Fish-coral interactions: do resident fish alter the relationship between local water flow and coral growth?

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Background

Hermatypic corals are functional mixotrophs that rely on water flow for the delivery of dissolved nutrients and prey. Thus, flow can directly affect growth rates of coral. Branching corals such as *Pocillopora eydouxi* are common in the lagoons of Moorea, French Polynesia. Like other such corals, *P. eydouxi* provides structural habitat for a variety of species of reef fishes. These fishes may augment the overall nutrient supply to the coral when sheltering.

Because fish augment the concentration of dissolved nutrients within a coral colony, we explored whether the relationship between local water flow and coral growth was altered by the presence of resident fish.

Our experiments revealed that *P. eydouxi* with resident fishes grew significantly faster than neighbors that lacked them. Our estimates of residence time of water within a coral indicated that it also varied considerably among the experimental colonies under the same general flow regime, suggesting that flow may interact with coral morphology to influence the flux of nutrients and thus, the growth rates of coral.

Methods

Effect of Resident Fishes on Coral Growth

All field experiments were carried out in the lagoons along the north shore of Moorea, French Polynesia. (Figure 1)

Two pre-weighed "nubbins" of *Pocillopora eydouxi* were transplanted into each of 20 mature colonies of *P. eydouxi*. Ten colonies were caged to exclude resident fishes. (Figure 2)

All nubbins were returned to the lab and re-weighed after 30 days.

Figure 1: Moorea, French Polynesia (17˚30' S, 149˚50' W). Arrows indicate typical direction of water flow over reef crest, through shallow lagoons and out the deep water passes.

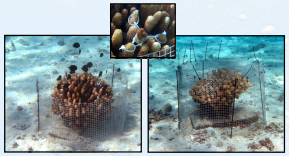


Figure 2: Fenced and caged colonies of *P. eydouxi*. Inset shows outplanted nubbin (ave. initial buoyant weight = 7.5 g, ± 1 SE = 0.4). Fish pictured in fenced treatment are *Dascyllus flavicaudus* and *D. aruanus*.

Laboratory Estimates of Ammonium Production by Coral Associated Fishes

Individual *Dascyllus flavicaudus* were added to each of 10 bucket aquaria. Five of these aquaria also contained small *P. eydouxi* colonies. An additional five aquaria contained *P. eydouxi* only, while five aquaria containing seawater served as controls. (Figure 3)

20 ml samples of water were collected from each aquaria every 6 hours over a period of 48 hours. Water samples were frozen at -80° C and ammonium concentrations determined using flow injection analysis.

Figure 3: Static bucket aquaria containing either seven *D. flavicaudus* (ave. total fish biomass = 30.0 g. ± 1 SE = 2.4), *P. eydouxi*, both fish and coral or seawater. Fish were not fed during the experiment. Inset shows aquaria containing both *D. flavicaudus and P. eydouxi*.

Relationship Between Potential Ammonium Retention Times, Water Flow and *P. eydouxi* Colony Morphology

Fluorescene dye was injected into the interior of 10 *P. eydouxi* colonies differing in morphology and the resulting concentration measured continuously over five minutes using a submersible fluorometer. Water flow near the colony was measured using an acoustic Doppler profiler. (Figure 4)

Digital photos of each *P. eydouxi* colony were analyzed to determine overall colony size and the degree of colony "openness". (Figure 5)

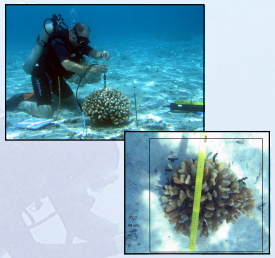


Figure 4 (Top): Injection of 10 ml of fluorescene dye (initial concentration = 2.5 mg/L) using syringe attached to a submersible fluorometer. Dye was used as a surrogate for ammonium produced by fishes resident within the colony. ADP used to measure water flow can be seen at the extreme right.

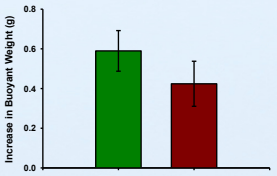
Figure 5 (Bottom): Top view of a *P. eydouxi* colony with superimposed sampling grid. Overall colony size and the amount of empty space between colony lobes, colony "openness", were estimated using the software program Vidana developed by J. Hedley, University of Exeter, U.K.

Field Measurements of Ammonium within Experimental Colonies of *P. eydouxi*

20 ml samples of water were collected from the interior of 10 *P. eydouxi* colonies containing outplanted nubbins five times per day over the course of three days. Water samples were frozen at -80° C and ammonium concentrations determined using flow injection analysis.

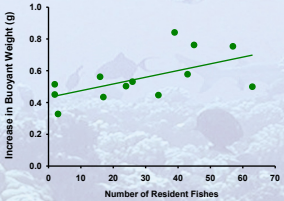
Results

Effect of Resident Fishes on Coral Growth



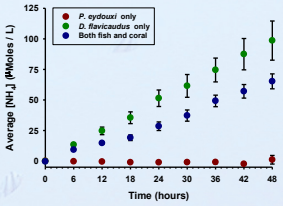
Nubbins outplanted into *P. eydouxi* colonies containing resident fishes grew significantly faster than those outplanted into colonies without fish ($P = 0.02$). Shown is the average increase in nubbin buoyant weight over 30 days ± 95% C.I. for each treatment.

Relationship between Fish Abundance and Coral Growth



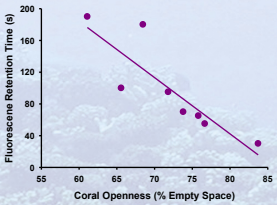
Variability in the amount of growth experienced by nubbins outplanted into *P. eydouxi* colonies containing resident fishes can be partially explained by differences in the number of fishes resident in these colonies ($P = 0.04$, $R^2 = 0.34$). Three of the colonies assigned to the "No Fish" treatments retained low abundances of resident fishes and so were included in the analysis.

Production of Ammonium by *Dascyllus flavicaudus*



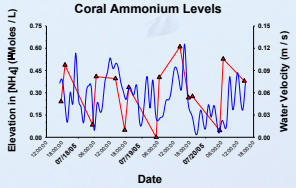
The rate of ammonium production by *D. flavicaudus* was significantly decreased in the presence of *P. eydouxi* as indicated by a significant Time by Treatment interaction ($P < 0.001$). Ammonium levels in aquaria containing only *P. eydouxi* actually decreased over time. Shown is the average ammonium concentration minus the average concentration measured in aquaria containing only seawater over 48 hours ± 1 S.E. for each treatment.

Effect of Coral Morphology on Potential Ammonium Retention



Coral morphology significantly affected the length of time fluorescene dye was retained in the interior of *P. eydouxi* colonies ($P < 0.01$, $R^2 = 0.75$) suggesting that morphology may effect the degree of benefits derived from ammonium produced by resident fishes. The relationship between mean water flow and fluorescene retention times was not significant ($P = 0.41$, $R^2 = 0.11$)

Effect of Resident Fishes on Within Coral Ammonium Levels



The presence of resident fishes resulted in elevated levels of ammonium within colonies of *P. eydouxi* compared with colonies where fishes were excluded. Measured ammonium levels varied with large scale changes in mean water velocity within the lagoon. Shown is the difference between the mean [NH_4] within corals hosting fish and those without fish (red triangles) and the mean lagoonal water velocity (blue line).

Conclusions

Resident fishes have the ability to produce substantial amounts of ammonium. The increased growth rates of nubbins outplanted to *P. eydouxi* colonies containing resident fishes may represent a response to increased levels of within colony ammonium levels. Availability of ammonium to corals is likely dependant on a complex interaction between overall water flow within the lagoon and the morphology of individual coral colonies.

Acknowledgments

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For further information

More information on this and related projects can be obtained from ***http://mcr.lternet.edu/home.html*** or by e-mailing ***brooks@lifesci.ucsb.edu***