Microscopic heterotrophs ameliorate nutrient limitation in the fast-growing seaweed, Cladophora columbiana

Cirse A. Gonzalez-Dorantes1, Matthew E.S. Bracken2, John J. Stachowicz1
1Department of Biology, Duke University; 2Section of Evolution and Ecology, University of California, Davis

Overview
Resident tidepool algae are expected to grow slowly as an adaptation to low nitrogen availability (Nielsen 2001, Nielsen 2003). Fast-growing algae would not, theoretically, thrive in these low nitrogen habitats because maintenance of their high growth rates would demand high concentrations of nutrients.

Cladophora spp. are fast-growing opportunistic algae and, therefore, have high demands for nutrients (Dodds and Gudder 1992). Studies show, however, that Cladophora columbiana is able to live in habitats independent of nutrient availability and thrive in high-intertidal pools where other algal species cannot (Breeden and Nielsen 2004). Because it is a fast-growing algae with a high demand for nutrients, its growth in these areas is seemingly paradoxical.

If C. columbiana is a fast-growing alga with high demands for nutrients, why is it able to live in habitats that are nutrient poor?

One possible explanation for the paradox is that microscopic heterotrophs living in association with C. columbiana contribute nutrients via ammonium excretion, allowing the algae to meet high nutrient demands in low-nutrient environments (Dodds 1991, Dodds and Gudder 1992, Bracken and Nielsen 2004). The aim of my project is to test this possibility.

Biodiversity and Biomass

Algal Abundances

- Four replicate samples of C. columbiana were sampled at each of the 3 study sites:
  - 12 g (wet weight) samples from each site were analyzed

- All organisms (i.e., algae, invertebrates, etc.) were identified (e.g., based on phylum)

- Invertebrates were grouped and counted

Biomass Measurements

- 0.5 g organisms or tissue samples were weighed using a microbalance

Fig. 2. Mean abundances and biomass measurements of invertebrates associated with C. columbiana. Plastic boxes indicate 95% confidence intervals. Values were not highly variable across treatments and sampling locations (n = 3 sites).

Ostracods were the most abundant taxonomic group in the C. columbiana plots, found in densities of up to 800 ostracods per gram of algae. Ostracod dry mass contributed the largest amount of invertebrate biomass in C. columbiana plots. Species diversity remained constant across the Bodega Marine Reserve sites sampled.

Conclusions

- Cladophora columbiana dominates tide pools high in the intertidal. Low nutrient availability probably prohibits the growth of other alga species in these pools.
- Microscopic heterotrophs reach high abundances and biomass in C. columbiana mats.
- Microscopic heterotrophs contribute significantly to NH4+ assimilated by C. columbiana via excretion.
- C. columbiana may thrive in high-intertidal pools with low nutrients because its associated invertebrates ameliorate nutrient stress.
- NH4+ concentrations within tide pools are not significantly altered in the absence of C. columbiana.
- NH4+ uptake by C. columbiana probably occurs at the same rate as does NH4+ excretion by microscopic heterotrophs.

Acknowledgements

We would like to thank Williams lab members for providing materials and lab space and other Stachowicz lab members for helping to provide assistance. This project was supported by a Doctoral Dissertation Improvement Grant from the National Science Foundation (DEB-1210220) to C.A.G.D. and a Graduate Research Fellowship to C.A.G.D. (NSF-1445012).