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Importance of mixotrophic nanoplankton in Aysén Fjord (Southern Chile) during austral winter

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ABSTRACT

Mixotrophy, the combination of autotrophic and heterotrophic nutrition in the same organism, is widespread in planktonic algae. Several reports from temperate and high-latitude fjords in Scandinavia suggest the occurrence of a niche in late summer and autumn during post-bloom conditions in which mixotrophic algae can become important grazers in pelagic ecosystems, accessing the nutrients bound in their prey to overcome nutrient limitation. Here, we experimentally determined the trophic modes and bacterivory rates for the nanoplankton community (2–20 μm) in Aysén Fjord located in the Chilean Northern Patagonia during two contrasting seasons: winter and spring. While mixotrophic nanoplankton was virtually absent from the system in spring, in winter at occasions it even constituted the dominant trophic group of the nanoplankton with abundances of >900 cells mL^{-1}. This indicates a second niche for mixotrophs in winter, when mixotrophy allows overcoming light limitation.

1. Introduction

Mixotrophy is defined as the ability of an organism to combine autotrophic and heterotrophic nutrition. The pervasive occurrence of mixotrophs in the plankton of both marine and freshwater ecosystems is now realized (Jones, 2000). Mixotrophy can be seen as a special form of omnivory allowing organisms to overcome nutrient, carbon, light, or energy limitation (Elser and Hessen, 2005). Surveys in Scandinavian fjords and coastal embayments have shown that mixotrophic nanoflagellates (nanoplankton size range 2–20 μm) can play an important role; mixotrophic flagellate algae dominate the protist community and constitute up to 86% of the total flagellate grazing (Havskum and Riemann, 1996). This phenomenon has been confirmed by less extreme but significant reports of mixotrophic nanoflagellates in such environments (Nygaard and Tobiesen, 1993; Havskum and Hansen, 1997). In the Chilean fjord region (43–56°S), the phytoplankton is typically dominated by large diatoms in spring and nanoflagellates in winter (Pizarro et al., 2005). Small algae are more effective than their larger competitors at dissolved nutrient uptake and in their use of light for photosynthesis (Raven, 1998), which should favor them in periods of light or nutrient limitation, as well as in situations in which mixotrophy might also offer them an advantage. However, up to this point, the use of mixotrophy as a nutritional strategy has not been analyzed in the Chilean fjord region. Here, we experimentally investigate the winter and spring communities of nanoflagellate algae (2–20 μm), asking one simple question: Is mixotrophy a major strategy in small algae (to overcome light limitation) during winter in high-latitude oligotrophic fjord environments?

Although simple, this question has at least three major implications. First, mixotrophs complicate the flow of energy and nutrients in fjord food webs by functioning as both producers and consumers, rendering classical models of ecosystem functioning incomplete. Second, as a consequence, mixotrophy requires considering the nutrients bound in the prey of the mixotrophs, which might change the nutrients finally limiting photosynthesis (Jansson, 1998). Third, theoretical food-web models suggest that mixotrophy has considerable effects, e.g., changes in the overall primary production and carbon and nutrient channeling systems as well as new competitive pressures on phyto- and zooplankton (Jones, 2000; Tittel et al., 2003). Field studies contrasting the role and impact of mixotrophic

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