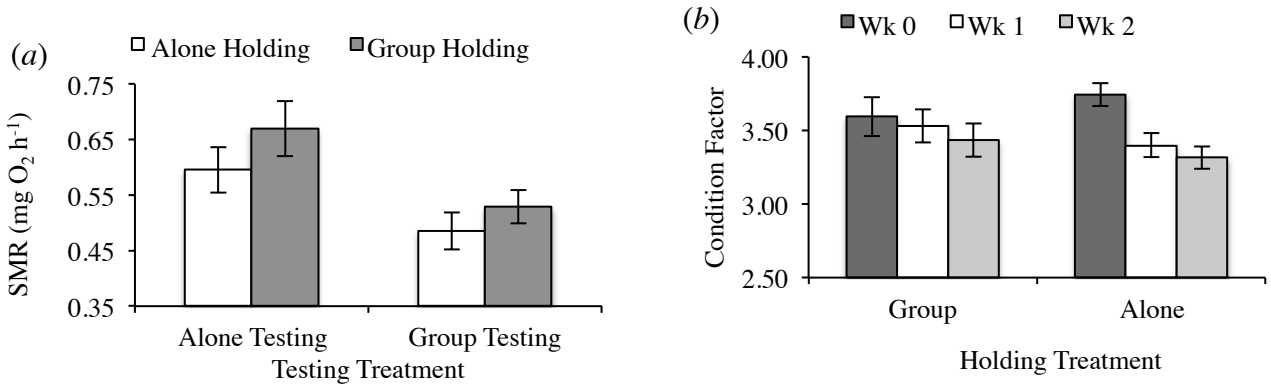

Figure 1. Effects of schooling on the (a) metabolism (SMR) and (b) body condition of *Chromis viridis*.

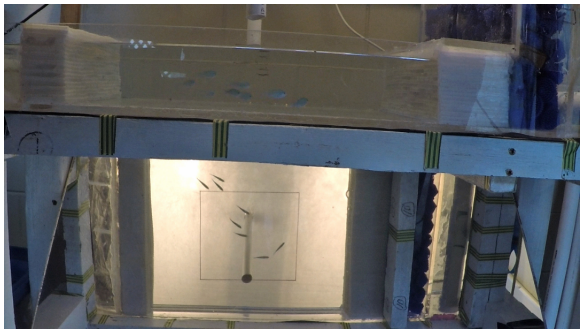

Figure 2. Side view of laminar flow swim tunnel.

Next, I investigated how the habitat characteristics of a school's home reef affected their ability to respond to predator threats. The mechanism by which fish avoid predators is called the fast start escape response, which is a rapid, anaerobically-driven acceleration in response to a threat stimulus. Studies indicate that habitat traits like water flow regime may influence fishes' ability to respond to predator threats. However, no one had yet examined whether this impaired performance would affect the school's ability to collectively evade predators. This

experiment was conducted in a laminar flow swim tunnel (Figure 2), which is a device that allows schools to swim in non-turbulent conditions at a slow uniform swim speed of about one body length per second (or about 3 cm/s. In order to stimulate an escape response in the school, a disturbing stimulus was released through a PVC pipe using an electromagnetic switch to record how the school responds to threat. Trials were recorded from below in high speed using a mirror placed at a 45° angle. Surprisingly, there was no effect of flow on school swimming behaviour or coordination. However, individual escape performance was significantly enhanced in individuals from high flow regime habitats, with fish accustomed to higher flow exhibiting a faster reaction time (latency) as well as a higher estimated muscle contraction speed with their reaction (average turning rate) (Figure 3). Flow could be modulating these defensive manoeuvres as there is less room for error when the water is moving quickly, with fish either being trained behaviourally to react more quickly to threats or fish with slower reactions are simply less likely to survive in high flow habitats. These results are currently being written up for submission to *Proceedings of the Royal Society B: Biological Sciences*.

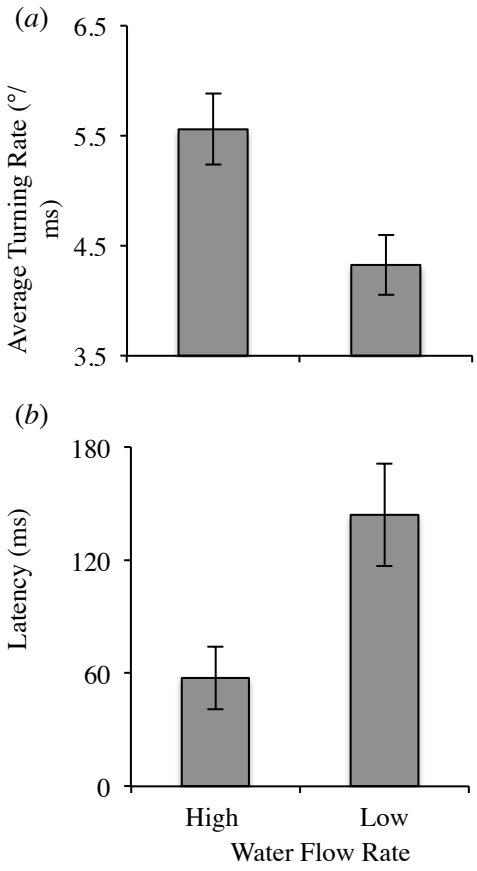

Figure 2. Effect of flow regime (low= 10-12 cm/s; high=21-22 cm/s) on the (a) turning rate and (b) latency of schooling fish.

The project has generally progressed as planned. I have focused mainly on one species, *C. viridis*, as it was an excellent model species in order to assess schooling behaviour and was abundant on the reefs around Lizard Island. In the 2015 fellowship year, I was able to investigate trends in a new species of schooling coral reef fish, the fusilier *Caesio cuning*. As this species is less site-attached and more mobile, it presented a fantastic opportunity to examine the species-specificity of certain trends. This data is still being analysed. An overall summary of the projects completed during my fellowship and publications planned can be seen below, under the publications and datasets sections.

Many thanks to the Lizard Island Reef Research Foundation for the opportunity to be a Lizard Island Doctoral Fellow, which allowed me to complete this novel and exciting research. The Lizard Island Research Station is an incredible place to work, especially as a student who is still learning. I learned a great deal not only from the opportunity to conduct my own independent research but also from numerous useful discussions with the many scientists from diverse backgrounds who were at the station during my research trips.

International Conference Travel Grant

Through my Lizard Island Reef Research Foundation travel award, I was able to attend the 2015 Annual Main Meeting of the Society for Experimental Biology (SEB) in Prague in the Czech Republic. I gained a variety of benefits from this year's meeting. First, as a finalist for the SEB Young Scientist Award, I had an especially large audience for my oral presentation, both in terms of the number of delegates who attended on the day and in the amount of social media attention

my session received. Therefore, through this honour, I received an incredible amount of feedback on my research. I met an array of scientists whose work I have personally learned from and heard about ways to improve and advance my methodologies. These interactions led to potential new collaborations and possible job opportunities for after I complete my PhD. In addition, I was able to attend presentations by distinguished scientists from around the world. The animal section of SEB's annual meeting often has a focus on behaviour and physiology, two very important aspects of my research. Fish kinematics (study of locomotion in fish) features heavily in the research I do at Lizard Island, and I was able to learn new ways for executing and analysing this type of research. Thank you very much to the Lizard Island Reef Research Foundation for their generous grant, which allowed me to attend this international meeting.

Conference Presentations:

1. **Nadler, L.E.**, Killen, S.S., Domenici, P., Munday, P.L., & McCormick, M.I. (2015) Go with the flow: Flow rate modulates metabolism and escape response in fish schools on coral reefs. Behaviour2015 Conference. Cairns, QLD.

2. **Nadler, L.E.**, Killen, S.S., Domenici, P., Munday, P.L., & McCormick, M.I. (2015) Metabolism and habitat modulate assorting and escape responses in fish schools on coral reefs. 89th Annual Australian Coral Reef Society Conference. Daydream Island, QLD.

3. **Nadler, L.E.**, Killen, S.S., Domenici, P., Munday, P.L., & McCormick, M.I. (2015) Metabolism and habitat modulate assorting and escape responses in fish schools on coral reefs. Society for Experimental Biology annual conference. Prague, Czech Republic.

4. **Nadler, L.E.**, Domenici, P., Johansen, J.L., Munday, P.L. and McCormick, M.I. (2014) Fish with friends: Effect of familiarity on schooling behaviour in coral reef fish. Society for Experimental Biology annual conference. Manchester University, Manchester, England.

5. **Nadler, L.E.**, Domenici, P., Johansen, J.L., Munday, P.L. and McCormick, M.I. (2014) Fish with friends: Effect of familiarity on schooling behaviour in coral reef fish. International Society for Behavioral Ecology biennial conference. New York, NY, USA. (poster)

6. **Nadler, L.E.**, Domenici, P., Johansen, J.L., Munday, P.L. and McCormick, M.I. (2014) Fish with friends: Effect of familiarity on schooling behaviour in coral reef fish. 51st Annual Conference of the Animal Behavior Society. Princeton University, Princeton, NJ, USA.

7. **Nadler, L.E.**, Domenici, P., Johansen, J.L., Munday, P.L. and McCormick, M.I. (2014) Fish with friends: Effect of familiarity on schooling behaviour in coral reef fish. 88th Annual Australian Coral Reef Society Conference. Brisbane, QLD.

Additional Datasets to be Analysed

1. Effect of group size and density on the escape response in fish schools.
2. Assessing mixed-species school composition and behaviour using a 3D stereo-camera recording technique.
3. Fission-fusion dynamics in fish schools on coral reefs: An assessment of inter-school migration in the northern Great Barrier Reef.
4. Effect of temperature and carbon dioxide on the swimming behaviour and escape response of wild schools.
5. Effect of carbon dioxide on swimming performance in fish schools.