Universidade Federal do Pampa

Daniela Schmitz

COMUNIDADES VEGETAIS DE ÁREA DE DEGELO DA ILHA HALF MOON, ARQUIPÉLAGO DAS SHETLANDS DO SUL, ANTÁRTICA.

Dissertação de Mestrado

São Gabriel

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Banca Examinadora:

Prof. Dr. Antônio Batista Pereira

Orientador

UNIPAMPA

Prof. Dr. Leandro Homrich Lorentz

UNIPAMPA

Prof. Dra. Margéli Pereira de Albuquerque

UNIPAMPA

Prof. Dra. Marisa Terezinha Lopes Putzke

UNISC

"Precisa-se homens para viagem perigosa, pequenos salários, frio intenso, longos meses de completa escuridão, perigo constante, retorno duvidoso, honra e reconhecimento em caso de sucesso."

Ernest Shackleton

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RESUMO

Este trabalho apresenta os resultados do estudo das comunidades vegetais de áreas de degelo realizado durante os verões austrais de 2013/2014 e 2014/2015, nos meses de fevereiro e março, na Ilha Half Moon, no Arquipélago Shetlands do Sul, Antártica Marítima, com o objetivo de avaliar a distribuição e abundância de musgos e líquens, bem como para descrever e mapear as comunidades de plantas que ocorrem na área. As plantas foram correlacionadas com a ocorrência de aves marinhas, relevo e umidade para entender sua influência sobre a distribuição de plantas. Para aferir as comunidades existentes na ilha através da fitossociologia e quantificar as espécies com maior significância ecológica (IES) foi utilizada a metodologia de quadrados (20 x 20cm) de Braun-Blanquet adaptado às condições Antárticas. Para o mapeamento da área foi utilizado o DGPS Astech Promark II®, com precisão sub-metrica e posteriormente processados no software Astech Solutions®. Foram identificadas 37 espécies de briófitas, 59 liquens, uma angiosperma, a *Deschampsia antarctica* Desv., e duas espécies de algas macroscópicas. Foram dispostos 358 quadrados e identificadas cinco comunidades vegetais na ilha, distribuídas de acordo com a ocorrência de animais e a influência marítima. As comunidades descritas foram as seguintes: Comunidade Liquens fruticulosos, Comunidade carpete de musgos, Comunidade de Liquens Muscicolas, Comunidade de Liquens crustosos e Comunidade Turfa de musgos. A espécie que apresentou o IES mais elevado da ilha foi *Sanionia uncinata* (Hedw.) Loeske aparecendo em 71.78% dos quadrados amostrados. A comunidade que apresentou maior número de espécies foi a Carpete de musgos e a mais diversa foi a comunidade liquens crustosos, que tem sua maior parte localizada na área onde estão as colônias de pingüins.

Palavras-chave: Fitossociologia, musgos, liquens, vegetação Antártica.

ABSTRACT

This paper presents the results of the study of plant communities of free ice areas conducted during the austral summer of 2013/2014 and 2014/2015, in February and March, on Half Moon Island in the South Shetlands Archipelago, Maritime Antarctica, aiming to evaluate the distribution and abundance of mosses and lichens, as well as to describe the plant communities occurring in the area, with mapping of the vegetation communities. To assess existing communities on the island through the phytosociology and quantify the species with the highest ecological significance (IES) was used the methodology square (20 x 20cm) of Braun-Blanquet adapted to Antarctic conditions. . The area was mapped using an Astech Promark II® DGPS, yielding sub-metric precision after post-processing with Astech Solutions® software. The number of species totalized 38 bryophyte species, 59 lichens, only one flowering plant (*Deschampsia antarctica* Desv.) and two macroscopic terrestrial algae. Five plant communities were identified in the island, distributed accordingly to animal occurrence and to sea influence. The plant communities were described as follows: Fruticose lichens community, Moss-carpet community, Muscicolous Lichens community, Crustose lichens community and Moss turf community. The species with the highest IES of the island was *Sanionia uncinata* (Hedw.) Loeske appearing in 71.78% of sampled squares. The community with the highest richness species was the Moss Carpet, and the most diverse community was the crustosos lichens, which has mostly located in the area where the penguin colonies.

Key-words: phytosociology, mosses, lichens, Antarctic vegetation

SUMÁRIO

INTRODUÇÃO GERAL

A Antártica foi o último continente a ser descoberto pelo homem, é o mais frio, ventoso, seco, remoto e preservado de todos os continentes. É considerada Antártica, todas as terras e gelo localizadas abaixo do paralelo 60°S, o que inclui o continente Antártico, as ilhas Sub-Antárticas e grande parte do Oceano Glacial Antártico (Ugolini & Bockheim, 2007).

O bioma Antártico pode ser subdividido biogeograficamente em zonas latitudinais que correspondem a regiões climáticas distintas (Ochyra, 1998). Segundo sistema apresentado por Greene (1964) e detalhado por Lewis-Smith (1984) era classificado em Zona Subantártica, Antártica Marítima e Antártica continental.

A Zona Subantártica de acordo com Longton (1988), é formada por oito grupos de pequenas ilhas isoladas, com climas oceânicos temperados, com temperaturas médias mensais acima do ponto de congelamento por pelo menos, metade do ano. A vegetação é desprovida de espécies arbóreas, composta principalmente por arbustos, pteridófitas e criptógamas. A Antártica Marítima compreende a costa oeste da Península Antártica e os arquipélagos e ilhas abaixo do paralelo 55°S. Com clima oceânico úmido frio e temperaturas médias mensais superiores a 0° nos meses de verão. A vegetação é composta por duas espécies de plantas vasculares e uma flora relativamente rica e diversa de briófitas e liquens. A Antártica Continental inclui todo continente, excluindo as ilhas ocidentais a norte dos 70°S da Península Antártica. O clima nesta área é severo com uma média de temperaturas mensais nunca superior ao ponto de congelamento. Esta área é muito pobre em termos vegetais, carecendo de plantas vasculares, a vegetação é principalmente representada por briófitas e liquens (Ochyra, 1998; Ochyra et al., 2008).

A Antártica é o único dos continentes da Terra que não tem uma história de habitação e contato humano a longo prazo. O continente começou a ser frequentado há cerca de dois séculos atrás (ao norte da Península Antártica), e a Antártica Oriental à apenas um pouco mais de um século atrás, enquanto as ilhas Sub-Antárticas foram descobertas e seus recursos marinhos rapidamente exploradas a aproximadamente 3 séculos (Convey, 2010).

Antártica tem uma área de cerca de 14 milhões km², em sua grande maioria permanentemente coberta por um manto de gelo de 2,1 km de espessura média, representando cerca de 90% do gelo do mundo (Campbell & Claridge, 1988). A camada de mar congelado circundante possui superfície que varia entre 1,6 milhões de km², no verão, e até 20 milhões de km², no inverno. O volume do gelo antártico (aproximadamente 30 milhões de km³) representa cerca de 90% da Criosfera e contém aproximadamente 68% da água doce existente no planeta (Turner et al., 2008).

Por não existir divisões geopolíticas, a Antártica passou a ser explorada sem o devido controle. Motivados principalmente por questões estratégicas, no final da década de 50, doze países, sete dos quais reivindicavam partes da Antártica para si, criaram um regime internacional que colocou toda área ao sul do paralelo 60° sob normas especiais. Para tanto, em 1959, foi assinado o Tratado Antártico, elaborado em Washington, por ocasião do Ano Geofísico Internacional (1957-1958), apresenta-se como legítimo instrumento jurídico internacional que regula a questão dos reclames territoriais na região austral (Gandra, 2009). No qual a Antártica foi definida como continente dedicado à paz e a ciência, cujos propósitos principais são a proteção do meio ambiente e a promoção de pesquisa científica.

A região Antártica desempenha um papel fundamental no equilíbrio da Terra, principalmente no que diz respeito à dinâmica atmosférica e climática. A parte continental é riquíssima em recursos naturais, principalmente minerais, ocupando 9,3% da superfície terrestre (Schellmann & Kozel, 2005).

As formas de vida existentes na Antártica evoluíram sob condições extremas de frio, vento, gelo e neve. O isolamento desse continente pelas massas de água e as condições especiais condicionaram o estabelecimento de espécies que só ocorrem naquele local. A biota Antártica, que se restringe a pequenos invertebrados, microorganismos e uma flora abundante de liquens e musgos, ocorre principalmente nas pequenas localidades livres de gelo localizadas principalmente em áreas costeiras da Antártica Marítima, fora desta zona, a vegetação é principalmente limitada a alguns afloramentos rochosos ao longo da costa, os vales e nunataks secos (Putzke & Pereira, 2001).

Poucas plantas são capazes de viver expostas às condições climáticas da Antártica e as suas grandes variações de temperatura, ventos fortes, neve e pouca

disponibilidade de água. A flora está adaptada às condições fotossintéticas e respiratórias em temperaturas abaixo de -10°C sobre o solo (Sancho & Pintado, 2011).

O clima nesta região é muito severo para permitir a existência de plantas superiores arbóreas (Campbell e Claridge, 1988). A flora da Antártica é composta principalmente de briófitas e espécies de liquens adaptados a verões curtos e a baixas temperaturas (Putzke & Pereira, 2001). Os ecossistemas das áreas livres de gelo da Antártica Marítima são fortemente condicionados pelas condições climáticas. Nesse ambiente, onde a temperatura média anual do ar é de -2,5°C, com predomínio de fortes ventos e baixa radiação solar incidente, faz-se necessário que as vegetações que ocupam essas áreas sejam adaptadas as rigorosas condições climáticas (Øvstedal & Lewis-Smith, 2001).

A flora de musgos da Antártica consiste em 111 espécies e duas variedades, entre as quais 55 gêneros e 17 famílias (Ochyra et al., 2008). Øvstedal & Lewis-Smith (2001) relatam aproximadamente 386 espécies de liquens, sendo trabalhos mais recentes sugerem que este número pode chegar a cerca de 500 espécies (Øvstedal & Scheafer, 2013). Para angiospermas há apenas duas espécies nativas registradas, *Deschampsia antarctica* Desv., pertencente a família *Poaceae*, e *Colobanthus quitensis* (Kunth) Bartl., pertencente à família *Caryophillaceae* (Putzke & Pereira, 2001). Há ainda, um gênero de algas macroscópicas terrestres conhecido para a Antártica, com apenas duas espécies: *Prasiola crispa* (Lightfoot) Menegh., e *P. cladophylla* (Carmich.) Menegh.

De maneira geral, o espaço limitado de áreas livres de gelo na região (menos de 2%) juntamente com as condições climáticas, são os principais fatores limitantes ao crescimento da população vegetal (Croxall, 1984). As taxas baixas de fluxo de energia e ciclagem de nutrientes, associado ao lento desenvolvimento das comunidades vegetais, fazem com que esses ecossistemas possuam uma grande sensibilidade a perturbações (Walker et al., 1997).

Os locais ocupados por plantas são aproveitados por aves para a nidificação, o que favorece a entrada de fósforo e nitrogênio no sistema, aumentando a atividade biológica e mudando o microclima do solo, devido a incorporação de carbono orgânico (Schaefer et al., 2004). Porém, na criação de colônias, a vegetação é geralmente é devastada devido à excessiva adubação e pisoteio por pinguins (Tatur & Myrcha, 1989).

No contexto das alterações climáticas, três elementos são fundamentais para a biologia de organismos antárticos terrestres: temperatura, água e radiação solar. Portanto, mesmo uma pequena mudança na temperatura, precipitação e disponibilidade de água líquida pode ter um importante impacto biológico (Chwedorzewska, 2010).

A radiação solar assume importante papel no desenvolvimento e na distribuição das comunidades vegetais nas áreas livres de gelo na região da Antártica Marítima, por influenciar direta ou indiretamente diversos processos que interferem no desenvolvimento das espécies presente na região (Pereira & Putzke, 1994; Francelino et al., 2007). As áreas com valores médios de radiação global mais elevados são aquelas ocupadas pelos musgos em encostas. Isso ocorre devido tratar-se de encostas voltadas principalmente para o norte. São nessas locais que inicia o processo de degelo, fazendo com que permaneçam mais tempo úmidas, favorecendo a formação de um ambiente propício ao desenvolvimento das briófitas, conforme verificado por Francelino (2004).

A Antártica reage imediatamente às mudanças globais. O continente perdeu mais de 15 mil quilômetros quadrados de gelo ao longo dos últimos 15 anos. Na região da Península Antártica, foi registrado aquecimento atmosférico de mais de 3ºC nos últimos 50 anos (MMA). Estimativas indicam que o derretimento do manto de gelo austral provocaria uma elevação de até 60 m no nível do mar, com consequências catastróficas sobre a vida das populações litorâneas (Rocha-Campos & Santos, 2001). Os impactos que o acréscimo de temperatura acarretará sobre os ecossistemas Antárticos excederá a muitas outras regiões do planeta com conseqüências diretas sobre a vida terrestre. Vários parâmetros ambientais, como precipitação, radiação ultravioleta e direção dos ventos, são passíveis de serem influenciados pelo aquecimento extra da atmosfera (Poeiras, 2010).

A posição geográfica, fatores astronômicos, a cobertura de gelo e altitude são os principais fatores que afetam o clima da Antártica, o lugar mais frio da Terra. Partes desse continente enfrentam as taxas mais rápidas de mudanças climáticas antropogênicas atualmente vistas no planeta. As mudanças climáticas estão ocorrendo em toda a Antártica, afetando três grandes grupos de variáveis ambientais de considerável significância biológica: temperatura, água, radiação UV-B. Acredita-se que ecossistemas de baixa diversidade sejam mais vulneráveis às mudanças globais do que ecossistemas de alta diversidade (Chwedorzewska, 2010).

O arquipélago das Shetlands do Sul localiza-se na Antártica Marítima, situando-se ao Noroeste da Península Antártica, da qual faz parte a pequena ilha Half Moon (62°36'S, 59°53'W) em forma de meia lua, que dá origem a uma bahia com aproximadamente 2Km de comprimento. A Ilha se encontra dentro da Bahia Luna, pertencente à Ilha Livingston e separada da Ilha Greenwich pelas águas do Estreito de Farlane (Esponda et al., 2000). Nela está situada a Base Câmara (62°35’43.1”S, 059°55’05.7”W) pertencente à Armada Argentina, fundada em 1° de abril de 1953, é uma base temporária utilizada somente em alguns meses do verão (Martinez & Parica, 2011).

Segundo Del Río et al. (1993), a ilha foi formada a partir de três pequenas ilhas posteriormente unidas por dois tômbolos do Holoceno: um central e outro ao sul. A elevação ao norte da ilha é a mais alta e larga, com o Morro Gabriel atingindo a altitude de 101m e o morro Xenia com 96 metros de altitude (Esponda et al., 2000). O morro ao sul denominado neste trabalho como La Morenita alcança 93 metros acima do nível do mar. Existe ainda outra pequena elevação situada na extremidade Sudeste da Ilha, designada Ponta Baliza, onde atualmente se encontram as colônias de pinguins *Pygoscelis antarctica e Pygoscelis papua*, com 40 metros de altitude. Este ponto da Ilha torna a mesma um dos locais mais visitados pelo turismo antártico, recebendo mais de 12mil turistas por verão austral.

O monitoramento das comunidades vegetais é um bom recurso para conhecer as alterações do clima nas regiões polares e subpolares. O aumento ou recuo das manchas de vegetação ou ainda a substituição de espécies, podem ser indicadores de mudança na temperatura e no aporte de umidade no ambiente. Como constatado por Pinto et al. (2013) que observou um aumento na vegetação de *Deschampsia antarctica* nas áreas adjacentes a Estação Polonesa Henrick Artowski quando comparou seu dados de IES aos de Victoria et al. (2009), que ele diz ser causado pelo aumento da temperatura.

Uma ferramenta importante para estudar as flutuações nas populações de briófitas foi idealizada por Lara & Mazimpaka (1998). Estes autores desenvolveram o Índice de valor ecológico (Index of Ecological Significance– IES), que compara os dados de frequência e a abundância, determinando a importância das espécies na área estudada. Victoria & Pereira (2007) adaptaram essa metodologia para as condições Antárticas e verificaram que a maioria das espécies de musgos são frequentemente

encontradas na região da Ilha Rei George, porém grande parte com baixa cobertura (IES<50). Os valores resultantes desse Índice variam de 0 a 600, sendo que valores acima de 400 são muito raros. São consideradas espécies com Significância Ecológica elevada as que representam índice superior a cinquenta (IES>50).

Objetivo Geral

-Descrever e mapear as comunidades vegetais da lha Half Moon.

Objetivos Específicos

- Identificar as espécies vegetais de áreas de degelo da Ilha Half Moon;

- Investigar a biodiversidade, sua distribuição e dinâmica de ocupação comunidades vegetais de áreas de degelo da Ilha Half Moon;

- Elaborar um mapa da vegetação através de dados fitossociológicos obtidos;

CAPÍTULO 1. PLANT COMMUNITIES OF HALF MOON ISLAND, ANTARCTICA.

(Artigo submetido para a revista *Polar Biology*)

PLANT COMMUNITIES OF HALF MOON ISLAND, ANTARCTICA

Daniela Schmitz; Jair Putzke; Filipe de Carvalho Victoria; Clarissa Kappel Pereira; Adriano Luiz Schünneman: Frederico Costa Beber Vieira; Antonio Batista Pereira.

ABSTRACT

During the austral summer of 2013/14 and 2014/2015 (February/March), field works were performed in Halfmoon Island, South Shetland Archipelago, Antarctica, aiming to evaluate the distribution and abundance of mosses and lichens, as well as to describe the plant communities occurring in the area, mapping the vegetal communities. The plants were correlated to the occurrence of seabirds to understand their influence on the plant distribution. The quadrate (20 x 20 cm) method was employed to phytosociological study and to describe the communities. The area was mapped using an Astech Promark II® DGPS, yielding sub-metric precision after post-processing with software. The number of species totalized 38 bryophyte species, 59 lichens, only one flowering plant (*Deschampsia antarctica* Desv.) and two macroscopic terrestrial algae. Five plant communities were identified in the island, distributed accordingly to animal occurrence and to sea influence. The plant communities were described as follows: (1) Fruticose lichens and moss cushion community; (2) Moss-carpet community; (3) Muscicolous Lichens community; (4) Crustose lichens community and (5) Moss turf community.

Key Words: phytosociology, mosses, bryophytes, lichens, mapping

INTRODUCTION

Half Moon (62°36' S, 59°53' W) is one of the smallest islands in the South Shetland Archipelago, Antarctica. The Teniente Camara base (Argentine) is located in the island. The island is visited daily by tourists, mainly attracted by the penguin rockeries and by the fact that, apart from the giant petrel, all birds that reproduce in Antarctic can be found in the island (Orlog, 1958; Favero et al., 1991; Esponda et al., 2000).

The Antarctic is a relatively preserved environment that contributes to the maintenance of the global changes. The harsh conditions of this habitat are fundamental

to selecting organisms able to survive in such an extreme habitat and to support the relatively simple ecosystems (Teixeira et al., 2010).

The Antarctic flora is composed mainly of bryophytes and lichen species adapted to strict conditions and low temperatures, with 111 moss species described, and 360 lichen species accepted by the taxonomists, but recent studies indicate that this number can reach 500 species. Regarding angiosperms, there are only two species of native plants described from Antarctica, *Deschampsia antarctica* and *Colobanthus quitenses* (Pereira & Putzke, 1994; Putzke & Pereira, 2001; Øvstedal & Lewis-Smith, 2001; Øvstedal & Lewis Smith, 2004; Ochyra, 2008; Øvstedal & Scheafer, 2013). Species that are limited by relatively narrow moisture or temperature ranges are potential indicators of climate and climatic change (Longton 1982; Gignac, 2001).

The vegetal formation in Half Moon Island was firstly reported by Lindsay (1971) after a short-term incursion in the place, but no reference was made to any species. There are colonies of almost all representative Antarctic birds breeding there, in addition to colonies of seals resting in the area, allowing to correlate their presence with plant occupation. Only studies with birds that were performed and the Island (Favero & Silva, 1991; Esponda et al., 2000), describing 10 species nesting in the austral summer of 95/96.

Tourism activity is increasing in Antarctica, and Half Moon is one of the more visited one. According to the Association of Antarctica Tourism Operators (AATO) the touristic activity in this island practically eight folded, from 1500 visitors in 1999 to 12.969 in 2014 (Keough, 2014). This raise contributed to some impact over vegetation, but judging from the area exposed to plant development, it is a opportunity to describe and map the communities to monitor the environmental impact and to diminish future damage from anthropic activities (Esponda et al., 2000).

The study aimed at describing and mapping the distribution of plant communities in Half Moon Island.

MATERIAL AND METHODS

The Half Moon Island is located at the South Shetland Archipelago, in the West side of the Antarctic Peninsula. It was visited in the 32nd Brazilian Antarctic Operation carried out in the 2013/2014 Austral Summer, using the facilities of the Camara base, Argentine (established in 1952/53), in the proximity of La Morenita, to install laboratories and equipment. The Island is located at 62°34'50.57"S and 62°35'54.04"S, 59°53'24.44"W and 59°56'04.16"W. Its dimensions for E/W and N/S are approximately 2 Km (Figure 01), being one of the smallest islands of the Archipelago.

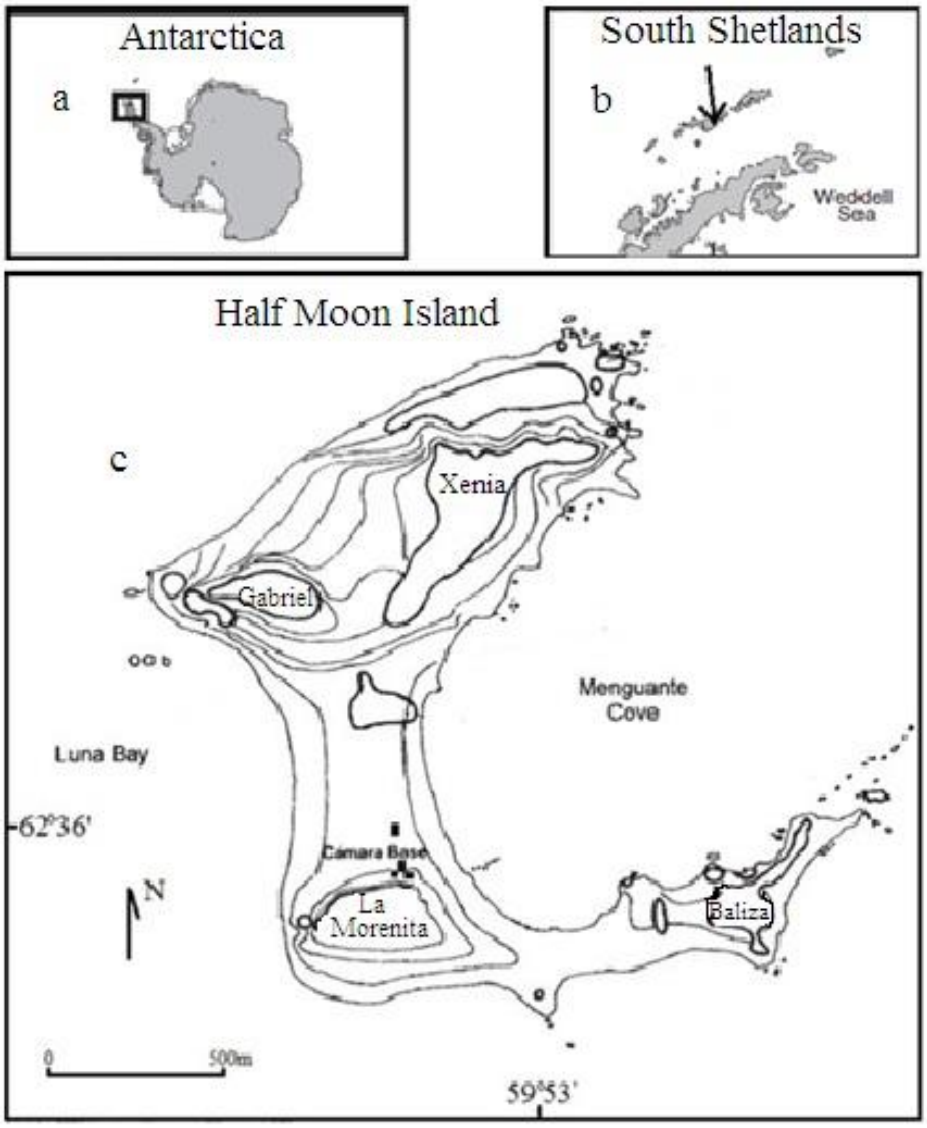

Figure 01. a) The Antarctic continent, b) the South Shetland Archipelago and c) The Half Moon Island. Modified from Esponda et al., 2000.

There are three main hills, in which Gabriel Hill is the highest point in the island, reaching 101 meters above sea level. Penguin rockeries are concentrated on Baliza Point, which are visited by tourists during summer time. La Morenita Hill is located in the middle of the island, just behind the Base Camara, and reaching 93 meters of altitude. And Xenia hill is located more to the north of the island, with approximately 96 meters.

The vegetal communities study started with a survey to locate the vegetated areas and the collection and identification of plant species occurring in the area. The phytosociological survey was done using the Braun-Blanquet (1964) method adapted to the Antarctic situation (Victoria & Pereira, 2007). Over each plant formation, South-North lines were placed, distant 5 m away from each other. Along each line, from 5 to 5 meters, the covering of each vegetation species was counted by using a quadrate of 20 x 20 cm, subdivided into 100 quadrates grid. Vegetal samples were taken for subsequent identification if needed. The squares are no longer launched if not appeared no new species in the last five samples. The phytosociological data were used for calculation of the Ecological Significance Index (IES). The IES combines the parameters of abundance (coverage and frequency, represented as C and F, respectively), as follow: IES= F(1+C) (Lara & Mazimpaka, 1998; Marques et al., 2005; Victoria & Pereira, 2007).

The species not identified at the field were sampled and identified later in the laboratory at the Camara Station. The species identification were performed according to Ochyra (1998, 2008) and Putzke & Pereira (2001) and their references for mosses; and Redon (1985), Ovstedal & Smith (2001) and Olech (2004) their references for lichens, using the usual procedures for each group.

The indices of diversity and e equitability were calculated using the frequency of species in each plant community found using the formula of Shannon-Wiener (H') and equitability of Pielou then comparing them with each other.

The vegetal communities were mapped using an Ashtech Promark II† DGPS (Ashtech OEM, Sunnyvale, CA, USA), with data processed with the Astech Solutions® software. Through them, vegetation spots were circled and subsequently classified according to the IES.

The samples were dried and deposited laterly at the HBEI herbarium in the UNIPAMPA University in Southern Brazil.

RESULTS

The phytosociological analysis was performed by using data from 358 squares sampled in the field work. There were found 37 bryophyte species (35 mosses and 2 hepatics), representing 33% of the species described for Antarctica; and 59 lichen species were identified, which comprises 15% of the lichen species described for Antarctic Territory. Only one flowering plant (*Deschampsia antarctica* Desv.) and two macroscopic terrestrial algae *Prasiola crispa* (Lightfoot) Kützing and *Prasiola calophylla* (Carmichael ex Greville) Kützing were found in the island. The richest family was *Bryaceae*, followed by *Pottiaceae* for mosses and *Physciaceae* and *Teloschistaceae* for lichens. The results demonstrate that Half Moon Island has a great diversity of plant species compared to the amount of existing species around the Antarctic continent, in spite of its small size. The large number of tourists and the fact that the ice free areas are restricted to some parts of the territory, mainly in the highest plateaus, during the summer, affects the plant composition and covering.

According to phytosociological studies on vegetation plots in Half Moon Island, five plant communities were identified (Table 01) covering approximately 19,17% of the studied area. The communities were mapped (Figure 02) and were characterized according to Lindsay (1971), as presented in Table 01.

Tabela 01. Diversity analysis for the plant communities found Half Moon Island, Antartica, in the austral summer 2013/2014 and 2014/2015. Number of squares launched in each plant community (N), number of species (R), specific diversity observed (H'), equability (E) and area in hectares(A).

Community	N	R	H'	E	A (ha)
Fruticulose Lichens	36	37	1.3817	0.8811	5,08
Moss Carpet	191	48	1.3640	0.7988	4,30
Muscicolous Lichens	46	35	1.3327	0.8631	0,64
Crustose Lichens	67	40	1.4700	0.9239	8,46
Moss Turf	18	30	1.3330	0.9024	0,70

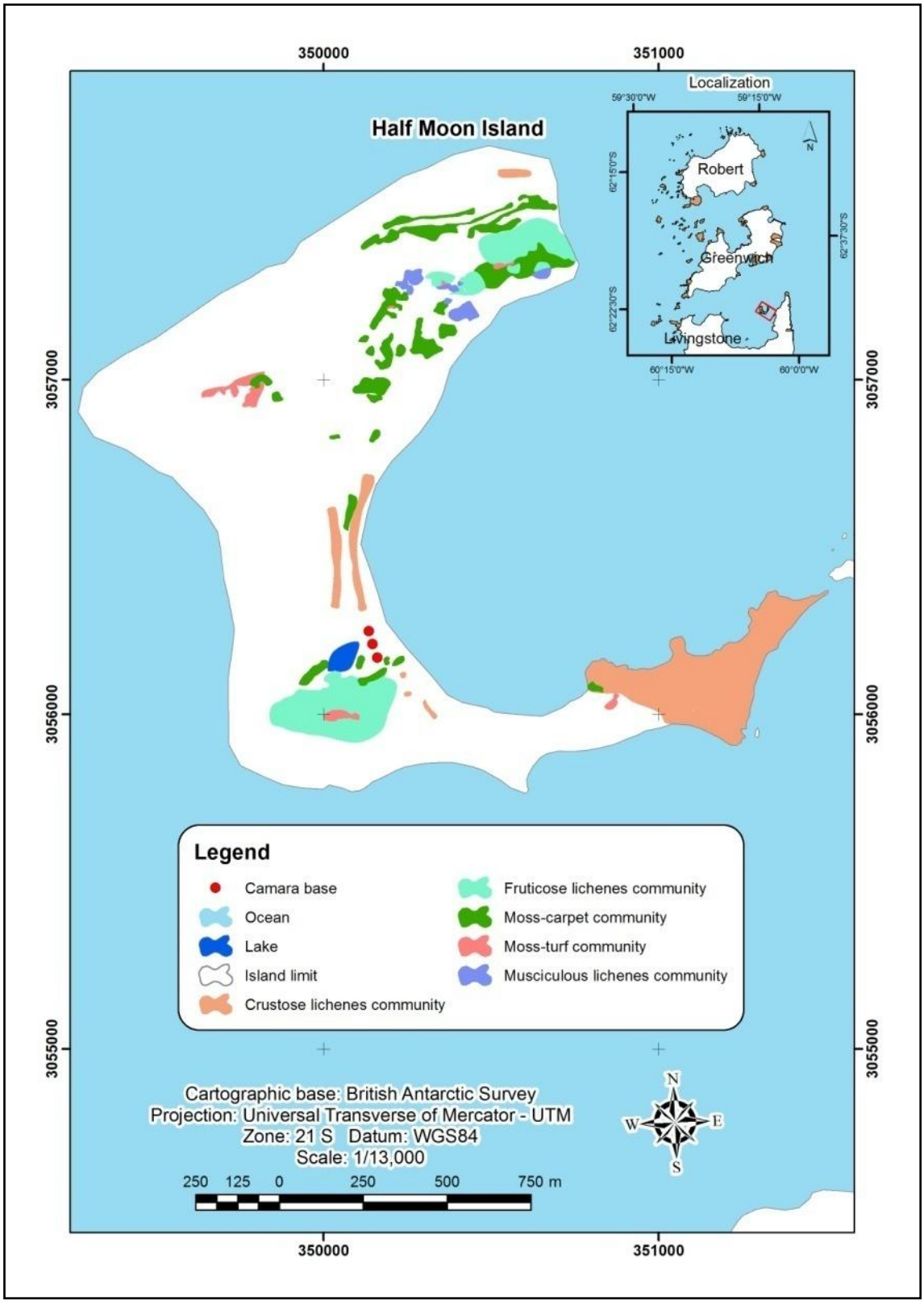

Figure 02. Distribution map of plant communities in Half Moon Island.

1. Fruticose lichens community

This community consists mainly of fruticose lichens as *Usnea aurantiaco-atra* and *Sphaerophorus globosus* (Huds.)Vain. on slopes facing the north of the island and for mosses as *Sanionia uncinata* and *Polytrichastrum alpinum* G.L. Smith in its most stable surface. This is one of the largest communities on the island. However, the difficulties to reach the location limited the number of phytosociological squares to 36, time which stopped appearing new species in the sample. Thirty-seven plant species were identified (E = 0.8811, H '= 1,3817) comprising mosses, lichens and the grass *Deschampsia antarctica* (Table 02), which appears sparsely in both hillsides La Morenita and Xenia.

Some areas are transitional between the *Andreaea* spp. and the truly fruticose lichens association, dominated by *Usnea aurantiaco-atra* among the saxicolous and *Sphaerophorus globosus*, *Cladonia borealis* S. Stenroos and *C. rangepherina* (L.) Weber ex F.H. Wigg. and *Stereocaulon glabrum* (Müll. Arg.) Vain among the muscicolous. So, the confluence of those communities generate a well-defined complex, aggregating these and other important species, mostly muscicolous lichens on *Andreaea* as *Psoroma hypnorum* (Vahl) Gray, *P. cinammomeum* Malme, *Parmelia saxatilis* (L.)Ach. and *Ochrolechia frigida* (Sw.) Lynge (the most common one).

One almost exclusive formation with fruticose lichens (saxicolous *Usnea aurantiaco-atra*) was found on a slope of high declivity which starts near the access to the beach at North of the Xenia Hill and arises up to approximately 250 m East to West. The small rock fragments are almost entirely covered by *Usnea aurantiaco-atra*, representing the major IES, reaching 425.00, followed by crustose saxicolous lichens which together reached (IES=266.43). Among the moss carpets only *Sanionia uncinata* was registered (IES =115.43), covering areas where a small amount of fine particles of soil was found. Among the cushion forming mosses of *Andrea gainii* Card. and *A. depressinervis* Card., *Himantormia lugubris* (Hue) Cordeiro IM was found sparsely, associated with other communities.

Table 02. Data of the phytosociology area with fruticose lichenes of Half Moon Island. F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES
Usnea aurantiaco-atra (Jacq.) Bory	100	3.25	425.00
Sanionia uncinata (Hedw.) Loeske	61.11	0.888	115.43
Sphaerophorus globosus (Huds.) Vain.	47.22	0.666	78.70
Ochrolechia frigida (Sw.) Lynge	44.44	0.444	64.19
Lecidea sciatrapha Hue	38.88	0.444	56.17
Polytrichastrum alpinum G.L. Smith	36.11	0.5	54.16
Verrucaria sp Schrad	33.33	0.388	46.29
Cladonia metacorallifera Asahina	33.33	0.361	45.37
Lecidea sp	30.55	0.416	43.28
Andreaea depressinervis Card.	27.77	0.527	42.43
Stereocaulon glabrum (Müll. Arg.) Vain.	22.22	0.472	32.71
Rhizoplaca aspidophora (Vain.) Redon	25	0.25	31.25
Andreaea gainii Card.	19.44	0.222	23.76
Andreaea regularis Muell.	16.66	0.222	20.37
Schistidium steerii Ochyra	13.88	0.166	16.20
Dicranoweisia grimmiaceae (Müll. Hal.) Broth	13.88	0.138	15.81
Microglaena antarctica IM Lamb	13.88	0.138	15.81
Rhizocarpon polycarpum (Hepp) Th. Pe	13.88	0.138	15.81
Psoroma cinammomeum Malme	11.11	0.166	12.96
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	11.11	0.138	12.65
Buellia latemarginata Darb.	11.11	0.111	12.34
Ceratodon purpureus (Hedw.) Brid.	11.11	0.111	12.34
Rhizocarpon geographicum (L.) DC.	11.11	0.111	12.34
Cystocoleus niger (Huds.) Har.	8.33	0.111	9.25
Polytrichum piliferum Hedw.	8.33	0.083	9.02
Caloplaca athallina Darb.	5.55	0.055	5.86
Cladonia furcata (Huds.) Schrad.	5.55	0.055	5.86
Ochrolechia parella (L.) A. Massal.	5.55	0.055	5.86
Parmelia saxatilis (L.) Ach.	5.55	0.055	5.86
Bartramia patens Brid.	2.77	0.027	2.85
Buellia russa (Hue) Darb.	2.77	0.027	2.85
Caloplaca cinericola (Hue) Darb.	2.77	0.027	2.85
Deschampsia antarctica Desv.	2.77	0.027	2.85
Cephallozia sp. (Dumort.) Dumort.	2.77	0.027	2.85
Leptogium puberulum Hue	2.77	0.027	2.85
Psoroma hypnorum (Vahl) Gray	2.77	0.027	2.85
Schistidium urnulaceum (Müll. Hal.) BG Sino	2.77	0.027	2.85

2. Moss-carpet community

Moss carpet communities are mostly composed by the specie *Sanionia uncinata* (table 03), which has the highest index of biomass in the Antarctic islands (Putzke & Pereira, 2001). This community is usually found in soft slopes or on slopes near drainage lines, forming extensive carpets both on the top of the hills and on areas adjacent to the beach level. Its occurrence is restrained to areas with a stable substrate. In this study, forty-eight species were identified, sampled in 191 squares (E = 0.7988; H '= 1.3640), being the richest community of the site.

The most extensive carpets are found in the Northern beaches, at almost sea shore level and sparsely on the top of the Xenia Hill, at the northern site of La Morenita Hill and in the elevations between them. The carpets are formed mostly by *Sanionia uncinata*, some tufts of *Brachythecium austrosalebrosum* (Müll. Hal.) Kindb., with at least 1m large and sparsely *Warnstorfia fontinaliopsis* (Müll. Hal.) Ochyra. In the Southern part of the island, among the penguin rockeries, the great rock fragments made it impossible to maintain organic matter to sustain a carpet. There is still competition specially with *Bryum argenteum*, *B. nivale* and *B. pseudotriquetrum* which are found together with the carpets of *Sanionia uncinata* or as completely isolated cushions. There are few muscicolous lichens, but ring fungi are frequent. In the areas with few guano deposits as La Morenita at South, Xenia and Gabriel Hills at North, the carpets are small and also furrowing small rocks. Sometimes, the carpets form great groups, highly parasitized by muscicolous lichens as *Ochrolechia frigida*, *Psoroma* spp., *Cladonia* spp., *Sphaerophorus globosus* and *Stereocaulon glabrum*.

Three different carpets are found at the North portion, almost at the sea level, forming a 500 m long group, accompanying two linear shallow lakes. The northmost one has only *Sanionia uncinata* in its formation, the middle one has *S. uncinata* together with some cushions of *Bryum niveum* Herzog and the southmost one has *S. uncinata* eventually associated *Cystocoleus niger* (Huds.) Har. and *Psoroma hypnorum* (Vahl) Cinza and with some small tufts of *Polytrichastrum alpinum*.

At the top of the Xenia Hill there is a carpet formed by *Sanionia uncinata* (exclusively associated with *Bryum argenteum*), small amount of muscicolous lichens and associated with a water pond. No other place has this association in the island.

Table 03. Data of the phytossociology area with moss carpet community of the Half Moon Island. F (frequency), C (converage) and IES (index of ecological significance).

Species	F	C	IES
Sanionia uncinata (Hedw.) Loeske	91.09	3.350	396.35
Polytrichastrum alpinum G.L. Smith	31.41	0.565	49.17
Usnea aurantiaco-atra (Jacq.) Bory	25.13	0.544	38.81
Lecidea sciatrapha Hue	27.74	0.335	37.04
Ochrolechia frigida (Sw.) Lynge	27.22	0.277	34.77
Verrucaria sp Schrad	22.51	0.246	28.05
Psoroma hypnorum (Vahl) Gray	14.65	0.214	17.80
Rhizocarpon polycarpum (Hepp) Th. Fr.	15.18	0.172	17.80
Sphaerophorus globosus (Huds.) Vain.	14.13	0.230	17.39
Andreaea regularis Muell.	14.13	0.146	16.20
Rhizoplaca aspidophora (Vain.) Redon	12.56	0.125	14.14
Andreaea gainii Card.	12.04	0.136	13.68
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	10.47	0.120	11.73
Cladonia metacorallifera Asahina	9.94	0.099	10.93
Rhizocarpon geographicum (L.) DC	8.37	0.083	9.07
Acarospora macrocyclos Vain.	7.85	0.078	8.47
Bryum niveum Herzog.	7.32	0.120	8.21
Stereocaulon glabrum (Müll. Arg.) Vain.	7.32	0.104	8.09
Usnea antarctica Du Rietz	6.80	0.104	7.51
Prasiola crispa (Lightfoot) Kützing	6.28	0.068	6.71
Cystocoleus niger (Huds.) Har.	6.28	0.062	6.67
Cladonia borealis S. Stenroos	5.75	0.083	6.24
Hennediella heimii (Hedw.)Zand	5.23	0.052	5.50
Andreaea depressinervis Card.	3.66	0.062	3.89
Himantormia lugubris (Hue) Cordeiro IM	3.14	0.036	3.25
Rhizoplaca melanophtalma (Ram.)Leuckert & Poelt	2.61	0.026	2.68
Polytrichum piliferum Hedw.	2.09	0.031	2.16
Buellia latemarginata Darb.	2.09	0.026	2.14
Bryum nivale Müll. Hal	1.57	0.026	1.61
Bryum pallescens Schleich. ex Schwägr.	1.57	0.015	1.59
Huea austroshetlanica	1.57	0.015	1.59
Microglaena antarctica IM Lamb	1.57	0.015	1.59
Pannaria hookeri (Borrer) Nyl.	1.57	0.015	1.59
Psoroma cinnamomeum Malme	1.57	0.015	1.59
Bartramia patens Brid.	1.04	0.010	1.05
Buellia anisomera Vain.	1.04	0.010	1.05
Pohlia cruda (Hedw.) Lindb.	1.04	0.010	1.05
Bryum pseudotriquetrum (Hedw.) Schwaegr.	0.52	0.010	0.52
Buellia racovitzae CW rodeio	0.52	0.010	0.52
Bacidia tuberculata Darb.	0.52	0.005	0.52
Brachythecium austrosalebrosum (Müll. Hal.) Kindb	0.52	0.005	0.52
Bryum dichotomum Hedw	0.52	0.005	0.52
Buellia russa (Hue) Darb.	0.52	0.005	0.52
Caloplaca athallina Darb	0.52	0.005	0.52
Ceratodon grossiretis Cardot	0.52	0.005	0.52
Haematomma eryhtromma (Nyl.) Zahlbr.	0.52	0.005	0.52
Lecanora skottsbergii Darb.	0.52	0.005	0.52

Pohlia nutans (Hedw.) Lindb.	0.52	0.005	0.52

At the southern face of the Xenia Hill, near its top, another carpet can be found, which has *S. uncinata* somewhat covered by muscicolous lichens as *Stereocaulon glabrum*, *Sphaerophorus globosus* and *Psoroma hypnorum*, *Ochrolechia frigida* and *Cladonia* spp. Some of the muscicolous lichens are associated with *Andreaea,* which is scarce on the association. This formation indicates that a muscicolous community is likely occupying the area and substituting the carpet.

At the slopes of the Xenia Hill there are other two carpets, one of which as *S. uncinata* slightly parasitized, but not justifying its characterization as muscicolous.

Another carpet is found at the way to the top of the Gabriel´s Hill, formed by *S. uncinata* with patches of *Andreaea* spp. covering the rocks. This association is noteworthy because it is difficult to identify to which it occurs exactly, but in fact there are two carpets isolated by an *Andreaea* association.

A carpet was found in the south of Camara Base, to about 20m, in which *S. uncinata* is the main component. In this area, the *S. uncinata* covering and frequency turns larger as it goes toward West. There are other components as *Andreaea* spp. and *Polytrichastrum alpinum* among mosses, but they are less representative toward West, and the same occurs with saxicolous and muscicolous lichens.

3. Muscicolous Lichens Community

This community represent the vast majority of the moss formations on the island. Thirty-five species were identified in this formation (Table 04), where a total of 46 squares were evaluated (E=0.8631, H'= 1.3327). There is a mix of many moss species, in which *S. uncinata* is the most abundant. The mosses are parasitized by lichens in different degrees of coverage, according to the environmental conditions. They are usually found in the upper part of the hills, in sites of transitional communities like carpets of mosses and fruticose lichens.

The pure *Andreaea* spp. formations are generally colonized by *Ochrolechia frigida*. The carpets are colonized by crustose, foliose and fruticulose ones. This is the case of the third plateau on the way to the Xenia's Hill summit, which is a community of mosses formed by *Polytrichastrum alpinum, Sanionia uncinata* and *Andreaea* spp. These mosses are almost completely parasitized by the lichens *Cladonia* spp., *Ochrolechia frigida*, *Psoroma hypnorum*, *Sphaerophorus globosus* and *Stereocaulon glabrum.*

Another muscicolous field is found near the edge of a cliff at the East point of the Xenia plateau, which is basically composed of *Andreaea regularis* and *Sanionia uncinata* almost entirely covered by lichens as *Ochrolechia frigida*, *Cladonia* spp. and *Psoroma hypnorum.*

Table 04. Data of the phytosociology area with Muscicolous lichens community of the Half Moon Island. F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES
Sanionia uncinata (Hedw.) Loeske	82.60	2.021	249.62
Usnea aurantiaco-atra (Jacq.) Bory	65.21	1.956	192.81
Ochrolechia frigida (Sw.) Lynge	67.39	0.760	118.66
Sphaerophorus globosus (Huds.) Vain.	54.34	0.956	106.33
Polytrichastrum alpinum G.L. Smith	54.34	0.760	95.69
Psoroma hypnorum (Vahl) Gray	50	0.782	89.13
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	47.82	0.608	76.93
Cladonia metacorallifera Asahina	32.60	0.326	43.24
Verrucaria sp Schrad	28.26	0.326	37.47
Stereocaulon glabrum (Müll. Arg.) Vain.	26.08	0.434	37.42
Andreaea regularis Muell.	23.91	0.478	35.34
Rhizocarpon polycarpum (Hepp) Th. Fr.	23.91	0.239	29.63
Andreaea depressinervis Card.	17.39	0.413	24.57
Lecidea sciatrapha Hue	19.56	0.239	24.24
Andreaea gainii Card.	19.56	0.217	23.81
Rhizoplaca aspidophora (Vain.) Redon	13.04	0.173	15.31
Cladonia borealis S. Stenroos	10.86	0.195	12.99
Usnea antarctica Du Rietz	10.86	0.195	12.99
Physconia muscigena (Ach.) Poelt	10.86	0.152	12.52
Umbilicaria antarctica Frey & IM Lamb	10.86	0.152	12.52
Microglaena antarctica IM Lamb	8.69	0.086	9.45
Prasiola crispa (Lightfoot) Kützing	8.69	0.086	9.45
Acarospora macrocyclos Vain.	6.52	0.086	7.08
Psoroma cinnamomeum Malme	6.52	0.065	6.94
Rhizoplaca melanophtalma (Ram.)Leuckert & Poelt	6.52	0.065	6.94
Pohlia cruda (Hedw.) Lindb.	4.34	0.086	4.72

Rhizocarpon geographicum (L.) DC.	4.34	0.043	4.53
Schistidium antarctici Card.) L.I. Savicz & Smirnova	2.17	0.065	2.31
Buellia latemarginata Darb.	2.17	0.043	2.26
Huea austroshetlandica (Zahlbr.) CW rodeio	2.17	0.043	2.26
Cystocoleus niger (Huds.) Har.	2.17	0.021	2.22
Hennediella heimii (Hedw.)Zand	2.17	0.021	2.22
Himantormia lugubris (Hue) Cordeiro IM	2.17	0.021	2.22
Verrucaria tessellata (CW rodeio) Øvstedal	2.17	0.021	2.22
Pohlia nutans (Hedw.) Lindb.	2.17	0.011	2.17

4. Crustose lichens community

This community is composed of crustose lichens that develop on gravel, generally low and plain areas, close to the beach level, where there is strong maritime influence (wind and salinity) and remains covered by snow for long periods. This community is also found in the southeastern end of the island, which is cited by Esponda et al. (2000) for Baliza Point. This site has a strong nitrophilous influence due to the penguin colonies, favouring the ornitocoprophilous species. Taking into account all the extension of the island, this community totalizes thirty-nine plant species (Table 05), including among them representative mosses and fruticose lichens appearing sparsely, and beginning to develop in locations that have favorable conditions. Where a total of 67 squares were disposed (E= 0.9239; H'= 1.4700).

Table 05. Data of the phytosociology area with Crustose lichens community of the Half Moon Island. F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES
Lecania brialmontii (vã). Zahlbr.	37.31	0.985	74.06
Buellia latemarginata Darb.	38.80	0.671	64.86
Sanionia uncinata (Hedw.) Loeske	22.38	0.417	31.74
Acarospora macrocyclos Vain.	20.89	0.283	26.82
Turgidosculum complicatulum (Nyl.) Kohlm. & E. Kohlm.	19.40	0.373	26.64
Haematomma eryhtromma (Nyl.) Zahlbr.	17.91	0.373	24.59
Rinodina petermannii (Hue) Darb.	16.41	0.477	24.25
Verrucaria sp Schrad	17.91	0.238	22.18
Prasiola crispa (Lightfoot) Kützing	17.91	0.194	21.38
Caloplaca regalis (Vain.) Zahlbr.	14.92	0.313	19.60
Xanthoria candelaria (L.) Th. Fr.	14.92	0.238	18.48
Candelaria murrayi Poelt	13.43	0.238	16.64
Lecidea sciatrapha Hue	13.43	0.223	16.44
Pannaria hookeri (Borrer) Nyl.	13.43	0.194	16.03
Bacidia tuberculata Darb.	11.94	0.238	14.79

Usnea aurantiacoatra (Jacq.) Bory	11.94	0.149	13.72
Rhizoplaca aspidophora (Vain.) Redon	11.94	0.119	13.36
Parmelia saxatilis (L.) Ach.	8.95	0.253	11.22
Xanthoria elegans (Link) Th. Fr.	7.46	0.149	8.57
Buellia anisomera Vain.	7.46	0.134	8.46
Ramalina terebrata Hook. f. & Taylor	7.46	0.134	8.46
Andreaea regularis Muell.	7.46	0.074	8.01
Hennediella antarctica (Angstr.) Ochyra & Matteri	7.46	0.074	8.01
Syntrichia magellanica (Mont.) RH Zander	7.46	0.074	8.01
Mastodia tessellata (Hook. f. & Harv.) Hook. f. & Harv.	5.97	0.104	6.59
Rhizocarpon geographicum (L.) DC.	5.97	0.059	6.32
Rhizocarpon polycarpum (Hepp) Th. Fr.	5.97	0.059	6.32
Polytrichastrum alpinum G.L. Smith	4.47	0.059	4.74
Psoroma cinnamomeum Malme	4.47	0.044	4.67
Usnea antarctica Du Rietz	4.47	0.044	4.67
Microglaena antarctica IM Lamb	2.98	0.044	3.11
Andreaea gainii Card.	2.98	0.029	3.07
Caloplaca cinericola (Hue) Darb.	2.98	0.029	3.07
Ochrolechia frigida (Sw.) Lynge	2.98	0.029	3.07
Umbilicaria decussata (Vill.) Zahlbr.	2.98	0.029	3.07
Physconia muscigena (Ach.) Poelt	1.49	0.014	1.51
Rhizoplaca melanophtalma (Ram.)Leuckert & Poelt	1.49	0.014	1.51
Usnea acromelana Stirt.	1.49	0.014	1.51
Verrucaria tessellata (CW rodeio) Øvstedal	1.49	0.014	1.51
Bartramia patens Brid.	0.14	0.007	0.15

The small peninsula that connects the hills at north and middle South and this to the penguin rockery at East are formed basically by rounded rocks in deposits with plateau shapes. Each different plateau has distinct level of stability. In general, they have larger firmness in the center than in sites close to the sea. Apparently, the central plateaus are only affected anthropically.

According to the altitudinal range and depressions between each other, the areas are differently affected by wind and snow deposits. The higher places are generally free from ice accumulation, while the depressions are generally covered by snow. However, the general geological structure do not allow the soil formation/retention, which allowed only a saxicolous community to establish in the peninsula, except for a small part at north and between each straight line of the two formations found. The pebble rocks are colonized by crustose lichens in general. Skuas uses the area for nesting, generating some finer particle accumulation, what allows the mosses to colonize those places, specially *Sanionia uncinata* and *Polytrichastrum alpinum*. Another identical community is found at the East side of the La Morenita Hill, at the plateau formed by the same

types of stones. *Verrucaria* spp., *Buellia* spp. and *Lecidea* spp. are the main crustose lichens in the community. *Sanionia uncinata* and *Andreaea* spp. sometimes parasitized by the lichen *Ochrolechia frigida* are the main mosses represented.

This community presents three characteristic groups on the island. One of them is restricted to the penguin rockeries at South, where the amount of guano is large. The second is found at the North and center of the island, where the guano is smaller and comes from skuas and *Cape pigeons* nesting in the areas. The third is very peculiar, since it is linked to the rounded small rocks disposed near the beach with the regression of the sea. Some animals (birds and Pinnipedia) use these places as resting or feathering points, depositing feather and feces on those rocks and generating an ornithocoprophilous community mainly composed by *Acarospora macrocyclos*. ´´

Significant ornithocoprophilous communities were found in seven areas of the island. One is located at the extreme North of the Island, a shallow cliff near the sea shore that is almost completely covered by *Nacella concina* shells in some places. The covering is mainly by foliose/fruticose lichens as *Rinodina pettermanii* and *Haematoma erythromma,* and as crustose ones, as *Buellia* spp., for example. This place was the only one in the island we have found *Usnea acromelana*.

Two giant rock fragments sometimes used by *Larus dominicanus* and Skuas area were covered by nitrophilous communities. This occurrence was found in two sites near the Camara Base, since the other *Larus* hills are situated inside the penguin colonies and, therefore, are influenced by them. The two isolated rocks are mainly covered by crustose lichens as *Acarospora macrocyclus, Bacidia* sp. and *Rhizoplaca aspidophora*. *Sanionia uncinata* is also found in one of them, but this is because the crevices are rich in guano, allowing the colonization by the moss.

5. Moss turf community

Were disposed 18 squares and 30 plant species were identified in this formation (E= 0.9024; H= 1.3330), which involves species of mosses, lichens and algae (table 06). This community is found in four sites of the island, in which three of them are located in higher altitudes, on the tops of La Morenita, Gabriel and Xenia Hill's. The other formation is at the entrance of Penguin colony (Baliza Point) located in a transition area composed of pebbles, ornitocoprophilous plants community and sparse carpets of *S.*

uncinata. There is constant presence of sea wolves in this site. The moss species with ecological significance in this community were *Pohlia* sp., *Polytrichastrum alpinum* and *S. uncinata*. Crustose lichens have also been identified in local coverage, totaling six distinct species.

Table 06. Data of the phytosociology area with Moss turf community of the Half Moon Island. F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES
Polytrichastrum alpinum G.L. Smith	72.22	2.055	220.67
Sanionia uncinata (Hedw.) Loeske	50	1.166	108.33
Polytrichum piliferum Hedw.	38.88	1.166	84.25
Ochrolechia frigida (Sw.) Lynge	50	0.666	83.33
Hennediella heimii (Hedw.)Zand.	38.88	0.888	73.45
Rhizoplaca aspidophora (Vain.) Redon	38.88	0.388	54.01
Cladonia metacorallifera Asahina	33.33	0.333	44.44
Verrucaria sp Schrad	27.77	0.277	35.49
Bryum argenteum Hedw.	22.22	0.388	30.86
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	22.22	0.333	29.62
Lecidea sciatrapha Hue	22.22	0.222	27.16
Pohlia cruda (Hedw.) Lindb.	22.22	0.222	27.16
Ceratodon purpureus (Hedw.) Brid.	22.22	0.166	25.92
Cystocoleus niger (Huds.) Har.	16.66	0.222	20.37
Andreaea regularis Muell.	16.66	0.166	19.44
Psoroma cinnamomeum Malme	16.66	0.166	19.44
Usnea aurantiacoatra (Jacq.) Bory	11.11	0.111	12.34
Andreaea depressinervis Card.	5.55	0.277	7.09
Acarospora macrocyclos Vain.	5.55	0.055	5.86
Andreaea depressinervis Card.	5.55	0.055	5.86
Bartramia patens Brid.	5.55	0.055	5.86
Buellia anisomera Vain.	5.55	0.055	5.86
Buellia latemarginata Darb.	5.55	0.055	5.86
Chorisodontium acyphyllum (Hook f. et. Wills.) Broth.	5.55	0.055	5.86
Prasiola crispa (Lightfoot) Kützing	5.55	0.055	5.86
Psoroma hypnorum (Vahl) Gray	5.55	0.055	5.86
Rhizocarpon geographicum (L.) DC.	5.55	0.055	5.86
Rhizocarpon polycarpum (Hepp) Th. Fr.	5.55	0.055	5.86
Rhizoplaca melanophtalma (Ram.)Leuckert & Poelt	5.55	0.055	5.86
Sphaerophorus globosus (Huds.) Vain.	5.55	0.055	5.86

From data obtained by phytosociological sampling over all the vegetation of the Half Moon Island, the moss *Sanionia uncinata* (Hedw.) Loeske had the greatest frequency, followed by the lichen *Usnea aurantiaco-atra* (Jacq.) Bory (Table 07).

Table 07. List of the most representative species found in the phytosociological survey at Half Moon Island.

Species	Number of quadrats[1]	F[2] (%)	IES[3]
Sanionia uncinata (Hedw.) Loeske	257	71.78	234.81
Usnea aurantiaco-atra (Jacq.) Bory	124	34.63	63.17
Polytrichastrum alpinum G.L. Smith	114	31.84	49.63
Ochrolechia frigida (Sw.) Lynge	110	30.62	40.85
Verrucaria sp. Schrad	83	23.18	29.27
Lecidea sciatrapha Hue	79	22.06	27.86
Sphaerophorus globosus (Huds.) Vain.	70	19.55	25.67

[1] Number of quadrats in which the species was recorded.
[2] Species frequency in 358 quadrats.
[3] Index of ecological significance (IES) in the total sampling.

DISCUSSION

Analyzing the diversity indices presented (table 01), we observed that the crustose lichens community is the most diverse, because of its highest index of Shannon (H') and even greater equitability (E), despite not being the richest in species, demonstrating to be a more homogeneous community in which no species stands out the other. The moss carpet community, in turn, has the highest richness of species (48), but in spite of that, does not have the greatest diversity and even the smallest equitability. This is due to the fact that the *S. uncinata* species stands out and shows the dominant community.

Study conducted in Hennequin Point (King George Island) in the austral summer of 2004/05 (Victoria et al., 2013) showed some similar communities found in Half Moon Island, but with different indices. The moss carpet community in Hennequin Point is also the richest in species, however this number is lower (28), and is the most homogeneous community. Fruticose and crustose lichens were also found, however within the same community, featuring only 28 species. The number of species for both

fruticose and crustose lichens in Hennequin is relatively lower than in Half Moon (table 01), where fruticose and crustose lichens are not found in the same community.

The fruticose Lichens community is similar to that cited by Lindsay (1971), but with the *Andreaea* moss cushion presence only in isolated spots, forming sociations similar to those described by the author. Accordingly, there is only one Association (Andreaea-Usnea) in this community and five sociations. The Sociations found in Half Moon Island in this community are *Usnea – Lecidea -Andreaea* and *Andreaea – Ochrolechia frigida*. The other three Sociations with *Himantormia lugubris* described by Lindsay to the South Shetlands were not found; despite some small patches of this species were observed, very sparsely located, they were not enough to be described as an association. The exposure to high salinity is probably hampering their growth, since the island is too small.

The formations of moss carpet community, in which *S. uncinata* appeared most often, were found near drainage lines or sites with influence of water, originated from the melting glaciers or lakes, as observed also in Admiralty Bay, King George Island (Victoria et al., 2004; Victoria et al., 2013). Spots in which several species have developed in association with *S. uncinata* were also found. Therefore, the same conditions that favour *S. uncinata* appears to promote adequate conditions for other species of both mosses and muscicolous lichens in these places.

The crustose lichen community is well represented since there are many areas completely covering rock fragments, has the greatest area of vegetation cover on the island and, in addition, is the most diverse. Most of this community is located in areas where the island birds and penguin colonies are concentrated. The direct relationship between the vegetation and the presence of nests is linked to the fact that birds provide the most nutrients for the initial development of the plants, since the emergence of plant communities is subsequent to the nest establishment (Francelino, 2006).

For Lindsay (1971), the community is composed mainly by crustose lichens, although fruticose lichens may attain appreciable cover, and they occur on rock surfaces, particularly those subjected to wind and salt spray. At this location, a high coverage of a crustose lichen *Verrucaria* can be observed, specifically associated with either fresh or salt water (Olech, 2004) and exposure to wind. The ornitocoprofilous

lichen community is restricted to the East extremity of the island, since there are penguin rockeries, and to the northeast cliffs, where *Daption capensis* is found.

Victoria et al (2013) found at Hennequin Point, King George Island, this community sociation with fruticulose lichens, describing the *Usnea aurantiaco-atra*, *Mastodia tesselata* (Hook. f. & Harv.) Hook. f. & Harv. and *Lecania brialmontii* (Vain.) Zahlbr. as the most common species. The last two, which are usually associated with colonies of birds and occur along with other ornitocoprophilous species, were not found at that location on Half Moon Island.

The formation located on the top of La Morenita Hill resembles the sociation *Polytrichastrum alpinum-Polytrichum piliferum* described by Lindsay (1971), in which these two mosses does not form extensive turves but occur in small colonies which form low piles and irregular loads. The flat top allows the development of mosses as *S. uncinata* occurring along these representatives of the *Polytrichaceaea* family. There are other mosses in the hill as *Bryum argenteum* and *Ceratodon* sp., which develop among the species referred above. Fruticose and crustose lichens are developed on the rocks nearby.

Moss-turf communities are found in a small area, due the featuring specie of that community, *Polytrichum juniperinum* Hedw. was not found in the island. Nevertheless, *Polytrichastrum alpinum* was found in lower coverage and frequency, being impossible to define this community. There are guano interference in practically all island, so ornithocoprophobous species as *Polytrichum juniperinum*, were rarely found or is absent.

The estimate of the extent of the coverage of plant communities is important to assess their temporal dynamics and to study in greater detail the ecological relationships with the different attributes of the physical environment as soil, rocks and landscape (Francelino et al., 2006). Our results indicate (table 07) that *Sanionia uncinata* has the highest IES value (234.81), followed by *Usnea aurantiaco-atra* (63.17) and *Polytrichastrum alpinum* (49.63). In Half Moon, the grass *Deschampsia antarctica* had an IES of 0.28, because its frequency was too low (0.28 %), suggesting that the establishment of this grass is closely associated with the nutrients availability in the soil, with water conditions in the area, and with the presence of animal colonies, as already evidenced in other areas of Maritime Antarctica (Nędzarek and Chwedorzewska, 2004).

In the vicinity of Arctowsky Station (Poland) in the Admiralty Bay, King George Island, Victoria et al. (2009) and Pinto et al. (2013), found that the maximum IES was observed for *Deschampsia antarctica* has the highest value (245 and 358, respectively), followed by *Sanionia uncinata* (215 and 269, respectively) and *Polytrichastrum alpinum* (153 and 81, respectively). In our study we found that the area with grass is not generally used by bird colonies, being used mostly by sparse skuas (*Catharacta mackormiki*) as nesting point. In two areas with grass in Half Moon, Esponda et al. (2000) counted only five and two skua nesting, respectively. The opposite occurs in Arctowski, as the areas colonized by *D. antarctica* have large nutrient input rate due to the penguin colonies. The low occurrence of the antarctic hair-grass is decisive for landscape changes, since the presence of the grass in plant communities generates changes in several factors in the antarctic soil. The grasses increase the carbon input in the soil, modifying exudates input and rhizosphere microbial diversity (Teixeira et al, 2013), as well as the soil genesis. The adaptative success of this plant in Antarctica is related to the efficient nitrogen acquisition from guano sources (Hill et al., 2011). In Half Moon Island, neither large colonies of birds nor well developed soils are found, in agreement with the scarcity of the grass.

Verrucaria species (except *V. racovitzae*) were found in all communities, in most of the sites studied in Half Moon, except at the top La Morenita and Xenia Hill's and on the slope and beach north side of the Xenia Hill, areas that are probably protected from the east-west winds acting on the island. The only plant community in which Verrucaria was not present is that predominating fruticose lichens, which occurs mainly on the north slope of the Xenia Hill's. According to Olech (2004), Verrucaria species are found on rocks in the spray zone above high-tide level. This indicates that the area is constantly sprayed by marine salt, especially because it is too small island, what explains the presence of these halophilous species.

Colobanthus quitensis (Kunth) Bartl. (*Caryophyllaceae*) was not found in Half Moon Island. This species, together with the grass *Deschampsia antarctica*, are the only native Angiosperm found in the Subantarctic Islands and the Maritime Antarctic, and reaching 68º 42' S in the Antarctic Peninsula (Edwards & Lewis- Smith, 1988; Putzke & Pereira, 2001; Olech, 2004; Moore, 1970; Parnikoza et al., 2007). *C. quitensis* is abundant in lower coastal regions, forming dense communities and occupying large areas associated with *D. antarctica* in all the South Shetland Islands, but this species

was found only in one of our sampled area (one square). Vera (2011) reported the occurrence of *C. quitensis* at Livingston Island (located at southeast of Half Moon Island) and proposed that its distribution there is related to the geomorphology, suggesting that in more interior and in elevated altitudes it grows only the vegetation becomes more restricted. Its dispersion is favored by skuas nesting points but can also occur by the strong winds. These environmental factors are also found in Half Moon Island: it is a small island, with different altitudinal ranges, strong winds and presence of skua nesting points. However, no *C. quitensis* was found in our survey, suggesting that the soil condition, the size of bird colonies or the maritime influence might have affected its development.

CONCLUSIONS

Five plant communities were found in Half Moon Island according to the phytosociological data obtained. These communities are heavily influenced by the guano of birds present all along the island, which probably affects the distribution of the same.

Other factors such as altitude, relief geomorphology and soil composition, island size, maritime influences, radiation can affect the distribution and growth of the species, and structuring plant communities that location.

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APENDICES

Table 01. Plant and lichen species found in Half Moon Island, South Shetlands. F is frequency and IES Index of Ecological Significance.

Family	Species	F	IES
Poaceae	*Deschampsia antarctica* Desv.	0,27	0,28
Amblystegiaceae	*Sanionia uncinata* (Hedw.) Loeske	71,78	234,81
	Orthotheciella varia (Hedw.) Ochyra	-	-
	Warnstorfia fontinaliopsis (Müll. Hal.) Ochyra	-	-
	Warnstorfia sarmentosa (Wahlenb.) Hedenäs	-	-
Andreaeaceae	*Andreaea depressinervis* Card.	7,26	8,37
	Andreaea gainii Card.	12,01	13,62
	Andreaea regularis Muell.	14,24	16,83
Bartramiaceae	*Bartramia patens* Brid.	1,39	1,41
Brachytheciaceae	*Brachythecium austrosalebrosum* (Müll. Hal.) Kindb.	-	-
	Brachythecium subpilosum (Hook. f. & Wilson) A. Jaeger	0,27	0,28
Bryaceae	*Bryum argenteum* Hedw.	3,91	4,30
	Bryum niveum Herzog.	3,91	4,12
	Bryum dichotomum Hedw.	0,27	0,28
	Bryum pallescens Schleich. ex Schwägr.	0,28	0,84
	Bryum nivale Müll. Hal.	0,83	0,84
	Bryum orbiculatifolium Card. Et Broth.	-	-
	Bryum pseudotriquetrum (Hedw.) Schwaegr.	0,27	0,28
	Pohlia cruda var. cruda (Hedw.) Lindb.	2,51	2,57
	Pohlia cruda var. *imbricata* (Hedw.) Lindb.	-	-
	Pohlia nutans (Hedw.) Lindb.	-	-
Dicranaceae	*Chorisodontium acyphyllum* (Hook f. et. Wills.) Broth.	0,27	0,28
Ditrichaceae	*Ceratodon grossiretis* Cardot	0,27	0,28
	Ceratodon purpureus (Hedw.) Brid.	2,23	2,27

Encalyptaceae	*Encalypta rhaptocarpa* Schwaegr.	-	-
Grimmiaceae	*Schistidium antarctici* Card.) L.I. Savicz & Smirnova	0,27	0,28
	Schistidium steerii Ochyra	1,39	1,42
	Schistidium urnulaceum (Müll. Hal.) BG Sino	0,27	0,28
Polytrichaceae	*Polytrichastrum alpinum* G.L. Smith	31,84	49,63
	Polytrichum piliferum Hedw.	3,91	4,23
Pottiacea	*Hennediella antarctica* (Angstr.) Ochyra & Matteri	-	-
	Hennediella heimii (Hedw.)Zand.	5,58	5,97
	Syntrichia filaris (C. Muell) Zand.	-	-
	Syntrichia magellanica (Mont.) RH Zander	1,39	1,41
	Syntrichia sp. Brid.	-	-
Seligeraceae	*Dicranoweisia grimmiacea* (Müll. Hal.) Broth	1,39	1,41
Scapaniaceae	*Scapania* sp Mig.	0,27	0,28
Cephaloziaceae	*Cephallozia sp*. (Dumort.) Dumort.	0,33	0,33
Prasiolaceae	*Prasiola crispa* (Lightfoot) Kützing	7,82	8,54
	Prasiola calophylla (Carmichael ex Greville) Kützing	-	-
Acarosporaceae	*Acarospora macrocyclos* Vain.	9,21	10,29
Bacidiaceae	*Bacidia* sp1	5,58	6,03
	Bacidia austroshetlandica	0,27	0,28
Physciaceae	*Buellia latemarginata* Darb.	2,51	2,59
	Buellia racovitzae CW rodeio	0,27	0,28
	Buellia russa (Hue) Darb.	0,55	0,56
	Buellia anisomera Vain.	2,23	2,89
	Buellia sp1	15,08	18,49
	Physconia muscigena (Ach.) Poelt	1,67	1,71
	Physcia caesia (Hoffm.) Hampe ex Fürnr.	-	-
	Rinodina petermannii (Hue) Darb.	3,07	3,34
Candelariaceae	*Candelaria murrayi* Poelt	0,83	0,85

Cladoniaceae	*Cladonia metacorallifera* Asahina	14,52	16,67
	Cladonia rangiferina (L.) Weber ex F.H. Wigg.	13,96	16,22
	Cladonia furcata (Huds.) Schrad.	0,55	0,56
	Cladonia borealis S. Stenroos	5,30	5,72
Collemataceae	*Leptogium puberulum* Hue	0,27	0,28
Haematommataceae	*Haematomma eryhtromma* (Nyl.) Zahlbr.	3,63	3,86
Lecanoraceae	*Lecanora skottsbergii* Darb.	0,27	0,28
	Rhizoplaca aspidophora (Vain.) Redon	15,08	17,35
	Rhizoplaca melanophtalma (Ram.)Leuckert & Poelt	2,79	2,87
Lecideaceae	*Lecidea sciatrapha* Hue	22,06	27,86
	Lecidea cinza	7,54	8,23
Mastodiaceae	*Mastodia tessellata* (Hook. f. & Harv.) Hook. f. & Harv.	1,11	1,13
	Turgidosculum complicatulum (Nyl.) Kohlm. & E. Kohlm.	3,63	3,88
Ochrolechiaceae	*Ochrolechia frigida* (Sw.) Lynge	30,72	40,85
	Ochrolechia parella (L.) A. Massal.	0,55	0,56
Pannariaceae	*Pannaria hookeri* (Borrer) Nyl.	3,35	3,50
	Psoroma cinnamomeum Malme	4,46	4,69
	Psoroma hypnorum (Vahl) Gray	14,80	17,86
Parmeliaceae	*Coelopogon epiphorellus* (Nyl.) Du Rietz.	-	-
	Himantormia lugubris (Hue) Cordeiro IM	1,95	1,99
	Parmelia saxatilis (L.) Ach.	2,23	2,35
	Usnea acromelana Stirt.	0,27	0,28
	Usnea antarctica Du Rietz	5,86	6,40
	Usnea aurantiacoatra (Jacq.) Bory	34,63	63,17
Ramalinaceae	*Ramalina terebrata* Hook. f. & Taylor	1,39	1,43
	Lecania brialmontii (vã). Zahlbr.	6,98	8,21
Rhizocarpaceae	*Rhizocarpon geographicum* (L.) DC.	7,54	8,11
	Rhizocarpon polycarpum (Hepp) Th. Fr.	13,68	15,78

Sphaerophoraceae	*Sphaerophorus globosus* (Huds.) Vain.	19,55	25,67
Stereocaulaceae	*Stereocaulon alpinum* Laurer.	-	-
	Stereocaulon glabrum (Müll. Arg.) Vain.	9,49	10,82
Teloschistaceae	*Caloplaca regalis* (Vain.) Zahlbr.	2,79	2,95
	Caloplaca sublobulata (Nyl.) Zahlbr.	-	-
	Caloplaca athallina Darb.	-	-
	Caloplaca millegrana (Müll. Arg.) Zahlbr.	-	-
	Caloplaca cinericola (Hue) Darb.	0,55	0,56
	Huea austroshetlandica (Zahlbr.) CW rodeio	1,11	1,13
	Xanthoria candelaria (L.) Th. Fr.	2,79	2,91
	Xanthoria elegans (Link) Th. Fr.	1,39	1,43
Thelenellaceae	*Microglaena antarctica* IM Lamb	2,51	2,57
Trapeliaceae	*Placopsis contortuplicata* Cordeiro IM	-	-
Verrucariaceae	*Verrucaria tessellata* (CW rodeio) Øvstedal	-	-
	Verrucaria sp Schrad	23,18	29,27
	Verrucaria racovitzae Vain.	-	-
Umbilicariaceae	*Umbilicaria antarctica* Frey & IM Lamb	1,39	1,42
	Umbilicaria decussata (Vill.) Zahlbr.	0,55	0,56
-	*Cystocoleus niger* (Huds.) Har.	5,30	5,61