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Signals in the Sea: predatory induced defences in marine phytoplankton

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Abstract

Phytoplankton make up less than one percent of the world's photosynthetic biomass, yet they are responsible for almost half of the world's total primary production. These small but mighty unicellular organisms possess some unique defence mechanisms in order to protect themselves from predation. Predation on these organisms is typically from zooplankton, in particular copepods. Copepods are tiny crustaceans typically 1-2mm in length. Many microscopic marine organisms lack a good set of eyes and ears and chemical cues have become important for how they locate food, find refuge, find a mate, or defend themselves from nearby predators. Predatory induced defences are a widespread phenomenon in terrestrial and aquatic environments, often mediated through chemical cues. In the marine environment phytoplankton respond to predator presence by morphological, behavioural, or biochemical changes.

This thesis investigates the impacts of chemical cues isolated from marine copepods, focusing on a group of polar lipids known as copepodamides. Copepodamides are general alarms signals that induce a range of defensive mechanisms in marine phytoplankton. Using copepodamides, I was able to simulate the presence of the grazers without direct predation. This allowed me to precisely manipulate defensive traits and evaluate their significance in the plankton food web. By conducting single species and mesocosm experiments, this thesis explores the effects of copepodamides on species composition, bioluminescence, toxin production and colony plasticity for various diatoms and dinoflagellates. In particular, I found that in the presence of copepodamides, the species *Thalassiosira rotula* and *Chaetoceros curvisetus* decrease their colony size drastically, which directly benefits them in terms of reduced losses to grazers. I also discovered that bioluminescence in dinoflagellates is intensified in response to copepodamides, specifically in the species *Lingulodinium polyedra* and *Alexandrium tamarense*. Together these findings suggest that grazer induced defensive traits are more common in marine plankton then previously recognized. Chemical signalling may potentially be vulnerable to changes in pH, but we show that copepodamide signalling is likely robust to the predicted future decrease in ocean pH. Finally, I exposed intact communities from the spring and summer and show that copepods and copepodamides (without copepods) drive similar changes in eukaryote and prokaryote community structure. I conclude that the structuring effects of copepods is driven by both direct grazing and indirect chemically mediated effects. Moreover, these small-scale interactions scale up to large-scale processes, and it is likely that grazer induced defences will facilitate harmful algal bloom formation and alter vertical flux of matter in the ocean. The identification of chemical alarm signals in plankton ecology has opened up a research avenue that will increase our mechanistic understanding of phytoplankton and zooplankton interactions, encompassing cellular processes, such as signal transduction pathways, individual predator prey interactions and community structure effects.