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†Ecological characteristics associated with the polar erect bryozoans

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Abstract

Antarctic bryozoans are well known for their diversity. Over 300 species have been described from this unique ecosystem and new species continue to appear. During the Third Indian Antarctic Expedition, 24 species of cheilomate bryozoans were collected. The most remarkable feature of majority of the species was a clear-cut coralline, fragile and thalloid morphology of the zoarium. Since this morphological feature was in striking contrast with the benthic bryozoans of the Indian Ocean, the possible reasons for the conspicuous difference in morphology were analyzed based on the ecological conditions prevailing in the mesobenthic regions of Southern Ocean in general and the coastal waters of the Antarctic continent in particular. The existence of different hydrological fronts influence the ecology of the waters of the Southern Ocean. The animals were collected from a depth of 200m where the hydrological conditions recorded were nearly hostile. This is accompanied by rarity of organic debris, microzooplankton and dead organic matter which form the source of energy for the microbenthos of the Antarctic. Therefore, the peculiar morphology of the bryozoan colonies could be an environment induced architecture ensuring and enhancing survival of the group in this hostile biological environment.

Keywords: Polar, benthic, erect, coralline, bryozoa

Introduction

The polar regions constitute about 25% of the earth's surface. This indicates the importance of these regions from a biogeographical stand point. In spite of the extreme environmental conditions, the Antarctic water holds a very diverse assemblage of benthic organisms. Understandably, animals which are morphologically adapted to collect food from the cold waters flourish in this area. Among the lower marine invertebrates, filter feeders dominate the fauna. Bryozoans are a highly evolved group of filter feeders, which have the capacity of separating dissolved organic matter from the surrounding medium by polymerization of surface active molecules. The basic colonial morphology of this group is evolved to grow as encrustations and a study on the bryozoans of the Indian waters showed less than 5% erect forms (Louis, 2006). On the other hand, preponderance of erect bryozoans in the polar bryozoan community demands an enquiry into the causative factors for this feature. Heavy calcification irrespective of major phyletic differences is a uniform feature of bryozoans of the Antarctic. Previous enquiries have shown a depth dependant variation in the morphology of the colonies. The rigid nature of the bryozoan colonies was found to be prominent in greater depths of the Antarctic (Dayton *et al.*, 1974; Winston, 1983; Winston and Hayward, 1994).Unilaminate and bilaminate arrangement of zooecia forming an erect colony having flexibility and anchoring with roots have been recorded (Barnes, 1995a; Barnes and Whittington, 1999). Unlike other regions of the world oceans, some parts of the Antarctic like Ross Sea, Weddell Sea, Shetland Island

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and the Antarctic Peninsula have been thoroughly studied (Hastings, 1943; Winston, 1983; Arntz *et al.*, 1992, 1997; Barnes *et al.*, 2007).

During the Third Indian Antarctic Expedition (1983-1984) an exclusive cruise by an 'Ice Class 1 A Super' vessel, *M. S. Finnpolaris*, Dr. K. J. Mathew from CMFRI, Kochi, collected samples of plankton and benthos from a region very close to the Antarctic circle (69° 54' S lat. and 12° 49' E long.) (Fig. 1). During one of the zooplankton hauls the ring of the plankton net scraped the vertical sides of a gorge of ca 700m depth, and the scrapings were collected from a depth of 200m in the net. The scrapings contained benthic organisms including bryozoans and these were used for the study.

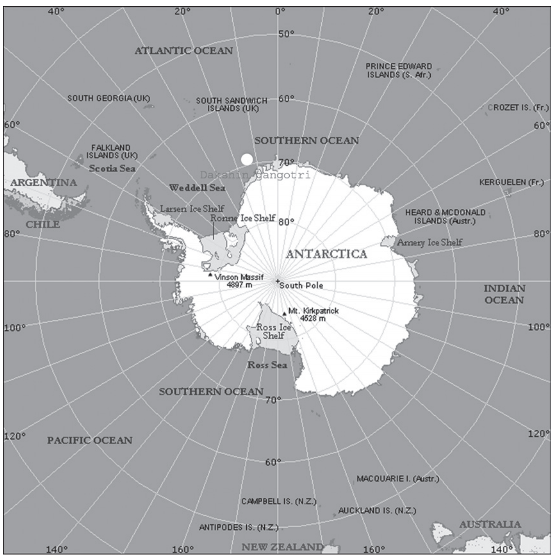

Fig. 1. The Third Indian Antarctic Expedition; Mythri (Dakshin Gangothri) station explored by M. S. *Finnpolaris*

Material and Methods

***Bryozoa*:** The specimens were cleaned with sodium hypochlorite (0.5%) washed and identified by preparing gold coated samples employing a vacuum evaporator (Agar, UK) and taking scanning electron micrographs using a Leo 435 VP Scanning Electron Microscope (Carl Zeiss SMT Ltd, UK).

***Physico-chemical parameters and plankton*:** Nutrient values (phosphate-phosphorus, nitrate-nitrogen, nitrite-nitrogen, and silicate-silicon), dissolved oxygen, alkalinity, pH and salinity were reported by Naqwi (1986) from water samples collected from the same location in the Third Indian Antarctic Expedition. (Table 1). Phytoplankton biomass and productivity were reported by Pant (1986) and zooplankton by Mathew and Vincent (1986) from water samples collected from the same location in the Third Indian Antarctic Expedition.

Table 1. The physico - chemical parameters of the waters of the collection site (Naqwi, 1986)

Parameters	Values
Salinity	34.3 $^0/_{00}$
Temperature	– 1.7°C
Density	27.6 $^6\theta$
Silicate-silicon	64 μM dm^{-3}
Dissolved oxygen	7.6 cm^3dm^{-3}
Apparent oxygen utilization	70 μg-at.dm^{-3}
Phosphate-phosphorous	2.5 μM dm^{-3}
Nitrate-nitrogen	26 μM dm^{-3}

Results

***Faunistic composition*:** The vertical haul which resulted in the rim of the plankton net scrapping the shelf region yielded more than a kilogram of colonies and fragments of bryozoans. Unfortunately it is not possible to estimate the area of the shelf sampled although the diversity of bryozoan fauna looks to be really staggering when compared with the other sedentary fauna especially sponges and gorgonids sampled from this area. The total number of species of gorgonids and sponges as reported by Thomas and Mathew (1986a, b) were around 10 while there were 24 species of bryozoans belonging to 3 major orders of calcareous group. Contrary to the normal morphological feature of bryozoan colonies, 50% of the species collected were adapted to an erect colonial morphology. Numerically 12 of the 24 had unilaminate or bilaminate zoaria. The species were *Chondriovelum adeliense* Hayward and Thorpe, 1988; *Chondriovelum* sp.; *Cellaria tecta* Harmer, 1926; *Cellaria praelonga* Harmer, 1926; *Cellaria aurorae* Livingstone, 1928; *Swanomia membranacea* Hayward and Thorpe, 1989; *Melicerita obliqua* Thornely, 1924; *Cellarinella laytoni* Rogick, 1956; *Rhynchozoon tubulosum* (Hincks, 1880); *Iodictyum anomala* sp. Novo; *Reteporella parva* Hayward, 1993; *Hornera spinigera* Kirkpatrick, 1988 (Menon and Menon, 2006; Gordon, 2008) (Plate 1).

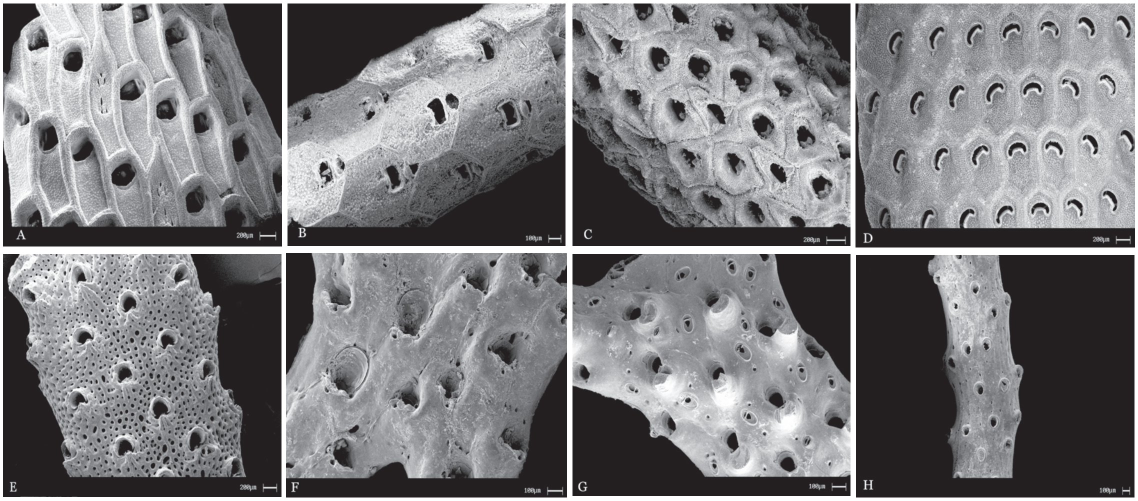

Plate 1. Erect species of bryozoans from the Antarctic waters; (A) *Chondriovelum adeliense* Hayward and Thorpe, portion of a colony showing vicarious avicularia; (B) *Cellaria aurorae* Livingstone, enlarged view of the zooids; (C) *Swanomia membranacea* Hayward and Thorpe, cellariform colony with vicarious Avicularia; (D) *Melicerita obliqua* Thornely, cellariform colony; (E) *Cellarinella laytoni* Rogick, zooids enlarged showing orificial avicularia; (F) *Reteporella parva* Hayward, Frontal view showing the details of orificial avicularia and ovicells; (G) *Iodictyum anomala* sp. novo. Frontal view enlarged; (H) *Hornera spinigera* Kirkpatrick, form of the colony

***Primary production*:** The phytoplankton community up to a depth of 150 m consisted of two different types of algae; one being the ice algae released by melting and the second consisting of the planktonic algae with possibly quite different life cycles and physiology. The phytoplankton species present in the water sample were *Fragilaria islandica*, *Navicula* sp., *Thalassiosira* sp., *Biddulphia* sp., *Eucampia* sp., and *Corethron* sp. The average primary production near the ice-edge was 0.66g $C.m^2day^{-1}$ as compared to 0.058 $gC.m^{-2}day^{-1}$ in the offshore areas (Pant, 1986).

***Zooplankton*:** Siphonophores, polychaetes, chaetognaths, copepods, ostracods, euphausiids and appendicularians were the major components in the plankton collections. *Euphausia superba* was the major constituent of euphausiids. However, copepods were the major group represented in the zooplankton according to Mathew and Vincent (1986).

Discussion

Gymnolaemate bryozoans are highly sensitive group of lower marine coelomates which are represented in saline waters only. Their sensitivity to environmental changes controls the distributional pattern. The 11 species of erect bryozoan recorded from this area are typically stenohaline and stenothermal and their existence and continuance in the benthic community depends on the stability of environmental conditions which are clearly ensured by the Antarctic surface watermasses. It is shown that the lower layers (100 - 200m) of the Antarctic surface watermass do not undergo any clear-cut variation in temperature and salinity due to the convective agitation that takes place in winter (Barkov, 1985). The changes in the physical processes of the Antarctic waters are known to influence the community structure upto 30m depth only and biological interactions are proved to be responsible for the community structure of waters beyond this depth (Dayton, 1990). The South polar front zone which is characteristically occupied by watermasses of pronounced temperature minimum was not noticed from the area which yielded the bryozoans. Wyrtki (1971) opined that temperature minimum levels sink beyond 200m.

Stiff competition for space, food and light are the most important factors which would control composition and morphology of species occurring in this area. Understandably, species of drastically different phyletic status should face less competition for food and space. The colonial polymorphic bryozoans have a great advantage to exist in such locations because of the inherent morphological peculiarities and mode of growth (Knowlton and Jackson, 2001). Diverse marine life of the Antarctic at phyletic levels with clear cut endemism has been reported by various authors (Arntz *et al.,* 1994, 1997; Brey *et al.,* 1994; Clarke and Johnston, 2003; Waller *et al.,* 2006). Adaptation in colony formation, especially the erect nature becoming dominant among abyssal bryozoans along with zooids with elongated tentacles and the presence of detritus as the major component of the gut substantiates the reasons for the modified colonial morphology (Schopf, 1969; Ryland, 1970). Antarctic cheilostomes exhibit remarkably developed spines, tubercles, calcareous projections and variegated avicularia (Hastings, 1943; Rogick, 1956; Androsova, 1973; Winston and Bernheimer, 1986; Louis, 2006).

An important aspect of bryozoan anatomy is the input of enormous quantities of calcium carbonate on a weight-by-weight basis contributing to the zooid. The simplicity in structure of bryozoan soft tissue probably increases the significance of availability of calcium and the mode of uptake. The hydrochemical characteristics of the polar waters in greater depths are of a very original condition for the secretion of calcium carbonate. It is known that 30% of the polar deposits are of calcium origin (Whitefield and Watson, 1983; Smith *et al*., 2001). The enhanced size of bryozoan zooids, the accumulation of biogenically rich material by high seasonal productivity, predominance of coccolithophores, a group where calcification is less light dependant also probably indicates the possibility of bryozoan skeletal formation resorting to comparable procedures of calcium carbonate secretions (Arntz *et al*., 1992; Balch *et al*., 1992; Teichmann *et al*., 1997). Understandably, the size of zooids of the erect forms was less when compared to that of the encrusting forms and the ovicells were found to be endozooidal nature in erect forms while hyperstomial in encrusting forms (Table 2). Studying the growth rate and its variability of Antarctic bryozoans, Barnes *et al.* (2007) have opined that these suspension feeders are the best example that could be used to measure variability in the growth of Antarctic invertebrates and the bryozoans are slow growing animals in the Antarctic. The variations in growth can be related to the quality and quantity of food intake, diet specificity and microhabitats. A study on the seasonal and annual growth of erect bryozoan species in shallow waters of the Antarctic obviously revealed that the maximum age and size were limited in the long term by frequency of iceberg impact (Barnes, 1995b). The branches break or the colony topples at the base as a result of complex current regimes often carrying water-borne debris (Barnes and Whittington, 1999). Among the species collected, the growth rate of only one species, *Melicerata obliqua* is known. Although growth rate variabilities and rates are important aspects of bryozoan colonies, the individual size achieved by the zooid is relatively high. This has been proved at least in the case of *Steginoporella buski* and *S. magnilabris* (Louis and Menon, 2005).

Table 2. Morphological features of erect and encrusting species (Lz- length of the zooid and lz- width of the zooid)

Morphological characters	Erect species	Encrusting species
Size of the zoecium	Lz: 900 μlz: 451 μ	Lz: 1040 μ lz: 605 μ
Density of avicularia/ zooid	1.72	1.5
No. of spines/ zooid	2 (on 1 species)	6 (on 3 species)
Ovicell	Endozooidal - 6; Endozooidal - 1;	Hyperstomial - 1 Hyperstomial - 6

It is of interest that among the sedentary invertebrates studies are available on growth rates of only bryozoans across tropical, temperate and polar regions and it has been proved that in the case of cellariform bryozoans growth is by and large slow in the Antarctic waters. Erect bryozoans produce varying quantities of skeletal carbonate per year and staggering variations in the production is recorded between Antarctic and tropical bryozoans. Barnes *et al.* (2007) have found that Antarctic bryozoans grow slowly which is true in the case of other invertebrates also. However, among bryozoans enough data are available to conclude that food in the water column is an important criterion controlling the growth of Antarctic bryozoans. The mode of filtration or capture of prey could normally be well organized by zooids of erect species with the help of well developed tentacular crowns and efficient avicularian assemblages and the erect nature ensures sufficient food availability and hence could probably be represented more in the benthic realm.

The morphological features of bryozoan colonies are very much influenced by the environmental conditions and food accessibility in the Antarctic. Discussing on the availability of heavy food particles either organic or inorganic and the physical level at which it is consumed by the animals, the position assumed by the feeding apparatus is of importance. In the case of erect bryozoans it is possible to both control and regulate (by branching), the level from which the food particles are trapped from the environment. The Antarctic water which depict clear seasonal pattern in food availability, is less loaded with food and probably erect posture of bryozoan colonies ensures effective food procurement. The abundance of erect bryozoans in various taxa which are dominated by encrusting forms is a clear indication of ecologically influenced variations in the morphology. Further, preponderance of species producing only lecithotrophic larvae is recorded interestingly, only in the case of bryozoans. Probably, an examination of fossil records would show the predominance of species with ovicells. The morphological features along with growth rate make bryozoans as indicator organisms to look for ecological indications.

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