



Contrasting patterns in lichen diversity in the continental and maritime Antarctic



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ABSTRACT

Systematic surveys of the lichen floras of Schirmacher Oasis (Queen Maud Land, continental Antarctic), Victoria Land (Ross Sector, continental Antarctic) and Admiralty Bay (South Shetland Islands, maritime Antarctic) were compared to help infer the major factors influencing patterns of diversity and biogeography in the three areas. Biogeographic patterns were determined using a variety of multivariate statistical tools. A total of 54 lichen species were documented from Schirmacher Oasis (SO), 48 from Victoria Land (VL) and 244 from Admiralty Bay (AB). Of these, 21 species were common to all areas. Most lichens from the SO and VL areas were microlichens, the dominant genus being *Buellia*. In AB, in contrast, many macrolichens were also present and the dominant genus was *Caloplaca*. In SO and VL large areas lacked any visible lichen cover, even where the ground was snow-free in summer. Small-scale diversity patterns were present in AB, where the number of species and genera was greater close to the coast. Most species recorded were rare in the study areas in which they were present and endemic to Antarctica.

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1. Introduction

Though Antarctica covers about 14 million km², the majority of its area (99.66%) is permanently covered by ice or snow. The remaining area (0.34%, or about 44,000 km²) is mostly only ice-free in summer and consists of bare rock, boulder fields, scree and simple soils (Brabyn et al., 2005). The region includes two widely recognised biogeographic zones: the continental Antarctic and the maritime Antarctic. Terrestrial vegetation mainly comprises isolated communities of lichens and mosses, with greatest diversity on the islands and archipelagos adjacent to the Antarctic Peninsula (Kappen, 2000; Øvstedal and Smith, 2001; Ochyra et al., 2008; Sung et al., 2008). The wide variety of unique adaptations possessed by these organisms enabling them to survive stresses due to the extreme growing conditions of the Antarctic has received considerable research attention (Hennion et al., 2006). It is also important to understand these unique ecosystems in order to manage and protect them, as is required under the obligations of the Antarctic

Treaty System (Green et al., 1999; Brabyn et al., 2005; Hughes and Convey, 2010).

The small-scale distribution of lichens within Antarctica is thought to be determined by the local environment providing favourable conditions (in particular moisture availability, Green et al., 1999) or exerting limiting effects (i.e. surface disturbance/instability, damage by wind action, etc. see Øvstedal and Smith, 2001). However, although lichen specimens have been collected from Antarctica by researchers over many years, more detailed and small-scale distributional and biogeographical studies based on systematic sampling have not been completed to date for the three study areas considered here, despite these being amongst the better characterized areas in terms of overall diversity in Antarctica. The current study was therefore undertaken in order to compare the lichen communities of three geographically distinct areas within Antarctica, the Schirmacher Oasis (SO, continental Antarctic), Victoria Land (VL, continental Antarctic) and Admiralty Bay (AB, King George Island, maritime Antarctic). We aimed to determine the major factors underlying patterns in local diversity and biogeography of lichens in these three areas.

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2. Materials and methods

2.1. Study sites

The Schirmacher Oasis (SO, 70° 46'04" – 70°44'21" S; 11°49'54" – 11°26'03" E) is a hilly strip of ice-free land in Queen Maud Land, continental Antarctic (Figs. 1 and 2a). It is divided into distinct topographical units – the southern continental ice sheet, rocky hills, valleys, lakes and the northern undulatory shelf ice. Its elevation varies from 0 to 236 m asl. The Oasis is oriented along an east–west axis and has a maximum width of 3.5 km and length of about 20 km, with a total area of about 70 km². This includes 35 km² of solid bedrock (ice free area). Freshwater lakes, ponds and pools cover a total area of 3 km². Permanently ice-covered tidal (epi-shelf) lakes cover an area of 4 km². There are also several nunataks protruding from the ice sheet near to the Oasis. Air temperature ranges between +4.2 and –25.2 °C, with a mean annual air temperature of –10.4 °C. The typical annual precipitation (snow) is 250–300 mm (water equivalent) and relative air humidity 15–20%. The area is underlain by permafrost with active layer depths ranging between 7 and 80 cm. The oasis is characterized by high-grade polymetamorphosed ortho- and paragneisses, the dominant rock types being biotite–garnet gneiss, pyroxene granulites, calc-gneiss, and khondalite along with migmatites and augen gneiss. The water content in loose soils of SO varies greatly. The meltwater of the inland ice and local snow and ice firn fields contributes significantly to the moisture content of sediments (Olech and Singh, 2010).

Victoria Land (VL) (Figs. 1 and 2b) is located in the Ross Sector of the continental Antarctic, and extends from Cape Hallett (72°S) along the coast (coastal continental Antarctic) southwards to the Dry Valleys (77°S), and connects to the Transantarctic Mountains. In Victoria Land 21 locations were investigated along a five degree latitudinal transect from Cape Hallett (72°26'S, 169°56'E) to Marble Point, in the McMurdo Dry Valleys region (77°24'S, 163°43'E). The climate of this region is frigid Antarctic (Øvstedal and Smith, 2001). In northern

Victoria Land the mean annual air temperature is around –16 °C and the annual precipitation occurs mostly as snow (with c. 270 mm y^{–1} water equivalent). The monthly mean air temperature ranges between –25.9 °C (August) and –0.1 °C (January). Further south in Victoria Land the climate is drier and colder with a mean annual air temperature of –17.4 °C at McMurdo Station (77°51'S, 166°40'E). The monthly mean air temperature at McMurdo Station ranges between –27.9 °C (August) and –1 °C (January). All sites were characterized by the occurrence of continuous permafrost, with an active layer thickness of 0–93 cm in Northern VL and of 0–60 cm in the McMurdo region. Although the climate has cooled slightly in the last decade, in Northern VL active layer thickness is currently slowly increasing, probably due to an increase in radiation receipt at ground level (Guglielmin and Cannone, 2012; Guglielmin et al., 2014). In this wide region almost all substratum types (granite, basalt, gabbro, metamorphic rocks, moraine and old marine deposits) were sampled in ice-free areas, sometimes close to glacier margins. Several sites included ornithogenic soils.

Admiralty Bay (AB, 61°50' – 62°15'S; 57°30' – 59°01'W) is the largest marine embayment on King George Island in the South Shetland Islands archipelago, maritime Antarctic (Figs. 1 and 2c). It has an area of 122 km² and a depth of up to 500 m. Of the total 361 km² catchment of the Bay, 242 km² is ice-free land surface. Its geology is dominated by Tertiary effusive basalt andesite and related pyroclastic rocks, having lithified and loose sedimentary rocks. Most of the ice-free terrestrial areas are adjacent to the sea. The main ice cap surrounding and draining into AB is the Arcowski Icefield. AB experiences a monthly temperature range of 1.3 °C to –7.5 °C, with an annual mean of –2.8 °C (Kejna, 1999). Mean wind velocity is about 6.5 m s^{–1}. Air humidity is typically high (83%), with annual precipitation of 508.5 mm.

2.2. Sampling and species determination

It is a well-established feature of biodiversity studies that the observed taxonomic richness of a given region is heavily influenced

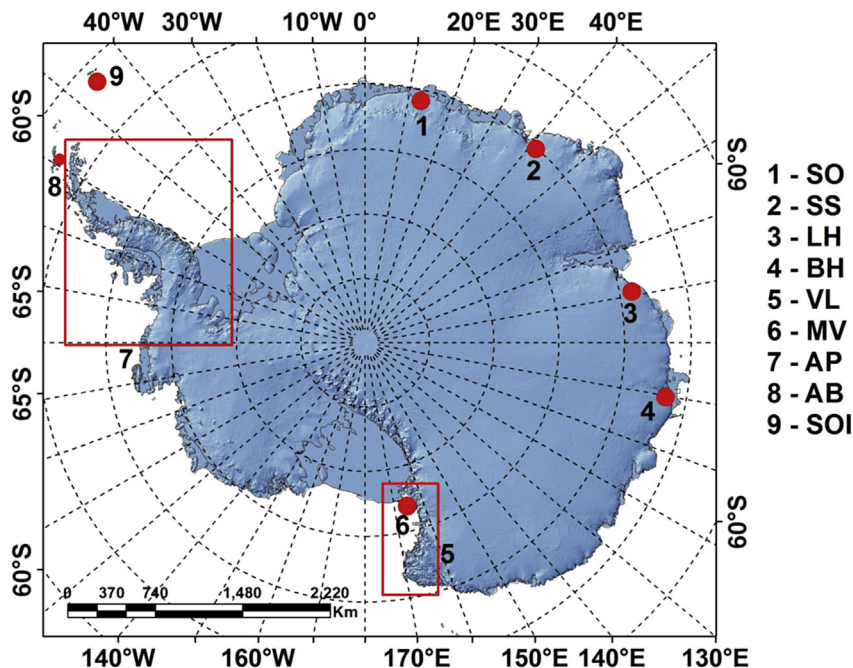


Fig. 1. Map of Antarctica showing the locations mentioned in the text. Legend: (1 = Schirmacher Oasis (SO), 2 = Syowa Oasis (SS), 3 = Larsemann Hills (LH), 4 = Bunger Hills (BH), 5 = Victoria land (Oasis (VL), 6 = McMurdo (MV), 7 = Antarctic Peninsula, 8 = Admiralty Bay (AB), 9 = South Orkney Island.

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