Korean Journal of Polar Research
Vol. 5, No. 2, pp. 37-47, December 1994

Floristic Composition of Stinker Point, Elephant Island, Antarctica*

Antonio Batista Pereira and Jair Putzke

Department of Biology, Universidade de Santa Cruz do Sul-UNISC, P.O. Box 188.
96,815-010 Santa Cruz do Sul, RS, Brazil.

Abstract: This paper presents the floristic composition of Stinker Point, Elephant Island, Antarctica and explains the relationship with the presence of bird colonies, soil wind, air humidity, light and temperature. In this coastal ice-free area, which is partially uncovered by ice and snow during the austral summer, there are around 20,000 bird nests. This relationship was studied in the austral summer of 88/89 to investigate the flora, in 91/92 the phytossociology study was undertaken, using the quadrat method and in 92/93 the criovegetation study was introduced and a survey was made to examine the plant communities distribuition and their relationship with the habitat conditions was examined. As a result of the flora survey: 2 flower plants species, 29 moss species, 6 liverwort species, 54 lichen species and 3 macroscopic fungi were listed. These species are arranged in two formation types, with ten subformations and two associations.

Key words: floristic, Stinker Point, Elephant Island, Antarctica

INTRODUCTION

Elephant Island is located at latitude 61° 07 'S and longitude 55° 03' W (Fig. 1). According to the Istituto Hidrografico de La Armada de Chile (1989), this island has 37 Km in the E-W direction and an average of 16 Km width in the N-S direction. It is mountainous and totally ice-covered in the central area. The ice-free areas are coastal, but the access is very difficult because there are steep cliffs and the wind and waves are often very strong. The climate is different from all other islands in the South Shetland Archipelago, because it is located near the Weddell Sea ice field, with colder weather, and greater fog conditions and snow-fall.

Stinker Point (Fig. 1-2) is the largest coastal ice-free area and richest in flora and floristic in the Elephant Island. The other coastal ice-free areas are mostly composed, by steep cliffs near the sea, often without beaches. Through a survey undertaken by helicopter, the identification of small Usnea fields was possible. The ornithocoprofilous such as: *Caloplaca regalis* (Vain.) Zahlbr. and *Xanthoria elegans* (Link.) Th. Fr., which are very frequent in other coastal areas, are scarse here. However, Prasiola crispa is very abundant. We explain the distributions of this plant through the presence of the guano produced by 80,000 penguins, which live on the beach or on the plateaus and through the rare occurrence of Larus dominicanus which live on the top of coastal cliffs.

Stinker Point is partially uncovered by ice and snow during the Austral Summer. The area is limited to the northwest near the beach by the Sultan Glacier and to the south by the Endurance Glacier, the distance betwen the two glaciers is approximately 4,500 m, and from the beach to the glacier is 800.m in a straight line.

The principal objective of this paper is not to mention the factors that influence the floristic composition at Stinker Point, but to describe the type that was found by the fitossociology study and justify the differents associations by a discussion of the existing literature on the main influencing factor.

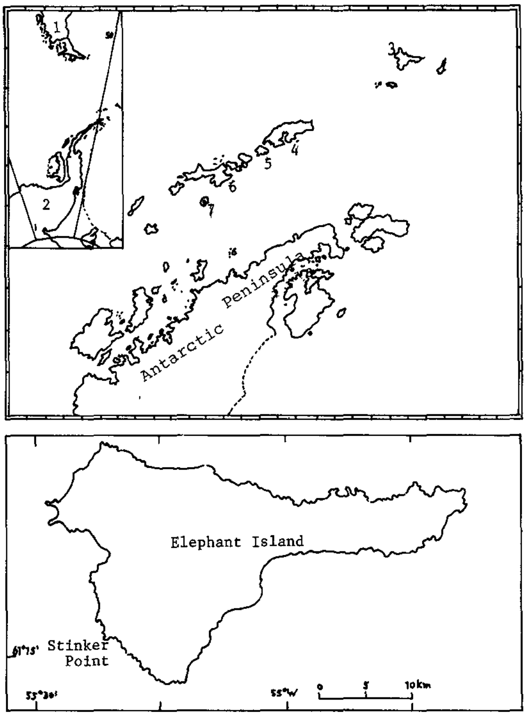

Fig. 1. 1. South of America; 2. Antarctica; 3. Elephant Island; 4. King George Island; 5. Nelson Island; 6. Livingstone Island; &. Deception Island

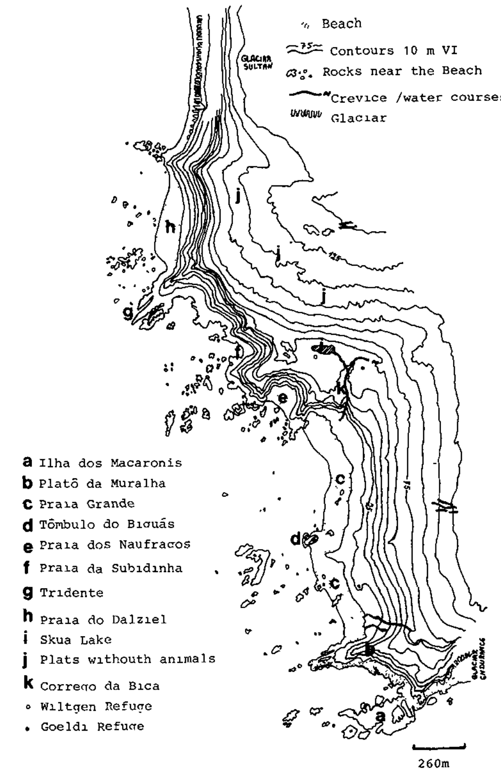

Fig. 2. Stinker Point Detailed Places

MATERIAL AND METHODS

The samples and data used in the present work were obtained in the field survey carried out in the 91/92 and 92/93 Austral Summers. The survey of the coastal ice-free areas around the island was made by helicopter in the March of 1993.

The methodology used was to take moss samples, the identification of the specific taxa and the ecological adaptations to each species studied followed Putzke and Pereira (1990). The methods of lichen collection, taxa identification and the data about the habitat were according to Redon (1985). The observation survey and description of the cryobionts and the terrestrial algae habitat and it's distribution, were based principally on Broady (1989a-b) and Kawecka (1986). The plant community nomenclature was based on Smith (1972) and Smith and Gimingham (1976), addapting their nomenclature to local formations and proposing new names to attend regional peculiarities.

RESULTS AND DISCUSSION

1. Vegetal Formation Found in Stinker Point

From the flora survey made on Stinker Point we listed two vascular plants (*Colobanthus quitensis* (Kunth.) Bartl. and *Deschampsia antarctica* Desv.), 38 (thirty eight) moss species, 7 (seven) hepatics, 68 (sixty eight) lichenes, two species of terrestrial algae [*Prasiola crispa* (Lightfoot) Menegh. and *P. cladophylla* (Carmich.) Menegh.] and 4 (four) macroscopic fungi. The species list is found on Putzke & Pereira (1995b).

The study of floristic and different types of vegetal formations requires the knowledge initially to consider the geographic region where they grow. Because the variation, relationship, and the wealth of the species, depends primery on the climate and the soil. For this reason we might consider that the Antarctic communities have little variability if compared with sub-tropical regions, but if com-

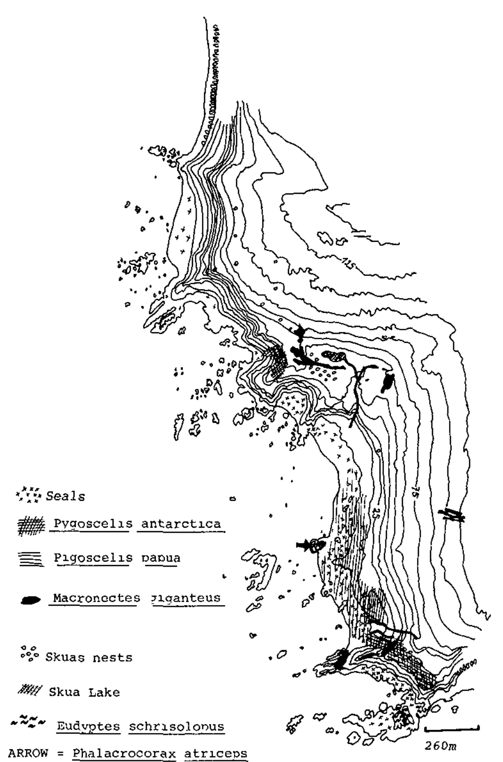

Fig. 3. Fauna distribution in Stinker Point

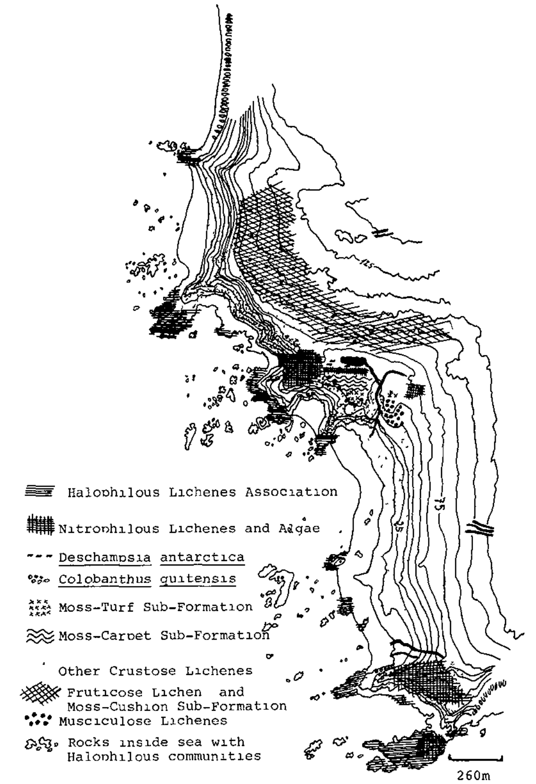

Fig. 4. Fauna Composition distribution in Stinker Point

pared with periglacial, they are not so disimilar.

In Redon (198S), Elephant Island is included in phytogeography elements that are dominant in the occidental coast of the Antarctic Peninsula and adjacent islands. This vegetal formation has a large number of species with the dispersal centre located in the Antarctic Peninsula, South Shetland, South Orkneys or South Georgia; occasionally the same populations reach the Falkland Islands and Tierra del Fuego.

2. Types of Vegetal Formations

1. Antarctic Cryptogam Tundra Formation
1.1 Fruticose Lichen and Moss-cushion sub-formation
1.2 Moss-turf sub-formation
1.3 Moss-calpet sub-formation
1.4 Moss-aquatic sub-formation
1.5 Crustose Lichen sub-formation
Ornitocoprophilous Association
Ornitocoprophobous Association
Halophilous Association
1.6 Musciculose Lichen sub-formation
1.7 Miscellany community cryptogam sub-formation
1.8 Terrestrial algae sub-formation
1.9 Cryophyta sub-formation
Red snow algae association
Green snow algae association
2. Antarctic Phanerogamic Tundra Formation

3. *Description of the Vegetal Formations and Sub-Formations Sat Stinker Point*

1. ANTARCTIC CRYPTOGAM TUNDRA FORMATION

In this formation there is a group of different subformation that depends on the non-vascular species found. The name of each formation is frequently based on the physiognomy of the vegetation and the species with higher biomass on it. The list shown above was based on the survey made at Stinker Point (Elephant Island), Nelson, King George (Keller and Fildes Peninsula, Turret Point) and Penguin Islands.

Fig. 5. Fruticose Lichen and Moss-Cuchion Sub-formation

Fig. 6. Moss-Turf Sub-Formation

Fig. 7. Moss-Carpet Sub-Formation

1.1 FRUTICOSE LICHENES AND MOSS CUSHION SUB-FORMATION

The predominant fruticulose lichenes in the area are *Usnea aurantiaco-atra* (Jacq.) Bory, *Usnea acromelana* Stirt., *Usnea antarctica* Du Rietz *Himantormia lugubris* (Hue) Lamb. Among the moss cushion, we have *Andreaea depressinervis* Card., *A. regularis* C. Muell., *A. gainii* Card., *Schistidium apocarpum* (Hedw.) B.S.G., *S. hialino cuspidatum* (C. Muell.) B.G. Bell., *Tortula saxicola* Card. and *Pottia heimii* (Hedw.) Mamp. This subformation is common on places free from bird colonies, where guano is not present. It is typically formed by nitrophobous species, found specially on higher places, distant from the coast. At Stinker Point the higher plateaus, North the Brazilian refuge, are dominated by this subformations (Fig. 5). Obviously, there are some areas with nitrophilous lichenes around the bird colonies, dominated by the fruticulose *Ramalina terebrata* HooK. f. et Tayl.

In some places the Moss-cushion is found isolated or mixed with crustose lichenes or with some foliose lichenes, like *Umbilicaria*.

1.2 MOSS-TURF SUB-FORMATION

Furse and Bruce (1972) reported a moss bank with 3 m depth in Elephant Island, being one of the biggest in Antarctica. However, we didn't find large turfes at Stinker Point, in spite of *Polytrichum* species are frequent but with small biomass. Following Smith and Gimingham (1976), who put *Chorisodontium aciphyllum* (Hook. f. et Wils) Broth in the Moss-turf Subformation, at Stinker Point there is a kind of very large turf (Fig. 6), the plateaus near the Brazilian refuges above the Naufragos Beach and in the higher places of Tridente.

1.3 MOSS-CARPET SUB-FORMATION

This subformation is formed specially by *Sanionia uncinata* (Hedw.) Loeske, *Calliergon sarmentosum* (Wahlenb.) Kindb. and *Calliergidium austro-stramineum* (C. Meull.) Bartr., occupying almost the entire ice free areas on the first plateau near the beach (Fig. 7). The last two species occur around, and the water flows originated from meltwater that cross the carpets. In the drier areas, this subformation is substituted by the *Chorisodontium* turf.

1.4 MOSS-AQUATIC SUB-FORMATION

Found only in the Skua Lake (Fig. 8), this subformation is composed of *Bryum pseudotriquetrum* (Hedw.) Schwaegr. and *Calliergon sarmentosum* (Wahlemb.) Kindb. at a depth of approximately 2 m. The water is rich in Guano, because the lake is visited by large groups of Skuas, but is poor in macro and microscopic algae.

1.5 CRUSTOSE-LICHEN SUBFORMATION

This sub-formation is composed by lichenes

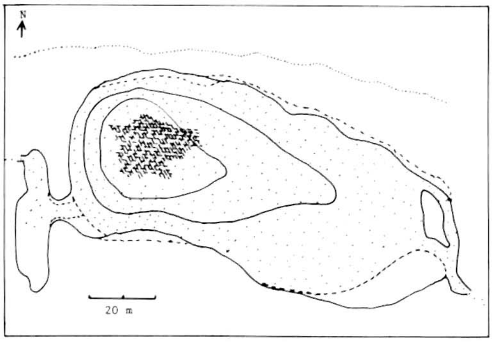

Fig. 8. Skua Lake

Fig. 9. Crustose Sichen Sub-Formation

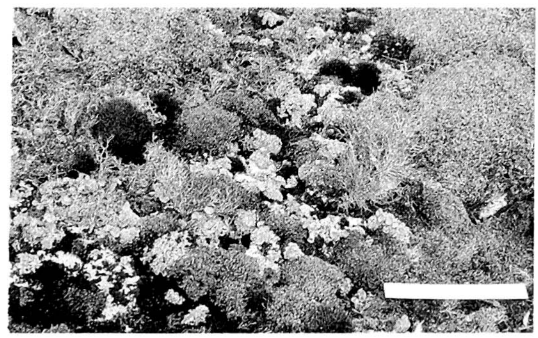

Fig. 10. Musciculose Lichen Sub-Formation

species, whose thallus is crustose (Fig. 9). This sub-formation may be divided into three associations:

1. Ornitocoprophilous: the richest in species and largest in this area, because there are large bird colonies; the most common species are *Xanthoria elegans* (Link.) Th.Fr., *Acarospora macrocyclos* Vain., *Haematomma erythroma* (Nyl.) Zahlbr., *Rhizoplaca* spp. and *Buellia* spp., amongst others.

2. Ornithocoprophobous: the most common species are *Placopsis contortuplicata* Lamb, *Lecidea* spp. and *Rhizicarpon geographicum* (L.) DC.

3. Halophilous: this association occurs in the intertidal zone and also includes the places washed by waves. It is composed mainly of *Verrucaria* spp. and *Caloplaca* spp., being found along the Stinker Point rocky coastal areas.

1.6 MUSCICULOSE LICHENES SUB-FORMATION

Found especially upon the carpet-mosses, sometimes so frequently that it is difficult to identify the parasited moss, which is normally killed by the lichen and then decomposed by fungi (Asco and Basidiomycotina are frequent). Species like *Ochrolechia frigida* (Sw.) Lynge, *Psoroma hypnorum* (Vahl.) Gray, *Usnea* spp., *Cladonia* spp., *Sphaerophorus globosus* (Huds.) Vain., *Stereocaulon glabrum* (Müll. Arg.) Vain, *Cornicularia aculeata* (Schreb.) Rch. and *C. epiphorela* (Nyl.) Du Rietz are common. Some foliose lichenes are also found.

1.7 MISCELLANY-COMMUNIIY CRYPTOGAM SUB-FORMATION

This sub-formation is found associated to such a degree that it is difficult to define which formation it belongs to. It is common on Stinker Point, especially in places where bird colonies are small, with few nests, early abandoned, like those built by Skuas. Sometimes there are large areas where Hepaticae are one of the characteristic species in the community, because *Lophosia exsisa, Cephaloziella varians* and *Marchantia* sp. are forming association mostly with *Sanionia uncinata* (Hedw.) Loeske, *Tortula saxicola* Card., *Bryum argenteum* Hedw., *Polytrichum alpinum* Hedw. and some musciculous lichenes.

1.8 TERRESTRIAL ALGAE SUB FORMATION

According to Broady (1982) knowledge about the Antarctic algae flora is accumulating slowly. Most phycological investigations have used direct microscopic examination of fresh or preserved material, however the rich diversity of terrestrial microscopic algae is revealed only by the use of culture techniques.

Works like Broady (1982) list 15 chlorophycean species from which five are new; Broady (1989b) lists 30 species, demonstrating that the Antarctic terrestrial algae flora is very rich, and probably that a lot of new species can be found.

The terrestrial algae flora composition of Stinker Point has been studied, the field survey and sample collections began in the 1992/1993 Austral Summer. Here, we present not a list of species, but the large terrestrial algae sub-formation that occurs in this ice-free area, near the beach and in first rocky elevations near the sea shore. No doubt it is basically represented by Prasiola crispa (Lightfoot) Menegh., in the vicinity of bird colonies, where there is considerable nutrient enrichment by the melt-water that carries the guano. This is the ideal habitat for the species which has been noted as one of the most nitrophilous organisms known.

According to Smith (1984), the *Prasiola crispa* (Lightfoot) Menegh growth is rapid from December to March, when the dry weight of individuals can double every two weeks, the maximum standing crops are near bird colonies where the substrate is rich in guano. This observation means that it is one of the antarctic plant that presents the most rapid growth.

1.9 CRYOPHYTA SUB-FORMATION

The presence of the cryophita communities on ice covered areas is the main factor responsible for the discoloration of snow and ice, and it is a frequent and natural phenomenon. In the cryovegetation there is a very interesting group of organisms, that live under unfavorable conditions, for example tempertures around 0°C and higher or lower light intensity. The difficulties for the field work, the microscopic observations and ilustrations, the rapid reproductive cycles and their peculiarities, have been the most difficult in order to know these organisms.

The cryobiological research is divided in to the following three periods by Kol (1975): 1. observation of coloured snows; 2. identification of nivicolous microorganism and its morphological, taxonomical and cytological research; 3. Iimnological, biological and culture researches.

It is important to note here that the cryovegetation is not composed only by algae, but that the occurence of fungi is also frequent, e.g. in Kol and Eurola (1973) four fungi species are listed; besides Bryales protonema. To Kol (1973) the red, green and yellow cryosestons are frequently in Antarctica, having highly different algae communities.

The first cryovegetation samples from Antarctica, according to Kol (1972), was by Dr. R.N. Rodmore Brown, botanist of the 1902-1904 Scottish National Antarctic Expedition, collected in Signy Island, South Orkney Islands. For this author the Antarctic cryovegetation might be grouped as follows: 1. cryovegetation of snow; 2. cryovegetation of ice; 3. facultative cryovegetation appearing in the seasonal ice of freshwater; 4. cryoedaphon.

In Kawecka (1986) about 460 species and varieties of snow algae have been identified, green and blue-green are more numerous but diatoms, euglenophytes, chrysophytes and dinoflagellates are also found in smaller quantities.

In the cryovegetation of Stinker Point we found two associations:

1. The red snow algae, which is very abundant, occur on the superficial snow layer and their basic biomass is *Chlamidomonas antarcticus* Wille, in different stages. However, a lot of different species in different stages of life cycle grow with it, where chlorophyte is more numerous.

2. The green snow algae is very frequent. This community occurs at the point of division between the soft snow and the ice, where there is a thin film of melt-water, which offers growth conditions to the algae. The floristic composition of this association is very rich. Field observation and cultures were started in the 1992/1993 Austral Summer.

The occurence of red snow algae on the superficie of the snow, can possibly to be explained by the presence of the reddish-brown pigment, which Ling and Sppelk (1990), protects the cells from the deterioration effects of ultraviolet or intense visible radiation. This fact also explains the presence of algae in deeper layers.

2. ANTARCTIC PHANEROGAMIC TUNDRA FORMATION

The Antarctic Phanerogamic Tundra Formation is usually composed by an association of *Colobanthus quitensis* (Kunth) Bartl. (Caryophyllaceae) and *Deschampsia antarctica* Desv. (Poaceae), that is very frequent in different coastal ice free areas in Penguin, Nelson and King George Islands (Turret Point and Keller Peninsula, in

Fildes Peninsula we didn't find *C. quitensis*). At Stinker Point this formation is represented by a field of *D. antarctica* that grows alone near Skua Lake and the *C. quitensis* was found on slopes near the beach.

THE FACTORS THIAT CONTRIBUTE TO THE FLORISTIC COMPOSITION AT STINKER POINT, ELEPHANT ISLAND, ANTARCTICA

The different types of vegetal association and formation, that occur at Stinker Point depend on the local conditions that are determinated by the factors described in the following:

1. Light

A shot discussion about light conditions in Antarctica is very important here, because this study is about a group of organisms whose growth depends on the light intensity. The first factor to be considered is the Antarctic day, in the Austral Summer, the sun does not set, in the Antarctic Winter, the sun does not rise.

The light conditions are very complex and depend on the place considered in the cryobiotope, because the intensity of light increases with the altitude and the depth the light radiation penetrates, increases with the density of snow, Kawecka (1986). The cryovegetation, principally the land plants, survive under conditions of light deficiency under a thick layer of ice and snow during the Antarctic winter. On the other hand the ultraviolet and the intense visible radiations are an important factor for the distribution of cryobionts algae, where the reddish-brown pigment protects the cells from the effects of these radiations, and is probably the reason for the occurence of the red-snow algae in the snow surface level and green-snow algae at depth.

Walton (1984) shows that in the polar environments the radiation, as part of the biological microclimate is complicated by snow. There are two distinct effects which must be considered: attenuation of radiation by the snow cover and high albedo of fresh snow which greatly increases, and heating on dark objects. The penetration of light in the snow is very important from a biological viewpoint. This effect is clearly observable in cryovegetation distribution, mostly in the red snow algae and green snow algae communities.

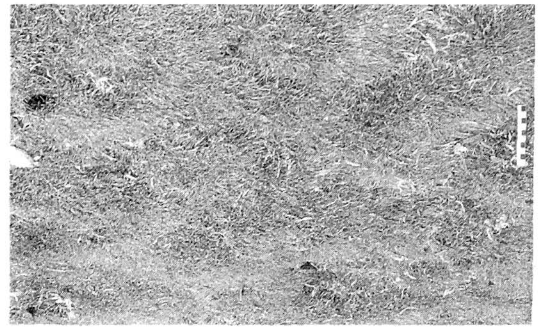

Fig. 11. Antarctic Phanerogamic Tundra Formation *Deschampsia antarctica*

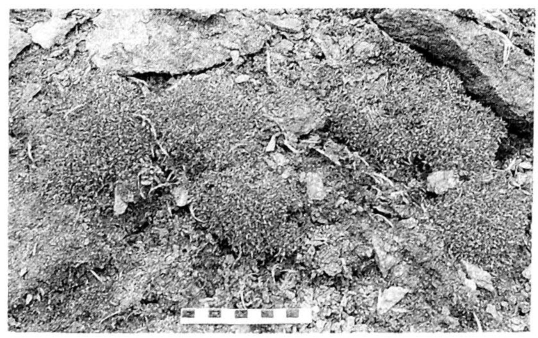

Fig. 12. Antarctic Phanerogamic Tundra Formation *Colobanthus quitensis*

Satyamurty et. al. (1989), describe a close relationship between snow, ice, albedo and temperature. If for any reason the snow cover increases, the albedo in present quickly, and the quantity of solar radiation absorbed decreases rapidly, the temperature falls favouring more ice formation and freezing the surrounding area.

Curl *et. al.* (1973), describe how the transmission of solar radiation in the snow cover, is important to ecological investigation of the snow algae. The intensity of radiation beneath the snow surface varies according to the wavelenght, with the major portion of energy found between 450 and 600 nm. However the absortion of radiation is a function of the water content and snow density. These coditions show that the absorption of solar radiation is very important in the distribution of the red snow and green snow algae.

2 Temperature

The temperature of the melting snow, taken on the surface as well as at a depth of 5 cm in the snow of the glacier is around 0° C, Kawecka (1986) it independs from the air temperature.

The low temperature to which the antarctic organisms are subjected, often for large periods in latent or dormant phases, has not yet been fully explained, only some general suggestions have been made, according to Kawecka (1986). This author believes that the plants survival is based on changes in the properties of the protoplast which undergoes gradual gelation, protecting the cells against deformation. The water permeability of cell membranes increases, thus facilitating the migration and preventing ice-cristal formation in the cells. The growing content of sugar in the tissues, the increment of cell osmotic pressure, causes a decrease of the freezing temperature. Thick cell walls are also efficient protection to prevent frozen cells.

Allison and Smith (1973) examined the changes in temperature of moss fields in Elephant Island, where they noted heat accumulation in the lower layers of the mosses colonies. The detected temperature at the plant-level (in *Polytrichum alpinum* Hedw., *Chorisodontum aciphyllum* (Hook. f. et. Wils) Brothh. and *Sanionia uncinata* (hedw.) Loeske, the last one named Drepanocladus) could be as much as 20°C or even more related to the air temperature, e.g. the heat accumulation reached a maximum of 32°C on a *C. aciphyllum* colony(5mm below apex) when the air temperature at 10cm was 8°C. So, the influence of this heat accumulation on the mycobiota on the moss field or colonies is obvious. Both saprofitic and parasitic fungi are independently influenced by the temperature (higher than those registred in the Antarctic climate) for their growth and reproduction, this means that they have some optimums for their development in some periods of the Austral Summer among the moss carpet.

It is interesting to note that the temperature is changed by the organisms using heat accumulation abilities. Heat accumulation also occurs on rock surfaces, where the saxicolous species are then affected. The color of the different lichenes obviously contribute to the heat accumulation of this large group. Blackish or darker species as *Himantormia lugubris* (hue) Lamb, *Alectoria nigricans* (Ach.) Nyl. and *Acarospora macrocyclos* Vain. can accumulate more heat, contributing to the development of other microorganisms.

Longton and Greene (1967), who study the influence of temperature on the growth and reproduction of Polytricchum alpestre in South Georgia, wrote that the growth begins some 3 to 4 weeks after the last winter snow has melted from the plants, ceasing some 4 to 6 weeks before the winter snow cover is re-established. It showed that the antarctic p!ants have a short period to complete their vegetative and reproductive cycles, and that this is a possible cause for the absence of a reproductive stage in a great number of Antacrtic species plants.

3. Wind

According to Walton (1984), the wind effects the Antarctic microclimate and the plant communities. It is mostly represented by three effects: 1- disturbance of local temperature and humidity; 2- abrasion damage due to transport of ice cristals and mineral particles; 3- transport of living propagules.

The relationship between wind, snow and plant life is not clear, and there have been no studies on this aspect, in our work in Maritime Antarctic, through field observations we found places where the rocks faces turned to the glaciers are very poor in vegetation, and rocks with faces turned to the sea are very rich. The prelinary data demonstrated that there are differences at purport humity in the wind which blowing from glaciar of sea.

At Elephant Island according to the Instituto Hidrografico de la Armada de Chile (1989), the predominant wind direction is NE and SW. The NE wind brings with it a nebulous weather and temperature elevation. The SW wind is mostly accompained by snow-fall and cold weather, and the NW wind brings strong tides.

4 Precipitation

According to Allen et. al. (1967), atmospheric precipitations can be important factors in the supply of chemical nutrients to an ecossystem, but very little data is avaliable about the chemical content of precipitation in Antarctica.

Lichen can absorb water directly from the rain, fog or atmospheric humidity according to Redon (1985), so it is important to the growth of the community, but wind and other climatic factors as sea conditions effect directly or indirectly effect the precipitation or water drainage (geological factors too).

5. Soil

The Antactic plant communities generally grow on the rocks like saxicolous lichenes or mosses. However, flowering plants like *Colobanthus quitenisis* (Kunth) Bartl. and *Deschampsia antactica* Desv. and some moss species grow on places with soil. This lither row mineral soil is originated from rocks and has a thick granulometry. It can be nutrient enriched (ornithogenic), by the substantial organic components derived from guano and bird corpse rest, which come from nest sites, carried by melt-water and wind. At Stinker Point the ornithogenic soil, is the most frequent at the vicinities of petrel, penguin colonies, and is generally located in the base and margin of cliffs near the beach.

According to Walton (1984), three major classes of antarctic soil can be recognised: ahumic, ornithogenic, and very small patches of humic soil occuring beneath the limited moss and grass stands. The Shetland Island comprise a transition, of the Sub-Antarctic to Antarctic, containing examples of both ahumic soils and humic, while the ornithogenic soils are associated with bird colonies.

The Antarctic soil can be identified as mineral and organic. The mineral soil results from the breakdown of rocks by physical processes (freezing cycles). The glaciar action and chemical weathering are also important.

Under the living vegetation there is usually a layer of firm brown material (dead) retaining the fibrous structures of the original plants. This layer may be only a few or several cm thick. In more stable grounds this organic peats can reach 1 to 2 meters deep. Some moss species of the genera *Andreaea* and *Shistidium* grow on the rock. In places where the drainage is fairly good, especially under vascular vegetation, development of mature brown soils occurs, as demonstrated by Allen et. al. (1966), which shows the composition of some of these soils studied in Sygny Island.

Allison and Smith (1973) concluded that there are no calcareus rocks or lavas and tufts in Elephant Island and consequently no rich-based soil. These authors discuss the results of the analysis of soil samples collected in Elephant Islands, concluding that the plant nutrient levels in the soils of this Island do not seem to be a limiting factor for plant growth, as Holdgate et. al. (1967), concluded for Signy Island.

In some places, the soil has been enriched by bird excrements (as described below), having higher contents of nutrients than other soils.

6. Bird colonies

Stinker Point is very rich in bird colonies and mammals. According to Furse and Bruce (1972), there are 12,455 Chinstrap Penguin (*Pygoscelis antarctica*) nests; 1,000 Gentoo Penguin (*Pygoscelis papua*) nests; 200 Macaroni Penguin (*Eudyptes chrysolophus*) nests; 3,065 Wilson Storrn Petrel (*Oceanites oceanicus*) nests; 1,056 Cape Pigeon (*Daption capensis*) nests; 555 Southern Giant Fulmar (*Macronectes giganteus*) nests; 1,705 Black-Bellied Storrn Petrel (*Fregetta tropica*) nests; 66 Brown Skua (*Cataracta lonnbergii*) nests; 48 Kelp Gull (*Larus dominicanus*) nests; 40 Blue-Eyed Shag (*Phalacrocarax atriceps*) nests and 13 Sheathbill (*Chionis alaba*) nests in Stinker Point.

The data obtained for this area by the researchers from the "Antarctic Continental and Marine Birds Project" from the Universidade do Vale do Rio dos Sinos - UNISINOS", (Rio Grande do Sul, Brasil), registered in the 87/88 Austral Summer, a total of 11,969 Chinstrap Penguin (*Pygoscelis antarctica*) nests; 1,879 Gentoo Penguin (*Pygoscelis papua*) nests; 1,462 Cape Pigeon (*Daption capensis*) nests; 750 Southern Giant Fulmar (*Macronectes giganteus*) nests; 40 Blue-Eyed-Shag (*Phalacrocorax atriceps*) nests; and the Black-Bellied Storrn Petrel (*Fregetta tropica*) was not estimated. In the December survey, the mammals were represented in the Austral Summer by 1,613 Southern Elephant Seals (*Mirounga leonina*); 45 Weddell Seals (*Leptonychotes weddellii*); 2 Crabeater Seals; 1 Leopard Seal (*Hydrurga leptonyx*) and 53 Antarctic Fur Seals. However, in their 1992 survey, the greatest Antarctic Fur Seal number was 1,180, and in 1993 (March 10) it was 2,024, this increase coincides with the presence of a great number of young penguins in the sea, which were in fledging and dispersal (Fig. 3).

In the 92/93 Autral Summer, when this field work was concluded, the birds and mammals were not surveyed, but in a superficial avaluation we concluded that the population in this year, was similar to the population previously.

The populations of birds and mammals at Stinker Point, that were cited above, specially bird colonies, help explain the floristic composition, mostly by the change of the substrate composition and condition, with chemical elements which are carried from the nest places by different agents, mostly the melt-water that runs from the glaciars. The large number of ornithocoprophobous species, and the small number of ornithocoprophilous, specially in higher places, outside the bird colonies and the absence of other species that have no tolerance to these conditions, are important characteristics of the floristic composition at Stinker Point.

Bird colonies are important factors to be considered in the plant community distribution.The influence is mostly due to production of the guano in these places, and the transport of it bymeltwater and wind. Fig. 3-4.

7. The sea

Stinker Point is an important area for studies about the influence of the sea upon the development of vegetation and especially plant succession. A lot of small rocks, sparce inside the sea water but exposed in low-tide or permanently projected and cliffs show very conspicuous plant zonations. *Verrucaria* species occur in a restricted area near the sea level in high-tide (sometimes below) up to 1 or 3 meters. This level receives strong influences of the sea and in some places, more exposed to the spray of salt water, it reaches about 4 meters, so this lichen community grows inclusively in this place. Above this area of constant influence of the sea we found the conspicuous *Caloplaca* spp zone, where the *Verrucaria* spp are rare or absent. Of course, this succession is also influenced by the wind, which contributes to the projection of spray (caused especially by braking wave) forward and by the proximity of bird nests or bird aggregation points, which allows the development of nitrophilous lichens (see discussion above), sometimes excluding the species of *Verrucaria* spp. When the bird colonies are absent this zone normally merges into the crustose lichens community (nitrophobous), with species of *Buellia* spp and *Lecidea* spp mostly, sometimes associated with fruticose species (*Usnea* spp and *Himantormia* sp) and Andreaea (Bryophyta). Lindsay (1971) observed the same succession in other islands of the South Shetland group.

The sea also has some influence on the Bryophyta distribution. At Elephant Island, firstly noted by Putzke and Pereira (1990), Muelleriella crassifolia (Hook f. et. Wils.) B.S.G. (Orthotrichaceae) was found, a moss that prefers habitats where the salt concentration is high, like cliffs near the sea. Probably occuring in the main islands of this archipelago, this species is, at this moment, the only one found on such habitat among the Bryophyta.

It is clear that sea spray must be considered as a source of nutrient supply, especially of Na, K and Mg Allen et. al. (1967) confirmed the extent of marine influence, explaining that nitrogen could be partially derived from the sea, being directly or indirectly of marine origin. The sea is the food supply for birds and mammals that, in turn, directly provides the nutrients to the nitrofilous plants and in some instances indirectly (to the other plant species, as well).

Of course, all the precipitated water (as snow or rain), comes from the ocean. Allen et. al. (1967) considered the ocean as a considerable source of ions in the precipitation of Signy Island. It shows that some plant nutrients are found on the sea surface of the southern ocean, and that in this region it represents an important source of air-borne nitrogenous material, among others, because there are mechanisms of exchange of substances between sea and air.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Lubomir Kovacik (Istitute of Botany - Academy of Sciences of the Czech Republic - Trebon - Czech Republic), for the pictures and Prof. Paulo Roberto Marcolla Araujo (Departamento de Letras - Universidade de Santa Cruz do Sul - UNISC - Sant Cruz do Sul - RS - BRASIL) and Mike Dearnaley Bsc PhD (HR Wallingford Ltd, Howbery Park, Wallingford, Oxfordshire, UK) for the English revision and cor-

rection.

REFERENCES

Allen, S. E.; H. M. Grimshaw and M. W. Holdgate 1967. Factors affecting the availability of plant nutrients on an Antarctic island. *Journal of Ecology* **55:** 381-396.

Allison, J. S. and R I. L. Smith 1973. The vegetation of Elephant Island, South Shetland Island. *Br. Antarct. Surv. Bull.* **33/34:** 185-212.

Broady, P.A. 1982. New records of Chlorophycean Micro-algae cultured from Antarctic Terrestrial habitats. *Nova Hedwigia* **36:** 445-484.

______. 1989a The distribution of *Prasiola calophylla* (Carmich) Menegh. (Chlorophyta) in Antarctic freshwater and terrestrial habitats. *Antarctic Science* **1(2):** 109-118.

______. 1989b. Survey of algae and other terrestrial biota at Edward VII Peninsula, Marie Byrd Land. *Antarctic Science* **1(3):** 214-224.

Curl, H. JR., J.T. Hardy and R. Ellrmeier 1973. Spectral absorption of solar radition in Alpine snowfields. *Ecology* **53(6):** 1189-1194.

Furse, J. R and G. Bruce 1972. Ornitology Report Annex F. in *Scientif Report, on the Joint Service Expeditions, England to Elephant Island* 1970-71: fl-fll, 5 tables, 11pag. and 19 maps.

Holdgate, M.W.; S.E: Allen and M.J.G. Chambers 1967. A preliminary investigation of the soil of Signy Island. South Orkey Islands. *Brit. Ant. Surv. BulL* **12:** 53-72.

Instituto Hidrografico de la Armada de Chile 1989. *Derrotero de la costa de Chile*, Vol. VI 2a ed., 363 pag.

Kawecka, B. 1986. Ecology of snow algae. *Polish Polar Research* **7(4):** 407-415.

Kol E. 1972. Snow algae from Signy Island (South Orkney Islands, Antarctica). *Annales Historico-Naturales Musei Nationalis Hungarici* 64: 63-70.

______. 1973. Green snow from Haswel Island (Antarctica). *Annales Historico-Naturales Musei Nationalis Hungarici* **65:** 58-62.

______. 1975. Cryobiological researches in the High Trata I. *Acta Botanica Academiae Scientiarum Hungaricae* **21 (1-2):** 61-75.

______ and S. Eurola. 1973. Red snow in the Kilpisjärvi Region, North Finland. *Astarte* **6:** 75-86.

Lindsay, D.C. 1971. Vegetation of the South Shetland Island. *Br. Antarct. Surv. Bull.* **25**: 59-83.

Ling, H. U. and R. D. Seppelt 1990. Snow algae of the Windmill Islands, Continental Antarctica. Mesotaeniurn berggenii (Zignematales, Chlorophyta) the algae of gray snow. *Antarctic Science* **2(2):** 143-148.

Longton, R. E. and S. W. Greene 1967. The growth and reproduction of *Polytrichum alpestre* Hoppe on South Georgia. *Philosophical Transaction of the Royal Society Series B* **252:** 295-322.

Ochyra, R and J. Vana 1989. The hepatics of King George Island, South Shetland Island, Antarctica, with particular reference to the Admiralty Bay region. *Polish Polar Research* **10 (2):** 183-210.

Putzke, J. A. B. Pereira 1990. Mosses of King Geroge Insland, Antarctica. *Pesquisa Antartica Brasileira* **2(1):** 17-71.

______. 1995a. Macroscopic fungi from the South Shetland Islands, Antarctica, (in press).

______. 1995b. The preliminary check list of land plants of Stinker Point, Elephnat Island, Antarctica, (in press)

Redon, J. 1985. *Lichena Antarticos*. Santiago. Instituto Antartico Chileno (INACH)

Satyamurty, P., V. B. Rao and Y. Yamasaki 1989. Caracteristicas e processos fisicos que afetam o clima da Antártica. in Pereira, E. B. and V. W. J.H. Kirchhoff. Ciências atmosféricas e espaciais na Antática, *Publ. Instituto de Pesquisas Espaciais e Sociedade Brasileira de Geofísica*: 139-161.

Smith, R. L. 1972. Vegetation of the South Orkney Island with particular reference to Signy Island. *British Antarctic Survey Scientific Reports* **68:** 124 pg.

_____ 1984. Terrestrial plant biology of the sub Antarctic and Antarctic. In: *Laws, R.M. (ed.), Antarctic Ecology voL 1.* Academic Press, London.: 61-161.

_____ and C. H. Girninghan, 1976. Classification of cryptogamic communities in the maritime Antarctic. *Br. Antarct. Surv. Bull.* **43:** 25-47.

Walton, D. W. H. 1984. The terrestrial environment. In Laws, RM. (ed.) *Antarctic Ecology Vol. 1* Academic Press, London.: 1-60.