Diversity of acclimatory strategies to Polar Night across Antarctic phytoplankton

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Phytoplankton residing in high latitude environments experience extended periods of complete darkness during the winter, known as the 'polar night'. Historically, the polar night represents a logistical challenge for field science and has also been considered a quiescent period of minimal biological activity. However, recent advancements in autonomous sensors/sampling have revealed new insight into seasonal dynamics of microbial communities. Photoautrophic and mixotrophic algal species, which represent the primary producers of most polar aquatic habitats, are expected to be particularly sensitive to the lack of light. While past research has proposed a few physiological mechanisms underlying winter survival, there remains a knowledge gap connecting findings based on lab-controlled experiments and responses of native algal communities. Here we combined field- and lab-based studies to evaluate how several key phytoplankton species acclimate to polar night within the permanently ice-covered Lake Bonney (McMurdo Dry Valleys, Antarctica). The phytoplankton communities in this lake are composed predominantly of chlorophytes (*Chlamydomonas* spp.), haptophytes (*Isochrysis* sp.), and cryptophytes (*Geminigera cryophila*). In the field, seasonal dynamics of these three algal groups were monitored by year-round autonomous profiling using a spectral Chlorophyll-a fluorometer. Additionally, four Lake Bonney isolates, *C. priscui*, *C.* sp. ICE-MDV (Chlorophytes), *Isochrysis* sp. MDV, and *G. cryophila* were subjected to mimicked polar night under lab-controlled conditions in a series of experiments to compare acclimation strategies among photoautotrophic vs. mixotrophic algae. In native Lake Bonney communities, green algae abundance declined during the polar night, whereas mixotrophic haptophytes and cryptophytes increase in abundance during early winter. In the lab, chlorophytes species decreased in culture density, functionally downregulated photosynthesis, but retained their photosystems. Conversely, the haptophyte, *Isochrysis* sp. MDV and cryptophyte *G. cryophila* exhibited minor reductions in cell density and photosynthetic capacity during mimicked polar night, and showed an increase in B-glucosaminidase, a key enzyme involved in complex carbon breakdown. A higher resolution study conducted in continuous cultures of *C. priscui* revealed that the alga increased photosynthetic activity during the transition from summer to winter. Photosynthetic activity rapidly recovered during the onset of summer in continuous cultures. On the other hand, recovery of growth lagged behind photosynthetic recovery by 10 days. Collectively, the results of this study will provide a more comprehensive understanding of how Antarctic phytoplankton communities prepare for and recover from several months of darkness.