Strong Indirect Effects on Coral Dynamics from Interactions between Planktivorous Damselfish and Hawkfish

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Pocilloporid corals host diverse sub-community of fishes, invertebrates, algae & microbes

Central Issue
• How is a host coral affected by its associated community?

Conspicuous community member:
Planktivorous damselfish
(feed in water column; coral provides shelter)

First Question
• Do resident damselfish alter the growth rate of the host coral?
Moorea, French Polynesia
Do resident damselfish alter the growth rate of the host coral?

- Manipulated damselfish abundance
- Outplanted coral nubbins
- Determined nubbin skeletal growth after 30 days (buoyant weighing technique)
Do resident damselfish alter the growth rate of the host coral?

YES: Corals grew ~ 30% faster when damselfish present but a lot of variance in growth response

Nubbin growth after 30 days

\[ p = 0.02 \]

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Means +/- 95% C.L.</th>
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</thead>
<tbody>
<tr>
<td>Fish</td>
<td>N = 10 0.6</td>
</tr>
<tr>
<td>No Fish</td>
<td>N = 10 0.4</td>
</tr>
</tbody>
</table>
Fish biomass – Coral growth relationship

Field nubbin growth experiment – Coral growth increased with biomass (or number) of resident fish

$r^2 = 0.34$
$p = 0.04$
Possible Mechanism

Fish biomass – Nutrient production relationship

Laboratory experiment – Fish enhance local concentration of ammonium
• Does coral morphology affect interstitial concentrations of $[NH_4]^+$?

Coral morphology (% open space) was described using digital photographs.

Potential for retention of $NH_4^+$ was estimated using injected fluorescein dye.
• Does coral morphology affect interstitial concentrations of $\left[\text{NH}_4\right]^+$?

Retention time inversely related to coral openness

$r^2 = 0.75$

$p < 0.01$
Field nubbin growth experiment – Best predictor of nubbin growth rates was combination of damselfish abundance & coral morphology (openness)

<table>
<thead>
<tr>
<th>Variable(s) in Model</th>
<th>Model</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphology &amp; Abundance*</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>Morphology alone</td>
<td>0.47</td>
<td></td>
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<tr>
<td>Abundance alone</td>
<td>0.35</td>
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</tbody>
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* $F_{(2,7)} = 11.35$  $p < 0.01$

Two variable model was significantly better fit than either one variable model
What is the frequency distribution of damselfish abundance on Pocillopora corals in the lagoons of Moorea?

Field survey – Reveals large variation in damselfish abundance

N = 256 corals
General pattern - Larger corals host more damselfish

Coral size – Fish abundance relationship

\[ r^2 = 0.30 \]
One Implication: Mutualistic relationship results in a positive feedback loop between corals & damselfish

Faster coral growth rate = Larger coral

Strength of feedback is dependant on coral morphology

Larger coral = More damselfish
Planktivorous damselfish not only type of fish sheltering in Pocilloporid corals

Questions

- What is the pattern of co-occurrence of damselfish & hawkfish on corals?
- Do hawkfish affect the abundance of damselfish & if so, how?
- What are the consequences to the host coral?

Arc-eye Hawkfish

Yellow-tail Dascyllus
General pattern of fish co-occurrence on *Pocillopora*

- **Small corals**
  - No fish

- **Medium corals**
  - Damselfish
  - or Hawkfish

- **Large corals**
  - Both fish groups
Do hawkfish affect abundance of damselfish?

Larval settlement of damselfish
(estimated daily)

Settlement rate much lower on corals with hawkfish
Do hawkfish affect abundance of damselfish?

Colonization of corals by damselfish

Field experiment - Corals initially empty; hawkfish transplanted to half
- Damselfish allowed to colonize naturally for 1 yr
Was there a consequence of hawkfish suppressing damselfish to growth of host corals?

Growth of experimental corals after 12 mos

![Graph showing coral growth comparison](image)

- **Hawkfish**
  - Coral Growth (change in volume / yr) = 20

- **No Hawkfish**
  - Coral Growth (change in volume / yr) = 80
What ecological processes were involved in the suppression of damselfish by hawkfish?

• Direct consumption by hawkfish (classic predator - prey interaction)

• Indirect via sublethal effect of hawkfish
  - Multi-predator effect (foraging by hawkfish enhances risk to other predators)
  - Competition for enemy – free space (both shelter from mutual predator)
Dynamics of Resident Fish and Coral Growth

- Invaded by HF
- Colonized by damselfish
- Coral Growth Difference
- No HF or damselfish
- Colonized by damselfish
- Invaded by HF

Time
• Biotic interactions can have substantial but non-obvious indirect effects on host corals

• Hawkfish decoupled positive feedback between group living fish & coral host