Nova Hedwigia 68 3—4 301—337 Stuttgart, Mai 1999

Bryophyte and lichen flora of South Bay (Livingston Island: South Shetland Islands, Antarctica)

by

Leopoldo G. Sancho

Dpto. Biología Vegetal II, Fac. Farmacia, Universidad Complutense, E-28040, Madrid, Spain

Florian Schulz

Institut für Polarökologie, Wischhofstr. 1-3, D-24148 Kiel, Germany

Burkhard Schroeter and Ludger Kappen

Botanisches Institut der Universität Kiel, Olshausenstrasse 40, D-24098 Kiel, Germany

With 2 figures

Sancho, L.G., F. Schulz, B. Schroeter & L. Kappen (1999): Bryophyte and lichen flora of South Bay (Livingston Island: South Shetland Islands, Antarctica). - Nova Hedwigia 68: 301-337.

Abstract: One hundred and ten lichen and fifty bryophyte species are reported from the vicinity of the Spanish Antarctic research station Juan Carlos I. (BAE; Livingston Island, South Shetland Islands). The study site consists of an ice-free area of around 3 km^2 on the southern coast of South Bay. Considering its small extent this area has a remarkably large biodiversity. The present catalogue is the largest so far reported for any single Antarctic locality. For some lichen genera such as *Caloplaca, Cladonia* and *Umbilicaria,* this part of Livingston Island probably has the highest species diversity of any site in the Antarctic region. We found very different phytogeographic patterns for lichens and bryophytes. Whereas 21% of the lichen species are endemic, only 10% of the bryophyte species have an exclusively Antarctic distribution. In contrast, bryophytes with a Southern Hemisphere distribution contribute 31% to the bryophyte flora, while only 10% of the studied lichens have this pattern of distribution. Ecology, distribution and taxonomic status of some of the recorded species are also briefly discussed.

Introduction

Lichens and mosses are the predominant elements of the terrestrial vegetation of Antarctica. In fact, the Antarctic is the only major land mass vegetated almost entirely by cryptograms (Skottsberg 1960). Apart from isolation of land masses climatic differences determine the biodiversity and the distribution of the vegetation. Holdgate

0029-5035/99/0068-0301 $ 9.25

(1964) and Longton (1979) distinguished between maritime and continental regions the former comprising the west coast of the Antarctic Peninsula and adjacent islands. The maritime Antarctic is characterised by relatively small seasonal and diurnal temperature changes and a comparatively mild summer with mean monthly air temperatures of c. 0-2°C and with mean monthly winter temperatures not lower than –20°C (Longton 1988). Under these climatic conditions a rich cryptogamic vegetation is formed as patches or carpets or even larger coherent stands in ice-free areas. Most of the lichen and bryophyte species reported for the Antarctic are found in the maritime region where also the only two native species of flowering plants occur.

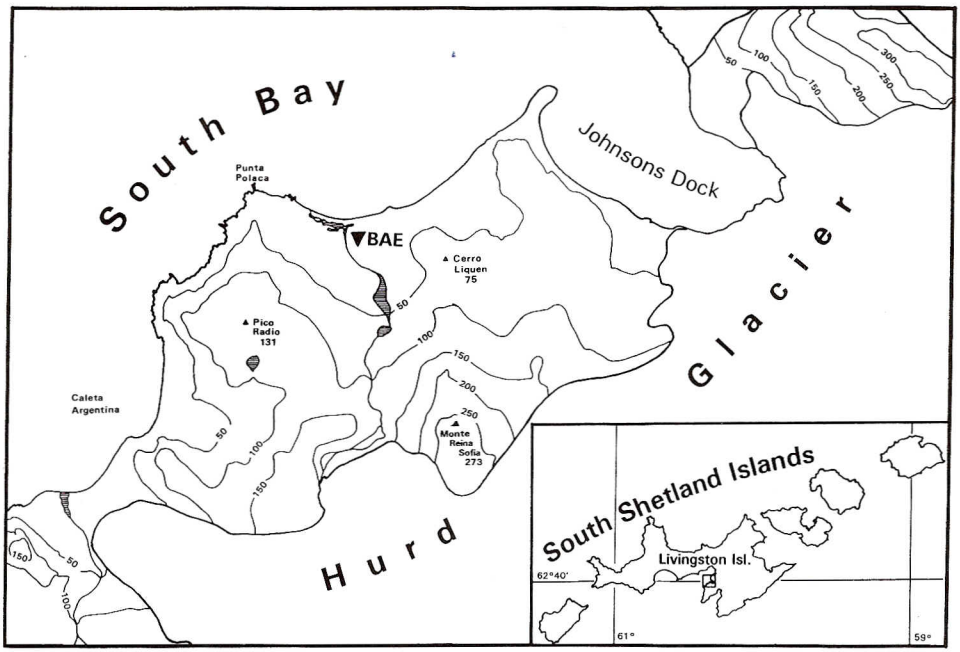

Fig. 1. Map of the studied area showing the major named localities referred to in the text. The frame of the enlarged map is ca. 4 × 2.5 km. Altitude is given in meters above sea level.

The lichen flora of the South Shetland Islands has been studied by different authors (Lindsay 1971b, Allison & Smith 1973, Redón 1985, Smith 1988a, 1988b, Jacobsen & Kappen 1988, Aptroot & Knaap 1993). Similarly, Livingston Island, and in particular the Johnson's Dock area, have been studied (Olech 1989; Sancho et al. 1990, 1992; Sancho & Sojo 1991) indicating the considerable floristic richness of this region. In the present floristic account, the taxonomic division and nomenclature of the lichens follow the monographs for the Antarctic of the genera *Acarospora* (Castello & Nimis 1994a), *Alectoria, Cornicularia* (Lamb 1964), *Buellia* (Lamb 1968), *Caloplaca* (Söchting & Olech 1995), *Candelariella* (Castello & Nimis 1994b),

Cladonia (Stenroos 1993), *Lecidea* s.l. (Hertel 1984), *Rinodina* (Lamb 1968), *Stereocaulon* (Smith & Övstedal 1991), *Usnea* (Walker 1985) and *Umbilicaria* (Lindsay 1969, Filson 1987, Sancho et al. 1992). The critical revision by Castello & Nimis (1995) on the Antarctic lichens has also been taken into account.

For the determination of the bryophytes the monographs on the Antarctic genera *Polytrichum, Psilopilum, Sarconeurum, Pohlia, Andreaea* (Greene et al. 1970), *Tortula* (Lightowlers 1986a), *Encalypta* (Newton 1974), *Dicranella* and *Distichium* (Newton 1977) and for hepatics (Ochyra & Váňa 1989a, 1989b) were used. The genera *Bryum, Schistidium, Dicranoweisia* and *Ceratodon* are poorly studied, causing confusion with Antarctic material, because of variable morphology or lack of sporophytes. During the last two decades extensive exploration of the moss flora of the maritime Antarctic was carried out mainly by R. I. Lewis Smith (Smith 1972, 1988a, 1988b, 1996, Smith & Corner 1973, Allison & Smith 1972). Additional information by H. Robinson (1972) and R. Ochyra (e.g. Ochyra & Váňa 1989a, 1989b) and, for the South Bay area, have been provided by Lindsay (1971b), Robinson (1972) and Olech (1989), but the total of studied species did not exceed 20.

Between 1989 and 1996 six summer expeditions to the Spanish station Juan Carlos I. (BAE) were undertaken to investigate different aspects of the terrestrial ecology and the flora of South Bay (Livingston Island). It was known that this small area has an exceptional floristic richness. The aim of this work is to offer a comprehensive description of the flora and vegetation of this area, as a document for future investigations of the terrestrial ecology. The present check list is based on the examination of more than 700 specimens of lichens, which are contained in the MAF (Fac. Farmacia, Universidad Complutense, Madrid, Spain), and 250 specimens of mosses and lichens housed in the Herbarium Antarcticum Kiel.

Area description

The South Shetland Islands are located north-west of the Antarctic Peninsula, the largest being King George Island and Livingston Island. The main geomorphological feature of Livingston Island is the notable contrast between the south-east mountain range (Friesland Mountains, 1700 m) and the relatively flat ice-free north-west region (Byers Peninsula). South Bay (62° 40' S, 60° 23' W) is the natural border between these regions. For this reason, the south side of South Bay is exposed to the mild and humid north and north-west winds, but is protected against the cold and strong south winds. The studied area consists of an ice-free region of around 3 km^2 bordered by Johnson's Dock and Argentine Bay. This area is formed by a complex of raised beaches and glacial moraines (López-Martinez et al. 1991; Sàbat et al. 1992), coastal cliffs and penguin rookeries. The highest point is Mount Reina Sofía (273 m). The geology of the investigated area differs considerably from the rest of the island and from the South Shetland Islands in general. Whereas most of Livingston Island and the other islands are of volcanic origin, the investigated area consists of sedimentary rocks. According to Smellie et al. (1984) the area can be assigned to the Miers Bluff Formation, a sequence of shales and greywackes (turbiditic deposits) containing no diagnostic fossils.

The summer season in the area is characterized by a relatively mild climate in comparison with other stations in the South Shetland Islands (Bañón 1997). The mean temperature during the summer months (December-February) 1988-1993 was ca. 3°C, showing very little day/night oscillation. The average precipitation in summer was around 200 mm and the relative air humidity averaged c. 80% but was frequently above 90%. Rainfall or snow occurred on about 70% of the days during the summer period (December-February). In more than half of this period the daily precipitation was less than 0.2 mm. Obviously the relatively mild and humid summers contribute to the development of the richness of the cryptogamic flora and its high biomass in the studied area.

Vegetation

The locally dense vegetation cover consists of a mosaic of different communities corresponding mainly with the relief and substratum and demonstrating a gradient from coast to inland, but also the influence of temperature, nutrient availability and water availability has to be considered.

Near the shoreline small stones and pebbles of raised beaches are covered by crustose lichens with *Caloplaca coralligera* being the characteristic and also the most abundant species. Wet places of the beach terraces are colonized by mosses, especially *Sanionia uncinata, Brachythecium austro-salebrosum* and *Bryum pseudotriquetrum.* On the more elevated beach terraces *Usnea aurantiaco-atra* grows densely on stable pebbles whilst on sandy ground the moss *Polytrichum piliferum* and *Peltigera didactyla* are more frequent.

The vertical slopes of coastal rocks and cliffs are almost completely covered by an extensive lichen vegetation consisting of several growth forms, whereas mosses such as *Schistidium antarctici* are scarce. The fruticose lichens *Usnea antarctica* and *U. aurantiaco-atra* dominate and, above ca. 40 m a.s.l., *Himantormia lugubris* becomes codominant. Near the coast the umbilicate species *Umbilicaria antarctica, U. africana, U. decussata, U. nylanderiana* and *U. kappeni* are locally abundant. In these communities *Parmelia saxatilis* is clearly the most abundant foliose lichen. Crustose lichens reach a high diversity, especially in microhabitats where macrolichens are absent. On rain-protected slopes only species of *Caloplaca* are present. On the base of protruding rocks several species of *Lecidea* s.l. and *Buellia* form a dense crust whereas higher on the rock, when competition with macrolichens begins, *Rhizocarpon geographicum* s.l. becomes more abundant.

Under the influence of bird perching the composition of the epilithic lichen communities changes dramatically. *Ramalina terebrata* becomes the dominant fruticose lichen, very often associated with the nano-fruticose *Bacidia stipata, Catillaria corymbosa* and *Lecania brialmontii* (see Follmann 1965). Foliose lichens mainly belonging to the genera *Physcia* and *Xanthoria,* and associated with crustose species such as *Buellia anisomera* and *Rinodina petermannii* occur close to the bird excrements. Mosses such as *Ceratodon purpureus, Polytrichum alpinum* and *Tortula princeps,* the green algae *Prasiola crispa* ssp. *antarctica* and the grass *Deschampsia antarctica* can also be found. If the ornithocoprophilous communities on rocks are influenced by

seaspray, the lichens *Mastodia tesselata* and *Caloplaca lucens,* together with several species of *Caloplaca* are among the dominant species.

Farther inland the slopes of the hills are mostly covered by a closed carpet of mosses and lichens. Most prominent are *Sanionia uncinata, Polytrichum alpinum, Tortula* species, *Pohlia cruda* and *Bartramia patens* and the lichen species *Stereocaulon alpinum, Sphaerophorus globosus, Cladonia* spp., *Peltigera didactyla, Psoroma hypnorum, Physconia muscigena* and *Coelocaulon epiphorellum.* In such stands the two vascular plants *Deschampsia antarctica* and *Colobanthus quitensis* are often present, but they prefer moderately dry conditions.

The rocks and cliffs farther inland are also densely covered by lichens and mosses. With increasing altitude the mosses *Andreaea gainii* and *A. regularis* gain importance. *Usnea aurantiaco-atra* and *Himantormia lugubris* are the most prominent lichens but are locally associated with *Pseudephebe pubescens* and *Ps. minuscula. Umbilicaria krascheninnikovii* occurs only on inland cliffs, associated with *U. decussata.* There, *Aspicilia glacialis, Sporastatia testudinea* and *Buellia latemarginata* are some of the most characteristic crustose species. Cracks and fissures in these rocks provide a habitat for several moss species including rarities (i.e. *Dicranella hookeri, Didymodon gelidus, Platydictya densissima* and *Bryoerythrophyllum recurvirostre).*

Meltwater channels are frequently lined by a moss vegetation formed by *Sanionia uncinata, Calliergon sarmentosum, Brachythecium austro-salebrosum* and *Bryum pseudotriquetrum. Schistidium rivulare* is typical for the inundated zone of these channels while the cyanolichens *Placopsis contortuplicata* and *Leptogium puberulum* occur in temporarily wet snow beds.

Permanently wet snowbeds are often entirely covered by *Calliergon sarmentosum.* In a slightly drier situation *Sanionia uncinata, Bryum pseudotriquetrum* and the small hepatic *Cephaloziella varians* often intrudes into these stands.

On moraines near the glacier front no prominent vegetation is visible but, on clayey substrate, the pioneer moss *Pottia austro-georgica* sometimes occurs. On boulders of recent moraines crustose lichens such as *Aspicilia glacialis, Amandinea coniops, Buellia latemarginata, Caloplaca sublobulata* and *Rhizocarpon geographicum,* constitute the pioneer vegetation.

In areas above 80 m a.s.l, an association is formed around the rock bases consisting entirely of the hepatics *Herzogobryum teres, Anthelia juratzkana* and *Pachyglossa dissitifolia.*

Near the glacier fronts the species composition of South Bay becomes increasingly depauperate but biomass is still high. Unexpected is the occurrence of both vascular plants near the summit of Mount Reina Sofia, at the north slope, associated with a poorly developed lichen community containing *Stereocaulon alpinum* and *Placopsis contortuplicata.*

The different geology seemingly does not affect the structure of the vegetation, in fact it is very similar to the described pattern given by Lindsay (1971b) for the whole South Shetland Islands.

Lichens

Acarospora gwynnii Dodge & Rudolph

The specimens of Livingston Island show a more or less dispersed thallus formed by smooth and quite flat areoles, as it is typical for *A. petalina,* a species previously reported from South Bay (Sancho et al. 1990). However, according to Filson (1975) and Castello & Nimis (1994a, 1994b) this species is considered to be synonymous with *A. gwynnii,* the only species of *Acarospora subgen. Xanthothallia* cited by Dodge (1973) that is currently accepted. In fact, all our specimens fit well into the variability described by Castello & Nimis (1994a) for *A. gwynnii.* This species is apparently endemic to Antarctica. It is common in continental Antarctica (Övstedal 1986a, Seppelt et al. 1995) and also known from Antarctic Peninsula, South Shetland Islands and sub-Antarctic regions (Lindsay 1974). In South Bay *A. gwynnii* is a rare species, growing only on protected overhanging rocks near the coast, on defoliating rock surfaces with a very poor lichen colonisation.

Acarospora macrocyclos Vain.

Probably synonymous with *A. siplei* Dodge (Castello & Nimis 1995), a species described from the maritime Antarctic (Dodge 1973). *A. macrocyclos* is quite common in the sub-Antarctic islands and in the maritime Antarctic region (Redón 1985). In South Bay it is mainly growing near the coast, but also on the larger boulders of a recent moraine 125 m a.s.l. (Sancho & Valladares 1993).

Amandinea coniops (Wahlenb. in Ach.) Scheid.

[syn. *Buellia coniops* (Wahlenb. in Ach.) Th. Fr.]

A bipolar species quite common in the maritime Antarctic (Smith 1972). In South Bay very frequent on bird perches and other eutrophicated localities.

Aspicilia glacialis Dodge

Thallus small (0.5-1.5 cm) more or less circular, areolate towards the centre somewhat effigurate at the margins, whitish grey. Apothecia (0. 3 -1 mm) typical for *Aspicilia,* immersed, disk plane, dark grey, but usually covered by a whitish pruina. Spores (13-16 × 7-8 μm) 8 per ascus, frequently not all of them well developed, hyaline, unilocular, ellipsoidal. This species is known from the continental Antarctic (Seppelt et al. 1995; Seppelt et al. 1996), where it was described (Dodge 1973). In South Bay *A. glacialis* is only located on stones of young moraines, close to the glacier front, belonging to the pioneer lichen community (Sancho & Valladares 1993). We have not seen previous reports of this species from the maritime Antarctic.

Austrolecia antarctica Hertel

External morphology similar to *Lecidea marginata* gr., but the asci have a dense amylaceous tholus of the *Catillaria*-type (Hertel 1984). Quite common in the maritime Antarctic and sub-Antarctic islands (Hertel 1984). Very common in South Bay, especially in the inland, growing together with *Usnea aurantiaco-atra* and *Himantormia lugubris.*

Bacidia stipata Lamb

This nano-fruticose species is common in the maritime Antarctic (Lamb 1954, Redón 1985), but has been also reported for Antarctic continent (Övstedal 1986a). In South Bay *B. stipata* is locally abundant, mainly on the cliffs visited by flying birds and penguins.

Bacidia trachona (Ach.) Lettau

Thallus morphology and the shape and number of cells in the spores of our specimens fit well with the description given by Övstedal (1986a) in the first report of *B. trachona* for the Antarctic. Previously reported as rare on Livingston Island (Olech 1989), *B. trachona* was frequently found in South Bay growing together with *Placopsis contortuplicata* and *Leptogium puberulum* in melt water channels.

Bryoria chalybeiformis (L.) Brodo & Hawksworth

A bipolar species, which seems to be common in the South Shetlands and South Orkney Islands (Lamb 1964, Smith 1972, Redón 1985). Associated to mosses in small and protected rock terraces. Not frequent.

Buellia anisomera Vainio

Mainly distributed in the maritime Antarctic (Lamb 1968, Redón 1985) but also known from the sub-Antarctic (Övstedal 1986b). In South Bay *B. anisomera* has always been found on bird perches, where it is one of the most abundant crustose lichen.

Buellia augusta Vainio

Apparently endemic to the maritime Antarctic (Lamb 1968, Redón 1985) and South Georgia (Lindsay 1973a). In South Bay it was always found growing on bird perches, more abundant towards the coast.

Buellia cladocarpiza Lamb

Dwarf-fruticose species locally abundant on bird perches and in most protected localities of coastal cliffs visited by flying birds and penguins. It is a typical species of the maritime Antarctic (Lamb 1968, Lindsay 1971b) and has also been reported from some localities in the continental Antarctic (Kappen 1985, Redón 1985, Smith 1988c).

Buellia granulosa (Darb.) Dodge

Apparently endemic to the maritime Antarctic (Lamb 1968, Redón 1985). In South Bay it is a relatively common species, growing on small boulders and pebbles near the coast.

Buellia latemarginata Darb.

Apparently endemic to the maritime Antarctic and sub-Antarctic (Lamb 1968, Lindsay 1973b, Filson 1974). In South Bay *B. latemarginata* is one of the most abundant species of the pioneer lichen community on recent moraines (Sancho & Valladares 1993).

Buellia papillata (Somm.) Tuck.

This bipolar species had been reported by Lamb (1968) and Redón (1985) from only one Antarctic locality (Ross Island). However, Olech (1989) mentioned *B. papillata* as a frequent species on Livingston Island. We can confirm this report having found *B. papillata* growing on raised beaches, mainly on small boulders, locally abundant.

Buellia russa (Hue) Darb.

Apparently endemic to the maritime Antarctic and to the sub-Antarctic (Lamb 1968, Lindsay 1973b, Övstedal 1986a, b) it is a very common species in South Bay, growing together with *Carbonea assentiens* (syn. *Lecidea sciatrapha*) on large boulders or on the base of cliffs near the coast.

Caloplaca athallina Darb.

Endemic to the Antarctic. This species is known from the continental Antarctic as well from the maritime Antarctic (Söchting & Olech 1995). Growing over cushions of mosses, frequent in South Bay.

Caloplaca austroshetlandica (Zahlbr.) Söchting & Olech

Endemic species from the western Antarctic (Söchting & Olech 1995). *C. austroshetlandica* is a pioneer species on rocks and boulders under the influence of melt water. Scattered in South Bay.

Caloplaca cirrochrooides (Vain.) Zahlbr.

This species has an insul-Antarctic distribution (Söchting & Olech 1995), that includes the maritime Antarctic and the sub-Antarctic islands. In South Bay *C. cirrochrooides* has only been found growing on nutrient-enriched rocks in Punta Polaca and Caleta Argentina.

Caloplaca citrina (Hoffm.) Th. Fr.

This bipolar species (Söchting & Olech 1995) is frequent in South Bay, where it grows on rocks and mosses.

Caloplaca coralligera (Hue) Zahlbr.

This brown *Caloplaca* frequently develops dwarf-fruticose thalli. From the primary horizontal thallus numerous vertical branches emerge which develop shrublike ramifications during their further development (Ott & Sancho 1993). *C. coralligera* seems to be endemic to the maritime Antarctic (Dodge 1973). In South Bay it is a very frequent lichen growing on rocks near the coast.

Caloplaca lucens (Nyl.) Zahlbr.

Antarctic and sub-Antarctic species (Söchting & Övstedal 1992). In South Bay it is common on rocks around the small penguin rookery of Caleta Argentina.

Caloplaca millegrana (Müll. Arg.) Zahlbr.

This is a sub-Antarctic species also known from Australia (Söchting & Olech 1995). In South Bay *C. millegrana* is a frequent species, mainly growing on nutrient-enriched rocks near the coast.

Caloplaca sublobulata (Nyl.) Zahlbr.

This is probably the most abundant *Caloplaca* in South Bay. It grows on nutrient-enriched stones and cliffs near the coast, and also on boulders of recent moraines in the inland (Sancho & Valladares 1993). *C. sublobulata* is a sub-Antarctic species, also known from South America, Africa, Australia and New Zealand (Söchting & Olech 1995).

Caloplaca tirolensis Zahlbr.

Bipolar and muscicolous species (Söchting & Olech 1995). In South Bay it grows on dead mosses, sometimes together with *C. athallina.*

Candelariella aurella (Hoffm.) Zahlbr.

This species differs from *C. vitellina* by its inconspicuous thallus and its 8-spored asci. Previously, another 8-spored species, *C. hallettensis* (J.S. Murray) Övstedal, currently synonymous with *C. flava* (Dodge & Baker) Castello & Nimis, had also been reported from Livingston Island (Olech 1989). *C. flava* shows a well-developed granulose thallus and it is considered as endemic to the continental Antarctic (Castello & Nimis 1994b). Olech (1989) listed *C. flava* as a rare species in South Bay. In the present study, we could not find this species again. *C. aurella* is a cosmopolitan species that has been reported from the South Shetland Islands as common (Aproot & Knaap 1993). In South Bay it is locally an abundant species, growing on nutrients-enriched stones near the coast.

Candelariella vitellina (Hoffm.) Müll. Arg.

This cosmopolitan species is common in South Bay, especially in the ornithocoprophilous community, together with species such as *Ramalina terebrata, Xanthoria*

candelaria and *Buellia anisomera.* The species is well known from the maritime Antarctic (Smith 1972, Redón 1985, Jacobsen & Kappen 1988) and has been reported from the Antarctic continent (Bowra et al. 1966, Castello & Nimis 1994b) also.

Carbonea assentiens (Nyl.) Hertel

(Syn. *Lecidea sciatrapha* Hue)

This species is characterised by the Lecanora type ascus (Hafellner 1984), the well developed light-brown or colorless hypothecium and the black carbonaceous excipulum. *C. assentiens* was previously reported by Hertel (1984) for the sub-Antarctic islands, Kerguelen, Marion I. and Prince-Edward I. In South Bay this is a very common species, growing over a wide altitudinal range, mainly on the bases of rocks, probably indicating the average snow cover during the winter (Kappen et al. 1990).

Carbonea vorticosa (Flörke) Hertel

Very common in South Bay where it can be found along a broad altitudinal range, from the coast to the summit of Mount Reina Sofia. In this area *C. vorticosa* shows an almost completely endolithic thallus. This bipolar species seems to be relatively common in the maritime Antarctic.

Catillaria corymbosa (Hue) Lamb

In South Bay this nano-fruticose species occurs in more or less openly exposed microhabitats but always influenced by bird excrements. Following this ecological variability several morphological and ecophysiological adaptations have been described (Sojo et al. 1997). In South Bay *C. corymbosa* is frequent on the coastal cliffs of Punta Polaca. It is endemic to the maritime Antarctic.

Cladonia borealis Stenroos

Cosmopolitan species scattered in South Bay, especially on ledges of the cliffs between Caleta Española and Johnson's Dock. Common in the maritime Antarctic it was previously reported from Livingston I. (Stenroos 1993).

Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel

Cosmopolitan species common in South Bay mainly on raised beaches taking part in moss-lichen communities. Common in the maritime Antarctic it was previously reported for Livingston I. (Stenroos 1993).

Cladonia fimbriata (L.) Fr.

Cosmopolitan species. It has in Livingston I. the same ecology as *C. chlorophaea.* Common in the maritime Antarctic and was previously reported for Livingston I. (Stenroos 1993).

Cladonia galindezii Övstedal

This endemic species of the maritime Antarctic (Stenroos 1993) is very common in South Bay where it can be found on raised beaches and small hills together with fruticose lichens such as *Stereocaulon alpinum* and *Sphaerophorus globosus* and mosses. It was previously reported for Livingston I. (Stenroos 1993). The record of C. *cariosa* (Ach.) Sprengel from South Bay (Olech 1989) is most probably based on samples of *C. galindezii.*

Cladonia gracilis (L.) Willd.

Cosmopolitan species, common in South Bay showing the same ecology as *C. galindezii.* Common in the maritime Antarctic it was previously reported from Livingston I. (Stenroos 1993).

Cladonia pleurota (Flörke) Schaer.

Cosmopolitan species common in the maritime Antarctic but not previously reported from Livingston I. In South Bay *C. pleurota* shows the same ecology as *C. galindezii.*

Cladonia pocillum (Ach.) O.-J. Rich.

Cosmopolitan species common in South Bay having the same ecology as *C. chlorophaea.* Common in the maritime Antarctic and previously reported from Livingston I. (Stenroos 1993).

Cladonia sarmentosa (J.D. Hooker & Taylor) Dodge

This species is widely distributed in the Southern Hemisphere, where it is known from South America, Australia and New Zealand (Stenroos et al. 1992). In the Antarctic C. *sarmentosa* is restricted to the maritime Antarctic region, it was previously reported from Livington I. (Stenroos 1993). In South Bay it has the same ecology and distribution as *C. gracilis.*

Cladonia squamosa Hoffm.

Cosmopolitan species common in South Bay having the same ecology as *C. chlorophaea.* Common in the maritime Antarctic but not previously reported from Livingston I. (Stenroos 1993).

Cladonia subulata (L.) Weber ex Wigg.

Cosmopolitan species seems to be rare in South Bay where it has been collected on raised beaches near the Spanish Station. Common in the maritime Antarctic and previously reported from Livingston I. (Stenroos 1993).

Coelopogon epiphorellus (Nyl. in Crombie) Brusse & Kärnefelt

(Syn. *Coelocaulon epiphorellum* (Nyl. in Crombic) Kärnefelt)

This species has a distribution restricted to the southern part of South America, South Africa and the maritime Antarctic. Kärnefelt (1986) suggests that *C. epiphorellus* is an ancient phytogeographical element, possible Jurassic in origin, developed in the western zone of the ancient continent of Gondwana. Within the lichen flora of Livingston I. *Caloplaca sublobulata* and *Umbilicaria africana* also show this type of distribution. In South Bay *C. epiphorellus* is a rare species known only from the hills between the Spanish station and Johnson's Dock, always growing over mosses.

Coelocaulon aculeatum (Schreber) Link

Cosmopolitan species, common in South Bay, up to ca. 100 m a.s.l. growing over mosses.

Dermatocarpon intestiniforme (Körb.) Hasse

Although the species has been recorded for the South Orkney Islands (Redón 1985, Smith 1992) and for the Antarctic Peninsula region (Lamb 1948, Smith 1993) we do not know any previous report of this bipolar species for the South Shetland Islands. In South Bay we only know one population of this species in Caleta Argentina, where it is growing on moist rock faces near the coast.

Haematomma erythromma (Nyl.) Zahlbr.

Endemic in the sub-Antarctic islands and maritime Antarctic (Redón 1985). It is a common ornithocoprophytic species in South Bay.

Himantormia lugubris (Hue) Lamb

Endemic in the maritime Antarctic, this is a very common species in South Bay where it can be found within a broad altitudinal range, from 30 m a.s.l. up to the summit of Mount Reina Sofia. Always saxicolous, *H. lugubris* seems to be unable to endure strong competition by other macrolichens (Kappen et al. 1987) as is typical in the very rich communities of the coastal cliffs. Gas exchange experiments have shown an extremely low photosynthetic rate in *H. lugubris* in comparison with other Antarctic macrolichens (Kappen et al. 1987).

Lecania brialmontii (Vain.) Zahlbr.

Endemic in the maritime Antarctic this species is ecologically similar to *Catillaria corymbosa.* In South Bay *L. brialmontii* is a frequent species especially on coastal rocks of Caleta Argentina, where it is growing together with *Ramalina terebrata.*

Lecanora albescens (Hoffm.) Branth & Rostrup

Cosmopolitan species, e.g. very common in Europe growing on more or less eutrophic rocks (Wirth 1995). We do not know any previous record of this species for the Antarctic. *L. albescens* was collected on a bird-influenced rock in Caleta Argentina.

Lecanora dispersa (Pers.) Sommerf.

This cosmopolitan species, very common in the Northern Hemisphere, has been reported for Cockburn Island (Smith 1993). In South Bay *L. dispersa* is a pioneer species, frequently growing on unstable pebbles with weak lichen cover.

Lecanora handelii Steiner

Pioneer lichen, in the Northern Hemisphere known to be a metallicolous species (Poelt & Ullrich 1964). We do not know any previous mention of this species for the Antarctic. In South Bay *L. handelii* was found between 15 and 60 m a.s.l growing on overhanging northerly exposed rock faces.

Lecanora intricata (Ach.) Ach.

In the Northern Hemisphere *L. intricata* shows an arctic-alpine distribution (Wirth 1995). No previous report is known for the Antarctic region. We have collected it on Cerro Líquen, 70 m a.s.l.

Lecanora margaritae Hue

This is an endemic species in the maritime Antarctic (Dodge 1973). No previous report of this species from the South Shetland Islands is known. In South Bay *L. margaritae* is an occasional species, growing on vertical rock faces near the coast.

Lecanora miranda Hue

Known from the South Shetland Islands, this species seems to be restricted to the northern part of the maritime Antarctic (Dodge 1973). In South Bay *L. miranda* has a similar distribution as *L. margaritae.*

Lecanora physciella (Darb.) Hertel

Apparently an Antarctic endemic. *L. physciella* was described from the continental Antarctic (Hertel 1984) but it has been later collected in the Antarctic Peninsula region (Smith 1993). In South Bay we have collected this species in a single locality, Pico Radio, 120 m a.s.l.

Lecanora polytropa (Hoffm.) Rabh.

This cosmopolitan species is common in the maritime Antarctic (Redón 1985). In South Bay *L. polytropa* is an occasional species, frequent in pioneer communities, growing on boulders of recent moraines (Sancho & Valladares 1993).

Lecidea sp. (nº 2414 sensu Hertel 1984)

According to Hertel (1984) *Lecidea* 2414 is related to *L. lapicida,* having an amyloide medulla, I+ violet, whereas the medulla of *Lecidea* 2414 is I–. Hertel mentions this species from the sub-Antarctic islands. It is probably new for the South Shetland I. In South Bay *Lecidea* sp. is growing on hard rocks, always above 120 m a.s.l.

Lecidea atrobrunnea (Ram.) Schaerer

This bipolar brown *Lecidea* is relatively common in the Antarctic Peninsula (Hertel 1984, Redón 1985) and it was previously reported from Livingston Island (Olech 1989). In South Bay *L. atrobrunnea* is a very common species growing on exposed rock surfaces from the coast up to the summit of Mount Reina Sofia.

Lecidea lapicida (Ach.) Ach.

Cosmopolitan species very common in the Northern Hemisphere. In the Antarctic *L. lapicida* has been reported from the sub-Antarctic islands (Hertel 1984) and from Livingston Island (Olech 1989). In South Bay it is a common species, especially in the Pico Radio region.

Lecidella stigmatea (Ach.) Hertel & Leuckert

Bipolar species, previously recorded for Livingston Island (Olech 1989). We collected this species in only one locality, on vertical rock faces near the coast.

Lecidella wulfenii (Hepp) Körber

This bipolar muscicolous species has been previously reported from Livingston Island by Olech (1989), where it is frequently growing on moss carpets near the coast. It was first recorded for the Antarctic from King George Island (Jacobsen & Kappen 1988).

Lepraria neglecta (Nyl.) Erichs.

This cosmopolitan species grows on moss cushions over a wide altitudinal range. *L. neglecta* has been previously reported from Livingston Island (Olech 1989).

Leptogium puberulum Hue

Endemic to the maritime Antarctic and to the sub-Antarctic (Smith 1972, Lindsay 1974, 1975, Jörgensen 1986) this is a very common species in South Bay. In this area *L. puberulum* prefers moist habitats that are supplied by snowmelt during spring and summer (Schlensog et al. 1997) usually sharing this habitat with *Placopsis contortuplicata.*

Massalongia carnosa (Dicks.) Körber

Muscicolous species with a bipolar distribution, quite common in the South Shetland Islands (Redón 1985). In South Bay it is a very common species growing on mosses, mainly *Andreaea* spp.

Mastodia tesselata (Hook. & Harv.) Hook. & Harv.

Bipolar species restricted to areas strongly influenced by bird excrements. *M. tesselata* is common in the maritime Antarctic (Redón 1985). In South Bay it is especially frequent in Caleta Argentina, growing on rocks near or within penguin colonies.

Megaspora verrucosa (Ach.) Haf. & V. Wirth

Bipolar species, common in South Bay growing on mosses near the coast. Previously reported from King George Island (Jacobsen & Kappen 1988) and Livingston Island (Olech 1989).

Ochrolechia antarctica (Müll. Arg.) Darb.

The distribution of this species is restricted to Tierra del Fuego, Falkland Is. and to the maritime Antarctic (Redón 1985). *O. antarctica* is a common species in South Bay where it grows on vertical and sloping north-facing rocks. Especially frequent on the cliffs of Punta Polaca.

Ochrolechia frigida (Sw.) Lynge

This cosmopolitan species is very common in South Bay growing on moss and lichen debris or at the lower base of fruticose thalli (e.g. *Himantormia lugubris).*

Pannaria hookeri (Borr. ex Sm.) Nyl.

Bipolar species. In the Antarctic it has been reported from the maritime Antarctic, including S. Orkney Is., Marion I. and West Antarctic Peninsula (Redón 1985, Jörgensen 1986). In South Bay it is a rare species, and was only found on gentle sloping rocks near the coast.

Parmelia saxatilis (L.) Ach.

Cosmopolitan species, relatively common in the maritime Antarctic (Lindsay 1973a, Redón 1985) where it has been found as far south as Adelaide I. (Lindsay 1973a). In South Bay it is a frequent species growing on vertical or gentle sloping rocks, mainly from the coast up to 60 m a.s.l. In South Bay *P. saxatilis* was never found beyond 110 m a.s.l.

Peltigera didactyla (With.) Laundon

Cosmopolitan species, quite common in the maritime Antarctic (Lindsay 1974, Redón 1985). In South Bay *P. didactyla* develops small thalli (1-3 cm diam.) growing mainly on moss debris on raised beaches around the Spanish station.

Pertusaria epibryon Redón

This species is endemic to the South Shetland Is. (Redón 1985). In South Bay it is rare and was only found in one locality (Cerro Líquen, 40 m a.s.l.) growing on mosses.

Pertusaria isidioides (Schaer.) Arnold

The morphological features of our samples fit well into the description of *P. isidioides* (e.g. Wirth 1995). We have collected this species in one locality only (Cerro Líquen, 70 m a.s.l.). We do not know any previous record of this species in Antarctica but its distinction from the Antarctic species *P. corallophora* Vainio should be studied.

Physcia caesia (Hoffm.) Fürnrohr

Cosmopolitan lichen quite frequent in the maritime Antarctic (Lindsay 1974, Redón 1985), also known for the continental Antarctic region (Melick et al. 1994, Seppelt et al. 1995). In South Bay a common species growing on bird perches and other localities more or less affected by bird excrements.

Physcia dubia (Hoffm.) Lettau

Cosmopolitan lichen with the similar ecology and distribution as *P. caesia.*

Physcia inordinata Hue (sensu Dodge 1973)

This is a sterile species without isidia or soredia, showing a well developed pale stramineous thallus with thin, short branched lobes; underside white with white rhizines. Known from some islands of the maritime Antarctic region (Dodge 1973) but not recorded previously from South Shetland Is. In South Bay *P. inordinata* has been collected on vertical and wind-protected north-facing rocks near the coast.

Physconia muscigena (Ach.) Poelt

Bipolar species, restricted to the maritime Antarctic region (Redón 1985). In South Bay *P. muscigena* can be found on soils near the coast, together with mosses and sometimes associated with vascular plants in plane areas or on gentle slopes.

Placopsis contortuplicata Lamb

Known from the Antarctic and southern Andes (Lamb 1947, Redón 1985). It is a very frequent species in South Bay, mainly growing in meltwater channels or on small stones of cryoturbated soils. We did not find *P. contortuplicata* on the coast but always above 30 m a.s.l. up to the summit of Mount Reina Sofía.

Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw.

Bipolar species with a broad distribution in the maritime Antarctic (Lamb 1964, Lindsay 1974, Redón 1985) and also known from the continental Antarctic (Melick et al. 1994). In South Bay *P. minuscula* is restricted to inland areas, close to glacier fronts.

Pseudephebe pubescens (L.) Choisy

Bipolar species, widely distributed in the maritime Antarctic (Lamb 1964, Lindsay 1974, Redón 1985). In South Bay *P. pubescens* is a common species growing on

rock or on stony soil, apparently avoiding competition with mosses and fruticose lichens, which may be related to the very low productivity of this species shown by gas exchange experiments (Sancho et al. 1997).

Psoroma hypnorum (Vahl) Cray

Muscicolous species with a bipolar distribution. Common in the maritime Antarctic (Lindsay 1974, Redón 1985). *P. hypnorum* is a frequent species in South Bay, less common in inland localities.

Ramalina terebrata Hook. f. & Tayl.

This species restricted to South America, maritime Antarctic and sub-Antarctic (Lamb 1964, Smith 1972, Lindsay 1974, Redón 1985, Huneck et al. 1986) is not common in South Bay. A well developed population of *R. terebrata* was found only in one locality in Caleta Argentina. This may be linked to the scarcity of penguin colonies in this area.

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Rhizocarpon badioatrum Flörke ex Spreng.

This grey-brown *Rhizocarpon* is a bipolar species which has been previously reported from South Bay (Olech 1989). It grows in melt channels and on moist rocks in the inland.

Rhizocarpon geminatum Körber

This grey-brown *Rhizocarpon* is a bipolar species which has been previously reported from South Bay (Olech 1989). We have found this species growing on bird perches around 90 m a.s.l.

Rhizocarpon geographicum (L.) DC

Dodge (1973) lists 3 yellow *Rhizocarpon* species for the Antarctic belonging to the *Rhizocarpon geographicum* group: *Rh. melanostichum* (Hue) Darb., *Rh. nidificum* (Hue) Darb. and *Rh. flavum* Dodge & Baker. Castello & Nimis (1995) when revising Dodge's collection found the type of *Rh. flavum* and recommended to maintain this taxon pending for a revision of Antarctic yellow species of *Rhizocarpon.* However, the low number of cells per spore in the Antarctic specimens in comparison to the typical *Rh. geographicum* is not sufficient to maintain *Rh. flavum* as a different species. We prefer to leave this taxonomical problem for forthcoming revisions to specialists in this group of lichens. This species has been reported for the maritime as well as for the continental Antarctic (Redón 1985, Övstedal 1986, Melick et al. 1994, Seppelt et al. 1995). *Rh. geographicum* is a very common saxicolous species in South Bay, occurring from the coast up to the summit of Mt. Reina Sofía.

Rhizocarpon af. **grande** (Flörke ex Flotow) Arnold

In our specimens the medulla gives only a weak I+ reaction violet but the large spores and thick thallus are typical of *Rh. grande.* We have collected this species on

small boulders near to Pico Radio , 110 m a.s.l. In the Northern Hemisphere it is a common species in the mountains (Wirth 1995).

Rhizocarpon polycarpon (Hepp) Th. Fr.

This grey-brown *Rhizocarpon* is a bipolar species which is known for South Bay (Olech 1989). We have found this species on nunataks and cliffs close to the glaciers growing as pioneer on rock faces.

Rhizoplaca aspidophora (Vain.) Redón

This is a maritime Antarctic endemic (Redón 1985). *Rh. aspidophora* is a frequent species in South Bay growing on bird perches on slightly inclined rock slopes.

Rhizoplaca melanophthalma (Ramond in Lam. & DC.) Leuckert & Poelt

Bipolar species, relatively frequent in the Antarctic (Redón 1985, Olech 1989b, Smith 1993, Melick et al. 1993, Gremmen et al. 1994, Seppelt et al. 1995). In South Bay *R. melanophthalma* ist less frequent than *Rh. aspidophora* but with the same ecology.

Rinodina nimbosa (Fr.) Th. Fr.

Bipolar species, previously reported by Lamb (1968) from the east coast of the Antarctic Peninsula and by Lindsay (1971a) from Signy Island (South Orkney Is.). In South Bay *R. nimbosa* has been collected from a single locality, on boulders in a recent moraine near the summit of the Mount Reina Sofia.

Rinodina olivaceobrunnea Dodge & Baker

According to the comparative study by Jacobsen & Kappen (1989) on distinguishing *R. olivaceobrunnea* and *R. turfacea* (Wahlenb.) Körber in the Antarctic, the specimens of Livingston Island should belong to *R. olivaceobrunnea,* a bipolar muscicolous species well known from the Antarctic (Lamb 1968).

Rinodina petermannii (Hue) Darb.

Apparently endemic in the sub-Antarctic islands and maritime Antarctic (Lindsay 1971a, Smith 1972, Filson 1974, Redón 1985). It has been recently reported from Vestfold Hills and Granite Harbour in the continental Antarctic (Seppelt unpub.) It is a common ornithocoprophytic species in South Bay.

Sphaerophorus globosus (Huds.) Vain.

This cosmopolitan species is common in the maritime Antarctic occurring on moss banks near the coast (Huneck et al. 1984, Redón 1985). In South Bay it is growing near the coast in very well developed cryptogamic communities often with *Stereocaulon alpinum, Cladonia* sp.pl. and *Ochrolechia frigida.* It disappears further inland.

Sporastatia testudinea (Ach.) Massal.

This species had not been previously reported from Antarctica, although it has been collected in several localities in the maritime Antarctic (R.I.L. Smith, pers. com.). In South Bay it is relatively common growing on vertical rocks above 150 m a.s.l. Especially common on vertical cliffs of the Hurd Peninsula nunataks.

Staurothele gelida (Hook ex Tayl.) Lamb

This species is widespread in Chile, Argentina and the maritime Antarctic (Lamb 1948, Redón 1985). *Staurothele gelida* has been previously reported from the South Shetland Is. (Jacobsen & Kappen 1988, Olech 1989). In South Bay, it is not common. It was found growing on moist rock debris mixed with *Placopsis contortuplicata* and *Buellia latemarginata.*

Stereocaulon alpinum Laur.

Bipolar species, quite common in the maritime Antarctic (Smith & Övstedal 1991). It is a very common species in South Bay, growing on dry or moist moss turfs, soil, soil-covered rock surfaces and crevices, from 10 m a.s.l. to the summit of Mount Reina Sofía.

Stereocaulon glabrum (Müll. Arg.) Vain.

Similar distribution and ecology as *St. alpinum.* It is less common in South Bay than the former species.

Thelenella antarctica (Lamb) Eriksson

(Syn. *Microglaena antarctica* Lamb)

Endemic of the South Orkney Is. and South Shetland Is. (Redón 1985). Quite rare in South Bay, where it was collected only in one locality on cliffs near the coast. *M. antarctica* has been recorded previously from this area (Olech 1989).

Tephromela atra (Huds.) Hafellner

Cosmopolitan species, very common in the area growing on eutrophicated stones.

Tremolecia atrata (Ach.) Hertel

Cosmopolitan species, very common in the area growing on eutrophicated stones, occasionally flooded by meltwater.

Umbilicaria africana (Jatta) Krog & Swinscow

In the Antarctic this species has so far only been reported from Livingston Island (Sancho et al. 1992). *U. africana* was described from the East-African mountains (Krog & Swinscow 1986) and was later recorded for South America (Sipman & Topham 1992). In South Bay *U. africana* is less common. It grows on more or less

sloping, north-facing rocks. Some populations from South Bay have numerous apothecia with entire or somewhat fissured discs.

Umbilicaria antarctica Frey & Lamb

Appears to be restricted to the maritime Antarctic, where it is common (Filson 1987). In South Bay it is locally abundant but restricted to north-facing small crevices of coastal rocks.

Umbilicaria decussata (Vill.) Zahlbr.

Bipolar species widely distributed in the Antarctic (Filson 1987). In South Bay *U. decussata* is a common species mainly growing on vertical and sloping north-facing rocks in the coastal region as well as on inland rocky ridges.

Umbilicaria kappeni Sancho, Schroeter & Valladares

This species appears to be restricted to the maritime Antarctic, where it has been found as far south as Adelaide I. (Sancho et al. 1998). In South Bay we only know one population on vertical and sloping faces of a north-facing rock near the coast.

Umbilicaria krascheninnikovii (Savicz) Zahlbr.

South Bay and the South Orkney Is. (R.I.L. Smith, personal communication) are the only known localities in the Antarctic for this species (Sancho et al. 1992). Here it is growing near the summit of Mount Reina Sofía, on vertical north facing rocks. Recently (summer 1995-96) we have found *U. krascheninnikovii* also on the south ridges of False Bay.

Umbilicaria nylanderiana (Zahlbr.) H. Magn.

The locality of South Bay was the first record for this species in Antarctica (Sancho et al. 1992). It has since been reported from the Argentine Islands, Antarctic Peninsula (Gremmen et al. 1994) and South Orkney Is. (R.I.L. Smith, personal communication). In South Bay *U. nylanderiana* is common on vertical and sloping north-facing rocks, mixed with *U. decussata* and locally with *U. africana.*

Usnea aurantiaeo-atra (Jacq.) Bory

In South Bay it is a very common species, dominant on rocks or stones in the hills south of the Spanish station.

Verrucaria dispartita Vain.

Endemic species of the maritime Antarctic (Redón 1985). In South Bay it is a common species growing on rock in the salt-spray zone.

Verrucaria elaeoplaca Vain.

Species known from both maritime Antarctic and sub-Antarctic (Smith 1972, Redón 1985, Övstedal 1986). In South Bay it is a common saxicolous species growing in small melt water channels.

Verrucaria maura Wahlenb.

Cosmopolitan species, common in South Bay growing on rocks in the salt-spray zone.

Verrucaria psychrophila Lamb

Endemic species of the maritime Antarctic (Redón 1985), in South Bay a rare species. Only collected in a single locality of Caleta Argentina, growing on rock in the salt-spray zone.

Xanthoria candelaria (L.) Th. Fr.

Cosmopolitan species. In South Bay it is a very common saxicolous, sometimes muscicolous, ornithocoprophytic species.

Bryophytes

Hepatics

Anthelia juratzkana (Limpr. in Cohn) Trev.

An arctic-alpine species which normally occurs in snowbeds, but in South Bay it is scattered around rock bases or in well watered rock crevices. Livingston Island is one of the few locations from where it has already been reported from the Antarctic (Schuster 1969). It is also known from Signy I. and King George I. (R.I.L. Smith pers. com.)

Barbilophozia hatcheri (Evans) Loeske

This taxon was collected only twice. On other islands of the South Shetlands it grows luxuriously mixed with *Chorisodontium aciphyllum* (Ochyra & Váňa 1989b), which is absent around Juan Carlos I. The two samples are poor developed. The situation for *B. hatcheri* on Hurd Peninsula seems to be unfavourable.

Cephaloziella hispidissima Schust.

Three collections were made but it seems to be impossible to discern it in the field from the common *Cephaloziella varians*. Under the microscope the cells with spines are a very striking feature which makes it easy to distinguish it from the following species. It is known from Livingston I. and the original description (Schuster 1973) may be based on material of Livingston I., but was erroneously reported to be from

New Zealand (Ochyra & Vana 1989b). At the moment it is also known from King George I. and and Signy I., but from no other localities within the Antarctic. It can be assumed that this taxon is commonly overlooked and may be widespread in the Antarctic.

Cephaloziella varians (Gott. in Neum.) Steph.

Together with *C. hispidissima* it is the smallest liverwort in the Antarctic. It is very common all over the South Bay (Ochyra & Vana 1989b). It occurs in a variety of habitats in pure or mats mixed into other mosses. Assuming that *C. varians* is conspecific with *C. exiliflora* (Tayl.) Steph. it is the only hepatic also occurring in the continental Antarctic (see Seppelt 1984) .

Herzogobryum teres (Carringt. & Pears.) Grolle

This Southern Hemisphere species – of similar habit to *Gymnomitrium corallioides* from the north – prefers elevated areas. Here it grows frequently at the bases of larger rocks, often associated with *Anthelia juratzkana* and/or *Pachyglossa dissitifolia.* Infrequently it also appears in cracks of rocks. Until now only a few locations are known for the Antarctic, including some at King George Island (Ochyra & Váňa 1989b).

Lophozia excisa (Dicks.) Dum.

In the area a very common hepatic which occurs in a variety of habitats as pure stands or intermixed with mosses. In the Antarctic this bipolar species is widespread and common (Ochyra & Váňa 1989b).

Pachyglossa dissitifolia Herz. & Grolle

This liverwort is found scattered in moist shady crevices or rock bases mostly around 100 m above sea level. This fits well with observations at King George Island (Ochyra and Váňa 1989a), growing "usually above 100 m and near the summits of nunataks...".

Riccardia cf. georgiensis (Steph.) Hässel

Only one small sample was found in turfs of *Deschampsia antarctica* in Johnsons Dock (10 m a.s.l.). This is the southermnost known location of the genus *Riccardia.* Only two records for the Antarctic exist (Grolle 1972, Smith and Gimingham 1976).

Musci

Andreaea gainii Card.

A very common rock-inhabiting moss species within the maritime Antarctic (Greene et al. 1970) and also in the investigated area. It is confined to Antarctic and sub-Antarctic regions.

Andreaea regularis C. Müll.

Common, but more restricted to moister rock and well-drained snowbeds. Like the preceeding species it is widespread in the Antarctic Peninsula region and the northern islands (Greene et al. 1970). Its distribution extends to southern South America.

Bartramia patens Brid.

This species with South American - Antarctic distribution is common in the maritime Antarctic (e.g. Robinson 1972) and also in the investigated area. It prefers moist habitats and especially in crevices of rocks it is frequently fruiting. Along melt streams it may grow luxuriously but without sporophytes.

Brachythecium austro-salebrosum (C. Müll.) Kindb.

Despite of the presence of two other species of *Brachythecium* (e.g. Robinson 1972, Myrcha et al. 1991) within the Antarctic, only the most common, *B. austro-salebrosum* has been found during the recent survey. It occurs in moist places, especially on beach terraces and along streams.

Bryoerythrophyllum recurvirostre (Hedw.) Chen

This calciphilous moss was found several times in rock crevices. Although being a cosmopolitan species it was only found in Alexander Island (71°S, Smith 1988b), and recently in Cockburn Island (64°S, Smith 1993) but it is widespread on the continent (Savicz-Ljubitskaya & Smirnova 1963). The material collected in South Bay differs from typical *B. recurvirostre* by the absence of some teeth near the leaf apex, but this character can be considered to be of minor importance. *B. recurvirostre* var. *antarcticum* Lyd. Savicz. & Z. Smirn. seems to be a cryotype. Within samples the variation of leaf length, the revolute margin and the shape of the leaf tip are considerable.

Bryum amblyodon C. Müll.

The distribution of this species is poorly known, because of the necessity to have capsules for determination. Originally described from Argentina by C. Müller (1879), in recent times Kanda and Ochi (1986) reported it in continental Antarctica including one sample with several sporophytes from soil. Probably it is frequent in South Bay but sterile.

Bryum argenteum Hedw.

Only one single sample found in South Bay, the sampled material has only very short shoots. The habit of European material is different, but for *B. argenteum* a considerable variability is known (Crum & Anderson 1981). Formerly Cardot (i.e. 1906) and other authors reported it for some places of the maritime Antarctic, it seems to be common also in the continental region. However, Seppelt and Kanda (1986) pointed out that on Antarctic material even the distinction between *B. ar-*

genteum and *B. pseudotriquetrum* is sometimes difficult or impossible. The material was collected near a penguin rookery on the west shore of South Bay.

Bryum pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb.

It is still unclear whether *B. algens* (Cardot 1906) is an endemic species to the Antarctic or the material belongs to the cosmopolitan *B. pseudotriquetrum* which has considerable variability including what is named *B. algens* (Ochi 1979). It is well known from many different places within the Antarctic but only rarely found fruiting. Also in the investigated area, despite its luxuriant growth on stream margins and raised beaches, it never fruits.

Calliergon sarmentosum (Wahlenb.) Kindb.

Commonly found in very wet places such as late snowbeds and along melt streams, where it is often dominant. This is also reported for many other localities within the maritime Antarctic (e.g. Robinson 1972, Smith & Gimingham 1976).

Ceratodon purpureus (Hedw.) Brid.

The concept of Horikawa and Ando (1963), based on descriptions made by Cardot (1900, 1906) of 4 different species of the genus *Ceratodon* within the Antarctic, could not be followed because of the extreme polymorphism of the cosmopolitan *C. purpureus.* In the Antarctic it is common in nutrient rich habitats, especially perching places of birds. It shows a considerable variability of leaf shape, denticulation of the upper margin, coloration, a pre- to excurrent nerve, and also cell size. However, despite the common occurrence in South Bay, *C. purpureus* has been seen fruiting only once.

Conostomum magellanicum Sull.

Formerly known only from South America and South Georgia this taxon was first reported from the maritime Antarctic by Smith (1972, as *C. perangulatum),* but it is still known from only a few places. In the investigated area it is scattered on moist organic matter, locally together with *Cephaloziella varians.*

Dicranella cardotii (R. Brown ter.) Dix.

D. cardotii was earlier considered to be endemic to New Zealand (Sainsbury 1955) but recently it proved to be widespread in the Southern Hemisphere (Ochrya & Newton 1985). In the Antarctic only one specimen is known from King George Island (Ochyra & Newton 1985), but these authors doubted whether a specimen from northern Victoria Land which was identified as *D. hookeri* by Cardot also belongs to this taxon. One sample of *D. cardotii* was gathered in a horizontal crevice of a steep cliff and therefore it is also very rare in the area.

Dicranoweisia antarctica (C. Müll.) Kindb.

With a habit and ecological preferences similar to Northern Hemisphere *D. crispula, D. antarctica* is known from southern South America, New Zealand and sub-Antarctic Islands. This species is common at low altitudes growing on rocks or sandy soil. It has a long seta with a pale cylindrical capsule and papillose peristome teeth. According to Sainsbury (1955) the length of the seta and the shape of the capsule vary a lot within D. *antarctica* from New Zealand but in Antarctic material these features seem to be stable. Like the following species it is normally fruiting at South Bay.

Dicranoweisia grimmiacea (C. Müll) Broth.

D. grimmiacea grows frequently in cracks and crevices of rocks. The material from South Bay has dark coloured, short capsules with nonpapillose peristome teeth. The colour of the cushions is mostly dark green, while in *D. antarctica* the colour is light green. It is known from the maritime Antarctic and some sub-Antarctic Islands (Bell 1976).

Didymodon gelidus Card.

Originally described for the Antarctic continent (1906) it was also known from a few islands of the maritime Antarctic (e.g. Smith 1988a). Around the Spanish station, it occurs infrequently in crevices of rocks. Some samples have plentiful gemmae on filaments in the leaf axils. R. Ochyra assumes (pers. comm.) that *D. gelidus* is identical with the cosmopolitan *Bryoerythrophyllum ferruginascens* (Stirt.) Giac. The shape of leaves from samples from South Bay grown under warmer conditions fits well with illustrations given by Eckel (1990) for the latter taxon.

Distichium capillaceum (Hedw.) B.S.G.

This cosmopolitan calciphilous species is common in rock crevices around the Spanish station. Occasionally it can be found in good fruiting condition. Despite the assumption of Robinson (1972) that all Antarctic material belongs to *Ditrichum austro-georgicum,* Newton (1977) showed that *Distichium capillaceum* is widespread in the maritime Antarctic.

Ditrichum austro-georgicum (Card.) Seppelt

Seppelt (1980) has demonstrated that *D. austro-georgicum* is a Southern Hemisphere species. In Antarctica it is known from the South Sandwich, South Orkney and South Shetland Islands (Robinson 1972 as *Pseudodistichium fuegianum,* Myrcha et al. 1991, Ochyra & Smith 1998). In South Bay *D. austro-georgicum* grows scattered on soil, sometimes with well developed sporophytes. Without sporophytes it is hard to detect in the field, it may therefore be overlooked.

Ditrichum lewis-smithii Ochyra

Recently described by Ochyra (1996) as new species, based also on a 1992 record by F. Schulz, but confusing information about the ecology was given. He stated that *D.*

lewis-smithii grows "on bare ground and on soil covering rock ledges and on humus in rock fissures.". In fact, in the South Bay area, this species occurs on surfaces of solid vertical rock with fine fissures, but in the absence of humus accumulation. It was found on at least 7 different rocks scattered over the area around the Spanish station.

Encalypta procera Bruch

This species is widespread in the Northern Hemisphere and also occurs in the sub-Antarctic and the Antarctic, but is still unknown in South America. Within the Antarctic it has been collected only a few times (see Newton 1974, Smith 1988b) which may be attributed to its preference for calcareous substrata. In Johnsons Dock and around the Spanish station *E. procera* is scattered but locally robust in deep crevices.

Encalypta rhaptocarpa Schwaegr.

E. rhaptocarpa (Myrcha et al. 1991) formerly referred to as *E. patagonica* (Newton 1974) occurs scattered in moist crevices with humus layers in South Bay. The frequently fruiting moss can be easily recognised in the field. The leaves are typical with a long excurrent costa.

Grimmia donniana Sm.

This arctic-alpine epilithic species has a remarkable distribution pattern in Antarctica. It is known from several localities on the continent (Kuc 1969), it is also quite common on the Antarctic Peninsula and some of the South Shetlands Is. (Smith 1996). In South Bay it was found infrequently growing in greywacke boulder fields with no other moss vegetation. All samples were fruiting profusely.

Isopterygium antarcticum (Mitt.) Card.

I. antarcticum is a rare element of the Antarctic flora. Until this study it was only found once on Signy Island (Smith 1972). In the northern part of South Bay it has been collected once in a rock crevice. The sample had one mature capsule.

Platydictya densissima (Card.) H. Robinson

This species is one of the few mosses which is still considered to be endemic to the Antarctic. No related species are yet known from the Southern Hemisphere. Only few localities are known but in South Bay it is quite abundant in deep moist cracks, where no other mosses survive. In less sheltered places *Pohlia cruda* var. *imbricata* is also present. No sporophytes have been seen, but some samples bear 3-celled axial gemmae.

Pohlia cruda (Hedw.) Lindb.

This cosmopolitan species is common in rock crevices and on moist substrata. When growing exposed the leaves are imbricate but when permanently shaded the leaves

are spreading. The two varieties *P.c.* var. *imbricata,* which was described from Antarctic material (Cardot 1900), and *P.c.* var. *cruda* seem to be morphotypes.

Pohlia inflexa (C. Müll.) Wijk & Marg.

Recently *P. inflexa* was added to the Antarctic flora (e.g. Myrcha et al. 1991), but it is possible that it may be confused with *P. nutans* which seems much more abundant in the maritime Antarctic. Often the absence of axial gemmea causes some problems with identifying the material.

Pohlia nutans (Hedw.) Lindb.

This cosmopolitan species occurs scattered on the moist slopes around the Spanish station. Large stands were never seen. Greene et al. (1970) stated that it occurs also in the continental region, finding the species to be polymorphic including the possibility of confusion with other species of *Pohlia.*

Polytrichum alpinum Hedw.

P. alpinum is an arctic-alpine species with a wide ecological range. Growing more luxuriously on nutrient enriched sites, sporophytes were observed only on slightly inclined hill slopes with extensive moss cover. In the maritime Antarctic it is common but absent in the continental Antarctic (Greene et al. 1970).

Polytrichum juniperinum Hedw.

This cosmopolitan species grows scattered on sandy soils in South Bay. It needs moister substrata than the following species.

Polytrichum piliferum Hedw.

This cosmopolitan species occurs only very scattered around the Spanish station. It is restricted to sandy soil often associated with *Peltigera didactyla.* It is known from several locations within the maritime Antarctic but is not common there (Greene et al. 1970).

Pottia austro-georgica Card.

This species is confined to areas with clayey substrata, e.g. in moraines and some cracks and exposed crevices. With these characteristics it is present in the area and also elsewhere in the Antarctic (Matteri 1977), but few collections were made. A confusion with *P. heimii* is possible, which seems to be more abundant in Antarctica, but lacking in South Bay.

Racomitrium austro-georgicum Par.

In South Bay this species grows scattered on rocks and pebbles in well drained late snowbeds. From the known localities in the Antarctic (Bell 1973) it seems to be a rare species.

Sanionia uncinata (Hedw.) Loeske

This taxon forms a major part of the moss vegetation in the maritime Antarctic and also the South Shetland Islands (Gimingham & Smith 1970, Lindsay 1971b). In South Bay it is the commonest moss in various habitats, but it was seen only three times with unripe sporophytes.

Schistidium cf. **hyalino-cuspidatum** (C. Müll.) B.G. Bell

Only once a sample of *S.* cf. *hyalino-cuspidatum* was collected in South Bay growing on open rock surface. Its gametophytic characters fit well to the description given by Bell (1984), but capsules are lacking. It was described from South Georgia, but the distribution is not known, at least partly because of still unsolved taxonomical problems in the genus *Schistidium.*

Schistidium antarctici (Card.) Savicz. & Smirn.

S. antarctici is a common rock inhabiting moss in the maritime Antarctic (Gimingham & Smith 1970) from where it was originally described by Cardot (1906), but is also widespread in the continental region (e.g. Robinson 1972, Kappen et al. 1989). In South Bay it is one of the commonest mosses on rocks and in *Usnea*-stands.

Schistidium apocarpum (Hedw.) B.S.G.

Only one collection from Johnsons Dock, growing on a very wet rock surface can be determined as the cosmopolitan *S. apocarpum* by its well developed peristome teeth (in *S. antarctici* these are rudimentary). The distribution within the Antarctic is unclear because of confusion with the former species. For instance, Robinson (1972) identified 12 of his samples from different locations on the South Shetland Island as *S. apocarpum* and only one as *S. antarctici,* but the latter is common (e.g. Lindsay 1971b).

Schistidium rivulare (Brid.) Podp.

This cosmopolitan moss is confined to stream margins and very wet rock. In the Antarctic it is only known from some locations (e.g. Myrcha et al. 1991). May be it is neglected because it was considered as a variety of *S. apocarpum* by some authors. However, even Bremer (1980) considered it a good species.

Schizohymenium austro-georgicum (C. Müll.) Shaw

It was only found once on a wet cliff in Johnsons Dock, but this is the first report from the South Shetland Islands. This species has been previously recorded from only few localities in the Antarctic (Smith & Corner 1973, Clarke and Lighttowlers 1983). Possibly it is not really rare because it can be mistaken as a scanty grown *Pohlia cruda.*

Tortella fragilis var. **tortelloides** (S.W. Greene) Zander & Hoe

Around the base and in the Johnsons Dock area this taxon occasionally grows in moist, but sunny cracks. The moss is calciphilous and therefore its occurrence very local in the Antarctic (Greene et al. 1970).

Tortula filaris (C. Müll.) Broth.

Only known from South Georgia and the maritime Antarctic (Lightowlers 1985, 1986a, b), *T. filaris* grows frequently in moss carpets, in wet crevices and on briefly snow covered slopes of moraines. No sporophytes have been observed.

Tortula princeps De Not.

This cosmopolitan species is one of the commonest in the maritime Antarctic and reaches also the continental region (Lightowlers 1986a, b), but also grows in deserts e.g. in Australia being extremely heat tolerant (Oliver & Bewley 1984). At South Bay it is especially abundant in bird influenced places. On wet slopes it has sporogones.

Tortula saxicola Card.

T. saxicola is the rarest species of this genus in South Bay. In the field and sometimes microscopically it is difficult to discern between *T. saxicola* and *T. filaris,* but normally leaf shape and areolation of the leaf tip are characteristic. The species occurs scattered on wet slopes or crevices of rocks and was never found fruiting. On present knowledge it is distributed in the sub-Antarctic-Antarctic (Lightowlers 1985), seemingly being everywhere uncommon.

Discussion

Since 1973 the number of lichen species in the maritime Antarctic has changed from 233 (Dodge 1973) to 169 according to the revision by Castello and Nimis (1995) but new records and species descriptions have added additional taxa (Castello & Nimis 1997) so that we presently can record about 200 species for this region of Antarctica. Nearly half of these recently detected species can be found in the area above South Bay. The phytogeographic structure of the South Bay flora is typical for the situation of the maritime Antarctic flora recently described by Castello & Nimis (1997). In our study (Figure 2) 21% of Antarctic endemic species, 14% of the sub-Antarctic element, 10% of the austral element and 55% of widly distributed species (including cosmopolitan and bipolar species) were found. These figures correspond well to those given by Castello and Nimis (31.3%, 11.5%, 5.3% and 51.3%) for these phytogeographic elements according to the revision of a checklist of all lichen records from recent authors reported so far for the maritime Antarctic. Therefore, the lichen flora of South Bay is considered to be representative for both, the lichen biodiversity and the proportion of phytogeographical elements.

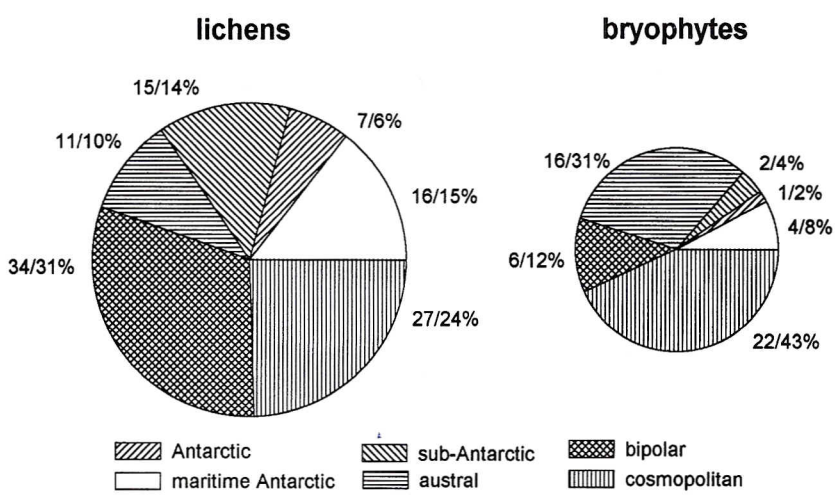

Fig. 2. Number of species and percentage occurrence of the main phytogeographic elements in the lichen and bryophyte flora of South Bay. Plotted areas correspond with the number of species.

As has been pointed out by different authors (Lindsay 1974, Jacobsen & Kappen 1988, Kappen 1993) the majority of maritime Antarctic lichen species belong to an alpine-cosmopolitan flora that is widely distributed over the globe. In contrast, the number of austral species, restricted to the Southern Hemisphere (Galloway 1991), is surprisingly low. From a phytogeographical point of view the great number of bipolar-cosmopolitan species indicates that the Antarctic region is less isolated than is generally assumed. In the maritime Antarctic arrival of spores and other propagules, mainly of algae, lichens and bryophytes originating from South America has been demonstrated (Smith 1984, 1991, Kappen & Straka 1988, Marshall 1996a, b). However, it seems that the transport in the opposite direction, from the Antarctic to South America, South Africa and Pacific region, hardly exists. Nevertheless, more floristic investigations, mainly in South America, are required to explore the real extent of propagule transport from and to the Antarctic.

Considering its small extent (ca. 3 km^2) the studied area has a large and remarkable biodiversity. The 160 lichens and mosses recorded here form one of the largest floristic catalogues for any Antarctic region so far, only comparable to the north part of Signy I. (R.I.L. Smith, pers. com.). For some lichen genera such as *Caloplaca, Cladonia* or *Umbilicaria,* this part of Livingston Island probably possesses the highest diversity anywhere in the Antarctic region. Moreover, it is expected that after revision of several crustose taxa *(Rhizocarpon* and *Lecidea* s.l.) the lichen check-list will be further increased. This species richness is certainly only possible under the relatively mild climatic conditions of South Bay (Bañón 1997), but probably also because of the wide range of different substrata in this area (López-Martínez et al. 1991).

The number of bryophyte species for the Antarctic appears to be about 120 mosses and perhaps 25 liverworts (Seppelt et al. 1998). This figure includes some species which exist exclusively on warm ground around fumaroles on Deception I. and South Sandwich Is. (Smith 1988a). Therefore the Antarctic moss flora can be considered as relatively poor, with only a few endemic species.

The known moss flora of the South Bay region has a distinct pattern in its phytogeography compared with lichens. Beside a large number of cosmopolitan species (22 species, 43%), many are of Southern Hemisphere origin (16 species, 31%). Mosses having an exclusively Antarctic distribution, including the sub-Antarctic, are rare (5 and 2 species, 10%/4%). At least 6 species (12%) have an arctic-alpine distribution.

The strong dissimilarity in the phytogeographic pattern between lichens and mosses may be explained by differences in their reproductive performance. The majority of the Antarctic lichens are crustose forms producing apothecia, but many bryophyte species do not produce sporophytes, as Clarke & Greene (1970) have demonstrated. In the investigated area the percentage of fertile mosses was comparatively high (18 mosses, = 36%) which again is indicating a favourable climatic situation.

Another outstanding feature of the vegetation in South Bay is the steep gradient from the coast to inland. This decrease of species may not only be a consequence of greater harshness of the microclimate with increasing altitude, as the altitudinal range is 273 m (Figure 1), it is also caused by the fact that the terrain was more recently uncovered by receding glaciers than the coastal fringe and terraces (Sancho & Valladares 1993) and that farther inland the general climatic conditions are influenced by the proximity of the glaciers, but this has yet to be tested. Also, the variations in some edaphic parameters, such as salt deposition and nitrogenous compounds (Smith 1996) permits a greater species diversity in the coastal area.

Acknowledgements

Dr. Josefina Castellví, Dr. Alberto Castejón and all the staff of the Spanish Antarctic Base Juan Carlos I. are thanked for their cooperation and hospitality. Help with the English manuscript given by Dr. T.G.A. Green is greatly appreciated. Authors are grateful to Dr. R.I.L. Smith, Cambridge, UK, and an anonymous referee for fitting criticisms and to Dr. U. Söchting, Copenhagen, Denmark, for stimulating comments on the manuscript. The map was drawn by S. Wolf, Kiel. Financial support was provided by the Comisión Interministerial de Ciencia y Tecnología (ANT94-0905) and by the Deutsche Forschungsgemeinschaft (Ka 390/6-16).

References

ALLISON, J.S. & R.I.L. SMITH (1972). The vegetation of Elephant Island, South Shetland Islands. - Brit. Antarct. Survey Bull. **33** & **34:** 185-212.

APTROOT, A. & W.O. van der KNAAP (1993): The lichen flora of Deception Island, South Shetland Islands. - Nova Hedwigia **56:** 183-192.

BAÑÓN, M. (1997): Resúmenes climatológicos de las campañas realizadas en la Base Juan Carlos I. Actas del Quinto Simposio Español de Estudios Antárticos (Madrid), 303-324.

BELL, B.G. (1973): Notes on Antarctic bryophytes: II. Records of *Racomitria* from the Antarctic botanical zone. - Brit. Antarct. Survey Bull. **37:** 91-94.

BELL, B.G. (1976): Notes on Antarctic bryophytes: VI. The genus *Dicranoweisia* on Signy Island, South Orkney Islands. - Brit. Antarct. Survey Bull. **44:** 97-100.

BELL, B.G. (1984): A synoptic flora of South Georgian mosses: *Grimmia* and *Schistidium.* - Brit. Antarct. Survey Bull. **63:** 71-109.

BOWRA, G.T., M.W. HOLDGATE & P.J. TILBROOK (1966): Biological investigations in Tottanfjella and central Heimefrontfjella. - Brit. Antarct. Survey Bull. **9:** 63-70.

BREMER, B. (1980). A taxonomic revision of *Schistidium* (Grimmiaceae, Bryophyta) 2. - Lindbergia **6:** 89-117.

CARDOT, J. (1900): Note préliminaire sur les mousses recueillies par l'expédition Antarctique Belge. - Revue Bryol. **27:** 38-46.

CARDOT, J. (1906): Notice préliminaire sur les mousses recueillies par l'expédition Antarctique Suédoise. - Bull. Herb. Boissier, 2ème sér., 6, **1:** 1-17.

CASTELLO, M. & P.L. NIMIS (1994a): Critical notes on Antarctic yellow *Acarosporaceae.* - Lichenologist **26:** 283-294.

CASTELLO, M. & P.L. NIMIS (1994b): Critcal notes on the genus *Candelariella* (Lichenes) in Antarctica. - Acta Bot. Fennica **150:** 5-10.

CASTELLO, M. & P.L. NIMIS (1995): The lichen vegetation of Terra Nova Bay (Victoria Land, continental Antarctica). - Bibl. Lichenol. **58:** 43-55.

CASTELLO, M. & P.L. NIMIS (1997): Diversity of lichens in Antarctica. - In B. BATTAGLIA, J. VALENCIA & D.W.H. WALTON (ed.): Antarctic communities. Species, Structure and Survival: 15-21. Cambridge University Press, Cambridge.

CLARKE, G.C.S. & P.J. LIGHTOWLERS (1983): Notes on Antarctic bryophytes: XI. *Mielichhoferia austro-georgica* and *Muelleriella crassifolia.* - Brit. Antarct. Survey Bull. **59:** 35-39.

CLARKE, G.C.S. & S.W. GREENE (1970): Reproductive performance of two species of *Pohlia* at widely separated stations. - Trans. Br. Bryol. Soc. **6:** 114-128.

CRUM, H.A. &. L.E. ANDERSEN (1981): Mosses of Eastern North America. - Columbia University Press, New York.

DODGE, C.W. (1973): Lichen flora of the Antarctic continent and adjacent islands. - Phoenix, Canaan, New Hampshire.

ECKEL, P.M. (1990): *Bryoerythrophyllum ferruginascens* (musci: Pottiaceae) in Eastern North America. - Bryologist **93:** 208-210.

FILSON, R.B. (1974): Studies in Antarctic Lichens II: Lichens from the Windmill Islands, Wilkes Land. - Muelleria **3:** 9-36.

FILSON, R.B. (1975): Studies in Antarctic Lichens V: Lichens Antarctici Exsiccati, Fascicle 1, with additional notes on the taxonomy of each species. - Muelleria **3:** 146-158.

FILSON, R.B. (1987): Studies in Antarctic lichens 6: Further notes on *Umbilicaria.* - Muelleria **6:** 335-347.

FOLLMANN, G. (1965): Una asociación nitrófila de líquenes epipétricos de la Antártica occidental con *Ramalina terebrata* Tayl. & Hook. como especie caracterizante. - Publ. Inst. Antártico Chil. **4:** 1-18.

GALLOWAY, D.J. (1991): Biogeographical relationships of Pacific tropical lichen floras. In: D.J. GALLOWAY (ed.) Syst. Assoc. Spec. Vol. 43 / Tropical lichens: Their Syst., Conserv. Ecol.: 1-16. Clarendon Press, Oxford.

GIMINGHAM, C.H. & R.I.L. SMITH (1970): Bryophyte and lichen communities in the maritime Antarctic. In: M.W. HOLDGATE (ed.) Antarctic ecology: 752-785. Academic Press, London.

GREENE, S.W., D.M. GREENE, P.D. BROWN & J.M. PACEY (1970): Antarctic moss flora. I. The genera *Andreaea, Pohlia, Polytrichum, Psilopilum* and *Sarconeurum.* - Sci. Rep. Brit. Antarct. Surv. **64:** 1-118.

GREMMEN, N.J.M., A.H.L. HUISKES & J.W. FRANCKE (1994): Epilithic macrolichen vegetation of the Argentine Islands, Antarctic Peninsula. - Antarctic Science **6:** 463-471.

GROLLE, R. (1972): The hepatics of the South Sandwich Islands and South Georgia. - Brit. Antarct. Surv. Bull. **28:** 83-95.

HAFELLNER, J. (1984): Studien in Richtung einer natürlichen Gliederung der Sammelfamilien *Lecanoraceae* und *Lecideaceae.* - Beih. Nova Hedwigia **79:** 241-371.

HERTEL, H. (1984): Über saxicole, lecideoide Flechten der Subantarktis. - Beih. Nova Hedwigia **79:** 399-499.

HOLDGATE, M.W. (1964): Terrestrial ecology in the maritime Antarctic. In: R. CARRICK, M. HOLDGATE & J. PRÉVOST (eds.): Biologie antarctique: 181-194. Hermann, Paris.

HORIKAWA, Y. & H. ANDO (1963): A review of the Antarctic species of *Ceratodon* described by Cardot. - Hikobia **3**(4): 275-280.

HUNECK, S., M. SAINSBURY, T.M.A. RICKARD & R.I. L. SMITH (1986): Ecological and chemical investigations of lichens from South Georgia and the maritime Antarctic. - J. Hattori Bot. Lab. **56:** 461-480.

JACOBSEN, P. & L. KAPPEN (1988): Lichens from the Admiralty Bay region, King George Island (South Shetland Islands, Antarctica). - Nova Hedwigia **46:** 503 -510.

JÖRGENSEN, P.M. (1986): Macrolichens of Bouvetøya. - Norsk Polarinstitutt Skrifter **185:** 23-34.

KANDA, H. & H. OCHI (1986): Fruiting plants of *Bryum* found in the vicinity of Syowa Station, Antarctica. - Mem. Natn. Inst. Pol. Res. Spec. Iss. **44:** 220-228.

KAPPEN, L. (1985): Vegetation and ecology of ice-free areas of northern Victoria Land, Antarctica. I. The lichen vegetation of Birthday Ridge and an inland mountain. - Polar Biology **4:** 213-225.

KAPPEN, L. (1993): Lichens in the Antarctic region. In: E.I. FRIEDMANN (ed.): Antarctic Microbiology: 433-490. Wiley-Liss., New York.

KAPPEN, L., M. BÖLTER & A. KÜHN (1987): Photosynthetic activity of lichens in natural habitats in the maritime Antarctic. In E. PEVELING (ed.): Progress and Problems in Lichenology in the Eighties. - Bibl.Lichenol. **25:** 297-312. J.Cramer, Berlin, Stuttgart.

KAPPEN, L., B. SCHROETER & L.G. SANCHO (1990): Carbon dioxide exchange of Antarctic crustose lichens in situ measured with a CO_2/H_2O porometer. - Oecologia **82:** 311-316.

KAPPEN, L., R.I.L. SMITH & M. MEYER (1989): Carbon dioxide exchange of two ecodemes of *Schistidium antarctici* in continental Antarctica. - Polar Biol. **9:** 415-422.

KAPPEN, L. & H. STRAKA (1988): Pollen and spore transport into the Antarctic. - Polar Biol. **8:** 173-180.

KÄRNEFELT, I. (1986): The genera *Bryocaulon, Coelocaulon* and *Cornicularia* and formerly associated taxa. - Opera Botanica **86:** 1-90.

KROG, H. & T.D.V. SWINSCOW (1986): The lichen genera *Lasallia* and *Umbilicaria* in East Africa. Nord. J. Bot - Lichenol **6:** 75-78.

KUC, M. (1969): Some mosses from an Antarctic oasis. - Revue Bryol. Lichén., N.S. **36:** 655-672.

LAMB, I.M. (1947): A monograph of the Lichen genus *Placopsis* Nyl. - Lilloa **13:** 151-288.

MÜLLER, C. 1879. Prodromus bryologiae Argentiniacea. I. - Linnaea, Berlin, **39:** 325-474.

MYRCHA, A., R. OCHYRA & A. TATUR (1991): Site of special scientific interest No.8 - western shores of Admirality Bay, King George Island, South Shetland Islands. In: First Polish-Soviet Antarctic Symposium: 157-168. Polish Academy of Sciences, Warschau.

NEWTON, M.E. (1974): Notes on Antarctic bryophytes: IV. *Encalypta* Hedw. - Brit. Antarct. Survey Bull. **39:** 1-6.

NEWTON, M.E. (1977): A synoptic flora of South Georgian mosses: VI. *Cheilothela, Dicranella, Distichium, Myurella* and *Catagonium.* - Brit. Antarct. Survey Bull. **46:** 1-21.

OCHI, H. (1979): A taxonomic review of the genus *Bryum,* Musci in Antarctica. - Mem. Natl. Inst. Polar Res., Spec. Iss. **11:** 70-80.

OCHYRA, R. (1996): Ditrichum lewis-smithii (Ditrichaceae, Bryopsida), a new species from Antarctica. - Ann. Bot. Fennici **33:** 303-309.

OCHYRA, R. & M.E. NEWTON (1985): The taxonomy and distribution of *Dicranella cardotii* (R.Br.ter.) Dix., an addition to the moss flora of Antarctica. - Lindbergia **11:** 94-98.

OCHYRA, R. & J. VÁŇA(1989a): The hepatics of King George Island, South Shetland Islands, Antarctica, with particular reference to the Admiralty Bay region. - Pol. Polar Res. **10:** 183-210.

OCHYRA, R. & J. VÁŇA (1989b): The hepatics reported from the Antarctic and an outline of their phytogeography. - Pol. Polar Res. **10:** 211-229.

OCHYRA, R. & R.I.L. SMITH (1998). Antarctic species in the genus *Ditrichum* (Ditrichaceae, Bryopsida), with a description of *D. gemmiferum* sp. nov. - Ann. Bot. Fennici **35:** 33-53.

OLECH, M. (1989): Lichens from the Admiralty Bay region, King George Island (South Shetland Islands, Antarctica). - Acta Soc. Bot. Pol. **58:** 493-512.

OLIVER, M.J. & J.D. BEWLEY (1984): Desiccation and ultrastructure in Bryophytes. In: W. SCHULTZE-MOTEL (ed.): - Advances in Bryology **2:** 91-131. J. Cramer, Vaduz.

OTT, S. & L.G. SANCHO (1993): Morphology and anatomy of *Caloplaca coralligera* (Teloschistaceae) as adaptation to extreme environmental conditions in the maritime Antarctic. - Plant Systematics and Evolution **185:** 123-132.

ÖVSTEDAL, D.O. (1986a): Lichens and lichen parasites from the British-Swedish-Norwegian-Antarctic expedition 1949-52 to Dronning Maud Land. - Cryptogamie, Bryol. Lichenol. **7:** 63-70.

ÖVSTEDAL, D.O. (1986b): Crustose lichens of Bouvetøya. - Norsk Polar Institut Skrifter **185:** 35-56.

POELT, J. & H. ULLRICH (1964): Über einige chalkophile *Lecanora*-Arten der mitteleuropäischen Flora (Lichenes, Lecanoraceae). - Österr. Bot. Z. **111:** 257-268.

REDON, J. (1985): Líquenes Antárticos. - INACH, Santiago de Chile.

ROBINSON, H.E. (1972): Observations on the origin and taxonomy of the antarctic moss flora. In: G.A. LLANO (ed.): Antarctic terrestrial biology. - Antarctic Research Series Vol. **20:** 163-177. American Geophysical Union, Washington.

SÀBAT, F., D. SERRAT & J.M. VILAPLANA (1992): Cenozoic tectonic evolution in Livingston Island (South Shetland, Antarctica): Mesostructural and Geomorphological approach. - Rev. Soc. Geol. España **5:** 159-166.

SAINSBURY, G.O.K. (1955): A handbook of the New Zealand mosses. Royal Society of New Zealand, Wellington.

SANCHO, L. G., L. KAPPEN & B. SCHROETER (1990): Primeros datos sobre la flora y vegetación liquénica de Isla Livingston (Islas Shetland del Sur, Antártida). Actas del Tercer Simposio Español de Estudios Antárticos (Madrid): 94-99.

SANCHO, L.G. & F. SOJO (1991): Adiciones al catálogo florístico de Isla Livingston. Actas del Cuarto Simposio Español de Estudios Antárticos (Madrid), 245-253.

SANCHO, L. G., L. KAPPEN & B. SCHROETER (1992): The lichen genus *Umbilicaria* on Livingston Island (South Shetland Islands, Antarctica). - Antarctic Science **4:** 189-196.

SANCHO, L.G., B. SCHROETER & F. VALLADARES (1998): *Umbilicaria kappeni* a new lichen species from Antarctica with multiple mechanisms for the simultaneous dispersal of both symbionts. - Nova Hedwigia **67:** 279-288.

SANCHO, L.G. & F. VALLADARES (1993): Lichen colonization of recent moraines on Livingston Island (South Shetland I., Antarctica). - Polar Biol. **13:** 227-233.

SAVICZ-LJUBITSKAYA, L.I. & Z.N. SMIRNOVA (1963): K biologii i geografii *Bryoerithrophyllum recuvirostre* (Hedw.) Chen - novogo vida dlya brioflory Antarktidy. - Bot. Zh. SSSR **48:** 350-361.

SCHLENSOG, M., B. SCHROETER, L.G. SANCHO, A. PINTADO & L. KAPPEN (1997): Effect of strong irradiance on photosynthetic performance of the melt-water dependent cyanobacterial lichen *Leptogium puberulum* Hue (Collemaceae) from the maritime Antarctic. - Bibliotheca Lichenologica **67:** 235-246.

SCHUSTER, R.M. (1969): Results of bryological field work in the Antarctic Peninsula, austral summer 1968-1969. - Antarct. J. U.S. **4:** 103-104.

SCHUSTER, R.M. (1973): Studies of *Cephaloziellaceae.* - Nova Hedwigia **22:** 121-265.

SEPPELT, R.D. (1980): The taxonomic status of *Pseudodistichium* Card. (Districhaceae). - Lindbergia **6:** 126-128.

SEPPELT, R.D. (1984): The Bryoflora of the Vestfold Hills and Ingrid Christensen Coast, Antarctica. - ANARE Research Notes **20:** 1-3 1.

SEPPELT, R. D., T.G.A. GREEN & B. SCHROETER (1995): Lichens and mosses from the Kar Plateau, southern Victoria Land, Antarctica. New Zealand Journal of Botany **33:** 203-220.

SEPPELT, R. D., T.G.A. GREEN & B. SCHROETER (1996): Additions and corrections to the lichen flora of the Kar Plateau, southern Victoria Land, Antarctica. - New Zealand Journal of Botany **34:** 329-331.

SEPPELT, R. D. & H. KANDA (1986): Morphological variation and taxonomic interpretation in the moss genus *Bryum* in Antarctica. - Mem. Natl. Inst. Polar Res. **37:** 27-42.

SEPPELT, R.D., R.I. LEWIS-SMITH & H. KANDA (1998): Antarctic Bryology: Past achievements and new perspectives. - J. Hattori Bot. Lab. **84:** 203-239.

SIPMAN, H. J. M. & P. TOPHAM (1992): The genus *Umbilicaria* (lichenized ascomycetes) in Colombia. - Nova Hedwigia **54:** 63-75.

SKOTTSBERG, C. (1960): Remarks on the plant geography of the southern cold temperate zone. - Proceedings of the Royal Society **152:** 447-457.

SMELLIE, J.L., R.J. PANKHURST, M.R.A. THOMPSON & R.E.S. DAVIES (1984): The Geology of the South Shetland Islands: Stratigraphy, Geochemistry and Evolution. - British Antarctic Survey Sci. Rep. **87:** 1-85.

SMITH, R.I.L. (1972): Vegetation of the South Orkney Islands with particular reference to Signy Island. - British Antarct. Survey Sci. Rep. **68:** 1-124.

SMITH, R.I.L. (1984): Colonization and recovery by cryptogams following recent volcanic activity on Deception Island, South Shetland Islands. - Brit. Antarct. Survey Bull. **62:** 25-51.

SMITH, R.I.L. (1988a): Botanical survey of Deception Island. - Brit. Antarct. Survey Bull. **80:** 129-136.

SMITH, R.I. L. (1988b): Bryophyte oases in Ablation Valleys on Alexander Island, Antarctica. - Bryologist **91:** 45-50.

SMITH, R.I.L. (1988c): Classification and ordination of cryptogamic communities in Wilkes Land, Continental Antarctica. - Vegetatio **76:** 155-166.

SMITH, R.I.L. (1991): Exotic sporomorpha as indicators of potential immigrant colonists in Antarctica. - Grana **30:** 313-324.

SMITH, R.I.L. (1993): The vegetation of Cockburn Island. - Antarctica. Polar Biol. **13:** 535-542.

SMITH, R.I.L. (1996): Terrestrial and freshwater biotic components of the Western Antarctic Peninsula. Foundations for Ecological Research West of the Antarctic Peninsula Antarctic Research Series **73:** 15-59.

SMITH, R.I.L. & R.W.M. CORNER (1973): Vegetation of the Arthur Harbour-Argentine Islands region of the Antarctic peninsula. - Brit. Antarct. Survey Bull. **33** & **34:** 89-122.

SMITH, R.I.L. & C.H. GIMINGHAM (1976): Classification of cryptogamic communities in the maritime Antarctic. - Brit. Antarct. Survey Bull. **43:** 25-47.

SMITH, R.I.L. & D.O. ÖVSTEDAL (1991): The lichen genus *Stereocaulon* in Antarctica and South Georgia. - Polar Biology **11:** 91-112.

SÖCHTING, U. & M. OLECH (1995): The lichens genus *Caloplaca* in polar regions. - Lichenologist **27:** 463-471.

SÖCHTING, U. & D.O. ÖVSTEDAL (1992): Contribution to the *Caloplaca* flora of the western Antarctic region. - Nordic Journal of Botany **12:** 121-134.

SOJO, F., F. VALLADARES & L.G. SANCHO (1997): Structural and physiological plasticity of the lichen *Catillaria corymbosa* in different microhabitats of the maritime Antarctic. - The Bryologist **100:** 171-179.

STENROOS, S. (1993): Taxonomy and distribution of the lichen family *Cladoniaceae* in the Antarctic and peri-Antarctic regions. - Crypt. Bot. **3:** 310-344.

STENROOS, S., L.I. FERRARO & T. AHTI (1992): Flora Criptogámica de Tierra del Fuego. Lichenes Lecanorales: Cladoniaceae. Tomo XIII - Fasc. 7. - Buenos Aires.

WALKER, F.J. (1985): The lichen genus *Usnea* subgenus *Neuropogon.* - Bull .Brit. Mus. Bot. Ser. **13:** 1-130.

WIRTH, V. (1995): Flechtenflora - Eugen Ulmer, Stuttgart.

Received 19 February 1998, accepted in revised form 10 August 1998.