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# The ecosystem role of macroalgal browsing fishes on coral reefs

Thesis submitted by

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in June 2010

for the degree of Doctor of Philosophy in Marine Biology  
within the School of Marine and Tropical Biology and  
the ARC Centre of Excellence for Coral Reef Studies,  
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## **Statement on the Contribution of Others**

This thesis includes some collaborative work with my supervisor Prof. David Bellwood. While undertaking these collaborations, I was responsible for the project concept and design, data collection, analysis and interpretation, and the final synthesis of results into a form suitable for publication. My collaborator provided intellectual guidance, equipment, financial support, and editorial assistance.

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## Abstract

Herbivory is a key process structuring plant communities in both terrestrial and aquatic ecosystems, with variation in herbivory often being related to shifts between contrasting groups of primary producers. On coral reefs, regional reductions in herbivores have underpinned shifts from coral-dominance to dominance by fleshy macroalgae. The capacity to remove macroalgae is, therefore, viewed as a key process in both preventing and reversing such transitions. The present study compared the role of macroalgal browsing fishes across two distinct exposure gradients, both among habitats within a single reef and across several reefs spanning the continental shelf, and among patches of differing macroalgal densities. Finally, the role of a second group of herbivorous fishes, the territorial damselfishes, in influencing macroalgal removal rates and shaping macroalgal distributions was explored.

Browsing intensity was quantified across eight habitats of varying depth and wave exposure on a mid-shelf reef in the northern Great Barrier Reef (GBR) using assays of two species of *Sargassum*. Removal rates of *Sargassum* varied significantly amongst habitats, with both species displaying broadly similar patterns. Reductions in *Sargassum* biomass were highest within the shallow habitats on the exposed aspect of the reef (81.4–91.6 %·d<sup>-1</sup>), lowest within the deeper exposed habitats (3.8–13.4 %·d<sup>-1</sup>), and intermediate within the sheltered habitats (37.9–76.5 % d<sup>-1</sup>). Surprisingly the rates of removal of *Sargassum* displayed no relationship with visual census estimates of the density or biomass of all roving herbivorous fishes or macroalgal browsing fishes, either collectively or independently. Stationary underwater video cameras revealed that, despite the reef supporting over fifty herbivorous fish species and six macroalgal browsing species, a single species, *Naso unicornis*, was almost solely responsible for

the removal of *Sargassum* biomass. Of the 42,246 bites taken from the *Sargassum* across all habitats, *N. unicornis* accounted for 89.8 % (37,982) of the total bites, and 94.6 % of the total mass standardized bites.

*Sargassum* assays revealed a distinct pattern in browsing across the continental shelf in the northern GBR, with the highest rates of removal recorded on mid-shelf reefs (55.2–79.9 % $\cdot$ d<sup>-1</sup>) and decreasing significantly on inner-shelf reefs (10.8–17.0 % $\cdot$ d<sup>-1</sup>). The low removal rates on inner-shelf reefs appeared to be directly related to the high cover of macroalgae on those reefs. Reductions in *Sargassum* biomass were also initially low on outer-shelf reefs (10.1–10.4 % $\cdot$ d<sup>-1</sup>), but increased markedly (32.1–73.4 % $\cdot$ 5h<sup>-1</sup>) after the resident fishes were allowed several days to familiarize themselves with the *Sargassum*. Despite considerable cross-shelf variation in the rates of removal of *Sargassum*, there was little variation in the agents of macroalgal removal across all reefs. Feeding on the transplanted *Sargassum* was again dominated by a single browsing species. *N. unicornis* accounted for 82 % of all mass standardized bites and explained over 80 % of the total variation in the reduction in *Sargassum* biomass across all reefs and habitats. Although the majority of this feeding activity was recorded on the mid- and outer-shelf reefs, *N. unicornis* accounted for over 72 % of the recorded feeding on the inner-shelf reefs.

The territory composition and effect of resident damselfish on the removal of *Sargassum* was quantified for six common species of damselfish on a mid-shelf reef in the northern GBR. The functional composition of algal communities within territories varied markedly among species. The territories of four species were characterized by algal turfs, while the territories of two species were characterized by foliose and leathery brown macroalgae. *Sargassum*, a generally rare alga on mid-shelf reefs, was a particularly common alga within *Dischistodus prosopotaenia* territories. *D.*

*prosopotaenia* was the only species to retain the transplanted *Sargassum*, with only a minimal reduction in *Sargassum* biomass ( $1.1 \text{ \%} \cdot \text{d}^{-1}$ ) being recorded within their territories. In contrast, reductions in *Sargassum* biomass were high in areas adjacent to *D. prosopotaenia* territories ( $83.8 \text{ \%} \cdot \text{d}^{-1}$ ), and within and adjacent to the territories of the five remaining damselfish species ( $76.2 - 92.5 \text{ \%} \cdot \text{d}^{-1}$ ). Overall, only *D. prosopotaenia* provided a refuge for leathery brown macroalgae, and may facilitate the development of this macroalgae on mid-shelf reefs of the GBR.

Habitat patches that varied in the spatial arrangement and density of macroalgae ( $0.25\text{-}6.23 \text{ kg} \cdot \text{m}^{-2}$ ) were created on an inshore reef in the central GBR using transplanted *Sargassum*. Feeding on the *Sargassum* was dominated by two species, *Kyphosus vaigiensis* and *N. unicornis*. Both species displayed a preference for the relatively open habitat patches with low cover and biomass of *Sargassum*; only switching to the higher density patches after much of the *Sargassum* biomass within the lower density patches had been consumed. Similarly, grazing on the algal turf covered substratum within the habitat patches displayed an exponential decline with increasing *Sargassum* biomass. These feeding preferences appeared not to be related to bottom-up factors as food availability was proportional to macroalgal density for browsers and broadly comparable among habitat patches for grazers. It appears more likely that the avoidance of the higher macroalgal density patches was related to an increase in the perceived risk of predation.

Overall, the consumption rates of *Sargassum* in the present study provided strong evidence for the potential role of browsing fishes in limiting the distribution of adult *Sargassum* on mid- and outer-shelf reefs of the GBR. Browsing intensity was, however, moderated by the presence of *D. prosopotaenia* and the density of the *Sargassum* presented. These negative interactors are important and provide the

mechanistic bases through which *Sargassum* may colonize new locations, and expand and persist once established. Despite some evidence of latitudinal variation on inshore reefs, the reliance on a single species removing *Sargassum* across a range of habitats and reefs in the northern GBR was striking. This limited redundancy, both within and across local (0.1 – 40 km) scales, highlights the potential for single-species functional groups and emphasizes the importance of looking beyond biological diversity as a source of ecological stability.

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