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COMUNIDADES VEGETAIS EM ÁREAS DE DEGELO NA ANTÁRTICA MARÍTIMA: REVISÃO E ESTUDO DE CASO

Dissertação de Mestrado

São Gabriel

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CRISTIANE BARBOSA D'OLIVEIRA

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Dissertação apresentada ao programa de Pós-graduação *Strito sensu* em Ciências Biológicas da Universidade Federal do Pampa, como requisito parcial para a obtenção do Título de Mestre em Ciências Biológicas.

Orientador: Dr. Antonio Batista Pereira

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RESUMO

A vegetação terrestre no continente é restrita as áreas livres de gelo, sendo composta principalmente por musgos o liquens. As primeiras coletas de exemplares botânicos foram realizadas por exploradores, somente nas décadas de 1820 a 1830, iniciaram as expedições científicas na Antártica. James Clark Ross empreendeu a quarta circunavegação austral (1839/43) e a viagem de investigação científica mais importante do século XIX, acompanhado de J. D. Hooker, primeiro botânico a visitar a Antártica. Nessa expedição foram realizadas coletas significativas de espécies de liquens e musgos na Península Antártica e Ilha Rei George. Em 1959 durante o Ano Geofísico Internacional é criado o Tratado da Antártica, tornando a Antártica reconhecida como reserva natural. O Brasil foi admitido como membro consultivo do Tratado em 1983, com a criação do Programa Antártico Brasileiro. O grupo Comunidades Vegetais de Áreas de Degelo, coordenado pelo doutor Antonio Batista Pereira (UNIPAMPA), há 25 anos desenvolve estudos na região. O objetivo geral deste estudo consiste em reunir informações contidas na literatura sobre a flora e fitossociologia reportados para as Ilhas Elefante, Rei George, Nelson e Deception do arquipélago Shetland do Sul, bem como avaliar a sucessão das comunidades vegetais de Stinker Point, Ilha Elefante, a partir dos dados fitossociológicos obtidos no verão austral de 1991/92 e 2011/12, com o propósito de obter dados que contribuam para a avaliação do impacto ambiental nessa área por meio de indicadores como a diversidade e cobertura vegetal. O presente estudo encontra-se dividido em dois capítulos, no primeiro foi realizada uma extensa revisão bibliográfica sobre a vegetação e a fitossociologia para as Ilhas Elefante, Rei George, Nelson e Deception. Esses dados foram agrupados em tabelas, sendo realizadas comparações e análises fitossociológicas utilizando como base o Índice de Significancia Ecológica (IES) e para as comunidades vegetais encontradas em Stinker Point, Ilha Elefante, foi utilizado os índices de Shannon, índice de diversidade máxima e o índice de Pielou - Equabilidade. No segundo capítulo foi realizado um levantamento fitossociológico em Stinker Point, Ilha Elefante durante o verão austral de 2011/12 e estes dados foram correlacionados com dados obtidos no verão austral de 1991/92 relacionando as mudanças nas comunidades e nas populações vegetais no local. No primeiro capítulo, *Sanionia uncinada* (Hedw.) Loeske foi a espécie que ocorreu em todas as localidades pesquisadas e que apresentou um IES mais elevado em todas as ilhas analizadas para o arquipélago das Shetland do Sul. Foi evidenciado no segundo capítulo o aumento das áreas com comunidades vegetais bem como uma variação na estrutura dessas comunidades em comparação as espécies dominantes no estudo realizado a 20 anos no local.

Palavras-chave: Fitossociologia, dinâmica vegetal.

ABSTRACT

The Terrestrial vegetation in Antarctica is restrict in the ice-free areas,comprised the most part by moss and lichens. The first collections of botanical specimens were made by explorers, only in decades from 1820 to 1830 they start the cientific expeditions for the austral land. James Clark Ross did the fourth circumnavigation (1839/1943) and the more important scientific expeditions in the XIX century with J. D. Hooker, the first professional botanist to visit Antarctica were collected species for lichens and mosses in the Antarctic Peninsula and King George Island. The Antarctic Treaty, signed in 1959, increase the botanical initiatives in the austral region. Brazil was admitted as a consultative member of the Antarctic Treaty in 1983, the creation of the Brazilian Antarctic Program (PROANTAR). At 25 year Brazilian researches working with plant communities in the ice-free areas of Antarctic coordinated for professor phD Antonio Batista Pereira (UNIPAMPA) when developing a significative studies with ecological and taxonomical approaches for terrestrial algae, mosses, liverworts, lichens and macroscopic fungi. The aim of this study was done a review in the literature about the flora and phytosociology reported to Elephant, King George, Nelson and Deception Islands of the South Shetland archipelago, Maritime Antarctica, and to assess evaluating the succession of plant communities in Stinker Point, Elephant Island, from data obtained in phytosociological austral summer of 1991/92 and 2011/12, in order to obtain data that contribute to the environmental impact assessment in this area through indicators such as diversity and vegetation coverage. This study is divided in two parts. The first is a review about the floristic characteristics for the phytossociology data to better understand the interactions of plant species in the South Shetland Islands. Tables listing the species of Antarctic moss, liverwort and lichen found in those islands were showed in this study. For the phytossociological study we used the index to ecological significance for the species found in the studies done in those islands, and for the Stinker Point, Elephant Island, we used the Shannon index, index for the maximum diversity and the index of Pielou. In the second chapter, we done a phytossociology study in Stinker Point, Elephant Island in the austral Summer 2011/12 and this result was compared to the data for the phytossociological study done in the same place during the austral Summer 1991/92 comparing the changes for the communities and the populations. For the first chapter, *Sanionia uncinada* (Hedw.) Loeske was the specie had more IES in all the places studied. Particularly characteristic for each island as observed in this study. In the second chapter, we related the increase for the areas coverage for the plants communities and the changes in the plant species structure for these communities in the twenty years.

Keywords: Phytossociology, plants communites dinamic.

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1. INTRODUÇÃO

Descoberto em 1599, a Antártica foi o último continente conhecido pelo homem. Localizado abaixo do paralelo 60º, as terras do continente antártico foram isoladas dos outros continentes na Era Cenozóica (Ochyra, 1998). Estudos realizados a partir de sedimentos oceânicos coletados na costa oriental da Antártica e datados do inicio do Eoceno demonstram que a 52 milhões de anos a Antártica apresentava uma alta diversidade próxima a de florestas tropicais (Pross et al. 2012). A Antártica possui aproximadamente uma superfície de 13,5 milhões de km² na qual a maior parte é coberta por uma camada permanente de gelo. Ballatyne et al. (2012) relatam que a Antártica esteve livre da cobertura de gelo até cerca de 34 milhões de anos.

As primeiras expedições ao continente foram organizadas com objetivos exploratórios e de caça a focas e baleias. Atualmente, vários países utilizam o continente antártico como um local para pesquisa e preservação, tendo como um dos principais objetivos evitar que se cometam os mesmos erros passados durante as ocupações e explorações continentais (ATCPs, 1996).

O continente Antártico é um dos habitat mais inóspitos do mundo, principalmente para as plantas. Os liquens, fungos e briófitas são as formas dominantes, sendo as angiospermas muito escassas, possuindo apenas duas espécies nativas (Kappen & Schoroeter, 1997; Ochyra et al. 2008). A vegetação se desenvolve limitada as regiões costeiras durante o verão austral em virtude dessas áreas ficarem livres de gelo e neve nesse período, bem como em rochas expostas no interior do continente, representando um total de 2% da área da Antártica (Redon, 1985). A combinação de circunstâncias únicas, em escala continental, torna a Antártica um local especial para estudo de colonização (Ellis-Evans & Walton, 1990), em virtude das condições climáticas hostis da Antártica as espécies devem receber um estímulo que induz uma resposta fisiológica e estrutural nas plantas que desafiam esse ambiente (Ochyra, 1998; Putzke & Pereira, 2001).

Desde 1940 são observadas evidências do aquecimento global na Antártica Marítima, em relação às oscilações na percentagem da cobertura vegetal, em virtude de nesta região terem sido registrados uma forte carga de radiação UV-B e um aumento significativo na temperatura nas ultimas décadas (Lewis-Smith, 2001; Robinson et al. 2003) além do recuo das coberturas de gelo.

Em virtude desse aumento da temperatura, estão sendo registrados recuos de glaciares, acarretando novas áreas livres de gelo, algumas dessas áreas estão pesquisadas, principalmente sobre a colonização biológica de sucessão. O recuo das geleiras fornece novo habitat para a colonização das plantas em virtude do acúmulo de matéria orgânica nesses locais. Informações relacionadas à taxa de colonização de plantas, especialmente das espécies dominantes e seus fatores limitantes são cruciais para predizer como os ecossistemas em áreas de degelo vão reagir às mudanças climáticas no futuro (Nakatsubo et al. 2010).

O ecossistema antártico pode ser dividido em zonas latitudinais que correspondem a distintas regiões climáticas: Antártica Marítima, Sub-antártica ou Península Antártica e Antártica Continental. (Ochyra et al. 2008). Segundo Longton (1973) a Zona Antártica Marítima possui clima oceânico gelado e úmido, com temperaturas médias mensais excedendo zero grau Celsius principalmente nos meses de inverno.

A maioria dos estudos sobre vegetação Antártica são restritos a ecologia, fisiologia e história de vida de musgos e liquens (Ochyra, 1998). O padrão dentro da vegetação está aparentemente relacionado aos fatores ambientais, como disponibilidade de água, exposição ao vento e à estabilidade do substrato, porém a concentração em excesso de minerais encontrada nas colônias de pinguins é decisiva para a distribuição de espécies vegetais. O guano presente nas fezes dos animais libera compostos nitrogenados, acarretando o desenvolvimento de espécies nitrófilas, e as espécies vegetais que não toleram esse tipo de composto se desenvolvem em áreas livres de gelo que não sofrem influência de aves (Pereira & Putzke, 1994; Putzke & Pereira, 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 líquens. As briófitas que ocorrem no continente antártico estão subdivididas em dois grandes grupos taxonômicos: *Marchantiophyta* (hepáticas) e *Bryophyta* (musgos) (Putzke & Pereira, 2001). Os musgos são mais numerosos que as hepáticas, possuem maior biomassa no continente, participando de extensas formações e associações. Em estudos fitossociológicos realizado por Lewis-Smith (2001) é apontado que muitas espécies estão associadas com espécies dominantes da formação, invariavelmente refletem a dependência das espécies de musgos associadas e, se as espécies dominantes estiverem ameaçadas, suas dependentes também estarão.

Os liquens apresentam a maior biodiversidade nos ecossistemas de áreas de degelo da Antártica, tendo uma importante contribuição na composição florística dessas áreas e sua existência depende dos regimes climáticos e da estabilidade do substrato (Kappen & Schroeter, 1997). O trabalho de taxonomia de Øvstedal & Lewis Smith (2001) é um dos mais abrangentes abordando praticamente todas as espécies conhecidas para a Antártica. Estudos recentes de coexistência de algas terrestres e espécies liquenizadas de fungos, sugerem uma relação de hábito de crescimento e adaptações ecológicas para o ambiente antártico. São reportadas associações entre musgos e liquens, para as Ilhas Rei George, Nelson e Elefante (Allison & Lewis-Smith, 1973; Pereira & Putzke, 1994; Putzke et al. 1998a; Putzke et al. 1998b; Victoria et al. 2006; Victoria et al. 2009).

Victoria & Pereira (2007) constataram que, de acordo com o Índice de Significância Ecológica (IES) das espécies de musgos, é possível verificar que a maioria das espécies são frequentemente encontradas na região da Ilha Rei George, porém grande parte com baixa cobertura (IES<50). Isto pode significar que estas espécies são mais sensíveis às alterações no ambiente, pois possuem populações pequenas com menor resistência e resiliência, em virtude das inter-relações entre os organismos serem reduzidas (Schaefer et al. 2004).

O arquipélago das Shetland do Sul localiza-se na Antártica Marítima, situando-se ao Norte da Península Antártica. As ilhas Elefante, Rei George, Nelson, Robert, Greenwich, Livingston e Deception são as maiores deste arquipélago. Dessas, a Ilha Elefante encontra-se mais ao Norte, entre as coordenadas 61^{o}10'S e 55^{o}14'W, localizada a cerca de 800 km sudoeste do Cabo Horn (América do Sul) e a cerca de 265 km da extremidade norte da Península Antártica. (Putzke & Pereira, 2001).

A Ilha Elefante é montanhosa com uma área central é permanentemente coberta de gelo, sendo as áreas costeiras livres de gelo durante o verão austral. É difícil o acesso aos pesquisadores em virtude de grande parte de sua costa ser composta por rochedos íngremes, ventos e ondas frequentemente fortes. A ilha apresenta uma grande diversidade de habitat o que provavelmente contribuiu para a colonização das plantas, além da sua localização geográfica singular, entra a região sub-antártica e Antártica (Allison & Lewis-Smith, 1973).

Stinker Point é uma grande costa na Ilha Elefante, livre de gelo e neve durante o verão austral e rica em fauna e flora. Limitada a nordeste pala praia do Glaciar Sultan e ao sul pelo Glaciar Endurance, estes distam entre si aproximadamente 4,5m, já em relação a praia do Glaciar a distancia é de 0.8m (Pereira & Putzke, 1994). Estudos sobre a vegetação no local foram desenvolvidos por Allison & Lewis-Smith (1973) e Pereira & Putzke (1994). No levantamento da flora realizado em Stinker Point por Pereira & Putzke (1994), foram listadas duas espécies de plantas vasculares *Deschampsia antartica* Desv. (*Poaceae*) e *Colobanthus quitensis* (Kunth.) Bart. (*Caryophylaceae*), 38 espécies de musgos, sete espécies de hepáticas, 68 espécies de liquens, duas espécies de algas terrestres e quatro espécies de fungos macroscópicos. Putzke & Pereira (2012) apresentam a relação dos fungos muscícolas encontrados para a Ilha Elefante, sendo 32 espécies de fungos liquenizados, duas espécies formadoras de anel e cinco de fungos Basidiomycota.

O objetivo geral deste estudo consiste em reunir informações contidas na literatura sobre a flora e fitossociologia reportados para as Ilhas Elefante, Rei George, Nelson e Deception do arquipélago Shetland do Sul, bem como avaliar a sucessão das comunidades vegetais de Stinker Point, Ilha Elefante, a partir dos dados fitossociológicos obtidos no verão austral de 1991/92 e 2011/12, com o propósito de obter dados que contribuam para a avaliação do impacto ambiental nessa área por meio de indicadores como a diversidade e cobertura vegetal.

Capítulo 01: A REVIEW ON THE ANTARCTIC PLANT COMMUNITIES IN THE SOUTH SHETLAND ARCHIPELAGO

(Artigo submetido para a revista *Annual Review of Plant Biology*)

A REVIEW ON THE ANTARCTIC PLANT COMMUNITIES IN FOUR ISLANDS OF SOUTH SHETLAND ARCHIPELAGO

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ABSTRACT

The Antarctic region comprise are all the lands located below the 60° parallel surrounded by the Southern Ocean. The development of the terrestrial vegetation is limited to ice-free areas, where lichens and mosses are the dominant components. The Antarctic biome is influenced by the geographical isolation, resulting in a special climatic condition for the plants development. The interesting about to the antarctic vegetation organized the first expeditions to the continent, where navigators were collecting plant samples and carried to the experts in European museums. Several studies on vegetation in this land were conducted in order to know the species diversity and the phytossociological features. The South Shetland Archipelago are compound to sixty-two island where can be highlighted the Elephant Island, King George Island, Nelson Island, Robert Island, Greenwich Island, Livington Island and Deception Island. This paper aims gather some information about the floristic characteristics based phytossociology data to better understand the interactions of plant species at South Shetland Islands. The islands selected in this paper are Elephant Island, King George Island, Nelson Island and Deception Island. Tables listing the moss, liverwort and lichen found in those islands were showed. For the phytossociological study we done an index to ecological significance for the species found in the works in those islands.

Key works: Antarctic vegetation, phytossociology, mosses, lichens, flowering plants, index to ecological significance.

INTRODUCTION

Antarctica was discovered around 1599, being the last continent discovered by the man. The first navigator to contact the Austral Lands was Américo Vespucio, when he arrived to the south latitude 53º. In the early navigation exploratory eras and cartographic studies, the Greek geographer Ptolomy named the southern region of the map was the "Incognito Land".

The first scientific expedition to the Austral Continent was done by Edmond Halley in 1700 (PUTZKE & PEREIRA, 2001).

Also known as *Terra Australis,* the Antarctica comprises the entire lands located bellow parallel 60 º surrounded by the Southern Ocean (OCHYRA, 1998). In these lands there was the possibility of not making the same mistakes made in other continents, preserving the environment. For these reason the Antarctica is considered the "Land of Science" according the Antarctic Treated (ATCPs, 1996).

The Antarctica Continent has been isolated from other landmasses for more them 25 Mya (ELLIS-EVANS & WALTON, 1990). Originally the region was part of Gondwana, the actual geographic isolation results of the fragmentation and subsequently continental drift during the Mesozoic and early Cenozoic Era when the vegetation initiated the process of differentiation.

In February of 1819, Willian Smith, an English captain of merchant ship, discovered the South Shetland Island on behalf of Majesty King George III (PUTZKE & PEREIRA, 2001). Samples of plants and lichens were collected and a casual observations was done a document in the board diaries for the ship personal (OCHYRA et al. 2008).

The South Shetland Archipelago lie between latitude 61º to 63º S and the longitude 53º to 63ºW (LINDSAY, 1971). A group of island consisting of sixty-two islands and many rocks emerge from the sea which lies off the northern tip of the Antarctic Peninsula. This archipelago has at north limit by the Drake Passage and it is separated from the Antarctic Peninsula by the Bransfield Strait (YOUNG & KLÄY, 1971; Olech, 2004).

The fourth visit of Willian Smith to the South Shetland Island was an important mark to the botanical knowledge for the region. In this expedition was discovered the north-western coast of Antarctic Peninsula (OCHYRA, 1998). The first description for a plant species for the South Shetland Island was for Torrey (1823). The work of Skottsberg in Harmony Point in Nelson and Livingston Island during the Swedish South Polar Expedition (1901-1903) is considered the first serious botanical work in this region (LINDSAY, 1971). Some important studies about the plant communities for the archipelago are GIMINGHAN & LEWIS-SMITH (1970), LYNDSAY (1971) and LEWIS-SMITH & GIMINGHAM (1976).

Antarctic has approximately 13,5 km² for surface, which are mostly covered for permanent ice. The vegetation develops in the austral summer limited in the coastal region when the region becomes ice and snow such as in some rock outcrops inside de continent, representing approximately 2% of the total area of Antarctica (REDON, 1985). With the consequence of the seasonally ice melting process, the large areas of camp previously covered by ice become exposed in front of glaciers (OLECH, 2010).

The Antarctic continent is one of the harshest habitats in the world, especially for Antarctic plants. Lichens and bryophytes form the dominant elements in rocks and vegetation on the rocky ground (KAPPEN & SCHROETER 1997). The Antarctic ecosystem can be divided in latitudinal zones which correspond a climatic distinct region, the Maritime Antarctica, Sub-Antarctica and the Continent Antarctic. The predominance formation is cryptograms tundra, composed by mosses and lichens. The flowering plants are very scanty and it is represented by only two native species (OCHYRA et al. 2008).

The Antarctic ecosystem is very sensitive, being necessary to do a measure the biological diversity for understanding the consequences of high and low biodiversity (ARNTZ & GUTT, 1997). The difficult conditions to the exploration the Antarctic environment are specially the freezing temperatures and strong winds, for this, the first botanic knowledge came from collections made by laymen hunters and sailors, who send their collections to specialist in the natural museum of Europe.

J. Torrey is considered the first botanist when in 1823 collected and described an Antarctic species and the botanist who collected lichens, bryophytes, algae and the only grass that occurs in the continent, during an expedition conducted between 1829 and 1830 (PUTZKE & PEREIRA, 2001; PEREIRA et al. 2007). Carl Skottsberg on his travels through Antarctica Switzerland Expeditions made various botanic collections between 1901 to 1903 that served as the basis for Cardot (1908) which included results of review of collections made by other expeditions, resulting in the first complete list of mosses known to data (FUMAŃCZYK & OCHYRA, 1982).

Only 1957-1958 in the International Geophysical Year when established the international cooperation in scientific exploration of the Antarctic region, in early 1960's the study about the plant in Antarctica restarted by Steere (1961) when he published a list of the hepatics reported from mosses and hepatics in the Antarctic botanical zone (OCHYRA et al. 1986).

The lichens were first investigated in the terrestrial vegetation since the early Antarctic expeditions (CASTELO & NIMIS, 1997). The greatest diversity of bryophytes and lichens also occur in the South Shetland Island, but the lichens are the dominant life-form (ØVSTEDAL & LEWIS-SMITH, 2001).

For Øvstedal & Lewis-Smith (2001), the flora of Antarctica is composed of two species of angiosperms – *Deschampsia antarctica* Desv. (*Poaceae*) and C*olobanthus quitensis* (Kunth) Bartl. (*Caryophilaceae*). These flowering plants occur only on the Scotia Ridge and along the western coast of the Antarctica Peninsula (OCHYRA et al. 2008).

The moss flora of Antarctica consisting about 111 species and two varieties, which belong within 55 genera and 17 families. (OCHYRA et al. 2008). Øvstedal & Lewiw-Smith (2001) comprising approximately 386 lichens species. The bryophytes who occurred in the Antarctica stay subdivided in two taxonomic groups: *Marchantiophyta* (liverworts) and *Bryophyta* (mosses). Bryophytes are the most predominant element in the Antarctic flora, being the mosses more numerous than liverwort (ROBINSON, 1972; PUTZKE & PEREIRA, 2001). The mosses and liverworts need a regular supply of water, for this restrictive needs the predominance for these communities prefer the lowland coastal habitat (OCHYRA et al. 2008).

During the 1960's detailed ecological and phytossociological studies were being undertaken for the first time in the Antarctic ecosystem, thus increasing the number of moss collections being made (OCHYRA et al. 2008). The composition, abundance and distribution for the plant community in Antarctica are directly related with the changes in the climatic conditions changes and the effects to the climate warming, resulting in alterations including changes in populations (FRENOT et al. 2005; CONVEY 2006; WASLEY et al. 2006, TIN et al. 2009 and FEVERO-LONGO et al. 2011).

Lichens are the group has the highest species diversity, found the best conditions adapted in Antarctic, having an important contributions in floristic composition in these areas, and their existence dependent on ice-free regions, climate and a stable substrate (REDON, 1985; KAPPEN & SCHRORTER, 1997).

Lewis-Smith (2001) in a phytossociological study found that many species of mosses are associated with dominant species in the formation, reflecting the dependence of these species of mosses because if the dominant species in danger, the dependent will be too (VICTORIA et al. 2009). Lindsay (1971) doing a study and a classification for the vegetation for the South Shetland Archipelago.

Studies on the coexistence of terrestrial algae species and lichenized fungi were also published, such their relationship within the growth habit and ecological adaptation in the Antarctic environment. Are reported associations between mosses and lichens species, and plant formations growing in associations at King George Islands, Nelson Island and Elephant Island (e.g.: ALLISON & LEWIS-SMITH, 1973; PEREIRA & PUTZKE, 1994; PUTZKe et al. 1998a; PUTZKE et al. 1998b; VICTORIA et al. 2006; VICTORIA et al. 2009). A mapping of these plant formations is being conducted to infer about the environmental changes as well the human impact over the years under the plant composition in the Antarctic ice-free areas.

In this paper we carried out an extensive copilation of flora and phytossociology data from the Elephant, King George, Nelson and Deception Islands for the South Shteland Archipelago in the Maritime Antarctica to better understand the interactions and floristic characteristics of these islands.

MATERIALS AND METHODS

Antarctic vegetation

This paper is a bibliographic review about the vegetation in some Islands of the South Shetland Archipelago (fig. 01), the places analysed are the Elephant Island, King George Island, Nelson Island and Deception Island to know the vegetation in these places. This review becomes possible to construct a table about the species of moss, liverwort and lichens was described to these islands.

Fig. 01: The South Shetland Archipelago.

Phytossociology

For the phytossociology review we used unpublished data for the Elephant and Deception Islands by Putzke & Pereira (unpublished data) in austral summer of 1991/1992 (Elephant Island) and 1993/1994 (Deception Island). These data have processed using excel programm to know the frequency (F) and cover (C) of species in each community were evaluated, being assigned the values of coverage degree presented by Kanda (1986). Based on these values was obtained the Index of Ecological Significance (IES) for each species (LARA & MAZIMPAKA, 1998) which consists in evaluating the coverage and frequency of species by the percentage of the area that the species occupy in the sample.

For Nelson Island we used the values which are in the table showed in Putzke et al. (1998a) where applying the same methodology used for the data for Elephant and Deception Islands. The table to Admiralty Bay - King George Island is the same in Victoria & Pereira (2007) where the authors used the same methodology to show the data. In both sampling, the researches were done a methodology of square of Braun–Blanquet (1964) adapted to Antarctic conditions by Kanda (1986).

The classifications for the plants communities presented was the same used in the papers when: formation is used for the vascular or non vascular communities, subformation was used for the growing form is the denomination for species in the formation, association is the denominatation for the small groups for the constant species and sociation is the denomination for the dominant ou co-dominant species in the formation.

RESULT AND DISCUSSION

Antarctic vegetation

Several studies were conducted in Antarctica to know phytossociology and plant diversity. For the South Shetlands Island Giminghan & Lewis-Smith (1970), Lyndsay (1971) and Lewis-Smith & Gimingham (1976) have done a study for the vegetations in the archipelago. The study of Allison & Lewis-Smith (1973) was related data about historical studies in Clarence, Gibbs and Elephant Islands. Also for the Elephant Island; can be highlighted the studies made for Putzke & Pereira (unpublished data); Putzke & Pereira (1998a, 1998b) in Rip Point – Nelson Island, Ochyra (1998) in King George Island, Victoria et al. (2009) in Arctowski region – King George Island, Putzke & Pereira (unpublished data), Lewis-Smith (2005) and Martins et al. (2008) in Deception Island.

The species cited in those work were gathered in a table for mosses and liverworts (Annex A) and a table for the species of lichens (Annex B). In this study which demonstrated for the mosses, only *Bryum pseudotriquetrum* (Hedw.) P. Gaertn., B. Mey. & Scherb. and *Polytrichastrum alpinum* (Hedw.) G.L. Sm of the 107 species cited were reported in eight of nine papers analyzed for discussed in this study (Table 01). Among the lichens, three of the 115 species listed, *Ramalina terebrata* Hook.f.& Taylor, *Usnea antarctica* Du Rietz and *Xanthoria elegans* (Link) Th. Fr. were found in four of the six studies discussed in this study (Table 02.). For mosses and liverworts, the data from Bednarek–Ochyra et al. (2000) and Ochyra et al. (2008) were not listed in the tables because are the complete works about Antarctic vegetation

Table 01. Moss species occuring in the majority islands for the South Shetland Archipelago. (1) Allison & Smith (1973); (2) Putzke & Pereira (unpublished date); (3) Putzke & Pereira (1998a); (4) Ochyra (1998); (5) Victoria et al. (2009); (6) Lewis – Smith (2005).

Species	Historical Clarence Island (1)	Gibbs Island (1)	Historycal Elephant Island (1)	Elephan t Island (1)	Stinker Point - Elephant Island (2)	Rip Point - Nelson Island (3)	King George Island (4)	Arctowski region -King George Island (5)	Deception Island (6)
Bryum pseudotriquetrum (Hedw.) P. Gaertn., B. Mey. & Scherb.	X		X	X	X	X	X	X	X
Polytrichastrum alpinum (Hedw.) G.L. Sm	X		X	X	X	X	X	X	X

Table 02: Lichens species occuring in the majority islands fo the South Shetland Archipelago. (1) Allison & Smith (1973); (2) Putzke & Pereira (unpublished date); (3) Putzke & Pereira (1998b); (4) Victoria et al. (2009); (5) Martins et al. (1998).

Lichens species	Historycal Elephant Island (1)	Elephant Island (1)	Stinker Point - Elephant Island (2)	Rip Point - Nelson Island (3)	Arctowski region - King George Island (4)	Deception Island (5)
Ramalina terebrata Hook. f. & Taylor	X	X		X		X
Usnea antarctica Du Rietz	X		X		X	X
Xanthoria elegans (Link) Th. Fr.		X	X	X		X

Kanda (1986) reports to Sôya Coast, Antarctic Continent in an ice-free areas the bryophytes composed by *Bryum argenteum* Hedw., *B. pseudotriquetrum, Ceratodum purpureus* (Hedw.) Brid., *Pottia heimii (now Hennediella heimii* (Hedw.) R.H. Zander) and *Grimmia lawiana* J. H. Willis. The author classified this species such as the basis of the species composition. Those species, except *G. lawiana* is found in both Islands.

The most work for Antarctic vegetation are restricted to taxonomy study, where the studies about the biological composition, evolution and biogeography of the flora from Antarctica and sub-antarctica and the relationship of fauna and flora are more recent (RUSSEL & LEWIS-SMITH, 1993).

Phytossociology

Elephant Island

Elephant Island is the northern to the South Shetland Islands (61º14'S and 055º21'W) border to Drake Passage and Weddell Sea. It is a mountainous island with just the ice-free coastal areas in the austral summer. This island have a more severe climatic conditions compared to other Island in the South Shetland Island or in the South Orkney Island (ALLISON & LEWIS-SMITH, 1973).

Elephant Island have the more difficult access in the South Shetland Island archipelago because the hard wind, the very strong waves and the steep cliffs (PEREIRA & PUTZKE, 1994). Therefore the first intensive botanical work in this Island was done by Allison & Lewis-Smith (1973) who the aim of the work was a phytossociological survey for the plant communities in the island.

The analyzed for phytosociology data obtained by Putzke & Pereira (unpublished data) in this study, te vegetation found for Stinker Point (Annex C) with have the most important occurrence in the land was *Sanionia uncinata* (Hedw.) Loeske (table 03), presented in 128 to 187 quadrants analized in this study, following to saxicolous lichens and *Andreaea* sp. present in 111 and 77 quadrants respectively. The species with have the less IES was *Hypogymnia lugubris* (Pers.) Krog, *Ochrolechia frigida* (Sw.) Lynge, *Xanthoria elegans* (Link) Th. Fr., *Caloplaca* sp., *Cephalozia* sp., *Rhizocarpon* sp. and *Pohlia nutans* (Hedw.) Lindb all have de IES 0.5375936.

Table 03: The species have a more and less IES in the phytossociological analyses made in Elephant Island in the year 1992. F (%) = species frequency in 240 sampled quadrates; IES = species index of ecological importance in the total sampling

Species	F	C	IES
Sanionia uncinata (Hedw.) Loeske	68.449	1.765	189.241
Saxicolous lichens	59.358	1.733	162.202
Andreaea sp1.	41.176	1.096	86.318
Ceratodon purpureus (Hedw.) Brid.	1.069	0.011	1.080
*Cornicularia aculeata (*Schreb.) Ach	1.069	0.011	1.080
Himantormia lugubris (Hue) I.M. Lamb	0.534	0.011	0.540
*Hypogymnia lugubris (*Pers.) Krog	0.534	0.005	0.537
Ochrolechia frigida (Sw.) Lynge	0.534	0.005	0.537
Polytrichum sp.	1.604	0.019	1.634
Psoroma sp.	1.604	0.016	1.630
Xanthoria elegans (Link) Th. Fr.	0.535	0.005	0.537

Brachythecium austrosalebrosum (Müll. Hal.) Paris	1.069	0.016	1.086
Caloplaca sp.	0.535	0.005	0.537
Cephalozia sp.	0.535	0.005	0.537
Lecidea sp.	1.069	0.021	1.092
Placopsis contortuplicata I.M. Lamb	1.069	0.011	1.081
Rhizocarpon sp.	0.534	0.005	0.537
Bartramia patens Brid.	1.604	0.016	1.630
Hepaticae	0.534	0.011	0.540
Pohlia nutans (Hedw.) Lindb	0.534	0.005	0.537
Pohlia cruda (Hedw.) Lindb.	1.604	0.016	1.630

For Elephant Island, another studied for the vegetation were done for Allison & Lewis-Smith (1973) when describe one formation (Antarctic non-vascular cryptogram tundra formation) with seven sub-formation to Elephant Island. Fruticose lichens and moss cushion sub-formation (*Andreae – Usnea* association, Bryophyte and Lichen assemblage of rock micro-habitats and *Tortula – Grimmia antarctici* association), Crustose lichen sub-formation (*Caloplaca – Xantoria* association, *Placopsis contortuplicata* association and *Buellia – Lecanora – Lecidea* association), Moss turf sub formation (*Polytrichum palestre – Chorisodonthium aciphylum* association, *Polytrichum alpinum* association); Moss carpet sub-formation (*Brachytecium cf. antarcticum – Caliergon sarmentosum* (*Sanionia uncinata* association); Moss Hummock sub-formation (*Bryum – Sanionia uncinata* association); Algae sub-formation *(Prasiola crispa* association) and Snow algae sub-formation.

Pereira & Putzke (1994) doing the study in Stinker Point, a large coastal ice-free area, rich in fauna and flora, being a important area for study the influences on the plant succession related to the influence to the sea. They describe two formations, nine sub-formation and five associations. Antarctic cryptogam tundra formation compound Fruticouse lichen and moss-cushion sub formation, moss-turf sub-formation, moss-carpet sub-formation, moss-aquatic sub-formation, crustose lichen sub-formation ornitocoprophilous association, ornitocoprophabous association, Halophilous association), Muscicolous lichen sub-formation, Miscellany community cryptogams sub-formation, terrestrial algae sub-formation, cryophyte sub-formation (red snow algae association, green snow algae association). Antarctic phanerogamic tundra association. The data for a phytossociology study done in the austral summer 1993/94 is shown in the table 04 where report the diversity stars in the formations to Elephant Island.

Table 04: The diversity stats to the different communities in the Stinket Point, Elephant Island. H' (Shannon index), Hmax (diversity maxima) and J (Pielou index) (0-1).

Communities		H'	Hmax	J
		1.20		
Moss carpet	0		1.477	0.812
		1.00		
Cushion	5		1.204	0.834
		0.91		
Crustose lichens	9		1.146	0.801

The formations found in the phytossociology study was agreed in the formations describe in Pereira & Putzke (1994), Crustose Lichen sub-formation, Musciculous lichens sub-formation, moss-carpet sub-formation and Fruticose lichen and Moss-cushion sub-formation. The more expressive result to Shannon index was in Naufragos Beach is the

Crustose Lichen sub-formation. In this area, was sampled 17 quadrants 18 different species. And the less Shannon index was found in Rango Beach Crustose lichen sub-formation.

King George Island

The largest island in the archipelago South Shetland is the King George Island (61º51'S e 57º30'W). Ochyra (1998) was reported sixty-one species for moss flora about this island and eleven species to liverwort (OCHYRA & VAÑA, 1989).

The first mosses collected in the King George Island was for James Eights where voyage of 1829 – 1831 commanded by Benjamim Pendleton and Nathaniel B. Palmer for United States. But the first botanist who investigates the vegetation of King Georgia Island was D. C. Lindsay during de austral summer of 1965-1966 (Ochyra, 1998). Furmanczyk & Ochyra (1982) describe in detailed de vegetations units, physiognomic, floristic and ecological characteristics. The study occurred in the III (1978/1979) and IV (1979/1980) expeditions of Polish academy of Science to Arctowski Station.

Ochyra & Vaña (1989) report eleven species of hepatics collected in King George Island and a detailed description of the habitat and distribution maps for each species in the Admiralty Bay. Ochyra (1998) reported that during the austral summer of 1979-1980 he collected 44 species (this 35 were new records for the locality) of moss on King George and Deception Islands.

Pereira et al. (1990) have done a preliminary studies about flora, birds and mammalian of Turret Point, King George Island. Victoria et al. (2009) showed a phytossociology study in the austral summer 2002/2003 and 2003/2004 in the ice-free areas adjoin the Polish Station Henrik Arctowski in the Admiralty Bay, at the King George Island, about the composition and distribution of moss formation. These authors found 30 species of bryophytes (28 mosses and 2 hepatics), 2 angiosperms, 1 algae and 7 species of lichenized fungi.

In the austral summer (2002/03 and 2004/05) Victoria & Pereira (2007) realising the phytossociological study used the index of significance value were analysed based on values of frequency (F) and the coverage (C) for the index [IES=F(1+C)] (Lara & Mazimpaka, 1998), when use de relative frequency and average for the vegetal communities in Antarctica (Table 05). In this study, the authors present the conservation status of moss species in Admiralty Bay and in the results found by Victoria et al. (2009) the phytossociological study had done in Arctowisky region, the specie *Sanionia uncinata* and *Polytrichastrum alpinum* have the same IEI in both regions (215,20 and 153,54).

Table 05. Table of the Victoria & Pereira (2007) of IES about moss flora in admiralty Bay, King George Island. *In:* Victoria & Pereira (2007)

Species	F (%)	C	IES
Sanionia uncinata (Hedw.) Loeske	57,87	2,7	215,20
Polytrichastrum alpinum (Hedw.) G.L. Sm	31,86	3,8	153,54
Bryum pseudotriquetrum (Hedw.) P. Gaertn., B. Mey. & Scherb.	27,9	0,9	53,3
Andreaea gainii Cardot	14,96	0,6	24,54
Polytrichum juniperinum Hedw.	11,36	2,02	34,3
*Syntrichia princeps (*De Not.) Mitt.	7,69	1,98	22,96
Pohlia cruda (Hedw.) Lindb.	2,28	0,15	2,03
Bartramia patens Brid.	1,71	0,6	2,03
Bryum pallescens Schleich. ex Schwägr.	1,47	0,38	2,03
Schistidium antarctici (Cardot) L.I. Savicz & Smirnova	1,33	0,36	1,87
Bryum orbiculatifolium Cardot & Broth.	0,95	0,74	1,66

Brachythecium austrosalebrosum (Müll. Hal.) Paris	0,38	3,36	1,66
*Chorisodontium aciphyllum (*Hook. f. & Wilson) Broth.	0,38	3,68	1,78
Dicranoweisia brevipes (Müll. Hal.) Cardo	0,38	3,68	1,78
Andreaea depressinerves Card.	0,19	3,31	0,83
Bryum ambliodon Müll. Hal.	0,19	3,31	0,83
Ditrichum hyalinum (Mitt.) Kuntze	0,19	3,31	0,83
Pohlia drummondii (Müll. Hal.) A.L. Andrews	0,20	3,32	0,84
Schistidium falcatum (Hook. f. & Wilson) B. Bremer	0,21	3,33	0,85

Nelson Island

Nelson Island (62º14'59''S and 059º03'00''W) is located in South Shetland Islands near the northern of the Antarctic Peninsula. Rip Point receives direct influence from the sea, and is isolated to King George Island to Fildes Strait (PUTZKE et al. 1998a).

The first study for the flora in Nelson Island was done in Harmony Point for Skottsberg when he visited together Livingston Island the Swedish South Polar Expedition in 1901-1903 (LINDSAY, 1971). In 1998, Putzke et al. studical the lichens at Rip Point, Nelson Island (Putzke et al. 1998b.) and moss communities (PUTZKE et al. 1998a.). In the paper with moss communities, the authors studied 58 sites during the austral summer in the 1980-1990 and 1994-1995, were indentified 33 mosses species organized in 25 different communities grouping in 5 different associations: *Sanionia uncinata* association, *Sanionia uncinata – Calliergon sarmentosum* association, *Calliergon sarmentosum – Sanionia uncinata* sociation, *Sanionia uncinata- Bryum* spp. Sociation and Other sociation is in addition to sociations describe another 20 sociations recognized to Rip Point.

In the lichen phytossociology study (PUTZKE et al 1998b) was identified 69 species of Rip Point, Nelson Island during two expeditions (austral summer 1990 – 1991 and 1994 – 1995), which 2.022 quadrates of 20X20 cm² were made using the methodology of Braun-Blanquet (1964), resulting in a paper with identification keys to the species of lichens occurring on site as well as discussion about them. They discussed de biotic and abiotic influence in those species and the influence of these factors for their distribution.

Using the data in the Putzke et al. (1998a) possibility estimated de index of significance value for the moss communities in Rip Point, Nelson Island (Table 06).

Table 06. IES to Nelson Island. The Data from Putzke & Pereira 1998a

Species	F	C	IES
Sanionia uncinata (Hedw.) Loeske	93.1	2.58	333
Lichens	63.6	1.22	141
Sarmentypnum sarmentosum (Wahlenb.) Tuom. & T.J. Kop.	44.8	1.05	91.7
Bryum sp.	44.8	0.38	61.7
Other algae	25.9	0.21	31.3
Polytrichastrum alpinum (Hedw.) G.L. Sm	17	0.22	20.8
Bartramia patens Brid.	15.5	0.1	17.1
Andreaea sp.	13.8	0.16	16
Pohlia cruda (Hedw.) Lindb.	14.2	0.09	15.5

Syntrichia saxicola (Cardot) R.H. Zander	13.8	0.11	15.3
Hypnum revolutum (Mitt.) Lindb.	10.3	0.22	12.6
Calliergidium austrostramineum (Müll. Hal.) E.B. Bartram	10.3	0.16	12
Prasiola crispa (Lightfoot) Kützing	10.3	0.1	11.4
Schistidium sp.	8.62	0.08	9.31
*Bryum pseudotriquetrum (*Hedw.) P. Gaertn., B. Mey. & Scherb.	6.9	0.14	7.85
Syntrichia sp.	6.9	0.09	7.51
Syntrichia princeps (De Not.) Mitt.	5.17	0.16	6.01
Bryum orbiculatifolium Cardot & Broth.	5.17	0.1	5.67
Pottia sp.	5.17	0.06	5.46
Polytrichum piliferum Hedw.	3.45	0.13	3.89
Deschampsia antarctica E. Desv	3.45	0.03	3.55
Dicranoweisia sp.	1.72	0.01	1.75
*Distichium capillaceum (*Hedw.) Bruch & Schimp.	1.72	0.02	1.75
Brachythecium austrosalebrosum (Müll. Hal.) Paris	1.72	0.01	1.74
Ceratodon sp.	1.72	0.01	1.74
Polytrichum sp.	1.72	0.01	1.74

Deception Island

Deception Island (62º57'S and 060º38'W) is in south-west South Shetland Island, locate in Bransfield Strait to 100 Km north of the Antarctic Peninsula (LEWIS-SMITH, 2005).

In Deception Island are a volcanically and geothermal active (YOUNG & KLÄY, 1971; LEWIS-SMITH, 1984) when the least eruptions of 1967-1969. The island has distinct formations, rock formations and fine sediments not consolidated (MARTINS, et al. 1998). There is great interest in knowing the dynamics of the local vegetation in this island because the activity volcanism, and the located a favourable geographic place to the immigration of plant propagule and establishment of vegetations, as well as identifying the Antarctic Special Managed Areas (ASMA) at the site, because of the great human pressure in the island (LEWIS-SMITH, 1988; 2005).

Deception Island is one of the islands more intensively studied in the Antarctic (YOUNG & KLÄY, 1971). In December of 1967 was a volcanic eruption in the Island (Clapperton, 1969) affecting the local flora. Young & Kläy (1971) report who Kläy found the live vegetation in the place after nine mouths the eruption, after this the authors return the same location and collected a vegetal species. Lewis-Smith (1984) studied the local vegetation to understand the process of colorization and cryptogams recovery in Deception Island after last three volcanic eruptions.

Lewis-Smith (1988) had done a botanical survey for the Island. Martins et al. (1998) conducted a study on lichens that grow on the material introduced by human actions in the ruins Old Whalers plant (Whalers Bay), Cove Peninsula, at the ruins of Telephone Bay and in the surroundings of the Argentine Base. Lewis-Smith (2005) doing a study to appoint the ASPA to Deception Island based on thermopile bryoflora.

In the Austral Summer 1994 Putzke & Pereira (unpublished data) made a phytossociological study in Deception Island (Table 07) used the methodology to Braun-Blanquet (1964).

Table 07. The species found in Deception Island in the phytossociological analyses made in the year 1994. F(%) = species frequency in 284 sampled square; IES = species index of significance value in the total sampling

species	F	C	IES
*Sanionia uncinata (*Hedw.) Loeske	71.83	1.838	203.9
Polytrichastrum alpinum (Hedw.) G.L. Sm	35.92	1.176	78.15
Bryum sp.	38.38	0.715	65.81
Calliergidium austrostramineum (Müll. Hal.) E.B. Bartram	25.35	0.616	40.97
Líquen muscicolas	20.42	0.546	31.57
Pohlia sp.	9.859	0.19	11.73
Syntrichia sp.01	10.21	0.127	11.51
Psoroma sp.	8.451	0.106	9.343
Bartramia patens Brid.	8.099	0.113	9.011
Schistidium sp.	7.394	0.085	8.019
Hennediella heimii (Hedw.) R.H. Zander	5.986	0.085	6.492
Polytruchum sp.	3.169	0.06	3.359
Sp.1	2.817	0.067	3.005
Lecanora sp.	1.761	0.018	1.792
Lecidea sciatropha Hue	1.056	0.032	1.09
Sp.2	1.056	0.018	1.075
Placopsis contortuplicata I.M. Lamb	0.704	0.014	0.714
Leptogium puberulum Hue	0.704	0.011	0.712
Biatora sp.	0.704	0.007	0.709
Syntrichia sp.02	0.352	0.007	0.355
Rinodina sp.	0.352	0.007	0.355
Syntrichia sp.	0.352	0.004	0.353
Parmelia saxatilis (L.) Ach.	0.352	0.004	0.353
Placopsis contortuplicata I.M. Lamb (fértil)	0.352	0.004	0.353
Carbonea sp.	0.352	0.004	0.353
Placopsis contortuplicata I.M. Lamb	0.352	0.004	0.353

In this study, *S. uncinata* is the specie presented de major index of significance value (IES=203,9), *Bryum sp.* and *P. alpinum* with a IES more 50, which shows that a significant taxa in place.

CONCLUSION

In this study *S. uncinata* was the moss carpet sub-formation, having the occurrence in the Elephant Island, King George Island and Deception Island. This specie has more adaptation in the environmental conditions, and appears when the vegetation formed, growing on another species and sometimes change de physiognomy of the vegetal communities in the formation.

It is very important realize more studies about the process to the plant colonization in the ice-free areas for the comprehension and the knowledge the status of conservations of the Antarctic species and the continue monitoring of plant communities in order to know the Antarctic vegetation dynamic and enable to understand comprehension what affecting these communities.

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Capítulo 2. PHYTOSSOCIOLOGICAL DYNAMICS IN 20 YEARS IN ICE-FREE AREA OF STINKER POINT, ELEPHANT ISLAND, MARITME ANTARCTICA.

(Artigo a ser submetido para a *Polar Biology*)

PHYTOSSOCIOLOGICAL DYNAMICS IN 20 YEARS IN ICE-FREE AREA OF STINKER POINT, ELEPHANT ISLAND, MARITME ANTARCTICA.

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ABSTRACT

The Antarctic vegetation is greatly affected by geographical isolation and changes in the climate in local and global scale. The present study aims to infer on biodiversity, and changes in the distribution of plants populations and dynamics of occupation of new melting areas. Data were compared with a previous study, using the same sampling methodologies conducted at a same site 20 years ago, enabling correlations about the changes and dynamics of these populations in the Antarctic environment. There were used the Braun-Blaquet's quadrats methodology in the same areas sampled in 1992 and in new ice-free locations during the austral summer of 2011/12. The richness and diversity indices were used to compare the plant community and the Ecological Significance Index that assigns with species found. There were found six plant communities and 13 associations for Stinker Point, being five associations found in new ice-free areas. For the seven formations found in 1992 only one remained with the same community structure, the others have clearly undergone significant changes, some attributed to animals, as the deactiveted or implemented birds colonies found, and other changes involving only the process of plant succession. It was also observed the predominance of *Hennediella heimii* (Hedw.) R.H. Zander in new melting areas near to the Endurance Glacier, along with *Pohlia nutans* (Hedw.) Lindb, observations in other Antarctic areas indicated the presence of the *Pohlia* ssp. as a colonizer in new ice-free areas close to glaciers.

Key-words: Antarctic ecossystem, plant communities, comparative phytossociology, plant sucession.

INTRODUTION

The Antarctic ecosystem has the most extreme weather conditions in the world and makes the polar region particularly sensitive to the global climate change (TURNER, 2005). Some life forms adapted to the region and some Antarctic species are important elements to observe the reactions related to the global change and climate change adaptation. This characterists is the focus of recent studies on global changes and the consequences of these changes in the Antarctic environment (ALBUQUERQUE et al.; 2012), since the heating promotes the growth of plant species (CONVEY et al. 2009).

The ice-free areas of Antarctica are scarce, and the plant communities are on restricted growth conditions, such as low temperatures, reduced photoperiod during winter and low water availability. Evidences on the distribution of polar species of bryophytes and lichens are correlated with the type of vegetation and environment. Moreover, the distribution is influenced by complex combinations of weather conditions and other variables that make them difficult to elucidate (LONGTON, 1988). Biological diversity must be measured for identify these factors and how that regulate the composition of plant communities to better understanding the effects of high or low diversity for different ecosystems (ARNTZ et al. 1997).

The Elephant Island is located from north of the South Shetland archipelago. It is a mountainous island and totally covered with ice in its central area, where the ice-free areas are coastal. Stinker Point (61 ° 14'S 055 ° 21'W and) is the largest ice-free área of island, bounded on the northeast shore of Sultan Glacier and by Glacier Endurance on the south. The locality has a particular climate distinct from other regions because the Drake Sea and Weddell Sea proximity, which makes the location a region with strong winds and very unstable weather conditions, making the site an area of dificult access. Stinker Point hosts an abundant fauna that remain in the area during the austral summer using the site for breeding and feeding (PEREIRA & PUTZKE, 1994).

The first study conducted with plant communities on Elephant Island was made by Allison & Lewis-Smith (1973) during the austral summer of 1979/71. The authors conducted a phytossociological investigation obtaining data on land plant communities to the region. Putzke & Pereira (1994) described the floristic composition for ice-free areas of Stinker Point during the austral summer of 1991/92, from the phytosociological data of plant communities obtained in this expedition (D'OLIVEIRA et al. in review).

The present study aims to investigate the biodiversity, distribution and occupancy dynamics of plant populations that occur in the ice-free areas of Stinker Point and Elephant Island, to present correlations of data obtained during the austral summer of 2011/12 with the expedition made in 1991/92 to observe the changes and dynamics of these communities and of the plant diversity found in Antarctic environment.

METHODS

The sample of plant communities in Stinker Point were made during the austral summer of 2011/12. For the study was used phytosociology quadrat method of Braun-Blanquet (1964) adapted for the Antarctic conditions (KANDA, 1986; VICTORIA & PEREIRA, 2007) that consists of a quadrates 20x20 cm subdivided into one hundred 2x2 cm. This quadrate was laid out along the plant patches every 10 m resulting in 376 quadrates sampling amounting a 3.760m to ice-free area sampling, guided from transects that covered the entire plant stain, always observing the direction of the land and the presence of animals on site or nearby. In the samples were evaluated the frequency and coverage of plant species.

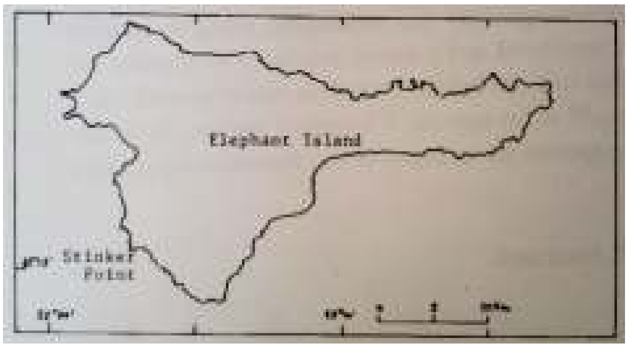

Figure 01. Elephant Island

The species were identified *in locus* and, when necessary, samples were collected and sent to laboratory for analysis of morphological characters using specialized bibliography to identify the species. For mosses identification were used Ochyra (1998), Putzke & Pereira (2001), Ochyra et al. (2008), for liverwort Bednarek-Ochyra et al. (2000) and the identification of lichens were based in Redon (1985) and Øvstedal-Lewis & Smith (2001). The species collected were dehydrated and stored in the Herbarium Bruno Irgan (UNIPAMPA-São Gabriel).

The frequency (F) and cover (C) of species in each community were evaluated, being assigned the values of coverage degree presented by Kanda (1986). Based on these values was obtained the Index of Ecological Significance (IES) for each species (LARA & MAZIMPAKA, 1998) which consists in evaluating the coverage and frequency of species by the percentage of the area that the species occupy in the sample.

Each community was named based on species with higher IES following the classification proposed by Longton (1988) adapted by Pereira *et al* (*in review*). The classifications of the presented plant communities formation for vascular or non vascular communities and association for the dominant or co-dominant species in the formation, the domination for the associations was established by the specie with highest IES. These communities that presented the same growing type were grouped to obtain the diversity status of each using the Shannon-Weiner (H '), the maximum diversity (Hmax) and Pielou's evenness index (J) that weighs the richness of species by the relative abundance in the area.

RESULTS AND DISCUSSION

Stinker Point is a site that hosts a fauna of birds and large marine mammals that remain there during the austral summer to breeding (i.e. birds), resting and feeding. Some plant formations are closely related to those animals, but there are some species that do not tolerate the areas used by the animals. These are known as ornithocoprophobous species. These are located in places such the animals do not usually land, mainly inner in the island or near glaciers.

During the expedition were sampled 13 plant communities, in a total of 376 square lauched for the region. Of these, seven formations were sampled for the site during the austral summer of 1991/1992 (D'OLIVEIRA et al. in review) using the same methodology, which enabled the comparative analysis from twenty years after, possibiliting observe the ecological dynamics of vegetation in these formations. The other six sampled areas are ice-free areas under less of 20 years of exposure.

The results of diversity stats for each community found in the present study are presented in the Table 1.

Table 1: Diversity analysis for the plant communities found in Stinker Point, Elephant Island, Antartica in the austral summer 2011/2012. H' (Shannon-Weiner diversity index), Hmax (Maximum diversity) e J (Pielou - eveness Index)

Community	H'	Hmax	J
Moss carpet	1.3445	1.6232	0.8283
Crustose lichenes	1.3438	1.5798	0.8506
Moss turf	1.3070	1.4770	0.8850
Fellfields	1.2286	1.5441	0.7957
Moss hummock	1.2007	1.3979	0.8589

Compared with the diversity analysis presented in D'Oliveira et al. (in review), the cushion community site disappeared. The Moss carpets that had shown an H' of 1200 were found with higher value (1.3445), indicating an increase of diversity in this formation. The same was observed in the crustose lichens community, where in 1992 showed an H 'of 0.919 and twenty years later the diversity in the community increased to 1.3438.

<u>Moss carpet communities</u>

The moss carpet community showed the greater diversity index, the name encompasses three plant formations sampled for the local (Formations 01, 02 and 03) such in the Fomation 01 there is a large presence of birds on site as well as impact anthropic because it's located near the Brazilian Refuge Emilio Goeldi. The Formation 02 was much smaller and the Formation 03 is located in a place where there is the presence of animals, which did not allow a direct inference about the presence or absence of animals or if it causes some kind of influence in these communities.

Sanionia uncinata – Usnea antarctica – Chorisodontium aciphyllum association

This association are located close of the Brazilian Refuge Emilio Goeldi, in a place that is under human action, mainly from the researchers that remain in place during the austral Summer. A large number of sea birds also contributes for the lanscape characteristics, due to the presence of a large Petrel's and Skua's rookeries in the vicinities, such being a place where them often build their nests, being characterized as a ornithocoprophilous community.

In this formation *S. uncinata* presents a lower IES for the moss carpet formations (Table 2). The association of this species with *U. antarctica* has been reported in the Arctowski Station on King George Island where *S. uncinata* also occurred in a less frequence in this community type (Victoria et al. 2009). One factor may be that *U. antarctica* is both saxicolous and muscicolous líquen of *S. uncinata* (REDON, 1985).

Table 2: Formation 01 –*Moss carpet* community –*Sanionia uncinata – Usnea antarctica – Chorisodontium aciphyllum* association. F (frequence), C (cover) e IES (Índex of Ecological Significance).

Species	F	C	IES
*Sanionia uncinata (*Hedw.) Loeske	75.000	2.275	245.625
Usnea antarctica Du Rietz	80.000	1.325	186.000
*Chorisodontium aciphyllum (*Hook. f. & Wilson) Broth.	72.500	1.475	179.438
Psoroma hypnorum (Vahl) Gray	67.500	1.075	140.063
Polytrichastrum alpinum (Hedw.) G.L. Sm	70.000	0.625	113.750
Cladonia metacorallifera Asahina	52.500	0.650	86.625

Sphaerophorus globosus (Huds.) Vain.	45.000	0.750	78.750
Ochrolechia frigida (Sw.) Lynge	47.500	0.625	77.188
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	35.000	0.350	47.250
Cystocoleus niger (Huds.) Har.	25.000	0.375	34.375
Cornicularia aculeata (Schreb.) Ach	22.500	0.238	27.844
Usnea aurantiacoatra (Jacq.) Bory	17.500	0.250	21.875
Rhizocarpon griseolum (Hue) Darb.	12.500	0.225	15.313
Andreaea depressinervis Cardot	10.000	0.125	11.250
Rhizoplaca aspidophora (Vain.) Redón	10.000	0.100	11.000
Buellia anisomera Vain.	10.000	0.100	11.000
Andreaea gainii Cardot	7.500	0.075	8.063
Lecidea sp.	7.500	0.063	7.969
Haematomma erythromma (Nyl.) Zahlbr.	5.000	0.050	5.250
Acarospora macrocyclos Vain	5.000	0.050	5.250
Pohlia wahlenbergii (F. Weber & D. Mohr) A.L. Andrews	2.500	0.075	2.688
Hennediella heimii (Hedw.) R.H. Zander	2.500	0.050	2.625
Prasiola crispa	2.500	0.025	2.563
Psoroma cinnamomeum Malme	2.500	0.025	2.563
Verrucaria sp.	2.500	0.025	2.563
*Sanionia georgico-uncinata (*Müll. Hal.) Ochyra & Hedenäs	2.500	0.025	2.563
Pannaria hookeri (Borrer) Nyl.	2.500	0.025	2.563
Cephaloziella varians (Gottsche) Stephani	2.500	0.025	2.563

The phytosociological study conducted in 1992 (D'OLIVEIRA et al. in review) reported that this area's being recently used as brazilian refugee substituted by a Petrel rookery. In that study, this community was characterized as a Cushion community on which the specie was *Andreaea* sp. (Figure 1). One hipothesis for the change in the physiognomy of this community, besides the natural process of species succession, is the fact that *Andreaea* is a ornitocoprofobous genus and abundant in acid soil (LONGTON, 1988).

The human presence, that uses the drainage line available in the place to water supply and organic wastes discharge, and the recent installation of Petrel's nests in that place can change the soil pH levels, possibiliting the development of species that were uncommon in the area in 1992 and the disappearance of the others species throughout those years. Due to a possible variation of pH levels with the presence of refuge and increased circulation of researchers and birds. *S. uncinata* is a species that fits in with local presence of birds and human action, and it's a moss with the very rapid development, which quickly changes the physiognomy of the plant community where it establishes.

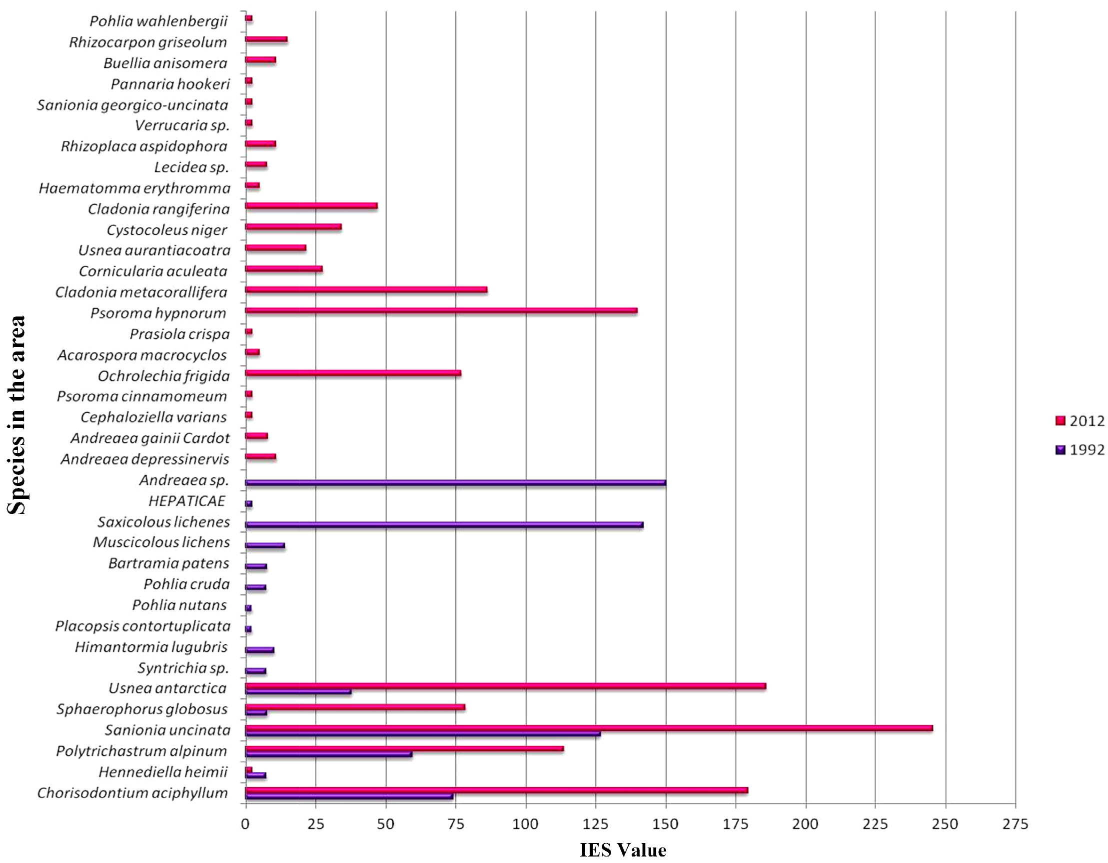

Figure 1: 1992/2012 Comparative phytossociology for formation 01 (Source D'Oliveira et al. in review).

Sanionia uncinata – Polytrichastrum alpinum Association

This association is located on the plateau of Naufrágos Beach close to a Petrel rookerie and to several Skua's nests. The site does not have a melting line, only a few drainage branches close to the site where the plants are established. In that site there is an evidence of an old Petrel rookery abandoned.

For this association, *S. uncinata* showed the highest IES value of all moss carpet communities found in Stinker Point (Table 3), and *P. alpinum* was found as the second most important moss specie in that formation. Vitoria et al. (2009) found for Arcktowski region, on King George Island, the same association, related to the presence of Skua's nests. However in Stinker Point, the species variation in that formation was higher than for Arctowski.

Table 3: Formation 02 – *Moss carpet* community –*Sanionia uncinata – Polytrichastrum alpinum* Association. F (frequence), C (cover) and IES (Index of Ecological Significance).

Species	F	C	IES
*Sanionia uncinata (*Hedw.) Loeske	85.714	2.619	310.204
Polytrichastrum alpinum (Hedw.) G.L. Sm	47.619	1.143	102.041
Deschampsia antarctica E. Desv.	42.857	0.905	81.633
Prasiola crispa	28.571	0.500	42.857

Hennediella heimii (Hedw.) R.H. Zander	28.571	0.429	40.816
Buellia russa (Hue) Darb.	28.571	0.381	39.456
Sphaerophorus globosus (Huds.) Vain.	28.571	0.357	38.776
Psoroma cinnamomeum Malme	23.810	0.333	31.746
Acarospora macrocyclos Vain	23.810	0.238	29.478
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	23.810	0.238	29.478
Rhizoplaca aspidophora (Vain.) Redón	23.810	0.214	28.912
Usnea antarctica Du Rietz	19.048	0.167	22.222
Lecidea sp.	14.286	0.190	17.007
Cystocoleus niger (Huds.) Har.	14.286	0.143	16.327
Andreaea depressinervis Cardot	14.286	0.143	16.327
Cladonia metacorallifera Asahina	14.286	0.143	16.327
Ochrolechia frigida (Sw.) Lynge	14.286	0.119	15.986
Verrucaria sp.	9.524	0.095	10.431
Ceratodon purpureus (Hedw.) Brid.	4.762	0.095	5.215
Brachythecium austrosalebrosum (Müll. Hal.) Paris	4.762	0.095	5.215
Lecania brialmontii (Vain.) Zahlbr.	4.762	0.048	4.989
Microglaena antarctica I.M. Lamb	4.762	0.048	4.989
*Syntrichia filaris (*Müll. Hal.) R.H. Zander	4.762	0.048	4.989
*Chorisodontium aciphyllum (*Hook. f. & Wilson) Broth.	4.762	0.048	4.989
Haematomma erythromma (Nyl.) Zahlbr.	4.762	0.048	4.989
Parmelia saxatilis (L.) Ach.	4.762	0.048	4.989
Xanthoria candelaria (L.) Th. Fr.	4.762	0.024	4.875

In the study conducted in 1992 (D'Oliveira et al. in review) this locality was characterized by the large presence of crustose lichens (Figure 2), however *S. uncinata* was the most dominant species on that site, and kept the same status after twenty years past. There weren't changes detected in the cover area for this community, being that the samples increased only by two quadrates more in 2011/2012 than the number of quadrates used in 1991/1992 to sample all community. It is interesting to note the rise of muscicolous lichen species in the community, suggesting that it may be entering in a succession process, because these lichens predate the moss species not allowing the community starts the process of succession after this change in community structure.

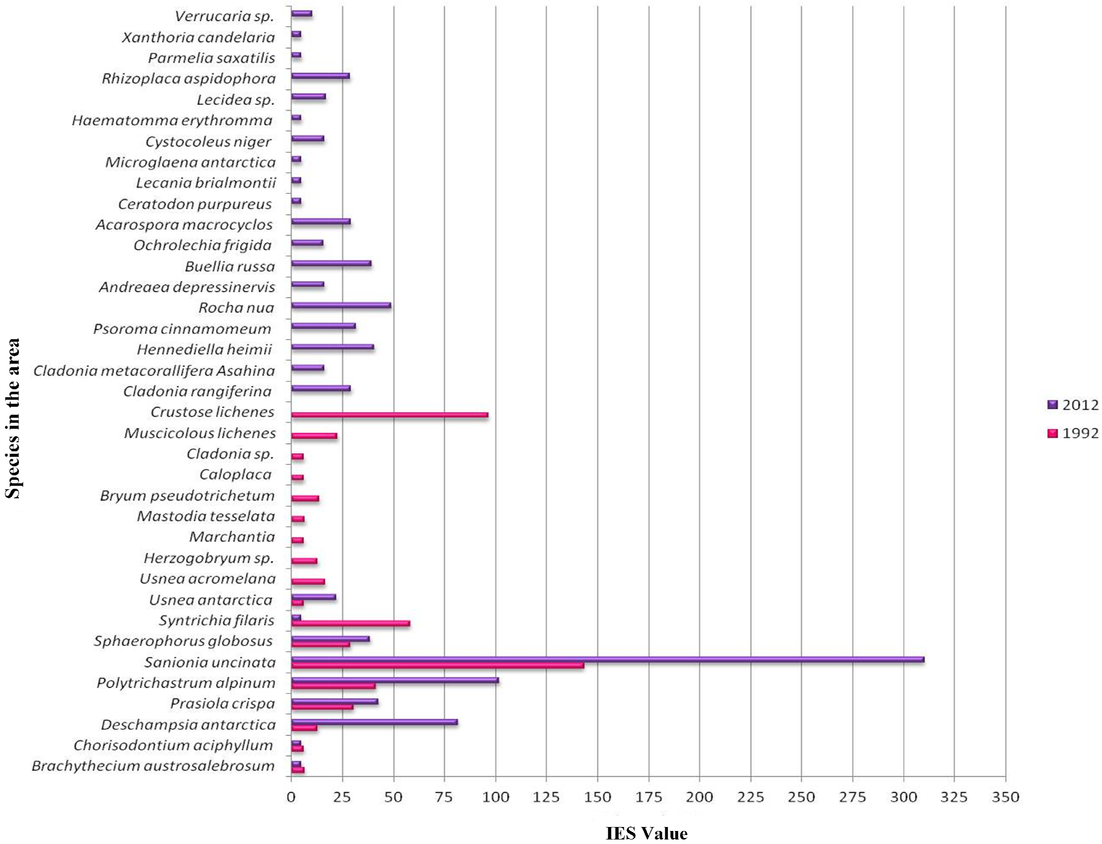

Figure 2: 1992/2012 Comparative phytossociology for Formation 02 (Source D'Oliveira et al. in review).

Sanionia uncinata – Usnea Antarctica association

This association is similar to that found in the Formation 01, but with a lower frequence of *C. aciphyllum* in the samples, evidenced by the lower IES value for this species, below those species considered important in a sample (VICTORIA & PEREIRA, 2007). Located on the plateau of Rango Beach, this plant community does not suffer with the direct influence of sea birds, being found some ornithocoprophobous species in the formation (Table 4).

Table 4: Formation 03 – Moss carpet communities - *Sanionia uncinata – Usnea antarctica* association. F (frequence), C (coverage) and IES (Index of ecological significance).

Species	F	C	IES
Warnstorfia sarmentosa (Wahlenb.) Hedenäs	3.571	0.143	4.082
Hennediella heimii (Hedw.) R.H. Zander	21.429	0.214	26.020
Psoroma cinnamomeum Malme	10.714	0.107	11.862
Andreaea depressinervis Cardot	28.571	0.357	38.776
Buellia russa (Hue) Darb.	10.714	0.107	11.862
*Sanionia uncinata (*Hedw.) Loeske	75.000	2.893	291.964
Bryum argenteum Hedw.	7.143	0.107	7.908

Ochrolechia frigida (Sw.) Lynge	21.429	0.214	26.020
Acarospora macrocyclos Vain	10.714	0.107	11.862
Prasiola crispa	3.571	0.036	3.699
*Syntrichia filaris (*Müll. Hal.) R.H. Zander	3.571	0.071	3.827
Psoroma hypnorum (Vahl) Gray	7.143	0.071	7.653
Cladonia metacorallifera Asahina	21.429	0.214	26.020
*Chorisodontium aciphyllum (*Hook. f. & Wilson) Broth.	28.571	0.446	41.327
Usnea antarctica Du Rietz	42.857	0.964	84.184
Cornicularia aculeata (Schreb.) Ach	21.429	0.321	28.316
Polytrichastrum alpinum (Hedw.) G.L. Sm	39.286	0.571	61.735
Sphaerophorus globosus (Huds.) Vain.	28.571	0.429	40.816
Usnea aurantiacoatra (Jacq.) Bory	3.571	0.143	4.082
Cystocoleus niger (Huds.) Har.	21.429	0.357	29.082
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	25.000	0.250	31.250
Lecidea sp.	10.714	0.107	11.862
Rhizoplaca aspidophora (Vain.) Redón	7.143	0.071	7.653
Parmelia saxatilis (L.) Ach.	3.571	0.018	3.635
*Sanionia georgico-uncinata (*Müll. Hal.) Ochyra & Hedenäs	3.571	0.036	3.699
Bacidia austroshentlandi	3.571	0.036	3.699
Prasiola calophylla (Carmichael ex Greville) Kützing	3.571	0.143	4.082
Stereocaulon alpinum Laurer	3.571	0.036	3.699

Performing the comparative analysis with the last 20 years, this formation was where we found the higher changes in the coverage area. In 1992 only 5 quadrates of 20x20 cm phytosociological could be sampled. In 2012 were sampled 28 quadrates on this site. Even with this difference in the size of the area of all communities studied in this work have some relationship to the study 20 years ago (D'OLIVEIRA et al. in review), this was the only area that stayed with the same characteristics of community and in both studies moss characterized as a carpet. Not a very common pattern in long-standing studies of vegetation in Antarctica as demonstrated by Brabyn et al. (2006).

S. uncinata continues as the dominant species in the community, but for 24 other species the occurreces increased in the site studied (Figure 3), probably, evidencing the early stage of the succession on that community.

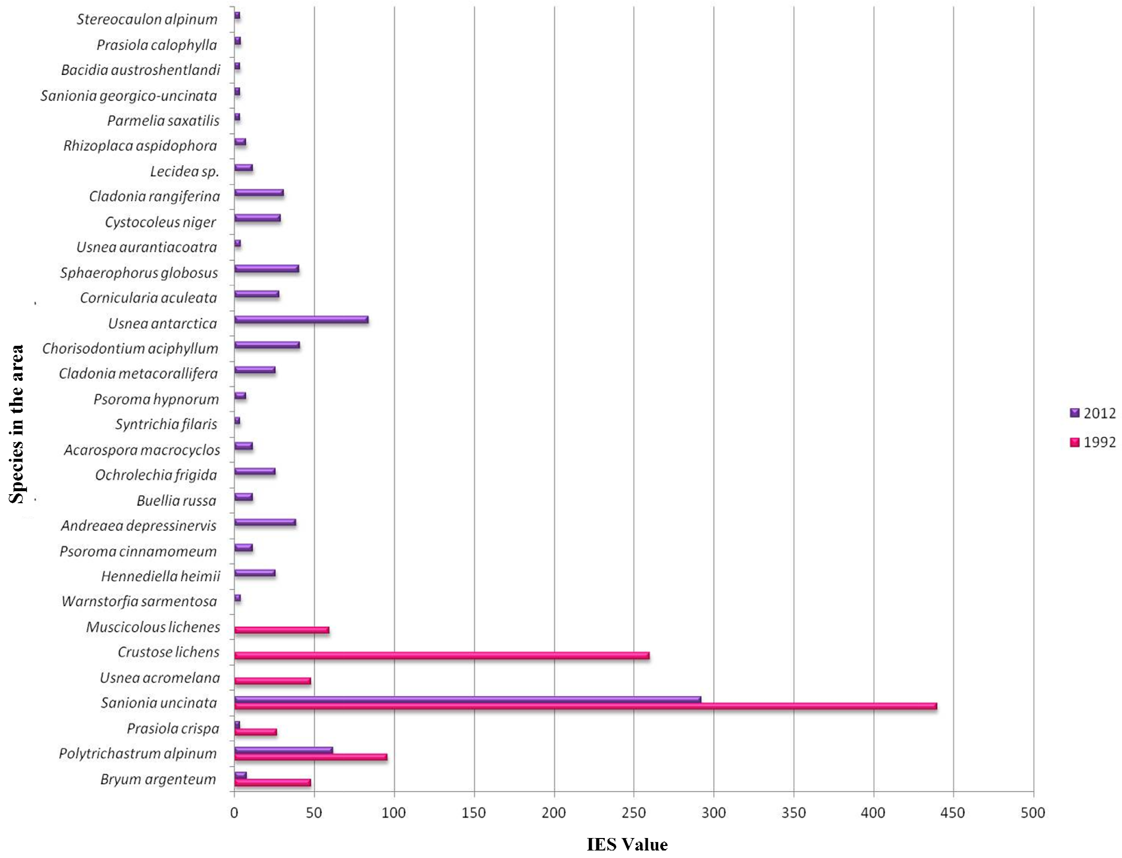

Figure 3: 1992/2012 Comparative phytossociology for Formation 03 (Source D'Oliveira et al. in review).

Only one community was observed as being dominated by lichens. The crustose lichens shows a diversity index more significant than that found to the community composed by the muscicolous lichens.

Crustose lichens community

Lecidea sp – Ochrolechia frigida – Sanionia uncinata Association

Located along a line connecting the Glacier Sultan to an area near the Wiltigen Brazilian refugee, this community goes through a small Petrel rookery. *Lecidea* sp. was observed as the highest IES, follow by *Ocrolechia frigida* that even being a muscicolous lichen, based in the growth-form and the diversity found these formation was characterized as a crustose lichens community (Table 5).

Table 5: Formation 04 – *Crustose lichens* community - *Lecidea sp – Ochrolechia frigida – Sanionia uncinata.* Association. F (frequence), C (coverage) and IES (Index of ecological significance).

Species	F	C	IES
Lecidea sp.	72.131	1.885	208.116
Ochrolechia frigida (Sw.) Lynge	62.295	0.852	115.399
Sanionia uncinata (Hedw.) Loeske	47.541	1.197	104.434
Andreaea gainii Cardot	44.262	0.82	80.543

Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	39.344	0.885	74.174
Cladonia metacorallifera Asahina	52.459	0.377	72.239
Usnea aurantiacoatra (Jacq.) Bory	39.344	0.541	60.629
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	36.066	0.459	52.62
Andreaea depressinervis Cardot	31.148	0.443	44.934
Psoroma hypnorum (Vahl) Gray	29.508	0.459	43.053
Sphaerophorus globosus (Huds.) Vain.	19.672	0.238	24.348
Usnea antarctica Du Rietz	16.393	0.311	21.5
Polytrichastrum alpinum (Hedw.) G.L. Sm	16.393	0.213	19.887
Cystocoleus niger (Huds.) Har.	16.393	0.213	19.887
Himantormia lugubris (Hue) I.M. Lamb	13.115	0.148	15.05
Verrucaria sp.	11.475	0.18	13.545
Stereocaulon glabrum (Müll. Arg.) Vain.	9.836	0.164	11.449
Buellia russa (Hue) Darb.	9.836	0.148	11.287
Acarospora macrocyclos Vain	9.836	0.098	10.804
Deschampsia antarctica E. Desv.	8.197	0.148	9.406
Colobanthus quitensis (Kunth) Bartl.	6.557	0.066	6.987
Rhizoplaca aspidophora (Vain.) Redón	6.557	0.066	6.987
Psoroma cinnamomeum Malme	4.918	0.066	5.241
Stereocaulon alpinum Laurer	3.279	0.033	3.386
Hennediella heimii (Hedw.) R.H. Zander	3.279	0.033	3.386
Bryum argenteum Hedw.	3.279	0.033	3.386
Lecanora skottsbergii Darb.	3.279	0.033	3.386
Rhizocarpon geographicum (L.) DC.	3.279	0.033	3.386
Bartramia patens Brid.	3.279	0.033	3.386
Lophozia excisa (Dicks.) Dumort.	3.279	0.033	3.386
Cornicularia aculeata (Schreb.) Ach	1.639	0.033	1.693
Prasiola crispa	1.639	0.016	1.666

Ceratodon purpureus (Hedw.) Brid.	1.639	0.016	1.666
Microglaena antarctica I.M. Lamb	1.639	0.016	1.666
Pannaria hookeri (Borrer) Nyl.	1.639	0.016	1.666
Cephalozia badia (Gottsche) Stephani	1.639	0.016	1.666
Dicranoweisia sp.	1.639	0.016	1.666
Caloplaca regalis (Vain.) Zahlbr.	1.639	0.008	1.653

Longton (1988) reports that this type of association of lichen species is common in areas near of birds nests, which is not one of the most striking features of this formation. But he also describes species that are relatively found on rocks at high altitudes and in areas near to the lakes formed by the snow melting, such found in the present study. That site is an area away from the coast and close to the glacier, in higher altitude.

C. badia was found in high altitude formations always along the Glacier Sultan and growing on *S. uncinata*. Ochyra (1998) does not report this type of association, but this pattern was observed for Stinker Point in all places where that liverworth was found.

D'Oliveira et al. (in review) characterized this community as saxicolous lichens (Figure 4) and with the information obtained in the survey in that year the number of species on that site could not be measured. Another significant element for these comparison was a drastic decrease of *Andreaea* population, which may be attributed to increased population of *S. uncinata*, *Lecidea* sp. and *C. aciphyllum* and possible changes in soil that had become unfavorable to *Andreaea* ssp., suggesting also a succession pattern for these communities, an example of the pattern found in area 01.

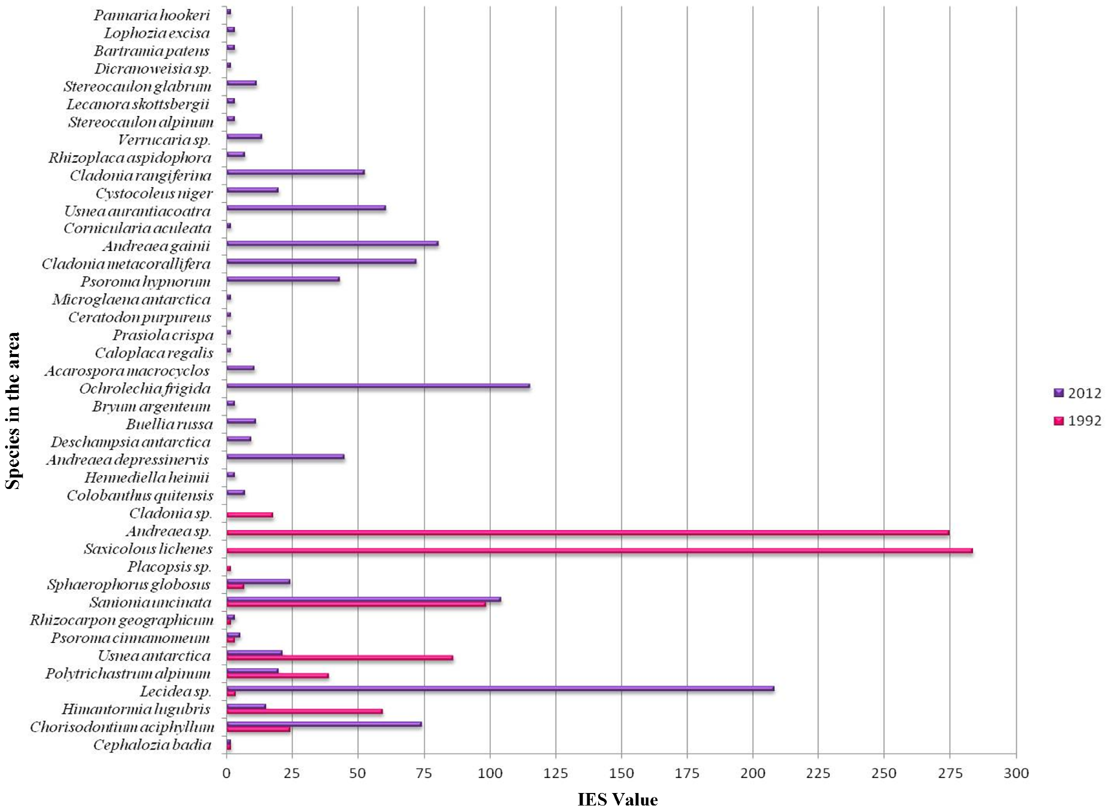

Figure 4: 1992/2012 Comparative phytossociology for Formation 04 (Source D'Oliveira et al. in review).

<u>Moss turf community</u>

Schistidium sp. – Sphaerophorus globosus – Cladonia rangiferina Association

These associations were found in a snow field not sampled in the 1992's survey, such does not characterized as a *fellfield*. This site is located in a plateau in the northern of Náufragos Beach besides the plateau of Rango Beach, being the communities found at both plateau were characterized as *moss carpet communities.* The main feature to classify the *moss turf communty* is the predominance of lichenized fungi and a higher frequency of *Schistidium* spp. in that place.

The main feature to characterize this community as a moss turf is the predominance of lichenized fungi and higher frequencies of *Schistidium* ssp. on site.

The area is a slope between the two plateaus and stays below of a Petrel rookery, where the organic matter and micronutrients, provided by the Petrels nests, were drained by gravity to this community. Besides this is under direct influence of Petrels and Skuas that are nesting and feeding on this site. The IES value for the lichen species found in the formation was very high (Table 6) compared with those obtained for other areas.

Table 6: Formation 05 – *Moss turf community –Schistidium sp. – Sphaerophorus globosus- Cladonia rangiferina association.* F (frequence), C (cover) e IES (Índex of ecological significance)

Species	F	C	IES
Schistidium sp.	100	2.667	366.667

Sphaerophorus globosus (Huds.) Vain.	88.889	1.667	237.037
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	88.889	1.111	187.654
Usnea antarctica Du Rietz	66.667	1.111	140.741
Prasiola crispa	66.667	0.667	111.111
Polytrichastrum alpinum (Hedw.) G.L. Sm	44.444	0.667	74.074
Cladonia metacorallifera Asahina	44.444	0.444	64.198
Verrucaria sp.	33.333	0.556	51.852
Sanionia uncinata (Hedw.) Loeske	33.333	0.444	48.148
Ochrolechia frigida (Sw.) Lynge	33.333	0.444	48.148
Rhizoplaca aspidophora (Vain.) Redón	33.333	0.333	44.444
Acarospora macrocyclos Vain	22.222	0.556	34.568
Buellia russa (Hue) Darb.	22.222	0.444	32.099
Cystocoleus niger (Huds.) Har.	22.222	0.222	27.16
Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	22.222	0.222	27.16
Psoroma hypnorum (Vahl) Gray	22.222	0.222	27.16
Hennediella heimii (Hedw.) R.H. Zander	22.222	0.222	27.16
Psoroma cinnamomeum Malme	11.111	0.111	12.346

Ochyra (1998) reports the *Schistidium* ssp. occuring often in rocky sites. The site where these association were observed are composed by stable soil and rock outcrops with few places to be colonized.

Chorisodontium aciphyllum – Warsntorfia sarmentosa association

Stinker Point is the locality where we observed a greater population of *C. aciphullum* at Antarctica. This area are located in the south side of the Refuge Wiltgen, in a deactivated Petrel colony area, there were found many clasts and pebbles on the site. The population of *C. aciphyllum* presented the highest IES value (Table 7) corroborating with the data from Victoria et al. (2009), which describe *C. aciphyllum* populations as a characteristics of moss turf communities results found by the same authors at King George Islands near the Arctowsky and Ferras stations.

Table 7: Formation 06 – *Moss turf community – Chorisodontium aciphyllum – Warnstorfia sarmentosa association.* F (frequence), C (cover) e IES (Index of ecological significance).

Species	F	C	IES
Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	76.471	2.882	296.886
Warnstorfia sarmentosa (Wahlenb.) Hedenäs	41.176	1.647	108.997
Sanionia uncinata (Hedw.) Loeske	47.059	1.118	99.654
Cystocoleus niger (Huds.) Har.	52.941	0.706	90.311
Deschampsia antarctica E. Desv.	29.412	0.824	53.633
Ochrolechia frigida (Sw.) Lynge	29.412	0.294	38.062
Usnea antarctica Du Rietz	29.412	0.235	36.332
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	17.647	0.176	20.761
Polytrichastrum alpinum (Hedw.) G.L. Sm	17.647	0.147	20.242
Sphaerophorus globosus (Huds.) Vain.	17.647	0.147	20.242

Andreaea depressinervis Cardot	11.765	0.118	13.149
Brachythecium austrosalebrosum (Müll. Hal.) Paris	5.882	0.059	6.228
Cladonia metacorallifera Asahina	5.882	0.059	6.228
Prasiola crispa	5.882	0.029	6.055

Comparing the data obtained in 1992 (D'Oliveira et al. in review), this community experienced a major change in its phytosociological features. In 1992 it was characterized as a *moss carpet* community, maily because the large population of *S. uncinata* (Figure 5), which suffered a major decline in these twenty years. Also occurred with *D. antarctica* which had a reduction in its population. That changes can be attributed to the reduced use of this site by researchers and animals, the *C. aciphyllum* is a species that colonize on rocks, at the end of the colony of petrels place, the clasts that were used by these animals to build nests became available for the development of this moss species.

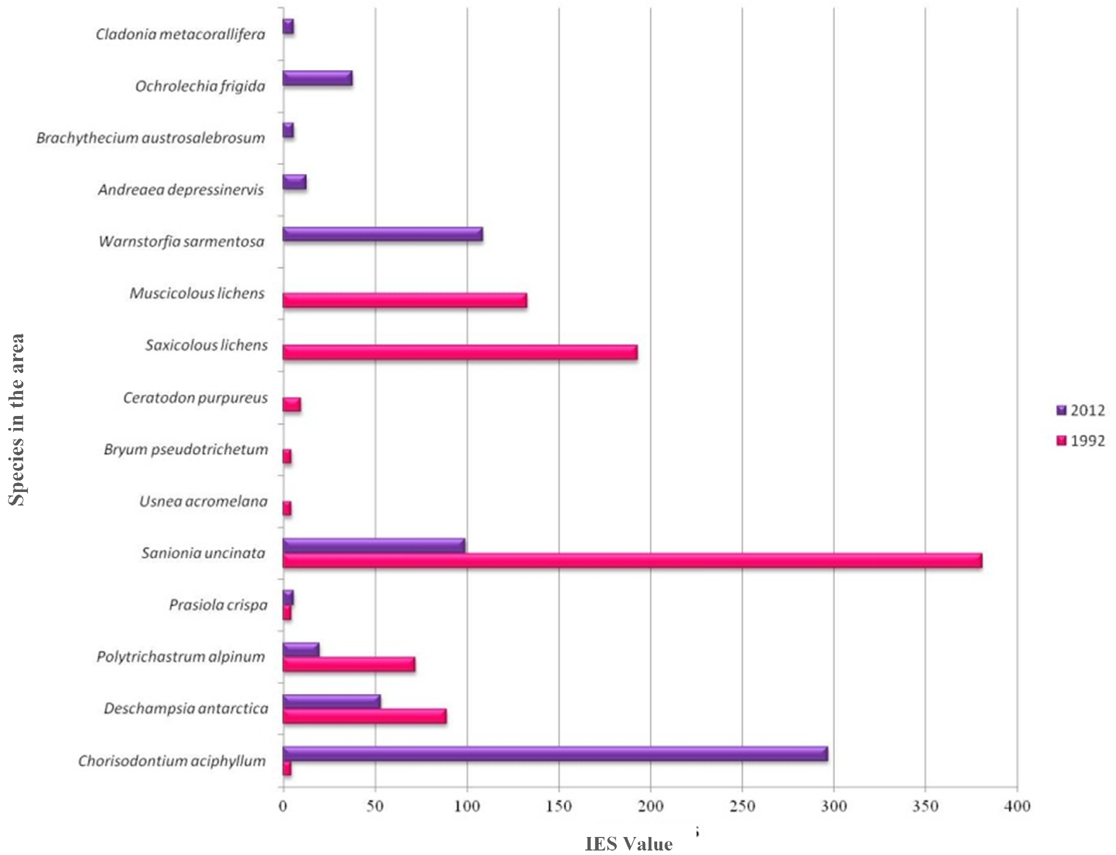

Figure 5: 1992/2012 Comparative phytossociology for formation 06 (Source D'Oliveira et al. in review).

Chorisodontium aciphyllum – Spharophorus globosus – Lecidea* sp. *Association

In this community *C. aciphyllum* shows an IES value similar to that found in previous community (Table 8), differing maily is the large number of muscicolous lichens found in this formation, prevailing *S. globosus* which is the main predator of this moss species (REDON, 1988). Located close to the Sultan Glacier, that is the highest and the farther place from the coast, where seabirds colonies were not found.

Table 8: Formation 07 – *Moss turf community – Chorisodontium aciphyllum – Sphaerophorus globosus – Lecidea* sp. association F (frequence), C (cover) e IES (Índex of Ecological Significance).

Species	F	C	IES
Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	80	2.65	292
Sphaerophorus globosus (Huds.) Vain.	75	1.45	183.75
Lecidea sp.	70	1.05	143.5
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	55	0.65	90.75
Sanionia uncinata (Hedw.) Loeske	45	0.9	85.5
Ochrolechia frigida (Sw.) Lynge	50	0.65	82.5
Usnea aurantiacoatra (Jacq.) Bory	45	0.65	74.25
Andreaea depressinervis Cardot	25	0.3	32.5
Cornicularia aculeata (Schreb.) Ach	25	0.25	31.25
Polytrichastrum alpinum (Hedw.) G.L. Sm	20	0.25	25
Psoroma hypnorum (Vahl) Gray	15	0.3	19.5
Usnea antarctica Du Rietz	15	0.2	18
Cystocoleus niger (Huds.) Har.	15	0.2	18
Stereocaulon glabrum (Müll. Arg.) Vain.	15	0.2	18
Himantormia lugubris (Hue) I.M. Lamb	10	0.15	11.5
Haematomma erythromma (Nyl.) Zahlbr.	10	0.15	11.5
Cladonia metacorallifera Asahina	10	0.1	11
Verrucaria sp.	5	0.1	5.5
Rhizocarpon geographicum (L.) DC.	5	0.05	5.25
Caloplaca cinericola (Hue) Darb.	5	0.05	5.25

On this site was observed distinct growth patterns of *S. globosus* population on the *C. aciphyllum* population, featuring an onsite plant succession. The decline in the population of *S. uncinata* in the place demonstrates a behavior of succession in that area also (Figure 6).

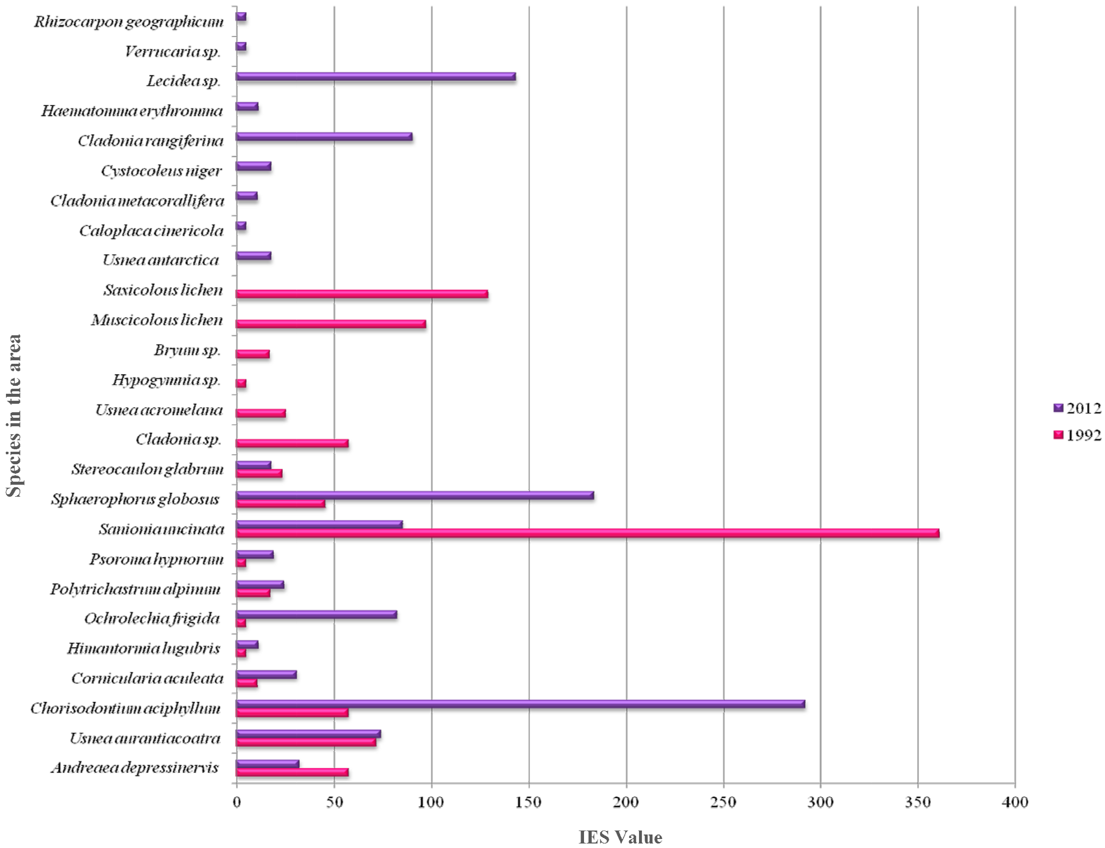

Figure 6: 1992/2012 Comparative phytossociology for Formation 07 (Source D'Oliveira et al. in review).

Community *fellfield*

That community showed a Pielou – Equability Index most significant (0.7), and consists in new areas that were exposed by the glaciers retraction. This area has many nutrients and minerals in the soil in significative quantities that are assimilated by the plants observed in such formation (ELLIS-EVANS & WALTON, 1990).

In these communities a higher occurrence of rock and bare soil was found in the phytosociological survey, this is an indication that the areas are newly exposed and are probably in the beginning of the plant colonization process.

Hennediella heimii – Pohlia nutans – Brachythecium austrosalebrosum association

The sites 8 and 9, sampled in the present study, were found close together and also to the Endurance Glacier. At that sites were found Skuas pellets (*egragopilas*), where *H. heimii* was found growing on these material. Site 8 is problaby a recent community, close to the base of the glacier. In this formation only three species were found (Table 9)

Table 9: Formation 08 – Moss turf communities for *Hennediella heimii – Pohlia nutans - Brachythecium austrosalembrosum* sociation. F (frequency), C (converage) and IES (index of ecological significance).

Species	F	C	IES
Hennediella heimii (Hedw.) R.H. Zander	0.75	0.5	1.125
Pohlia nutans (Hedw.) Lindb	0.075	0.05	0.079

Brachythecium austrosalebrosum (Müll. Hal.) Paris	0.025	0.025	0.026

Hennediella heimii – Pohlia nutans association

The other *fellfield* community was found farther away from the glacier, and had a greater diversity of species, but the dominant species in the formation remained the same found in the community discussed above (Table 10).

Table 10: Formation 09 – Moss turf communities for *Hennediella heimii – Pohlia nutans - austrosalembrosum* association. F (frequency), C (converage) and IES (index of ecological significance).

Species	F	C	IES
Hennediella heimii (Hedw.) R.H. Zander	1	2.643	3.643
Pohlia nutans (Hedw.) Lindb	0.429	0.429	0.612
Bryum sp.	0.357	0.5	0.536
Ochrolechia frigida (Sw.) Lynge	0.286	0.286	0.367
Caloplaca cinericola (Hue) Darb.	0.286	0.25	0.357
Lichenomphalia umbellifera (L.) Redhead, Lutzoni, Moncalvo & Vilgalys	0.286	0.25	0.357
Psoroma cinnamomeum Malme	0.214	0.429	0.306
Prasiola crispa	0.071	0.071	0.077
Sanionia uncinata (Hedw.) Loeske	0.071	0.071	0.077
Marchantia berteroana Lehm. & Lindenb.	0.071	0.071	0.077
Caloplaca regalis (Vain.) Zahlbr.	0.071	0.036	0.074
Omphalina antarctica Singer	0.071	0.036	0.074

H. heimii is a species found in other formations, but mostly in consolidated sites, usually along with *B. austrosalembrosum*. *P. nutans* were often found as an ornithocoprophabous species, indicating that the study area is distant of that with birds colonies and the low influence of them as dispersers of these seedlings on site, considered also an adapted species to mostly of the sites, often found on drainage lines. Victoria et al. (2009) reported the occurrence of *Pohlia drummondii* (Müll. Hal.) A. L. Andrews and *P. nutans* along drainage lines near to the Ecology Glacier Área, close to the Arctowski region in Admiralty Bay, King George Island.

Sanionia uncinata – Polytrichastrum alpinum association

This community is located on the plateau of Praia Grande, but it's a place where it was recently exposed as the Endurance Glacier came up there. It's similar to the Formation 02 where *S. uncinata* and *P. alpinum* are also the most dominant species.

This can not be considered a *moss carpet* community, because the IES values of its species are low (VICTORIA & PEREIRA, 2007), probably to be a newly exposed area with vegetation, being thus considered as *fellfield* (Table 11).

Table 11: Formation 10 – *Moss turf community* - Sanionia *uncinata – Polytrichastrum alpinum association.* F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES

*Sanionia uncinata (*Hedw.) Loeske	1	4.733	5.733
Polytrichastrum alpinum (Hedw.) G.L. Sm	0.733	1.433	1.784
Cladonia metacorallifera Asahina	0.2	0.2	0.24
Buellia sp.	0.2	0.2	0.24
Bryum argenteum Hedw.	0.133	0.133	0.151
*Syntrichia filaris (*Müll. Hal.) R.H. Zander	0.133	0.133	0.151
Hennediella heimii (Hedw.) R.H. Zander	0.133	0.133	0.151
Psoroma hypnorum (Vahl) Gray	0.067	0.067	0.071
Rhizoplaca aspidophora (Vain.) Redón	0.067	0.067	0.071
Hepática	0.067	0.067	0.071

This pattern of dominant species does not corroborates with the fact that *S. uncinata* and *P. alpinum* are associated with Skuas nests as demonstrated in the Community 02 and others approaches (Victoria et al. 2009), however it's a place where it's not possible to infer early colonization, so that these vegetation patterns will remain.

Chorisodontium aciphyllum – Sanionia uncinata Association

This formation is located at a plateau close to the *Moss turf* communities, where tufts of *C. aciphyllum* dominate the landscape. It is a place that suffers most influence of Petrel colonies, and was observed a large number of ornithocoprophilous species (Table 12). On this site occurs a drain line from the glacier which is used by researchers as a place to dispose the biological waste from the camps. It is important to highligth that any change in the water availability can affect the vegetation more than the temperature change, because it also changes the dynamics of the local fauna (CONVEY et al. 2009).

Table 12: Formation 11 – *Moss turf community - Chorisodontium aciphyllum - Sanionia uncinata association.* F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES
Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	0.958	3.708	4.512
Sanionia uncinata (Hedw.) Loeske	0.667	1.458	1.639
Prasiola crispa	0.625	0.479	0.924
Warnstorfia sarmentosa (Wahlenb.) Hedenäs	0.208	0.583	0.33
Ochrolechia frigida (Sw.) Lynge	0.25	0.25	0.313
Usnea antarctica Du Rietz	0.25	0.229	0.307
Sphaerophorus globosus (Huds.) Vain.	0.208	0.229	0.256
Cephalozia badia (Gottsche) Stephani	0.167	0.208	0.201
Buellia sp.	0.125	0.125	0.141
Deschampsia antarctica E. Desv.	0.083	0.063	0.089
Acarospora macrocyclos Vain	0.042	0.042	0.043
Cladonia metacorallifera Asahina	0.042	0.042	0.043
Cornicularia aculeata (Schreb.) Ach	0.042	0.042	0.043
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	0.042	0.021	0.043
Buellia anisomera Vain.	0.042	0.042	0.043
Bryum pseudotriquetrum (Hedw.) P. Gaertn., B.	0.042	0.042	0.043

Sanionia uncinata – Cephalozia badia association

This is a new area located close to the Rango beach plateau, near of a penguin trail used to access a local penguin rookery. As reported for the Formation 04, *C. badia* was always found growing on dead *S. uncinata*, such evidencied in this association (Table 13). This behavior was not reported in the literature, being cited *C. badia* associated with other mosses than *S. uncinata*.

Table 13: Formation 12 – Moss *turf community - Chorisodontium aciphyllum - Sanionia uncinata association*. F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES
*Sanionia uncinata (*Hedw.) Loeske	1	3.733	4.733
Cephalozia badia (Gottsche) Stephani	0.8	1.733	2.186
Cladonia metacorallifera Asahina	0.6	0.733	1.04
Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	0.333	0.867	0.622
Ochrolechia frigida (Sw.) Lynge	0.333	0.4	0.466
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	0.267	0.267	0.338
Prasiola crispa	0.267	0.267	0.338
Buellia sp.	0.133	0.13	0.151
Usnea antarctica Du Rietz	0.133	0.133	0.151
Warnstorfia laculosa (Müll. Hal.) Ochyra & Matteri	0.067	0.267	0.085
Sphaerophorus globosus (Huds.) Vain.	0.067	0.067	0.071
Usnea aurantiacoatra (Jacq.) Bory	0.067	0.067	0.071
Acarospora macrocyclos Vain	0.067	0.067	0.071
Andreaea depressinervis Cardot	0.067	0.067	0.071

The pattern within plant community is apparently related to environmental factors such as water availability, wind exposure and substrate stability (PUTZKE & PEREIRA, 2001). Olech (2010) reports that in studies of plant population dynamics in Antarctica, indicating that a change in habitat conditions results primarily from warming of the local climate, drastically influencing the decrease in moisture from the substrate, which may influence the species that will colonize new ice-free areas.

Moss Hummock community

Hennediella heimii – Colobanthus quitensis association

This formation is located on the hillside along the Grande beach. The location is mostly influenced by mammals and seabirds, occurring a penguin colony on the site. The main species encountered in the formations was *H. heimii*, but in all communities found to Stinker Point, this is the only one that presents an angiosperm with high IES value (Table 14).

Table 14: Formation 13 – *Moss hummock community - Chorisodontium aciphyllum - Sanionia uncinata* association. F (frequency), C (coverage) and IES (index of ecological significance).

Species	F	C	IES
Hennediella heimii (Hedw.) R.H. Zander	58.333	1.033	118.611
Colobanthus quitensis (Kunth) Bartl.	51.667	1.108	108.931
Brachythecium austrosalebrosum (Müll. Hal.) Paris	51.667	0.817	93.861
Bryum argenteum Hedw.	28.333	0.558	44.153
Caloplaca cinericola (Hue) Darb.	28.333	0.3	36.833
Warnstorfia sarmentosa (Wahlenb.) Hedenäs	20	0.45	29
Syntrichia magellanica (Mont.) R.H. Zander	20	0.283	25.667
Sanionia uncinata (Hedw.) Loeske	16.667	0.367	22.778
Leptogium puberulum Hue	16.667	0.267	21.111
Psoroma cinnamomeum Malme	16.667	0.2	20
Prasiola crispa	15	0.192	17.875
Deschampsia antarctica E. Desv.	13.333	0.183	15.778
Mastodia tessellata (Hook. f. & Harv.) Hook. f. & Harv.	10	0.133	11.333
Caloplaca regalis (Vain.) Zahlbr.	10	0.125	11.25
Acarospora macrocyclos Vain	8.333	0.083	9.028
mushroom	8.333	0.067	8.889
Lecania brialmontii (Vain.) Zahlbr.	5	0.067	5.333
Andreaea depressinervis Cardot	5	0.05	5.25
Marchantia berteroana Lehm. & Lindenb.	3.333	0.025	3.417
Buellia russa (Hue) Darb.	1.667	0.017	1.694
Ceratodon purpureus (Hedw.) Brid.	1.667	0.017	1.694
Lecanora mons-nivis Darb.	1.667	0.017	1.694
Candelaria murrayi Poelt	1.667	0.017	1.694
Microglaena antarctica I.M. Lamb	1.667	0.017	1.694
Xanthoria elegans (Link) Th. Fr.	1.667	0.008	1.681

In the study made in 1992 (D'OLIVEIRA et al. in review) that community was characterized as a *moss carpet* due to the higher occurrence of *S. uncinata* (Figure 7).

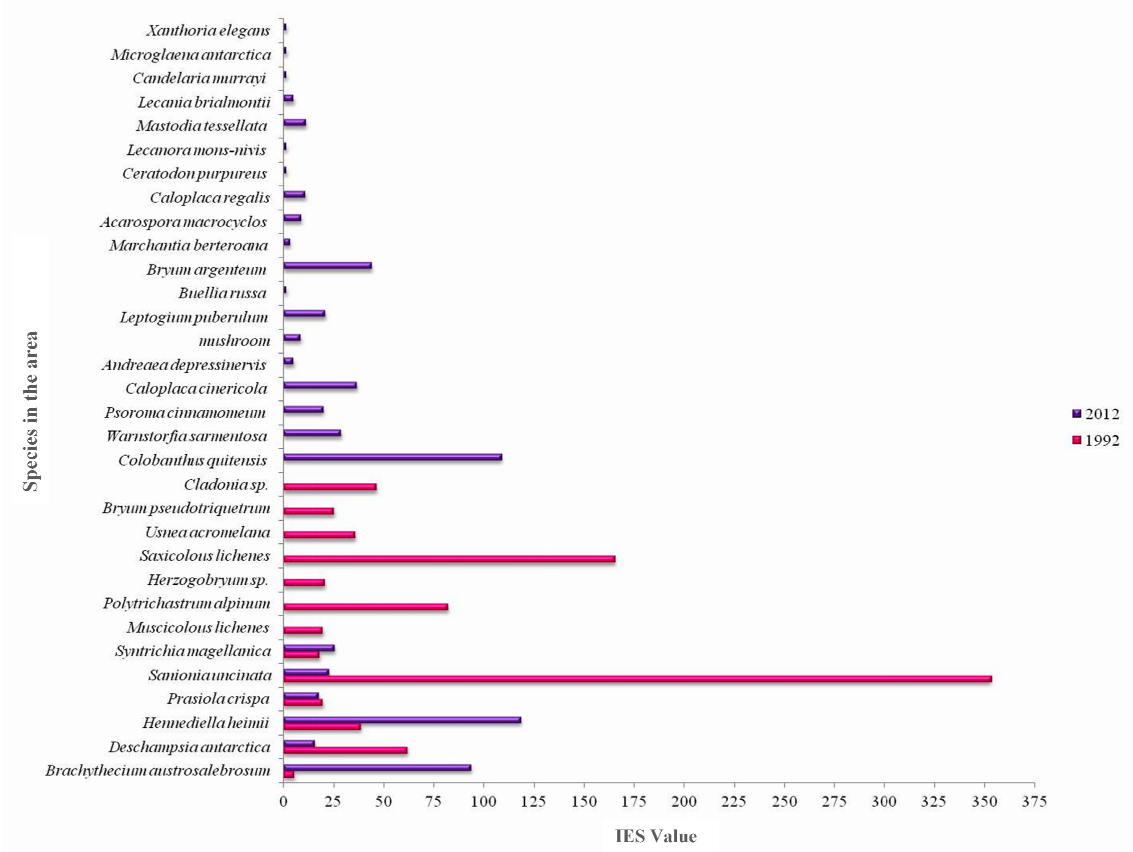

Figure 7: 1992/2012 Comparative phytossociology for formation 13 (Source D'Oliveira et al. in review).

The establishment of *C. quitensis* population in the site may be due to the soil formation and the others communities that existed before in the locality, which allows the organic matter deposition and the establishment of angiosperms. Therefore *H. heimii* is a species that is closely associated with large deposit of organic matter, corroborating the hipothesis that it has developed in a place with a strong influence of animal presence.

CONCLUSIONS

It was evidenced a pattern to each species linked to each glaciar. In the areas near to Sultan Glaciar, S. uncinata was the most frenquent and with more coverage species found, often showing higher IES value, along with lichens. However in the areas near Endurance Glaciar and drainage lines of it, the most abundant species is H. heimmi.

Changes in plant community observed over the past twenty years highlights the importance of reconciling both phytosociological studies of plant communities and studies of the edaphic factors, solar radiation and climate change, to better understanding of the plant sucession processes, as it's occurring on this sites.

Over twenty years Stinker Point shows a significant increase of ice-free areas resulting from the retraction of the two glaciers bordering the site. It is interesting analyze the pattern of species that has remained connected to each glacier.

Further studies about the relationship of mosses propagules in glaciers are needed, as already reported in the literarure observations about species relates to recent ice-free areas of Antartic as, for example, *Pohlia* generum.

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2. CONCLUSÕES

Com uma flora característica e que se desenvolve sobre as condições mais rigorosas de clima, nutrientes e disponibilidade de água, é muito importante o monitoramento dos processos de fitossociologia dessas populações.

Stinker Point é um local com pouco impacto humano, sendo uma área exclusiva para a pesquisa. Pela localização mais ao norte da Antártica Marítima foi possível evidenciar com este estudo uma grande retração dos glaciares que limitam o local, o que expos algumas áreas ao longo dos vinte anos que separam os estudos.

No arquipélago das Shetland do Sul existem ilhas com característica muito particulares, a Ilha Elefante com uma fauna abundate e condições climáticas especiais, a Ilha Rei George com várias estações e bases de pesquisa e que recebe visitação intensa de turistas bem como na Ilha Deception, que além de ser um local de interesse turístico teve a pouco anos um evento de geotermismo com a erupção vulcânica. Mesmo com essas diferenças e o distanciamento entre elas é possível evidenciar a similaridade em alguns aspectos da vegetação, onde espécies são presentes em todas elas, bem como, para cada tipo de condições climáticas, edáficas, geológicas e com a presença ou ausência de animais tornam as comunidades vegetais de cada ilha com características própias.

Ao longo dos vinte anos que separam os estudos Stinker Point, houve um aumento de 85% das áreas com formações vegetais (de sete áreas amostradas em 1991/92 para 13 amostras em 2012/12) sendo das sete formações analizadas, apenas uma se manteve com o mesmo tipo de formção de comunidade, o que caracteriza um desenvolvimento mais rápido do que era atribuída a vegetação antártica.

Estudos de longo prazo devem ser realizados nas localidades com vegetação na Antártica, acompanhando o desenvolvimento e os mecanismos ecológicos dessas populações. Relações com a dinâmica de geleiras, fatores ambientais, edáficos e climatológicos devem ser desenvolvidos em paralelo para melhor compreender os processo de sucessão vegetal e, possibilitar analizar os impactos da prensença antrópica na região e da mudança no clima para essas espécies.

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ANEXOS

ANEXO A.

Annex A: The moss and liverwort species found in studys for Shouth Shetlands Islands. (1) Allison & Smith (1973); (2) Putzke & Pereira (unpublished date); (3) Putzke & Pereira (1998); (4) Ochyra (1998); (5)Victoria et al. (2009); (5) Lewis – Smith (2005)

	Historical Clarence Island (1)	Gibbs Island (1)	Historycal Elephant Island (1)	Elephant Island (1)	Stinker Point - Elephant Island (2)	Rip Point - Nelson Island (3)	King George Island (4)	Arctowski region -King George Island (5)	Deception Island (6)
Andreaea gainii Cardot				X		X	X	X	
Andreaea regularis Müll. Hal.				X		X	X	X	X
Andreaea depressinervis Cardot				X		X	X	X	
Andreaea sp.					X				
Anisothecium cardotii (R. Br. bis) Ochyra							X		
Anomobryum subrotundifolium (A. Jaeger) J.R. Spence & H.P. Ramsay									X
Anthelia juratzkana (Limpr.) Trevis.				X					
*Barbilophozia hatcheri (*A. Evans) Loeske				X					X
Bartramia patens Brid.				X	X	X	X	X	X
Brachythecium austrosalebrosum (Müll. Hal.) Paris	X	X	X	X	X			X	X
Brachythecium cf. antarcticum				X					
Bryum amblyodon Müll. Hal.						X	X	X	X
Bryum argenteum Hedw.					X	X	X		
Bryum dichotomum Hedw.									X

Bryum orbiculatifolium Cardot & Broth.					X	X	X	X
Bryum pallescens Schleich. ex Schwägr.						X	X	
Bryum pseudotriquetrum (Hedw.) P. Gaertn., B. Mey. & Scherb.	X	X	X	X	X	X	X	X
Bryum sp.			X					
Bucklandiella didyma (Mont.) Bednarek-Ochyra & Ochyra								X
Bucklandiella pachydictyon (Cardot) Bednarek-Ochyra & Ochyra								X
Bucklandiella subsecunda (Hook. & Grev. ex Harv.) Bednarek-Ochyra & Ochyra								X
Bucklandiella sudetica (Funck) Bednarek-Ochyra & Ochyra								X
Calliergidium austrostramineum (Müll. Hal.) E.B. Bartram					x			
Campyliadelphus polygamus (Schimp.) Kanda					X	X		
Cephalozia badia (Gottsche) Stephani			X					X
Cephaloziella hispidissima R.M. Schust.								X
Cephalozia sp.			X	X				
Cephaloziella varians (Gottsche) Stephani			X				X	X
Ceratodon purpureus (Hedw.) Brid.	X		X	x	X	X	X	X
Ceratodon sp.		X	X					

Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	X	X	X	X	X	
Conostomum magellanicum Sull.			X	X	X	
Cryptochila grandiflora (Lindenb. & Gottsche) Grolle						X
Dicranella hookeri (Müll. Hal.) Cardot						x
Dicranoweisia antarctica (Müll. Hal.) Paris			x			
Dicranoweisia brevipes (Müll. Hal.) Cardo				X	X	
Dicranoweisia crispula (Hedw.) Milde				X		
Dicranoweisia grimmiacea (Müll. Hal.) Broth.			X	X		
Dicranoweisia sp.	X					
Didymodon brachyphyllus (Sull.) R.H. Zander				X		X
Distichium capillaceum (Hedw.) Bruch & Schimp.			X	X		
Ditrichum conicum (Mont.) Mitt.						x
Ditrichum ditrichoideum (Cardot) Ochyra						X
Ditrichum heteromallum (Hedw.) E. Britton						X
Ditrichum hyalinocuspidatum Cardot				X		X
Ditrichum hyalinum (Mitt.) Kuntze			X			X
Ditrichum lewis-smithii Ochyra				X		
Encalypta patagonica Broth.			X			
Encalypta rhaptocarpa Schwägr.				X		

Funaria hygrometrica Hedw.								X
Grimmia reflexidens Müll. Hal.						X		
*Hennediella antarctica (*Ångström) Ochyra & Matteri						X		X
Hennediella heimii (Hedw.) R.H. Zander					X	X	X	X
Holodontium strictum (Hook. f. & Wilson) Ochyra						X		
Holodontium sp								X
Hymenoloma antarcticum (Müll. Hal.) Ochyra								X
Hymenoloma crispulum (Hedw.) Ochyra								X
Hypnum revolutum (Mitt.) Lindb.		X	X	X	X			
Kiaeria pumila (Mitt.) Ochyra						X		
Leptobryum pyriforme (Hedw.) Wilson								X
*Lophozia excisa (*Dicks.) Dumort.				X			X	X
Lophozia sp.			X					
Marchantia berteroana Lehm. & Lindenb								x
Marchantia polymorpha L								X
Meesia uliginosa Hedw.						X	X	
Muelleriella crassifolia (Hook. f. & Wilson) Dusén						X		
Notoligotrichum trichodon (Hook. f. & Wilson) G.L. Sm.				X		X		X
Orthotheciella varia (Hedw.) Ochyra	X	X	X			X		
Pachyglossa spegazziniana (C. Massal.) Herzog & Grolle								X

Philonotis polymorpha (Müll. Hal.) Kindb.									X
Pohlia cruda (Hedw.) Lindb.				X		X	X	X	x
Pohlia cruda var. imbricata (Cardot) E.B. Bartram				X					
Pohlia drummondii (Müll. Hal.) A.L. Andrews				X			X	X	
Pohlia inflexa (Müll. Hal.) Wijk & Margad.				X	X	X			
Pohlia nutans (Hedw.) Lindb							X	X	X
Pohlia sp.					X				
Pohlia wahlenbergii (F. Weber & D. Mohr) A.L. Andrews							X		X
Polytrichastrum alpinum (Hedw.) G.L. Sm	X		X	X	X	X	X	X	X
Polytrichastrum longisetum (Sw. ex Brid.) G.L. Sm.									X
Polytrichum juniperinum Hedw.						X	X	X	X
Polytrichum strictum Menzies ex Brid.				X	X		X		X
Polytrychum sp.					x				
Polytrichum piliferum Hedw.						X	X	X	X
Racomitrium lanuginosum (Hedw.) Brid.									x
*Racomitrium sudeticum (*Funck) Bruch & Schimp.							X	X	
*Sanionia georgico-uncinata (*Müll. Hal.) Ochyra & Hedenäs				X			X		X
*Sanionia uncinata (*Hedw.) Loeske					X	X	X	X	X
*Sarmentypnum sarmentosum (*Wahlenb.) Tuom. &						x			

T.J. Kop.							
Schistidium amblyophyllum (Müll. Hal.) Ochyra & Hertel					X		X
Schistidium andinum (Mitt.) Herzog							X
*Schistidium antarctici (*Cardot) L.I. Savicz & Smirnova							X
Schistidium cupulare (Müll. Hal.) Ochyra					X		
*Schistidium falcatum (*Hook. f. & Wilson) B. Bremer	X	X			X	X	
Schistidium halinae Ochyra		X			X		
Schistidium hyalinocuspidatum (Müll. Hal.) B.G. Bell				x			
Schistidium occultum (Müll. Hal.) Ochyra & Matteri					X		
Schistidium rivulare (Brid.) Podp.				X	X		
Schistidium steerei Ochyra					X		
Schistidium urnulaceum (Müll. Hal.) B.G. Bell					X		
Sciuro-hypnum fuegianum (Broth.) Ochyra & Żarnowiec							X
Stegonia latifolia (Schwägr.) Venturi ex Broth.					X		
*Syntrichia filaris (*Müll. Hal.) R.H. Zander					X		X
*Syntrichia magellanica (*Mont.) R.H. Zander		X		X			
*Syntrichia princeps (*De Not.) Mitt.					X	X	X
*Syntrichia saxicola (*Cardot) R.H. Zander			X		X	X	X

ANEXO B.

Annex B: The lichens species found in studys for Shouth Shetlands Islands. (1) Allison & Smith (1973); (2) Putzke & Pereira (unpublished date); (3) Putzke & Pereira (1998); (4) Victoria et al. (2009); (5) Martins et al. (1998)

Lichens species	Gibbs Island (1)	Historycal Elephant Island (1)	Elephant Island (1)	Stinker Point - Elephant Island (2)	Rip Point - Nelson Island (3)	Arctowski region - King George Island (4)	Deception Island (5)
Acarospora macrocyclos Vain			X	X			X
Alectoria nigricans (Ach.) Nyl.			X				
Alectoria pubescens (L.) R. Howe			X				
Amandinea coniops (Wahlenb.) M. Choisy ex Scheid. & H. Mayrhofer,							X
Amandinea petermannii (Hue) Matzer, H. Mayrhofer & Scheid. 1994					X		
Amandinea punctata (Hoffm.) Coppins & Scheid.							X
Arthonia subantarctica Øvstedal 198							X
Bacidia stipata I.M. Lamb					X		
Bacidia tuberculata Darb. 1912							X
Blastenia austroshetlandica Zahlbr.							X
Bryoria chalybeiformis (L.) Brodo & D. Hawksw.	X						
Buellia anisomera Vain.			X				
Buellia augusta Vain.					X		
Buellia cladocarpiza I.M. Lamb					X		
Buellia coniops (Wahlenb.) Th. Fr.			X		X		
Buellia isabellina Malme							X
Buellia latemarginata Darb.			X		X		

Buellia nelsonii Darb.			X		
Buellia russa (Hue) Darb.	X				
Caloplaca athallina Darb.			X		
Caloplaca cinericola (Hue) Darb.		X	X		
Caloplaca cirrochrooides (Vain.) Zahlbr.					X
Caloplaca holocarpa (Hoffm.) A.E. Wade					X
Caloplaca johnstonii (C.W. Dodge) Søchting & Olech					X
Caloplaca mawsonii C.W. Dodge			X		
Caloplaca millegrana (Müll. Arg.) Zahlbr					X
Caloplaca nigrescens N.S. Golubk. & Savicz			X		
Caloplaca regalis (Vain.) Zahlbr.	X		X		X
Caloplaca sp.	X		X	X	
Caloplaca sublobulata (Nyl.) Zahlbr.			X		X
Candelaria murrayi Poelt			X		X
Candelaria vitellina (Ehrh.) A. Massal.			X		
Candelariella aurella (Hoffm.) Zahlbr					X
Candelariella vitellina (Ehrh.) Müll. Arg.					X
Catillaria corymbosa (Hue) I.M. Lamb	X		X		
Cladonia cf. balfourii	X		X		
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.,			X		
Cladonia furcata (Huds.) Schrad	X				
Cladonia gracilis (L.) Willd. 1787,			X		
Cladonia metacorallifera Asahina	X				
Cladonia pyxidata (L.) Hoffm.			X		
Cladonia rangiferina (L.) Weber ex F.H. Wigg.			X		
Cladonia rangiferina var. vicaria (R. Sant.) Ahti	X		X		
Cladonia sp.	X	X		X	

Cladonia cf. sulphurina	X		X		
Collema coccophorum Tuck.					X
Cornicularia aculeata (Schreb.) Ach		X	X		
Cornicularia epiphorella (Nyl.) Du Rietz			X		
Cornicularia sp.				X	
Cystocoleus niger (Huds.) Har.	X				
Haematomma erythromma (Nyl.) Zahlbr.	X		X		X
Himantormia lugubris (Hue) I.M. Lamb	X	X	X		
Huea austroshetlandica (Zahlbr.) C.W. Dodge			X		
Huea coralligera (Hue) C.W. Dodge & G.E. Baker			X		
Hypogymnia lugubris (Pers.) Krog		X	X		
Lecania brialmontii (Vain.) Zahlbr.	X				X
Lecanora aspidophora Vain.	X		X		
Lecanora atra (Huds.) Ach.	X				
Lecanora dispersa (Pers.) Röhl.					X
Lecanora hagenii (Ach.) Ach.					X
Lecanora mons-nivis Darb.			X		X
Lecanora hagenii (Ach.) Ach.					X
Lecanora skottsbergii Darb.			X		
Lecanora sp.	X				
Lecidea sciatropha Hue					X
Lecidea sp.	X	X	X		
Leptogium menziesii (Sm.) Mont.			X		
Leptogium puberulum Hue			X		X
Leptogium sp.	X		X	X	
Mastodia tessellata (Hook. f. & Harv.) Hook. f. & Harv.		X			X
Ochrolechia antarctica (Müll. Arg.) Darb.	X				
Ochrolechia frigida (Sw.) Lynge	X	X	X		

Oevstedalia antarctica (C.W. Dodge) Ertz & Diederich						X
Pannaria hookeri (Borrer) Nyl.				X		
Pannaria sp.		X		X		
Parmelia saxatilis (L.) Ach.		X				X
Peltigera rufescens (Weiss) Humb.		X		X		
Pertusaria epibryon Redón				X		
Pertusaria sp.		X				
Physcia caesia (Hoffm.) Hampe ex Fürnr.				X		X
Physcia dubia (Hoffm.) Lettau						X
Physcia sp.		X				
Physconia muscigena (Ach.) Poelt				X		
Placopsis contortuplicata I.M. Lamb		X	X			
Polycoccum rugulosarium (Linds.) D. Hawksw						X
Psoroma hypnorum (Vahl) Gray				X		
Psoroma sp.		X	X	X		
Ramalina terebrata Hook. f. & Taylor	X	X		X		X
Rhizocarpon geographicum (L.) DC.		X		X	X	
Rhizocarpon sp.			X			
Rhizoplaca aspidophora (Vain.) Redón				X		X
Rhizoplaca melanophthalma (DC.) Leuckert				X		X
Sphaerophorus globosus (Huds.) Vain.		X	X	X		
Stereocaulon alpinum Laurer				X		
Stereocaulon glabrum (Müll. Arg.) Vain.			X			
Thelenella antarctica (I.M. Lamb) O.E. Erikss						X
Thelenella kerguelena (Nyl.) H. Mayrhofer						X
Tephromela atra (Huds.) Hafellner						X
Turgidosculum complicatulum (Nyl.) Kohlm. & E. Kohlm				X		
Umbilicaria antarctica Frey & I.M. Lamb	X	X		X		

Usnea acromelana Stirt.				X	X		X
Usnea antarctica Du Rietz		X		X		X	X
Usnea aurantiacoatra (Jacq.) Bory					X	X	X
Verrucaria elaeoplaca Vain.					X		
Verrucaria famelica Darb.							X
Usnea fasciata Torr.			X		X		
Verrucaria cf. maura			X				
Verrucaria microspora Nyl.					X		
Verrucaria racovitzae Vain.		X	X				
Verrucaria sp.	X						
Verrucaria tessellatula Nyl.					X		
Xanthoria candelaria (L.) Th. Fr.			X				X
Xanthoria elegans (Link) Th. Fr.			X	X	X		X
Xanthoria sp.			X		X		

ANEXO C.

Annex C. The phytosociology study in Stinker Point – Elephant Island in austral summer

	F	C	IES
Bryum argenteum Hedw.	2.673796791	0.0214	2.731016043
Crustose lichens	7.486631016	0.1176	8.367058824
Muscicolous lichenes	19.78609626	0.3428	26.56877005
Polytrichastrum alpinum (Hedw.) G.L. Sm	25.13368984	0.3112	32.95529412
Prasiola crispa (Lightfoot) Kützing	4.812834225	0.0647	5.124224599
Sanionia uncinata (Hedw.) Loeske	68.44919786	1.7647	189.2414973
Usnea acromelana Stirt.	7.486631016	0.1176	8.367058824
Bryum pseudotriquetrum (Hedw.) P. Gaertn., B. Mey. & Scherb.	3.743315508	0.0481	3.923368984
Ceratodon purpureus (Hedw.) Brid.	1.069518717	0.0107	1.080962567
Chorisodontium aciphyllum (Hook. f. & Wilson) Broth.	20.32085561	0.3529	27.49208556
Deschampsia antarctica E. Desv.	11.76470588	0.1337	13.33764706
Polytrichum sp.	8.021390374	0.107	8.879679144
Saxicolous lichens	59.35828877	1.7326	162.2024599
Andreaea sp1.	4.278074866	0.0481	4.483850267
Cladonia sp.	12.8342246	0.1765	15.09946524
Cornicularia aculeata (Schreb.) Ach	1.069518717	0.0107	1.080962567
Himantormia lugubris (Hue) I.M. Lamb	0.534759358	0.0107	0.540481283
Hypogymnia lugubris (Pers.) Krog	0.534759358	0.0053	0.537593583
Ochrolechia frigida (Sw.) Lynge	0.534759358	0.0053	0.537593583
Polytrichum sp.	1.604278075	0.0187	1.634278075
Psoroma sp.	1.604278075	0.016	1.629946524
Sphaerophorus globosus (Huds.) Vain.	3.20855615	0.0561	3.38855615
Stereocaulon glabrum (Müll. Arg.) Vain.	2.139037433	0.0214	2.184812834
Usnea aurantiacoatra (Jacq.) Bory	4.812834225	0.0642	5.121818182
Xanthoria elegans (Link) Th. Fr.	0.534759358	0.0053	0.537593583
Brachythecium austrosalebrosum (Müll. Hal.) Paris	1.069518717	0.016	1.086631016
Caloplaca cinericola (Hue) Darb.	0.534759358	0.0053	0.537593583
Herzogobryum sp.	2.673796791	0.0428	2.788235294
Marchantia sp.	0.534759358	0.0053	0.537593583
Mastodia tessellata (Hook. f. & Harv.) Hook. f. & Harv.	0.534759358	0.0053	0.537593583
Sphaerophorus globosus (Huds.) Vain.	5.882352941	0.0695	6.291176471
Synchitria sp.	6.417112299	0.0936	7.017754011
Usnea antarctica Du Rietz	22.45989305	0.3663	30.68695187
Hennediella heimii (Hedw.) R.H. Zander	4.278074866	0.0642	4.552727273
Naked soil	4.278074866	0.1016	4.712727273
Naked rock	2.673796791	0.0374	2.773796791
Andreaea sp2.	41.17647059	1.0963	86.31823529
Cephalozia sp.	0.534759358	0.0053	0.537593583

Himantormia lugubris (Hue) I.M. Lamb	14.97326203	0.1979	17.93647059
Lecidea sp.	1.069518717	0.0214	1.092406417
Placopsis contortuplicata I.M. Lamb	1.069518717	0.0107	1.080962567
Rhizocarpon geographicum (L.) DC.	0.534759358	0.0053	0.537593583
Bartramia patens Brid.	1.604278075	0.016	1.629946524
HEPATICAE	0.534759358	0.0107	0.540481283
Pohlia nutans (Hedw.) Lindb	0.534759358	0.0053	0.537593583
Pohlia cruda (Hedw.) Lindb.	1.604278075	0.016	1.629946524