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Culturable bacteria associated with Antarctic lichens: affiliation and psychrotolerance

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Abstract Antarctic habitats harbour yet unexplored niches for microbial communities. Among these, lichen symbioses are very long-living and stable microenvironments for bacterial colonization. In this work, we present a first assessment of the culturable fraction of bacteria associated with Antarctic lichens. A phylogenetic analysis based on 16S rRNA gene sequence of 30 bacterial strains isolated from five epilithic lichens belonging to four species (*Lecanora fuscobrunnea*, *Umbilicaria decussata*, *Usnea antarctica*, *Xanthoria elegans*) shows that these represent the main bacterial lineages *Actinobacteria*, *Firmicutes*, *Proteobacteria* and *Deinococcus-Thermus*. Within the *Actinomycetales*, two strains group in the genera *Arthrobacter* and *Knoellia*, respectively. Most of the other *Actinobacteria* form well-supported groups, but could be assigned with certainty only at the family level, and one is in isolated position in the *Mycobacteriaceae*. The strains in *Firmicutes* and *Proteobacteria* belong to the genera *Paenibacillus*, *Bacillus* and *Pseudomonas*, which were already reported from lichen thalli. Some genera such as *Burkholderia* and *Azotobacter*, reported in the literature as also associated with lichens, have not been detected in this study. One strain represents the first record of *Deinococcus* in epilithic lichens; it is related to the species *Deinococcus alpinitundrae* from Alpine environments and may represent a new species. Further separated and well-supported clades indicate the presence of possibly new entities. Some of the examined strains are related to known psychrophilic bacteria isolated from ice and other extreme environments, others with bacteria distributed worldwide even in temperate climates. Most of the strains tested were able to grow at low temperatures, but tolerated a wider range of temperature. Ecological and evolutionary implications of these lichen-associated bacteria are discussed.

Keywords Antarctica · Bacteria · Extreme conditions · Lichens · Microbial associations · SSU rDNA

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Introduction

The symbiotic association of fungi with photosynthetic organisms had a profound impact on the eukaryotic evolution. Mycorrhizal symbioses with plants likely supported the early colonization of land, the evolution of higher plants and vegetation as we know it today from temperate to tropical regions (Pirozynsky and Malloch 1975; Heckman et al. 2001; Schüßler et al. 2001). On the other hand, radiation of the fungi apparently correlates with the evolution of the lichen symbiosis of fungi and algae and/or cyanobacteria (Gargas et al. 1995; Lutzoni et al. 2001; Liu and Hall 2004; Reeb et al. 2004), some 600 million years ago (Yuan et al., 2005). The worldwide distribution of lichens and their estimated cover of more than 8% of land surface is a clear testimony to the ecological success of this lifestyle (Ahmadjian 1995). Other than higher plants, lichens are