

Habitat associations of tropical fishes across
latitudes: Implications for ocean warming and
species range expansion

Thesis submitted by

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Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree at this or any other university, nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

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Abstract

Climate change is fundamentally altering the structure and functioning of terrestrial and marine ecosystems globally. In coral reefs, fishes are under increasing pressure from elevated temperatures and habitat degradation associated with climatic warming. Their ability to cope with these changing conditions will be key to species persistence and population sustainability into the future. The poleward shift in the geographic distribution of tropical fishes has also been documented in response to the warming and intensification of poleward boundary ocean currents, which strongly influence dispersal of fishes. However, high latitude reefs present novel conditions (e.g. temperature, resource availability, species interactions) which influence the ability of species to successfully colonise these areas. This thesis examines how habitat associations of tropical fishes may vary with latitude and temperature, in light of dynamic climate change impacts, including ocean warming and the poleward range expansion in species distributions. Such knowledge will be critical in managing coastal and coral reefs under pressing climate change scenarios.

Firstly, this thesis examined habitat associations of reef fishes, with particular focus on tropical species, across a latitudinal gradient. Fish assemblages were compared across four reef locations spanning 17 degrees of latitude along the east coast of Australia to determine the role that benthic complexity and composition of the receiving environment have in structuring the distribution of reef fish assemblages from tropical to temperate reef environments (Chapter 2). Total fish density was highest at the temperate location followed by the subtropical and two tropical locations. Overall, the densities of adult fishes were greater than juvenile fishes across all locations and among latitudinal affinities (i.e. tropical, subtropical and temperate fishes). The only exception was the greater abundance of tropical juvenile fishes than adults at the temperate location. There was also a clear difference in the functional groups driving the separation of fish assemblages among the temperate, subtropical and tropical locations. Benthic composition, compared to habitat complexity, best predicted differences in the distribution of total fish assemblages, and specifically tropical fish assemblages, among latitudinal locations. These results suggest species that rely on particular corals or have highly specialised habitat and/or trophic requirements (e.g. obligate corallivores) are

unlikely to successfully establish populations in temperate environments. Overall, local benthic composition is likely to play a role in determining which tropical fish species successfully colonise temperate reefs in the future.

Building on this foundation, behavioural time budgets, social group structure, feeding patterns and movement were quantified for three common tropical fishes (*Chaetodon auriga*, *Abudefduf sexfasciatus* and *Pomacentrus coelestis*), across three locations, spanning tropical to temperate reefs (Chapter 3). Species behavioural time budgets and social group structure varied both among latitudes and among species. Species were only observed to aggregate with conspecifics at the tropical location; however, mixed species aggregations were more common at subtropical and temperate locations. A reduction in movement and feeding at the higher latitudes may indicate the physiological constraints of temperature and/or impact of predation risk for tropical species in these locations. Resource availability (e.g. food, habitat, conspecifics) is also likely to have caused variation in the patterns of behaviour observed at the higher latitudes.

Following these latitudinal surveys, the influence of water temperature associated with ocean warming events on species habitat preferences were investigated (Chapter 5). Habitat choice experiments were conducted in the laboratory to isolate the effect of temperature on habitat preference. Prior to this, however, a suitable method needed to be established for detecting habitat preferences in species with varying levels of habitat association (*C. auriga*, *C. flavirostris*, *P. coelestis* and *A. sexfasciatus*) (Chapter 4). This study revealed that a commonly used observation interval (10 min) was not suitable, and that hourly measurements were better at detecting habitat preferences of species known to use a range of habitats (*C. flavirostris*, *P. coelestis* and *A. sexfasciatus*). The application of discrete choice modelling in understanding these habitat preferences was also found to be useful. Hourly measurements were then utilised to determine the influence of water temperatures (22°C, 28°C and 31°C) on habitat preferences of three common damselfishes (*P. moluccensis*, *P. coelestis* and *A. sexfasciatus*) selected for their range of habitat preferences (Chapter 5). Results showed *P. moluccensis* consistently selected its preferred complex coral habitat across all temperatures. Unexpectedly, however, *A. sexfasciatus* and *P. coelestis* who usually associate with a

range of habitats, developed strong habitat preferences (respectively for complex coral and boulder, and complex coral) as temperature increased from ambient levels.

Therefore, we may be currently underestimating the impact of climate change on species that are known to associate with a range of habitats.

Overall, the findings of this thesis highlight that, in addition to temperature and larval supply, benthic composition likely plays a role in structuring the availability of suitable habitat and trophic resources, and thus may constrain the establishment of some tropical fishes while promoting others within high latitude reef environments. These results also provide evidence of differences in species behaviour across latitudes, giving us greater insight into the novel constraints of temperate environments, as well as which species are likely or unlikely to shift with ongoing climate change. Furthermore, within tropical reefs there are potential cumulative impacts of global warming, with risks associated both directly with habitat degradation (e.g. loss of complex coral) and possibly increasing resource overlap and competition between species in ways that have not previously been accounted for in climate prediction models. The shifts in habitat preferences observed in this study suggest we may also see increased pressure on species that do not currently rely on a particular habitat, indicating that climatic warming could affect ecological relationships in subtle and unexpected ways, prompting new lines of inquiry.