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Symbiosis at its limits: ecophysiological consequences of lichenization in the genus *Prasiola* in Antarctica

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• **Background and Aims** Lichens represent a symbiotic relationship between at least one fungal and one photosynthetic partner. The association between the lichen-forming fungus *Mastodia tessellata* (Verrucariaceae) and different species of *Prasiola* (Trebouxiophyceae) has an amphipolar distribution and represents a unique case study for the understanding of lichen symbiosis because of the macroalgal nature of the photobiont, the flexibility of the symbiotic interaction and the co-existence of free-living and lichenized forms in the same microenvironment. In this context, we aimed to (1) characterize the photosynthetic performance of co-occurring populations of free-living and lichenized *Prasiola* and (2) assess the effect of the symbiosis on water relations in *Prasiola*, including its tolerance of desiccation and its survival and performance under sub-zero temperatures.
• **Methods** Photochemical responses to irradiance, desiccation and freezing temperature and pressure–volume curves of co-existing free-living and lichenized *Prasiola* thalli were measured *in situ* in Livingston Island (Maritime Antarctica). Analyses of photosynthetic pigment, glass transition and ice nucleation temperatures, surface hydrophobicity extent and molecular analyses were conducted in the laboratory.
• **Key Results** Free-living and lichenized forms of *Prasiola* were identified as two different species: *P. crispa* and *Prasiola* sp., respectively. While lichenization appears to have no effect on the photochemical performance of the alga or its tolerance of desiccation (in the short term), the symbiotic lifestyle involves (1) changes in water relations, (2) a considerable decrease in the net carbon balance and (3) enhanced freezing tolerance.
• **Conclusions** Our results support improved tolerance of sub-zero temperature as the main benefit of lichenization for the photobiont, but highlight that lichenization represents a delicate equilibrium between a mutualistic and a less reciprocal relationship. In a warmer climate scenario, the spread of the free-living *Prasiola* to the detriment of the lichen form would be likely, with unknown consequences for Maritime Antarctic ecosystems.

Key words: Abiotic stress, alga, desiccation tolerance, freezing tolerance, glassy state, lichen, *Mastodia tessellata*, photobiont, photoprotection, photosynthesis, polar, *Turgidosculum*.