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SURVEY, COLLECTION AND PRESERVATION OF LOWER PLANT DIVERSITY IN ANTARCTICA, WITH SPECIAL REFERENCE TO BRYOPHYTA

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ABSTRACT

Antarctica, also known as the frozen continent, is the only geographic region in the world where vegetation is dominated by Cryptogams. The harsh climatic conditions met with in the continent has restricted its terrestrial biological diversity to ice-free areas of coastal outcrops and offshore islands, inland nunataks, mountain ranges and oases. The paper, gives a brief overview of the biodiversity profile of Antarctica and provides detailed methodology for survey, collection, preservation and study of its bryophytes.

INTRODUCTION

Extending northward from South Pole to 66.67° South latitude or the 'Antarctic Circle', Antarctica has a total area of about 14 million sq. km, with its 98 per cent landmass covered under ice. If the entire ice cover on Antarctica is removed, its size will be reduced to just 7 million sq. km. The entire continent is surrounded by frozen ocean, the extent of which varies from about 2.65 million sq. km during summers to about 18.8 million sq. km during winters. Because of this fluctuating size Antarctica is also known as the "pulsating continent" The ice sheet covering the continent is on an average 2450 m thick and at places it is as thick as 4750 m. The total volume of the Antarctic ice is estimated to be 24.5-30 million cubic km which accounts for almost 91 per cent of the world's total ice. Interestingly, it is estimated that about 75 per cent of the world's fresh water is locked in the Antarctic ice. If for any reason this ice were to melt it will result in the rise of sea level around the world by 50-75 m. The 32000 km long coast-line of the continent largely comprises ice-shelf (about 44 per cent,) ice cliff (38 per cent), glaciers (13 per cent) and only 5 per cent of its coast-line is rocky. Every year about 1450 cubic km of ice-shelf is lost in the form of icebergs. At the same time approximately 1700 cubic km ice is added to the continent each year through precipitation or wind blown snow.

Antarctica, also known as the frozen continent, is the land of many superlatives. It is the "remotest" continent situated about 990 km from the southern most tip of South America,

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2000 km from New Zealand, 2500 km from Australia, 4000 km from South Africa and about 12000 km from India. It is the highest continent in the world with an average altitude of about 2300 m above mean sea level, which is approximately three times higher than any other continent. It is the coldest continent with average temperature ranging around 0°C in the coastal areas during the summer and –30° to –15°C during winters, whereas in the interior of the continent temperature ranges between –35° to –15°C in summers and –70°C to –40°C during winters. It is also the driest continent in the world with average precipitation ranging between 50-150 mm in the form of either fallen or wind blown snow. It is the lack of free water that imposes an absolute limit on the occurrence and distribution of both plants and animals in the continent.

THE BIOLOGICAL DIVERSITY

Antarctica's present geographic isolation in the polar region, blanketed under thick ice cover, is the result of long and complex geological evolution. Until about 200 million years ago, Antarctica was situated in the southern temperate region in the centre of super-continent "Gondwanaland" surrounded by South America, Africa, India, Australia, New Zealand, etc. This fact is borne out by innumerable geological and palaeontological evidences, especially the discovery of fossil deciduous conifer, *Glossopteris* and the fern *Dicroidium*, etc. But as the Gondwana began to break towards the end of Jurassic some 160 million years ago and continents began to drift due to convective motion of the huge water masses, Antarctica was completely separated during the Tertiary period. It is presumed that until about 50 million years ago Antarctica had evergreen, temperate vegetation with associated plant and animal species. But the changed climatic conditions prevalent in the continent because of its present geographic location have almsot entirely wiped out all the biota from the region.

Because of its harsh environmental conditions (low temperature, low humidity, rocky soil, raging winds/blizzards and extreme seasonal variations) the terrestrial habitat in Antarctica is one of the least densely populated and differentiated on the earth. In terms of availability of water and the temperature regime, the two vital environmental factors, the Antarctica represents climatically the harshest region of the world. The only parallel of the Antarctic biome that could be seen elsewhere, though with only a small degree of overlap, is that with arctic and alpine tundra. Whereas, the extreme conditions met in the interior of the continent more or less present the "Martian environment" (Vishniac & Mainzer, 1973; Walton, 1987; Singh & Semwal, 2000). The Antarctic terrestrial biological diversity is, therefore, confined to ice-free areas of coastal outcrops and offshore islands, inland nunataks, mountain ranges and Oases.

The bryophytes, because of their poikilohydric nature and alternative strategy of adaptation, are one of the very few plant groups which grow in Antarctica. As such, their role in habitat modification, nutrient cycling, primary production and providing shelter and security to associated invertebrate animals - the bryobionts, bryophiles, bryoxenes as well as occasionals, assume a particular significance. Incidentally, barring just two species of vascular plants, *viz. Deschampsia antarctica*, a grass belonging to family Poaceae, and *Colobanthus quitensis*, a pearlwort of family Caryophyllaceae reported to be occurring in Antarctica (Seppelt & Broady, 1988), the only other groups of plant recorded from the icey continent include lichens, fungi, algae and bacteria. Thus the antarctic continent, with its off-lying islands, is unique in being the only major landmass almost entirely vegetated by cryptogams, with the lichens predominanting in drier, more exposed situations, while the bryophytes dominate in the more sheltered and moister habitats. The antarctic flora in general is impoverished due to both, harsh environment and isolation of the continent because of vast, cold and turbulent oceanic barrier of the southern seas.

The bryophytic flora of Antarctica comprise about 70 species of mosses and 14 liverworts (Seppelt, 1986). But most of these are confined to maritime antarctic region, i.e. more northernly part of Antarctic Peninsula and the islands to the north, whereas the continental Antarctic bryoflora is characterised by just a few species of generally wide distribution belonging to 8-10 genera only, *viz. Bryoerythropyllum*, *Bryum*, *Cephaloziella*, *Ceratodon*, *Dicranella*, *Didymodon*, *Grimmia*, *Plagiothecium*, *Pottia* and *Sarconeurum*. *Bryum* is the largest moss genus occurring in antarctica. But, because of great phenotypic plasticity exhibited by it in response to extreme environmental conditions, coupled with general lack of sporophytes make this as taxonomically most difficult and confused genus in the continent. *Sarconeurum*, a monotypic moss genus widely distributed in Antarctica and southern South America (Green, 1975; Matteri, 1982), shows the southern most distribution by any bryophyte, being recorded at 82°42'S latitude (Wise & Gressit, 1965).

The land here roughly comprises three habitats, with declining complexity and variety of ecosystems, characterised by the increase in latitude and severity of weather conditions :

- The sub-Antarctic zone encompassing the islands between 46°-55°S latitudes North of the Antarctic Circle.
- The Antarctic Ocean comprising Antarctic Peninsula and surrounding Archipelago, and
- The Continental Antarctica comprising the landmass within the polar or Antarctic circle (66.7°S latitude).

Most of the biodiversity, both plants and animals (Table 1) recorded from Antarctica are found along the western coast of Antarctic peninsula, on the nearby Archipelago and on the islands North of the Antarctic circle.

Table 1. Biodiversity Profile of Antarctica

Groups		***No. of Species**
	Plants	
Algae	...	700 (239)
Fungi	...	52 (17)
Lichens	...	200 (28)
Bryophytes	...	84
Mosses	...	70 (9)
Liverworts	...	14
Angiosperms	...	02
	Animals	
Mites	...	50
Spring-Tails (Collembola)	...	20
Diptera	...	02
Tardigrades	...	28
Nematodes	...	51
Few species of Protozoans, Turbellarias and fresh water crustaceans :		
Seals	...	7
Whales	...	10
Birds (including 8 spp. of Penguins)	...	58

COLLECTION AND PRESERVATION

As the herbarium is a great filing system for information about plants, both primary in the form of actual specimens and secondary in the form of recorded field notes, drawings,

* Approximate. The number in the parenthesis indicates number of taxa recorded from Schirmarcher Oasis - the hub of Indian activity in Antarctic.

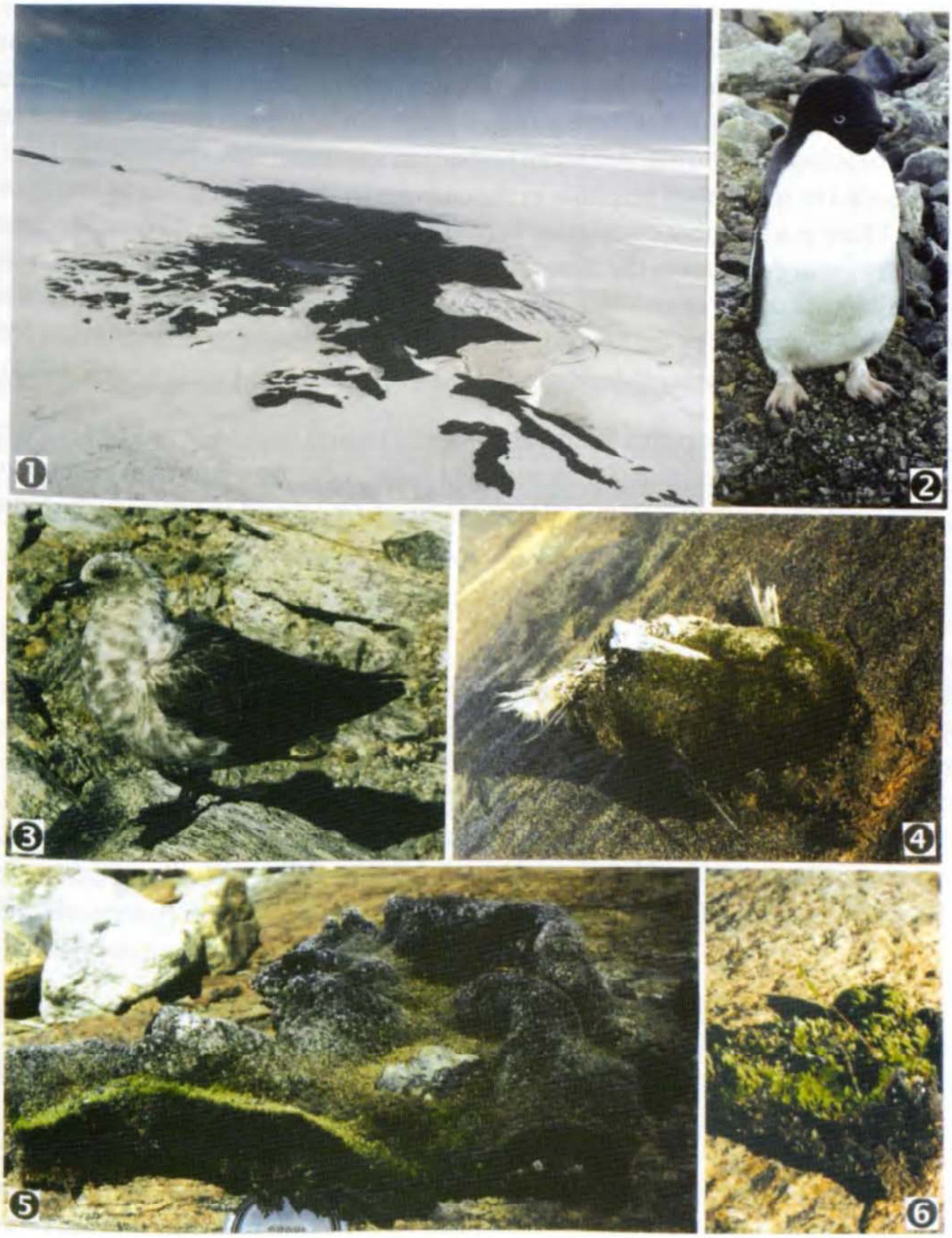

Plate I : 1. An aerial view of Schirmarcher Oasis, East Antarctica–the hub of Indian activities; 2. An adelie penguin (*Pygoscelis adeliae*); 3. A South Polar skua (*Catharacta macromicii*); 4. Moss cushion on biogenic remains of snow petrel; 5. Moss turf comprising *Bryum pseudotriquetrum* (Hedw.) Schwaegr; 6. Sporophyte bearing plants of *Pottia heimii* (Hedw.) Hamp.–a rare phenomenon in Antarctica.

etc. It functions as a centre for assimilation and dissemination of all basic information about plants. It is of particular interest in case of bryophytes and lichens, which are well known for their capacity to absorb, accumulate and retain not only minerals but also toxic pollutants. Thus the herbarium specimens of these group of plants can be used in biogeochemical analysis as well as pollution monitoring. Antarctic herbarium specimens also provide the time series material needed to study plant response to the changes in stratospheric ozone levels over the continent. There is a negative correlation between the UV-protective flavonoid pigments in the moss *Bryum argenteum* in the Antarctica and the ozone levels as calculated from UV-B radiation measurements since 1960. This potential "ozone-monitoring" capability of mosses is being further examined by the analysis of herbarium specimens of *B. argenteum* collected during late nineteenth century (Markham & al., 1990; Russell & Lewis Smith, 1993).

The biological collections from the Antarctic region date back to 1844-47 when Sir J.D. Hooker collected specimens of mosses and lichens during a British Antarctic voyage. These have been housed in museums and herbaria around the world and provide the foundation

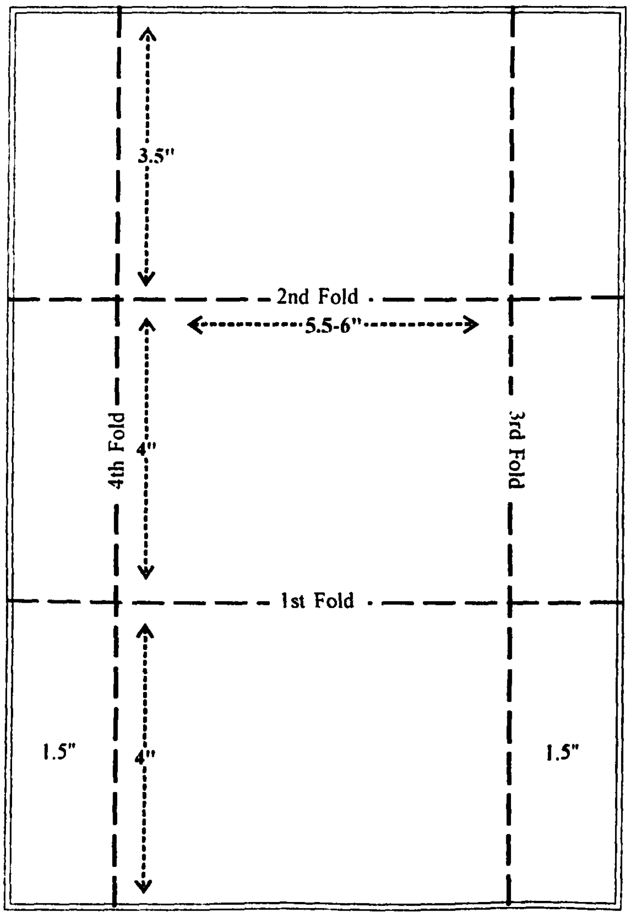

Fig. 1. Layout of the Herbarium packet.

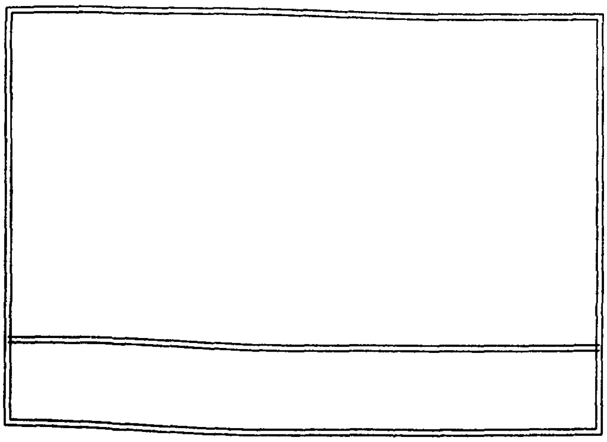

Fig. 2. The herbarium packet in front view.

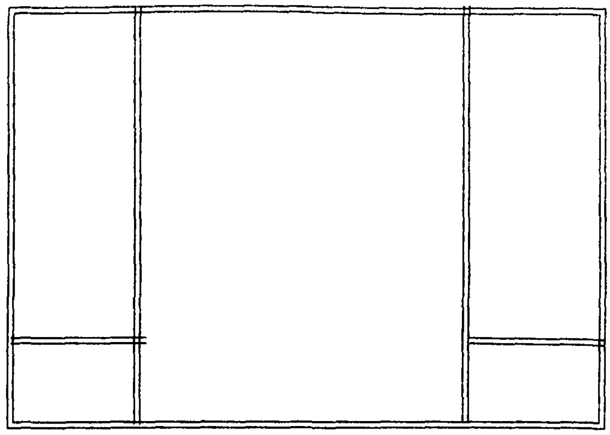

Fig. 3. The same in back view.

of all the subsequent research on the biology and ecology of plants of the Antarctic and sub-Antarctic biomes. Study of these collections has provided insight into the taxonomy, distribution and phytogeographical relationship of the flora of southern continental landmass. While the assessment of early biological surveys in Antarctica was basically systematic in nature, the importance of taxonomy in Antarctic biological research declined as the ecological and physiological researches gained ground.

As the bryophytes usually grow closely adpressed to the substratum, for bryological field work one needs large, rather sharp sheath knife with non metalic handle (for scraping the specimens from various habitat type, such as soil, rock faces or crevices), and a good doublet or triplet hand lens of about 10 to 20 × having a field of about one centimetre or more. It is important to learn the use of such lens in the field as it allows one to be effectively selective in making collections. The material should be collected with as much little substrate as possible. Because of their small size and the multitude of habitats in which they grow one requires a really keen eye to locate them in the field.

A good specimen, which in case of bryophytes may constitute part or sometimes the entire population, is about the size of one's palm, although at times only a smaller amounts may be found. While collecting the specimens, a part of the population should always be left, especially if the species is not common, to allow its natural growth. So long as there is sufficient material to facilitate necessary dissections and storage, the specimen would be adequate to establish record. But such minimal collection should normally be restricted to rare or interesting species and in normal cases efforts should be made to gather 50-100 plants if possible. The specimens are of maximum value when they are collected as whole plants. Tufted terrestrial species should be separated into thin slabs and as much soil removed as possible. It is always useful to remove a few plants from the substrate and packet them seperately when the species is small and the individuals are somewhat scattered.

In the field, specimens are collected in an envelop or small craft paper bag or brown paper sacks. The data can be written directly on such bags/packets with soft pencil or waterproof ink. Alternatively prenumbered bags/packets could also be used and the field data is recorded by that number in the field book. Each collection should be separately packaged in the field for subsequent study. Plastic bags should normally be avoided for the collection of herbarium specimens of bryophytes because the wet specimens have a tendency to mold.

Collections in the paper bags/packets can be air dried without transfer. While drying the specimens care should be taken to apply very little pressure to save them from getting distorted. It is advisable to remove as much of the substrate material as possible in order to get clear and thin specimens.

The preservation of collected specimens in case of bryophytes is very simple. Collections are usually preserved in Herbarium Packets, folded from a standard 8.5-9" × 11" brown sheet, with a finished size of 5.5"-6" × 4". Such packets can be easily made with the help of either a file card of identical size or an improvised "Packet Machine" made from an old file folder or card. As the bryophytes in general have a very high content or flavonoids and turpenoids, which render them a natural antibiotic, fungicide and pesticide, poisoning of the specimens is normally not required. The storage of specimens without poisoning has another advantage too. Bryophyte propagules (both spores as well as vegetative regenerants) have very long viability. As such even herbarium materials can sometimes be used for propagation of bryophyte species.

Name of the species and other collection data is written on the labels which can be printed directly on the packet or printed separately and pasted on the packet. The labels may be plain or have the map or the area of study. The mininum data for the specimen should include : scientific name with authority; family name; state, country and location (with altitudes etc.); vegetation type; life-form; substrate; collector name; date of collection; field or collection number and the name(s) of the identifier. The coordinates of the locality, if provided, greatly help in phytogeographic work.

In packeting specimens it should be kept in mind that often rare species are found in admixture, with just a few plants occurring. Such plants of individual species should be sorted out and packeted in small packets made of tissue paper or lens tissue. Similarly fertile plants of a species (it only few of them occur) should be singled out and wrapped in individual, small packets.

Properly identified and curated specimens can be stored in trays in airtight steel herbarium cabinets with fumigant or pest strips. Usually a natural system may be followed for arranging the specimens whereby related families and genera are located near to one another. Smaller herbaria and the amateurs may conveniently file the packets alphabetically by family or genera and genera/species similarly arranged within family/genus. The herbarium packets can also be stored in shoe boxes or other card board boxes on shelves or in metal cabinets. In many herbaria sometimes the packets are glued to standard herbarium sheet, which are in turn placed in folders in large drawers or pigeon holes. Such practice, however is not recommended for maintaining bryophyte collections.

STUDY OF MATERIAL

The collected material can be studied fresh or dried first to work over leisurely at a later date. In the latter case, the specimens should normally be soaked in the warm water to allow them to regain their shape. Smaller species and individual shoots of large species can be advantageously studied while placed in water in a watch-glass or petriplate. For critical study of various morphological details of *Key Characters* a compound microscope is essential.

For the identification of bryophytes a proper understanding of the structure or morphology of various groups is necessary. Accordingly cross-sections and dissections are to be made as per the requirement of the *Identification Key* which should invariably be derived from both gametophytic and sporophytic features. However, as the dominant generation in bryophytes as a whole is a gametophyte, the variations in its structure is normally and conveniently (as in many case sporophytes are very rare) utilised to segregate families, genera and species. But Antarctic environmental conditions, such as extremes of temperature and moisture availability, wind erosion, chemical enrichment near animal colonies, invertebrate grazing, fungal parasitism and exposure to UV-B radiation in early summer when ozone depletion is greatest (Russell & Lewis Smith, 1993), lead to great phenotypic variability including poor development of reproductive structure or complete sterility, thus making the identification difficult. Therefore, repeated and comprehensive biological collections encompassing the entire range of variability displayed by an individual species, is important for solving identification related problems. Many of the taxonomic and phytogeographical problems relating to bryophytes may be solved by laboratory culture studies, especially if the sporophytic development could be induced.

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