Lichen synusiae in East Antarctica (Schirmacher Oasis and Larsemann Hills): substratum and morphological preferences

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Abstract
Antarctic terrestrial ecosystems experience some of the most extreme growth conditions, where plant distribution is determined by favourable environmental gradients of temperature and moisture along with micro-topography of habitats. Lichens are among the most tolerant symbiotic organisms which constitute dominant component in the terrestrial biota of Antarctica. There are various studies dealing with patterns of lichen diversity of various regions of Antarctica are done but in east Antarctica such studies are scanty. Lichen synusiae of Schirmacher Oasis and McLeod Island, Larsemann Hills, East Antarctica were studied in order to determine their morphological and substratum affinities. The Lichen synusiae of the study sites was represented by 71 species, 24 genera and 13 families in Schirmacher Oasis and 27 species, 18 genera and 10 families in McLeod Island, Larsemann Hills. Hierarchical cluster analysis of lichen communities on the basis of growth form diversity and substratum occurrence showed that crustose growth form and saxicolous (on rock, stones and moraines) habitat were the most preferred, in both study sites. The study presents a representative account of morphological and substratum preference patterns in lichen synusiae of east Antarctica, which can be of fundamental importance for future lichenological investigation in the region.

Key words: crustose, growth form, McLeod Island, Queen Maud Land, saxicolous

Abbreviations: m s^{-1} - meter per sekond, mm - millimeter, ^{0}C - degree Celsius, SO - Schirmacher Oasis, MLH - McLeod island-Larsemann Hills

Introduction

Lichens, a mutualistic composite of a fungus and green and / or blue green algae, due to their anatomical and physiological peculiarities have been able to inhabit nearly all of the terrestrial habitats. Lichen communities are variously influenced by

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both climatic (*e.g.* atmospheric temperature, relative humidity, environmental lapse rate, and precipitation) and substratum characteristics. Variety of substratum to colonize, decides the microhabitat diversity, which in turn influences the taxonomic as well as growth form diversity of lichens. Lichen growth forms (*e.g.* crustose, foliose, leprose and fruticose) are good indicators of habitat heterogeneity and clearly indicate the climatic conditions of a habitat (Rai et al. 2012).

Lichens along with mosses are the most prominent vegetation groups in Antarctic terrestrial ecosystems. Their poikilohydric nature, production of anthocyanins, and presence of freeze-protective compounds in the fungal and algal cells help lichens to tolerate intense desiccation, extreme low temperature, damaging quantities of solar radiation and insure their survival below ice and snow cover (Kappen et Lange 1970, Kappen et al. 1995, Green et al. 1999, Kappen 2000, McGonigal et Woodworth 2001).

The distribution of lichens within Antarctica is also determined by local edaphic factors (*e.g.* cryoturbation of soils and stones, exfoliation of rock surfaces), rock type and surface texture, shading from direct solar radiation, exposure to strong winds, abrasive action of wind-blown mineral particles along with ice crystals, the proximity of bird and seal colonies and availability of moisture (Green et al. 1999, Øvstedal et Smith 2001).

Antarctica covers about 14 million km^2, the majority of its area (99.66%) is permanently covered by ice or snow while remaining area (0.34%, or about 44,000 km^2) is ice-free in summer only and consists of bare rock, boulder fields, talus and simple soils (Fox et Cooper 1994, Brabyn et al. 2005, Convey et al. 2009a, b). The region includes two generally recognised biogeographic zones: the continental Antarctic and the maritime Antarctic (Smith 1984, Convey 2001). Terrestrial vegetation in the form of lichens and mosses, are limited to small, isolated, ice-free areas and reach their greatest diversity on the islands and archipelagoes adjacent to the Antarctic Peninsula (Smith 1984, 1996, Kappen 2000). Though study of Antarctic lichens dates back to 1823, there have been considerable advancement in recent decades (Torrey 1823, Green et al. 1999, Øvstedal et Smith 2001, Brabyn et al. 2006, Bergstrom et al. 2006, Ochyra et al. 2008).

Among 20,000 lichen species known from the world, Antarctica has about 427 species, with around 40% being endemic to the continent (Øvstedal et Smith 2001). The Antarctic Peninsula, Victoria Land and other localities in the western regions of Antarctica have been well explored lichenologically during the past hundred years and a good amount of information on the lichens of that area is available. However, only a few reports on lichens are available from the Eastern Antarctica (Golubkova et Simonov 1972, Richter 1995, Upreti et Pant 1995, Upreti 1996, Upreti 1997, Gupta et al. 1999, Pandey et Upreti 2000, Nayaka et Upreti 2005, Singh et al. 2007, Olech et Singh 2010, Upreti et Nayaka 2011, Nayaka et al. 2011). The current study was undertaken to study the lichen synusiae from two sites of East Antarctica- Schirmacher Oasis (denoted as SO in the further text) and McLeod Island, Larsemann Hills (denoted as MLH) with reference to determine their morphological and substratum preferences. Schirmacher Oasis, houses the Indian Antarctic research station "Maitri" and Larsemann Hills, Peydz bay area, is the site for proposed new Indian Antarctic research station "Bharati".

Material and Methods

Study area

Among the two sites, Schirmacher Oasis (70°43'-70°47'S, 11°23'-11°55'E) is a small ice-free land mass of 35 km^2 area, situated in Queen Maud Land Area, East Antarctica (Fig 1) whereas, Larsemann Hills (69°20'-69°30'S, 75°55'-76°30'E), is an ice-free coastal oasis with exposed rock and low rolling hills (Fig. 1).

Schirmacher Oasis is located between the edge of the Antarctic continental Ice Sheet and the Novolazarevskaya Nivl Ice Shelf (Fig. 1). The northern edge of the oasis has epishelf lakes, which are connected with the ocean underneath the surface of the ice (Fig 1). A total of ten Nunataks (exposed, often rocky element of a ridge, mountain, or peak not covered with ice or snow within an ice field or glacier) protrudes from the continental ice sheet at the southern edge of SO. The annual average temperature is −10.4°C which ranges from 0.9°C in summer, to −22°C in winter .The annual average wind speed is 9.7 m s^{-1}, the annual average precipitation is 264.5 mm, and there are 350 hours of sunshine per month. The climate of Schirmacher Oasis is regionally classified as a 'coastal climate zone' (Richter et Bormann, 1995).

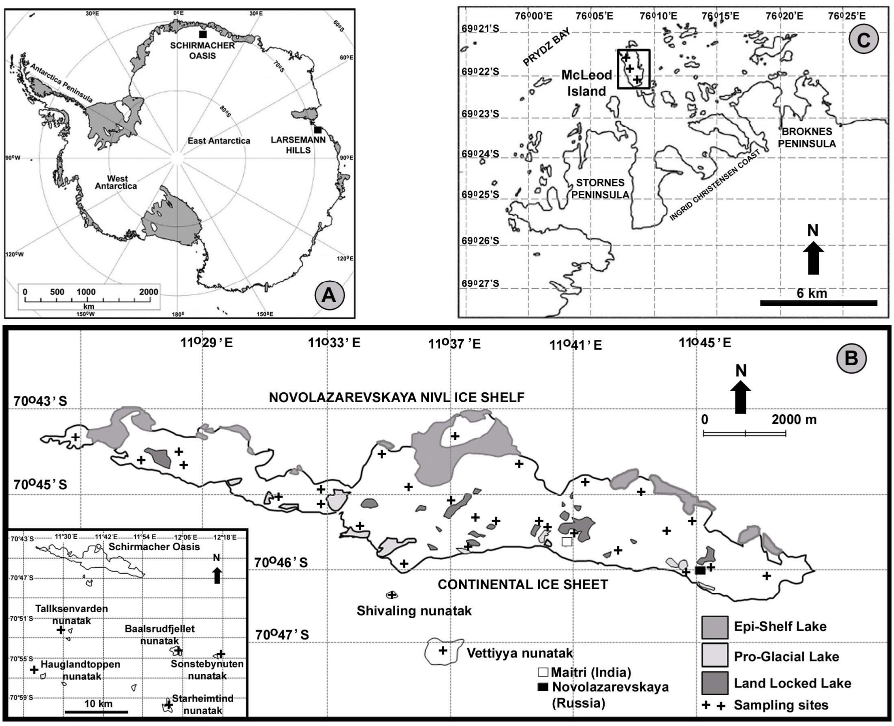

Fig. 1. A - Location map of Schirmacher Oasis and Larsemann Hills in Antarctica; **B** - Map of Schirmacher Oasis and neighboring nunataks, showing sampling sites (modified after Ravindra *et. al.* 2002); **C -** Map of Larsemann Hills, showing sampling sites in McLeod Island.

Larsemann Hills contain hundreds of freshwater lakes of varying sizes, depth and biodiversity of organisms (Ellis-Evans et al. 1998, Gillieson et al. 1990). It is the second largest (50 sq. km) of only four major ice-free oases found along the 5000 km coastline of East Antarctica. It consists of two main peninsulas- Broknes and the Stornes. McLeod Island is situated about 2 km north of the Stornes Peninsula (Fig. 1). Daytime air temperatures from December to February ranges from 4˚C to 10˚C, with mean monthly temperature a little above 0˚C (Turner et Pendlebury 2004). Mean monthly winter temperatures are between –15˚C and –18˚C. Extreme minimum temperature recorded so far is -40˚C (Turner et Pendlebury 2004). Precipitation occurs as snow and unlikely exceeds 250 mm water equivalent annually (Turner et Pendlebury 2004). A major feature of the climate of the Larsemann Hills is the existence of persistent, strong katabatic winds that blow from the north-east most summer days. Severe storms having wind speed of 50 m s^{-1} have been reported from the region (Turner et Pendlebury 2004).

Data recording

About 500 samples of Antarctic lichens from Schirmacher Oasis (SO), its neighbouring nunataks and from McLeod island- Larsemann Hills (MLH), collected during Indian Antarctic Expeditions (IAE) from 1992 to 2006 were studied for the present investigation (representative specimens lodged in lichenology herbarium- LWG of CSIR-NBRI and the data of Antarctic lichen specimens indentified by the laboratory were taken into consideration). Lichen samples were examined up to species level using relevant literature (Øvstedal et Smith 2001). Data regarding their growth form diversity (*e.g.* crustose, foliose and fruticose) and substratum were carefully recorded.

Data analysis

Antarctic lichen groups from both SO and MLH were sought through hierarchical cluster analysis (Ludwig et Reynolds 1988, Jongman et al. 1995) using presence (1) absence (0) data matrices, employing Raup-Crick similarity measure and unweighted pair-group moving average (UPGMA) algorithm, on two criteria: lichen growth form diversity (*e.g.* crustose, leprose, foliose and fruticose) and their substratum of occurrence (on rock/ stone/ moraine, on mosses and on soil) (Scutari et al. 2004, Rai et al. 2012). Cluster analysis was performed using a multivar option in PAST version 2.12 (Rai et al. 2012).

Results

Average community structure and patterns

The study resulted in the record of 71 lichens species belonging to 13 families in SO and 27 species belonging to 10 families in MLH (Table1 and Table2). In SO where, *Lecanoraceae* (14 spp.) was the dominant family followed by *Caliciaceae* (13 spp.), *Teloschistaceae* (7 spp.), *Acarosporaceae* (6 spp.) as primary, secondary and tertiary co-dominant families, in MLH *Teloschistaceae* (7 spp.)

was the dominant family followed by *Physciaceae* (4 spp.) –*Lecanoraceae* (4 spp.), *Lecideaceae* (3 spp.) as primary, secondary and tertiary co-dominant families (Fig. 2). Taxonomic distribution of lichens in both sites show that the majority of taxonomic ranks (family, genus, and species) of MLH share strong affinity with SO, as there was 85% sharing at species level, 94% at genus level and 100% at family level (Fig. 3). In both sites saxicolous habitats (rocks, stones) were preferred by lichens followed by muscicolous (on mosses) and terricolous (on soil) habitats (*see* Table 1, Table 2).

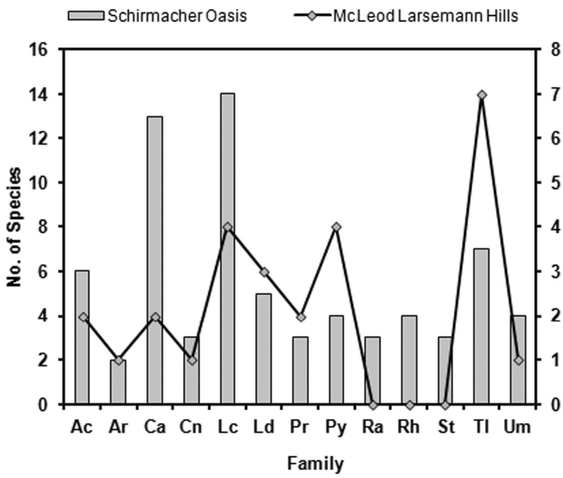

Fig. 2. Comparative family and species diversity of lichens from Schirmacher Oasis and McLeod Island, Larsemann Hills. *Ac* - Acarosporaceae, *Ar* - Arthoniaceae, *Ca* - Caliciaceae, *Cn* -Candelariaceae, *Lc* - Lecanoraceae, *Ld* - Lecideaceae, *Pr* - Parmeliaceae, *Py* - Physciaceae, *Ra* - Ramalinaceae, *Rh* - Rhizocarpaceae, *St* - Stereocaulaceae, *Tl* - Teloschistaceae, *Um* - Umbilicariaceae.

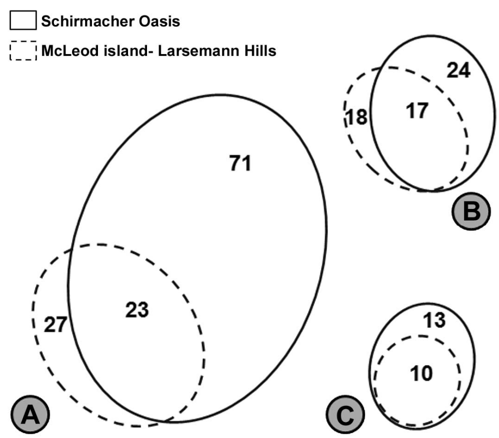

Fig. 3. Venn diagrams depicting the distribution and sharing of taxonomic ranks (**A** - species; **B** - genera, and **C** - families) among lichens of Schirmacher Oasis and McLeod Island, Larsemann Hills.

S. No.	Lichen species	Family	Growth forms[a]	Substra-tum[b]
1.	*Acarospora flavocordia* Castello & Nimis	*Acarosporaceae*	Cr	R
2.	*Acarospora gwynnii* C.W. Dodge & E.D. Rudolph	*Acarosporaceae*	Cr	R
3.	*Acarospora macrocyclos* Vain.	*Acarosporaceae*	Cr	R
4.	*Acarospora williamsii* Filson	*Acarosporaceae*	Cr	R
5.	*Amandinea coniops* (Wahlenb.) M. Choisy ex Scheid. & H. Mayrhofer	*Caliciaceae*	Cr	R
6.	*Amandinea petermannii* (Hue) Matzer, H. Mayrhofer & Scheid.	*Caliciaceae*	Cr	R
7.	*Amandinea punctata* (Hoffm.) Coppins & Scheid.	*Caliciaceae*	Cr	R
8.	*Arthonia molendoi* (Heufl. ex Frauenf.) R. Sant.	*Arthoniaceae*	Cr	R
9.	*Arthonia rufidula* (Hue) D. Hawksw., R. Sant. & Øvstedal	*Arthoniaceae*	Cr	R
10.	*Bacidia johnstonii* C.W. Dodge	*Ramalinaceae*	Cr	R
11.	*Bacidia stipata* I.M. Lamb	*Ramalinaceae*	Cr	R
12.	*Buellia darbishirei* I.M. Lamb	*Caliciaceae*	Cr	R
13.	*Buellia frigida* Darb.	*Caliciaceae*	Cr	R
14.	*Buellia grimmiae* Filson	*Caliciaceae*	Cr	R, M
15.	*Buellia grisea* C.W. Dodge & G.E. Baker	*Caliciaceae*	Cr	R
16.	*Buellia illaetabilis* I.M. Lamb	*Caliciaceae*	Cr	R
17.	*Buellia lingonoides* R.Filson	*Caliciaceae*	Cr	R
18.	*Buellia pallida* C.W. Dodge & G.E. Baker	*Caliciaceae*	Cr	R
19.	*Buellia papillata* (Sommerf.) Tuck.	*Caliciaceae*	Cr	R
20.	*Buellia pycnogonoides* Darb.	*Caliciaceae*	Cr	R
21.	*Buellia subfrigida* May. Inoue	*Caliciaceae*	Cr	R
22.	*Caloplaca athallina* Darb.	*Teloschistaceae*	Cr	R
23.	*Caloplaca citrina* (Hoffm.) Th. Fr.	*Teloschistaceae*	Cr	M, R
24.	*Caloplaca frigida* Søchting	*Teloschistaceae*	Cr	M, R
25.	*Caloplaca lewis-smithii* Søchting & Øvstedal	*Teloschistaceae*	Cr	M, R
26.	*Caloplaca saxicola* (Hoffm.) Nordin	*Teloschistaceae*	Cr	M, R
27.	*Candelaria murrayi* Poelt	*Candelariaceae*	Fo	R
28.	*Candelariella flava* (C.W. Dodge & G.E. Baker) Castello & Nimis	*Candelariaceae*	Cr	R
29.	*Carbonea capsulata* (C.W. Dodge & G.E. Baker) Hale	*Candelariaceae*	Cr	R
30.	*Carbonea assentiens* (Nyl.) Hertel	*Lecanoraceae*	Cr	R
31.	*Carbonea vorticosa* (Flörke) Hertel	*Lecanoraceae*	Cr	R
32.	*Lecania cf racovitzae* (Vain.) Darb.	*Ramalinaceae*	Cr	R
33.	*Lecanora epibryon* (Ach.) Ach.	*Lecanoraceae*	Cr	R
34.	*Lecanora expectans* Darb.	*Lecanoraceae*	Cr	M, R
35.	*Lecanora fuscobrunnea* C.W. Dodge & G.E. Baker	*Lecanoraceae*	Cr	R
36.	*Lecanora geophila* (Th. Fr.) Poelt	*Lecanoraceae*	Cr	R, M
37.	*Lecanora cf mawsonii* C.W. Dodge	*Lecanoraceae*	Cr	R, R
38.	*Lecanora mons-nivis* Darb.	*Lecanoraceae*	Cr	R

39.	*Lecanora orosthea* (Ach.) Ach.	*Lecanoraceae*	Cr	R
40.	*Lecanora polytropa* (Ehrh.) Rabenh.	*Lecanoraceae*	Cr	R
41.	*Lecanora sverdrupiana* Øvstedal	*Lecanoraceae*	Cr	R
42.	*Lecidea andersonii* Filson	*Lecideaceae*	Cr	R
43.	*Lecidea auriculata* Th. Fr.	*Lecideaceae*	Cr	R
44.	*Lecidea cancriformis* C.W. Dodge & G.E. Baker	*Lecideaceae*	Cr	R
45.	*Lecidea lapicida* (Ach.) Ach.	*Lecideaceae*	Cr	R
46.	*Lecidea* cf *placodiiformis* Hue	*Lecideaceae*	Cr	R
47.	*Lecidella siplei* (C.W. Dodge & G.E. Baker) May. Inoue	*Lecanoraceae*	Cr	R
48.	*Lecidella stigmatea* (Ach.) Hertel & Leuckert	*Lecanoraceae*	Cr	R
49.	*Lepraria cacuminum* (A. Massal.) Kümmerl. & Leuckert	*Stereocaulaceae*	Lp	R
50.	*Lepraria neglecta* (Nyl.) Erichsen	*Stereocaulaceae*	Lp	R, M
51.	*Lepraria membranacea* (Dicks.) Vain.	*Stereocaulaceae*	Lp	R, M
52.	*Physcia caesia* (Hoffm.) Hampe ex Fürnr.	*Physciaceae*	Fo	R
53.	*Physcia dubia* (Hoffm.) Lettau	*Physciaceae*	Fo	R
54.	*Pleopsidium chlorophanum* (Wahlenb.) Zopf	*Acarosporaceae*	Cr	R
55.	*Pseudephebe minuscula* (Nyl. Ex Arnold) Brodo & D. Hawksw.	*Parmeliaceae*	Fr	R
56.	*Rhizocarpon geminatum* Körb.	*Rhizocarpaceae*	Cr	R
57.	*Rhizocarpon geographicum* (L.) DC.	*Rhizocarpaceae*	Cr	R
58.	*Rhizocarpon nidificum* (Hue) Darb.	*Rhizocarpaceae*	Cr	R
59.	*Rhizocarpon flavum* C.W. Dodge & G.E. Baker	*Rhizocarpaceae*	Cr	R
60.	*Rhizoplaca melanophthalma* (Ram.) Leuckert and Poelt	*Lecanoraceae*	Cr	R
61.	*Rinodina endophragmia* I.M. Lamb	*Physciaceae*	Cr	R
62.	*Rinodina olivaceobrunnea* C.W. Dodge & G.E. Baker	*Physciaceae*	Cr	R
63.	*Sarcogyne privigna* (Ach.) A. Massal.	*Acarosporaceae*	Cr	R
64.	*Umbilicaria africana* (Jatta) Krog & Swinscow	*Umbilicariaceae*	Fo	R
65.	*Umbilicaria aprina* Nyl. 1863	*Umbilicariaceae*	Fo	R
66.	*Umbilicaria decussata* (Vill.) Zahlbr.	*Umbilicariaceae*	Fo	R
67.	*Umbilicaria vellea* (L.) Ach.	*Umbilicariaceae*	Fo	R
68.	*Usnea antarctica* Du Rietz	*Parmeliaceae*	Fr	R
69.	*Usnea sphacelata* R. Br.	*Parmeliaceae*	Fr	R
70.	*Xanthoria elegans* (Link) Th. Fr.	*Teloschistaceae*	Fo	R
71.	*Xanthoria mawsonii* C.W. Dodge	*Teloschistaceae*	Fo	R

Table 1. Taxonomic, morphological and substratum attributes of Lichens from Schirmacher Oasis, East Antarctica. Growth forms[a]: *Cr* - Crustose, *Fo* - Foliose, *Fr* – Fruticose, *Lp* - Leprose; Substratum[b]: *R* - rock, moraine and stones, *S* - Soil, *M* - Moss.

Lichen groups

Hierarchical cluster analysis in case of SO resulted in two major clusters I and II. Major cluster I constituted *Lepraria* species having leprose growth forms and preference for rocks and mosses as their substratum (Fig. 4). Major cluster II, constituted by species of *Carbonia, Leacnia, Acarospora, Rhizocarpon, Amandinea, Buellia, Pleopsidium, Lecidea, Lecidella, Bacidia, Lecanora, Rhizoplaca, Candelariella, Arthonia, Rinodina, Sarcogyne, Caloplaca, Candelaria, Physcia, Xanthoria, Umbilicaria, Pseudephebe,* and *Usnea*, was characterize by predominance of crustose growth forms which preferred rock substratum (saxicolous habitats) (Fig. 4). The cluster was further divided into four groups (a, b, c and d) on the basis of decreasing preference towards crustose growth form and differential substratum affinities (*i.e.* a - crustose, saxicolous; b - crustose, saxicolous as well as muscicolous; c - foliose, saxicolous; d- fruticose, saxicolous) (Fig. 4).

Hierarchical cluster analysis in case of MLH resulted in two major clusters I and II (Fig. 5). Major cluster-I constituted species of *Physcia*, *Xanthoria*, *Umbilicaria*, *Psedephebe* and *Usnea* and was characterize by predominance of foliose and fruticose growth forms and preference to saxicolous (on rock) habitats (Fig.5). Major cluster I, was further divided into two groups (*i.e.* a, b) having foliose growth forms in group-a, and fruticose growth forms in group-b. Except *Physcia caesia*, which was also reported from mosses, all other lichen species of group-a, were mainly reported from rocks (Fig.5). *Pseudephebe minuscula* and *Usnea antarctica* constituting group-b were found both on rock and soil. Major cluster-II, constituted by species of *Acarospora, Arthonia, Buellia, Caloplaca, Candelaria, Carbonia, Huea*, *Lecanora, Lecidea, Lecidella, Rhizoplaca, Rinodina, Sarcogyne* was characterize by lichens of crustose growth form which preferred rock substratum (saxicolous habitats) was further divided into four groups (c, d, e, f and g) on the basis of differential substratum preferences (*i.e.* c -rock and soil; d - rock; e - rock, soil and moss; f - soil, moss; g - moss) (Fig.5).

Discussion

Though throughout the Antarctic biomes lichens dominate the terrestrial biota, their occurrence and development of communities are delimited by the regional and local environmental conditions (Øvstedal et Smith 2001). The comparative assessment of both the sites (*i.e.* Schirmacher Oasis and McLeod Island, Larsemann Hills), concluded that both the sites harbour crustose growth form dominated lichen community which prefer saxicolous habitats (Table 1, 2; Fig. 4, 5) (Upreti et Pant 1995, Upreti 1996, Upreti 1997, Gupta et al. 1999, Pandey et Upreti 2000, Nayaka et Upreti 2005, Singh et al. 2007).The extremely limited occurrence of foliose (*i.e.* species of *Candileria*, *Physcia*, *Xanthoria*, *Umbilicaria*) and fruticose (*i.e.* species of *Pseudephebe* and *Usnea)* lichens is due to harsher continental climate of east Antarctica (Øvstedal et Smith 2001).

S. No.	Lichen species	Family	Growth forms[a]	Substra-tum[b]
1.	*Acarospora gwynnii* C.W. Dodge & E.D. Rudolph	*Acarosporaceae*	Cr	R
2.	*Arthonia lapidicola* (Taylor) Branth & Rostr.	*Arthoniaceae*	Cr	R
3.	*Buellia frigida* Darb.	*Caliciaceae*	Cr	R
4.	*Buellia grimmiae* Filson	*Caliciaceae*	Cr	S, M
5.	*Caloplaca athallina* Darb.	*Teloschistaceae*	Cr	M
6.	*Caloplaca citrina* (Hoffm.) Th. Fr.	*Teloschistaceae*	Cr	R
7.	*Caloplaca lewis-smithii* Søchting & Øvstedal	*Teloschistaceae*	Cr	M
8.	*Caloplaca saxicola* (Hoffm.) Nordin	*Teloschistaceae*	Cr	R, S
9.	*Candelariella flava* (C.W. Dodge & G.E. Baker) Castello & Nimis	*Candelariaceae*	Cr	R, S, M
10.	*Carbonea vorticosa* (Flörke) Hertel	*Lecanoraceae*	Cr	R
11.	*Huea coralligera* (Hue) C.W. Dodge & G.E. Baker	*Teloschistaceae*	Cr	M
12.	*Lecanora expectans* Darb.	*Lecanoraceae*	Cr	S, M
13.	*Lecanora geophila* (Th. Fr.) Poelt	*Lecanoraceae*	Cr	M
14.	*Lecidea cancriformis* C.W. Dodge & G.E. Baker	*Lecideaceae*	Cr	R, S
15.	*Lecidella patavina* (A. Massal.) Knoph & Leuckert	*Lecanoraceae*	Cr	R, S
16.	*Lecidella siplei* (C.W. Dodge & G.E. Baker) May. Inoue	*Lecanoraceae*	Cr	R
17.	*Physcia caesia* (Hoffm.) Hampe ex Fürnr.	*Physciaceae*	Fo	R, M
18.	*Physcia dubia* (Hoffm.) Lettau	*Physciaceae*	Fo	R
19.	*Pseudephebe minuscula* (Nyl. Ex Arnold) Brodo & D. Hawksw.	*Parmeliaceae*	Fr	R, S
20.	*Rhizoplaca melanophthalma* (Ram.) Leuckert and Poelt	*Lecanoraceae*	Cr	R, S, M
21.	*Rinodina olivaceobrunnea* C.W. Dodge & G.E. Baker	*Physciaceae*	Cr	S, M
22.	*Rinodina peloleuca* (Nyl.) Müll. Arg.	*Physciaceae*	Cr	R
23.	*Sarcogyne privigna* (Ach.) A. Massal.	*Acarosporaceae*	Cr	R, S
24.	*Umbilicaria decussata* (Vill.) Zahlbr.	*Umbilicariaceae*	Fo	R
25.	*Usnea antarctica* Du Rietz	*Parmeliaceae*	Fr	R
26.	*Xanthoria elegans* (Link) Th. Fr.	*Teloschistaceae*	Fo	R
27.	*Xanthoria mawsonii* C.W. Dodge	*Teloschistaceae*	Fo	R

Table 2. Taxonomic, morphological and substratum attributes of Lichens from McLeod Island, Larsemann Hills, East Antarctica. Growth forms[a]: *Cr* - Crustose, *Fo* - Foliose, *Fr* - Fruticose; Substratum[b]: *R* - Rock, *S* - Soil, *M* – Moss.

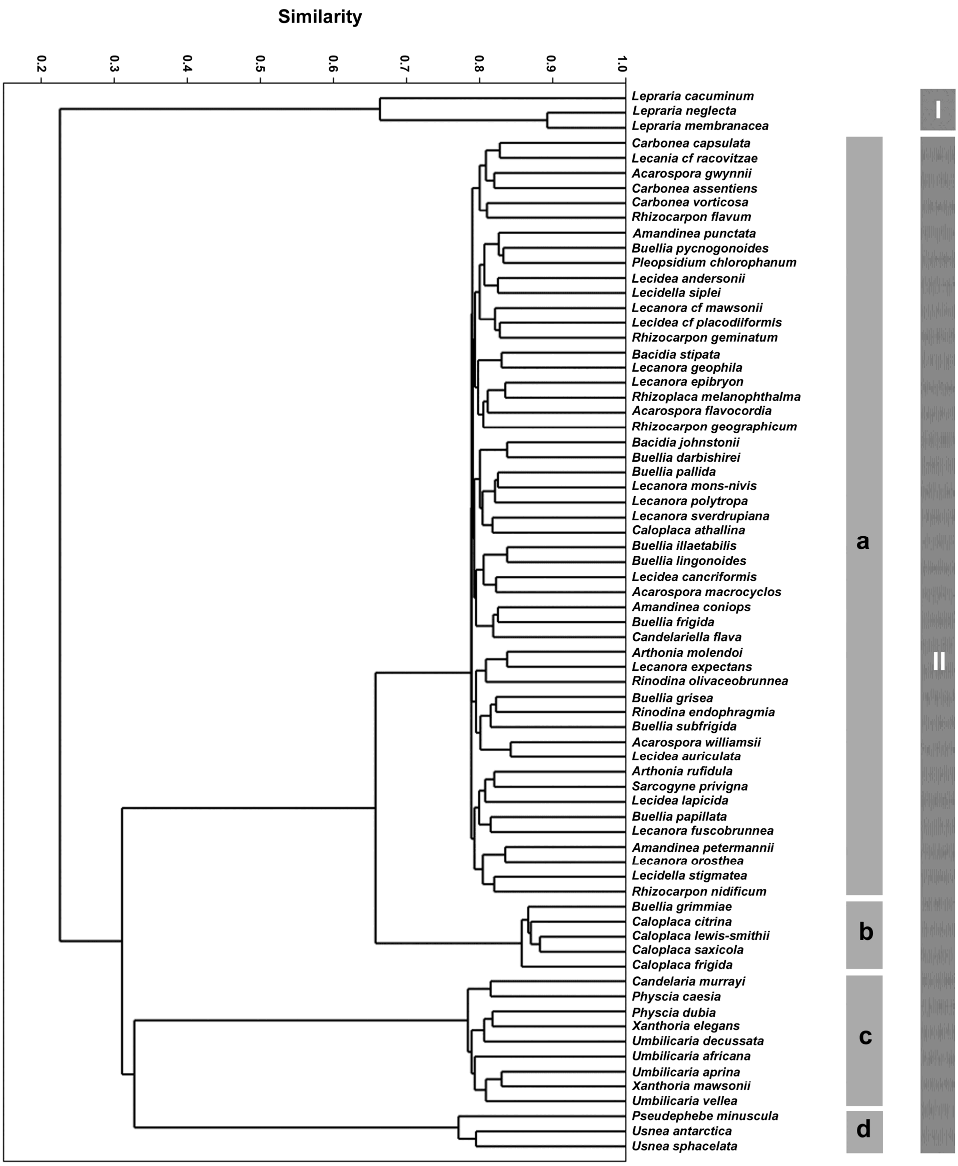

Fig. 4. Groups of lichens of Schirmacher Oasis resulting from hierarchical cluster analysis based on morphological characters (growth form type) and substratum (rock/ moraines/stones, mosses) preference.

The substantial sharing (species-85%, genus- 94%, family-100%) of lichen taxon ranks, between MLH and SO (Fig. 3), suggest their similar community constitution. The higher turnout of lichen species from SO than MLH can be attributed to diverse microhabitats of SO, which is enriched by lakes and nunataks and also due to milder coastal climate of SO than MLH which faces Katabatic winds in summer and minimum temperature extreme of -40^{0}C (Turner et Pendlebury 2004). The higher affinity of lichens to saxicolous habitats (rock, moraines and stones) than soil and mosses, is in accordance with the predominance of rocky substratum in continental Antarctica (Øvstedal et Smith 2001).

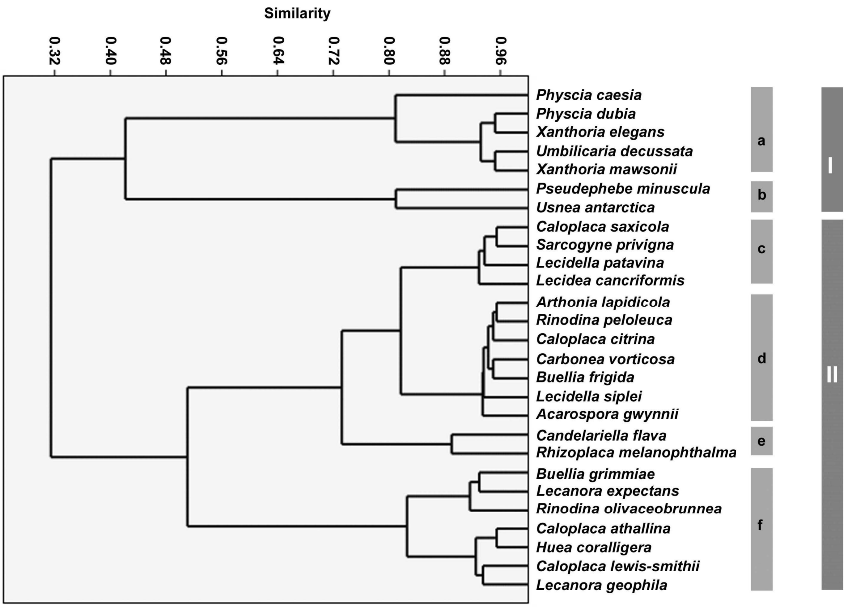

Fig. 5. Groups of lichens of McLeod Island, Larsemann Hills resulting from hierarchical cluster analysis based on morphological characters (growth form type) and substratum (rock, soil/ moss) preference.

Conclusion

Most habitats in continental Antarctica are regarded as extreme, in terms of low temperature, prolonged drought, rapidly fluctuating thermal and hydric regimes, higher solar irradiance and ultraviolet-B radiation levels and prolong winter darkness (Øvstedal et Smith 2001). The present study is though limited to two sites of east Antarctic - Schirmacher Oasis and McLeod island, Larsemann Hills, where the activities of Indian Antarctic programme are currently going on. Representative accounts of lichens of East Antarctica and their morphological and substratum preferences are presented in this study. The findings of the study will add substantially to the limited knowledge of east Antarctic lichens and their ecology. These findings can be confidently extrapolated for further studies of terrestrial biota of East Antarctica and can be valuable data for designing future research programmes and management activities.

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