

Some observations on the Biota of the Vestfold Hills, Antarctica

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The icy Antarctic continent has an extent of nearly 14 million sq. Kilometers of which 4% is exposed rocky area (Lamb, 1970). The Vestfold Hills is one of the of the largest exposed areas on this continent (Johnston *et al.*, 1973), which supports considerable biota consisting of remarkably few species. The major limiting factors are the severe climatic and physical factors which minimize colonizing places and sources of food. These severe conditions restrict the terrestrial plant life to a few flowering plants, lichens and mosses (Holdgate, 1977).

Inshore waters of the Vestfold Hills is remarkably rich in marine algal flora and invertebrate as well as vertebrate fauna (Blandford, 1975; Johnston *et al.*, 1973).

The present paper gives in brief some observations made during 1983 Australian National Antarctic Research Expedition on the biota of the Vestfold Hills. Attempts have been made to relate the animal species to the abundance of food available during the seasons.

Description of the Area

The Vestfold Hills lie between latitudes 68°22's and 68°40's and longitudes 77°49'E and 78°33'E, on the eastern side of the Prydz Bay on the coast of Princess Elizabeth land (Fig. 1). The triangular 500 sq. km. ice free area is bounded by the Sorsdal Glacier on the southern side, by the sea on the north-west and the ice cap to the east. There are hills upto 160 m. high, moraine and lake filled valleys, offshore islands and fjord like inlets which penetrate deeply in to the area. There are four

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fjords, 66 saline and more than 100 freshwater lakes (Fig. 1). The salinity of these lakes varies from fresh to hypersaline depending on their proximity to the ice cap and the sea.

Climate

The climate of the Vestfold Hills is cold, dry and windy, typical of the Antarctic coastal belt. Temperature remains below freezing except during summer when it rises above zero. Katabatic winds are common along the coastal Antarctic areas. In summer, exposed rocks warm the surrounding air that induces sea breeze (Streten, 1969) Precipitation is received mostly in the form of snow during winter and very rarely as rain during summer. Most of the snow melts during summer providing the only source of moisture. The mean annual humidity is about 62% (Heywood, 1972).

Sea ice

The sea ice affects the biota of the Vestfold Hills. The formation of sea ice usually starts during early April and increases in thickness until November. Annual growth and breakup of sea ice and Vestfold Hills has been described by Mellow (1966) and McLeod (1967) where the average thickness of sea ice was recorded to be 2 m. The plant life during winter was limited by the seasonal low levels of light with further attenuation by the ice and snow covering.

During summer strong radiation and relatively high temperature causes rapid melting of the sea ice. The exposed surface of the inter-tidal zone remained barren due to the scouring of the sea ice which prevented settlement of floral and faunal elements in this region.

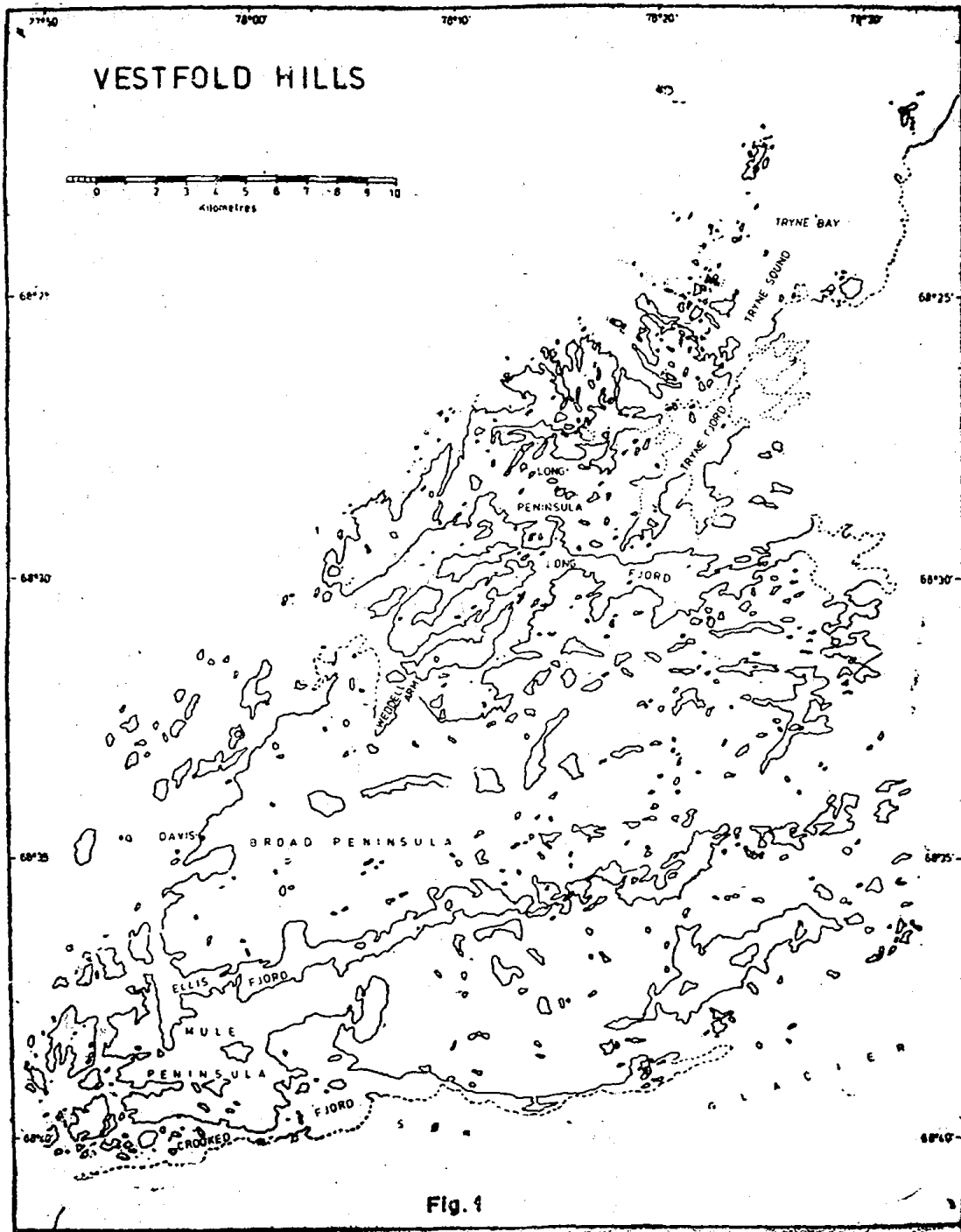
Biota

As compared to the other parts of the world, exposed areas of Antarctica such as the Vestfold Hills support diverse biota comprising unique animal and plant species. According to Skottsberg (1962) *Lithothamnion* and related genera known from mesozoic period have produced various species that can withstand wide temperature and salinity ranges.

Marine benthic flora showed marked seasonal differences in species composition. The phaeophyta showed luxuriant growth during summer while Rhodoyhyta dominated the entire area. The average biomass was estimated to be 1.43 kg/m².

Marine invertebrates were found to be associated with seaweeds and other sheltered and protected places. However, a few localities along the Vestfold Hills showed dominance of the invertebrate species. Few invertebrate species of protozoa, nematodes and mites were also found to survive and thrive well during the Antarctic Austral summer.

The vertebrate marine life was mainly represented by the birds and pinnipeds.



Eight bird species including two penguins and five seal species have been recorded from this area (Table 1&2). The terrestrial communities belong to bacteria, fungi and algae with widely distributed flora of Lichen and mosses.

Marine Flora

Distributions of Antarctic marine algae was summarized by Papenfus (1961). Some of the genera recorded are unique and endemic to the area. Since many new species have been recorded from various localities of Antarctica, the revision of the recorded taxa is necessary.

Table 1
ANNUAL CYCLE OF ANTARCTIC BIRDS AT THE VESTFOLD HILLS

BIRD SPECIES	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE
EMPEROR PENGUIN	← HATCH →		← CHICKS →			← CHICKS LEAVE →		← MOULT →			← LAY → INCUBATE →	
ADELIE PENGUIN			← RETURN →	← LAY →	← INCUBATE →	← HATCH →	← CHICKS →		← CHICKS LEAVE →	← MOULT →		
GIANT PETREL (NELLIE)		← RETURN →	← LAY →	← INCUBATE →	← HATCH →	← CHICKS →			← CHICKS FLY →	← LEAVE COLONY →		← FEW SEEN DURING WINTER →
CAPE PIGEON (PINTRADO)			← RETURN →	← LAY →	← INCUBATE →	← HATCH →	← CHICKS →		← CHICKS FLY →	← LEAVE →		
SNOW PETREL		← RETURN →	← LAY →	← INCUBATE →	← HATCH →	← CHICKS →		← CHICKS FLY →	← ADULT LEAVE →		← SOME STAYS DURING WINTER →	
ANTARCTIC PETREL			← RETURN →	← LAY →	← INCUBATE →	← HATCH →	← CHICKS →			← CHICKS FLY →	← LEAVE →	
WILSON'S STORM PETREL			← RETURN →	← LAY →	← INCUBATE →	← HATCH →	← CHICKS →		← LEAVE →			
MCCORMICK SKUA			← RETURN →	← LAY →	← INCUBATE →	← HATCH →	← CHICKS →		← CHICKS FLY →	← LEAVE →		

Inshore waters of the Vestfold Hills showed abundance in benthic marine algae. Fjords, islands and coastal areas were found to be inhabited with diverse algal flora providing a favourable habitat for various invertebrate species.

The marine algal flora of the Vestfold Hills comprised of 30 algal species (Table 3). The Rhodophyta species *Palmaria decipiens* (Reinck) Ricker comb Nov., *Phyllophora antarctica* A. et E.S. Gepp and *Iridaea cordata* (Turner) Bory were the most resistant species of the region and *P decipiens* dominates the entire area. The

Table 2

ANNUAL CYCLE OF ANTARCTIC SEALS AT THE VESTFOLD HILLS.

SEAL SPECIES	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE
SOUTHERN ELEPHANT SEAL (MIROUNGA LEONINA)	BREED ON SUB ANTARCTIC I.				ARRIVE	FEED AND MATE			DEPART			
							MOULT					
WEDDELL SEAL (LEPTONYCHOTES WEDDELLI)	ARRIVE BREED		PUPS WEAN		PUPS READY TO ENTER WATER FOR FEEDING			DEPART				
	SOME REMAINS ON THE PACKICE AND SUB ANTARCTIC ISLAND.											
LEOPARD SEAL (HYORURGA LEPTONYX)	PACK ICE OR SUB ANTARCTIC ISLAND ARRIVE							BREED?		DEPART	PACKICE	
ROSS SEAL (OMMATOPHOCA ROSSI)						PACK ICE INHABITANTS						
CRAB EATER SEAL (LOBODON CARCINOPHAGUS)	PACK ICE INHABITANTS AND RARELY SEEN DURING SUMMER ON THE CONTINENT											

Phaeophyta was represented by *Himantothallus grandifolius* (A. et E.S. Gepp) Zinova and *Desmarestiella menziesii* J. Agardh while Chlorophyta was poorly represented on biomass basis, even then, *Enteromorpha bulbosa* (Suhr) Montagne and *Cladophora subsimplex* Kutzing occurred during most of the months. *Monostroma hariotii* Gain occurred from late spring through the summer.

The sublittoral region showed an abundant algal crop even under the ice cover. Growth of some spp. like *P. decipiens* was recorded during winter months indicating photosynthetic production under fast ice. In other Rhodophyta species healthy growth was observed and some of the old algal thallus showed profused proliferation during winter months.

The intertidal region was dominated by filamentous Chlorophyta species during summer months. These species were found to be growing in the furrows, crevices of the rocks and tide pools where they were protected from scouring by the sea ice. *Porphyra endiviifolium* (A. et E.S. Gepp) Chamberlain a Rhodophyta species showed abundance on the rocky surface in the supralittoral region.

Terrestrial Flora

The distribution of terrestrial plant life is limited by the availability of suitable ice free niches on coastal outcrops and inland nunataks and mountain range. Availability of liquid water during summer months is the major factor determining distribution and abundance of plant life (Seppelt and Ashton, 1978 and Ando, 1974).

TABLE 3

List of the benthic marine algae recorded from the inshore waters of the Vestfold Hills, Antarctica

CHLOROPHYTA

1. *Cladophora subsimplex* Kutzing
2. *Cladophora* sp.
3. *Enteromorpha* sp. cf. *E. bulbosa* (Suhr) Montagne
4. *Enteromorpha gunniana* J. Agardh
5. *Enteromorpha* sp.
6. *Monostroma hariotii* Gain
7. *Prasiola crispa* sp. *antarctica* (Kutzing) Knebel f. *antarctica*
8. *Rosenvingiella* sp.
9. *Ulothrix* sp. cf. *U. australis* Gain
10. *Urospora penicilliformis* (Roth) Areschoug
11. *Antarctosaccion applanatum* (Gain) Delepine
12. *Rhizoclonium* sp.

PHAEOPHYTA

13. *Desmarestia menziesii* J. Agardh
14. *Elachista* sp.
15. *Geminocarpus austrogeorgiae* Skottsberg
16. *Himanothallus grandifolius* (A. et. E. S. Gepp) Zinova
17. *Leptonematella falklandica* (Skottsberg) Wynne
18. *Lithoderma antarcticum* Skottsberg
19. *Myrionemataceae*

RHODOPHYTA

20. *Antarcticothamnion polysporum* Moe & Silva
21. *Ballia callitricha* (C. Agardh) Kutzing)
22. Corallinaceae—one encrusting sp.
23. *Gymnogongrus antarcticus* Skottsberg
24. *Iridaea cordata* (Turner) Bory
25. *Palmaria decipiens* (Reinsch.) Ricker comb. Nov.
26. *Phyllophora antarctica* A. et. E.S. Gepp
27. *Plocamium cartilagineum* (Linnaeus) Dixon
28. *Porphyra endiviifolium* (A. et. E.S. Gepp) Chamberlain
29. *Rhodochorton membranaceum* (Magnus) Hauck
30. *Leptosarca simplex* A. et. E.S. Gepp

Terrestrial flora of the Vestfold Hills is comprised of widely distributed species of lichens mosses (Table 4). The species of lichen and mosses start growing during late

TABLE 4

List of lichens, mosses and freshwater algae from the Vestfold Hills

LICHENS

1. *Acarospora gwynnii* Dodge & Rudolph
2. *Alectoria minuscula* Nyl.
3. *Biatorrella antarctica* Murray
4. *Buellia frigida* Darb.
5. *Buellia lignoides* R. Filson
6. *Caloplaca citrina*
7. *Candelariella antarctica*
8. *Lecanora expectans* Darb.
9. *L. melanophthalma*
10. *Physcia caesia* (Hoffm) Hampe
11. *Umbilacaria decussata* (Vill.) Frey D. & F.
12. *U. aprina*
13. *Xanthoria elegans* (Link) Th. Fr.
14. *Xanthoria mawsonii* Dodge

MOSSSES

1. *Bryum elegans* Brid
2. *B. argenteum* Hedw.
3. *Grimmia lawiana* J.H. Willis Spec. Nov.
4. *G. antarctica*
5. *Ceratodon purpureus* (Hedw.) Brid.

FRESH WATER ALGAE

1. *Prasiola crispa*
2. Unidentified

spring and flourish well during summer months on the exposed rocky substrate where moisture was available from the melt water of the snow. The distribution of moss and lichen communities closely related to the pattern of snow drift governed by the

prevailing wind direction. In the Vestfold Hills bryophyte vegetation is distributed over the easterly inland region.

Marine Invertebrates

Twenty four animal taxa were identified (Table 5). Their habitat types were characterized by the community composition and physical environment. The animal species with abundant macrophytes, anoxic muddy basins with deposit feeding species and poorly sorted sands with mainly motile fauna.

TABLE 5

List of animal taxa found in the vicinity of the Vestfold Hills, Antarctica

1. *Paramoera walkeri* (Stebbing)
2. Other crustaceans
3. *Chorismus antarcticus* (Pfeffer)
4. *Cymodocella tubicauda* Pfeffer
5. Other isopods.
6. *Scheroconcha gallordoi* Kornicker
7. *Glyptonotus acutus*
8. *Lagisca floculossa*
9. Other polychaetes
10. Tube worms
11. Nematode worms
12. *Laevilacunaria* sp.
13. *Submargarita crebrilirulata* (Smith)
14. *Philobrya sublaevis* Pelseneer
15. *Laternula elliptica* King and Broderip
16. *Donax* sp.
17. Limpets
18. Holothurians
19. Brittle star
20. Star fish
21. Pycnogonoids
22. Sea anemone
23. Sea urchins
24. Salp like

Marine invertebrates showed abundance during the summer months. A marked zonation of communities with depth was noticed by ~~Stebbing and Lowry~~ Knox and Lowry (1977). Sponges dominated in deeper water, while sessile coelenterates and motile foraging animals were found to dominate at intermediate depths. Very high species diversity was recorded, however under ice, iceberg scouring and seasonal sea ice modify the benthic environment

In the species recorded, crustaceans were found to be dominant. Their distribution and abundance depended on the availability of food resources. *Paramoera walkeri* (Stebbing), *Cymodoceella tubicauda* (Pfeffer), nematodes and *Laevilacunaria* sp. were the dominant phytal associate on alga *P. antarctica*. Echinoderms were found usually associated with *P. antarctica*. These echinoderms plant ~~the~~ alga on their spines (Zaneweled, 1965). Large bed of *P. antarctica* alongwith echinoderms were found at the mouth of the Ellis fjord.

Another crustacean species *Euphausia superba* Dana commonly know as Krill, showed abundance in the coastal waters of the Vestfold during summer when some phytoplankton spp. was in bloom. This crustacean is the key species of the Southern Ocean on which the entire food chain depends. Krill is directly consumed by pinnipeds, birds, fishes, squids and whales. The Minke Whale is estimated to consume about 20 million tons of krill of which *E. superba* makes upto 60 to 70%, while the total consumption of krill by birds is abobt 20 million tons (Law, 1977). Crabeater seals consume about 63 million tons of krill and rest of the pinnipeds only 1 million ton.

Because of krill's importance to Southern Ocean ecosystem, Scientific Committee on Antarctic Research (SCAR) started a coordinated project on Biological Investigation of Marine Antarctic Systems and Stocks (BIOMASS) to provide data and information of the living resources of the Southern Ocean and inter-relationship of the animal communities.

Vertebrate Animal Species

Marine birds and mammals spend most of their time in water than on land. Antarctic waters during summer was found to be very rich in microscopic plants and animals that support large stock of seals, whales and sea birds. Forty species of birds and six species of seals breed in the Antarctic region, covering islands and coasts within the Antarctic convergence (Stonehouse, 1965). On the contrary, only twelve species of birds and four species of seals breed on the Antarctic continent.

Six species of flying birds and two species of penguins (flightless) have been recorded from the Vestfold Hills (Table 1). There are many colonies of birds on the islands and coastal exposed area in the Vestfold Hills. Snow petrel, wilson's Storm Petrel, Antarctic Petrel, Cape Peginon were noticed at Bluff Island rookery while Giant Petrel was found breeding at Hawker Island. These birds come to the mainland during spring, mate and lay eggs. Their annual cycle is given in Table 1.

Hawker Island in the Vestfold Hills is the most southerly (68°38'S) known

breeding locality of the Giant Petrel (Johnston *et al.*, 1973). The colony is situated on exposed rocky area about 20 m above sea level (Plate 12).

Wilson's Storm Petrel and Snow Petrel breed on various Islands in the Vestfold Hills. The nests of these birds were usually found hidden under boulders and cliff where the entrance is not blocked by accumulated snow.

Penguins are seafaring birds, feathered and warm blooded like other birds but flightless and highly adapted for swimming. There are 18 known species of penguins of which only two species, Emperor and Adelie, are found on the Antarctic continent.

Emperor penguin remained on the continent throughout the year and breed under the most ghastly conditions than that of other birds in the total darkness while Adelie penguin arrives at the nesting sites during spring and breed when the conditions were much favourable (Plate 13).

All these birds feed on krill, fishes and squids. Some of the species (like skuas) are scavengers and prey on penguin chicks, dead animals and station garbage. The abundant food supply during summer months help to complete their annual breeding cycle

There are about 100 species of fishes in Antarctic waters. The families Notothemidae, Bathydraconidae, Chaenichthyidae and Harpagiferidae include over 95% while Notothemidae alone comprise over 50% of the total fish fauna. These four families are combined to form a compact group which is predominantly distributed in Antarctica.

Seals

Out of the five species of seals, Weddell seal is the only species that breed inshore on the fast ice (Plate 14). These seals arrive during August-September and pupping occurs during October-November (Table 2). They feed on fishes, krills and squids.

Crabeater and Rose seals are the inhabitants of the pack ice and few individuals were seen on the beaches and inshore ice. The Crabeaters feed mostly on krill by filtering water through their lobed teeth (Plate 15).

The Leopard seals were spotted during September when Adelie penguins started to arrive. These seals feed mainly on penguins, fishes, other seals and birds.

The Elephant seal, a Subantarctic species arrived at the Vestfold Hills during November-December and aggregate in large number on the beaches and wallows. They were usually found near the open water (Plate 16). The maximum count recorded for elephant seal was 703 individuals in 1969 while during 1983 only 113 individuals were recorded.

DISCUSSION

The littoral belt around Vestfold Hills, showed marked seasonal characteristic

which was largely due to the fact that the littoral rocks were covered by sea ice for six to nine months of the year preventing algal growth. However, when exposed during summer, filamentous Chlorophyceae starts growing in the rock crevices, sheltered areas and the rock pools forming a conspicuous dark green band. At some of the sites dark brown patches of diatoms were seen on the rock surface and tide pools of the supralittoral region.

The rock pools showed similar community structure inspite of the extreme variations. These rock pools were usually found rich with organic compounds from the guano, penguin and other birds. While rock pools which are situated at higher level were also found rich with organic compounds where in *Prasiola crispa* grows luxuriantly. This alga usually forms a crust on the rocky crevices in the melt water.

The infralittoral region is dominated by the most resistant species *P. decipiens*, *P. antarctica* and *I cordata* of the region. These three species were usually found in association with each other, however, their proportion varies with locality. At the entrance of Ellis Fjord *P. antarctica* showed luxuriant growth while at the other sites may be due to the vast beds of polychaete tubes and molluscan shells which provide favourable substrate for attachment.

The filamentous Chlorophyta species showed dominance in the turbulent water and very few filamentous algae were recorded as epiphytes from the infralittoral region. *Monostroma* sp. showed patchy distribution and juvenile plants were usually found growing on *Laevialcunaria* shells. This species was never recorded from under fast ice presumably because the low light intensity is not adequate for its growth.

Luxuriant growth of Phaeophyta members *H. grandifolius* and *D. menziesii* was seen during summer months which was probably due to the availability of high concentrations brought in by an influx of melt water. Higher temperature and high light intensity were also likely to have aided the growth (Plate 17).

From the present study it seems that although species composition differs, the zonation pattern of the littoral and supralittoral communities in the antarctic region is similar to that of temperate areas except when it is covered by sea-ice and communities thrive soon after rocks are ice free. The littoral region is classified on the basis of the tide levels and not on the animal communities as the settlement of the animal communities is hindered by scouring and movement of sea-ice as suggested by Zaneveld (1937).

Five species of mosses have been recorded from the Vestfold Hills. Out of the six genera of the Vestfold Hills, *Bryum* is the largest while *Grimmia* and *Ceratodon* are the most southerly moss record and was considered an endemic to the region (Seppelt, 1984).

Life cycle of the mosses have been found difficult to study because fruiting takes place very rarely and life span is very short. Only authentic record of the fruiting of *Bryum* was from continental Antarctica (Filson and Willis, 1975). The distribution of terrestrial flora in Antarctica depends largely on the ice free areas and availability of liquid water for growth during summer months (Yamanaka and Sato, 1970;

Seppelt and Ashton, 1978 ; Ando, 1979). Low temperature during summer also helps in the luxuriant growth of cryptogamic species in Antarctic vegetation (Greene and Longton, 1970, Lamb, 1970; Rudolph, 1971).

Species of mosses showed morphological differences under different conditions in the Antarctic region (Seppelt, 1984).

The benthic communities in the inshore waters of the Vestfold Hills were found dominated with deposit feeding organisms. Large number of animal species were seen associated with macroalgae. The highest degree of animal association was seen with *P. decipiens* throughout the season. The polychaetes were found in large number on *P. antarctica* while crustacean *Paramoera walkeri* showed preference for *P. decipiens*. This short preference probably depends on the availability of food source, protection from the external predators and grazers.

The nematodes were found in high number in the holdfast of *H. grandifolius* and *D. menziesii*, probably the accumulated detritus in the holdfast provides a favourable food source (Boucher and Chamroux, 1976).

The number of animal species found in this severe climatic conditions is very small. Marine birds and mammals make use of Antarctic continent for a very short time, Sea birds breed on the shores and coastal areas. There are many breeding sites of the Adelic penguin in the Vestfold Hills, Few of these breeding sites have been shifted in the interior probably for the sheltered areas (Taylor, 1962). Present colony of Cape Royds area was deserted about 300-400 years ago possibly during the climatic deterioration (Spellerberg, 1970 a). The reason for shifting of the breeding sites at the Vestfold Hills is not known.

Penguin vomits collected during 1983 expedition in different seasons showed presence of Emphausids. The percentage of *E. superba* dominates during most of the months, however, results showed that they may be opportunistic feeders which would limit their dependence on krill (Puddicombe, personal communication).

The distribution of penguins along the Antarctic continent is mostly related to the availability of krill as such various colonies indicate the abundance of krill in the nearby open water (Green-Hamond, 1983).

The Weddell seal is most southerly in distribution. Survey of these seals in the Vestfold Hills are being done since 1961. It is estimated that in this area about 200 pups are born annually (unpublished ANARE Biol. Logs. and Rep.). The Weddell Arm in the Long Fjord is the common sites of the occurrence of Weddell seals. Other fjords such as Crooked and Tryne fjords also showed presence of Weddell seals during 1983. No record of the occurrence of Weddell seals at these two fjords was reported earlier (Johnston et al., 1983). Probable reason for their occurrence at these two sites is not clear.

Out of the five species of seals only crabeater feeds exclusively on the krill. Based on their biology, distribution and abundance this species is taken as the indicator species to study the harvest related changes in the availability of Antarctic krill. (Green-Hamond et al., 1983).

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