Part-I

Taxonomy
Oceans are bountiful and beckoning, unvarying and vast and full of unwound mysteries. They cover approximately three fourths of the earth's surface. The marine environment extends vertically from intertidal to great depths of the deep sea floor. The continental shelves of the world's oceans represent only 10% of the total oceanic area but account for 99% of the marine organisms. The benthic organisms form a vital part of the continental shelf of the marine environment and play an important role in its ecology. Bryozoans are hard bottom benthos, constituting an important component of the benthic community. They are found from subtidal to the great ocean depths up to 6000 m. Many bryozoans are fairly stenobathic and represented in large number in the infralittoral zone, although not themselves directly dependent on illumination (Ryland, 1970). The myriads of species composing the contemporary flora and fauna have been derived through the many failures and success of opportunistic evolution (Simpson, 1961) from the biological primordium of ancient seas. The marine biota of today is the product of (1) the tendency of living matter to assume every possible form compatible with environment, (2) the capacity of living matter to utilise non-living and living matter as a source of energy and materials for survival and multiplication, and (3) nature's most abundant commodity: time (Kinne, 1970).

Biological taxonomy is "the theory and practice of classifying organisms" (Mayr, 1969), while systematics has been defined by Simpson (1961) as "scientific study of the kinds and diversity of organisms and of any and all relationships among them". The scarcity of national support for systematics – ecological research during last 35 years and hence
the lack of value placed on that sector by higher education has led to a great shortage of expertise and progress in the basic science aspects of ecology such as taxonomy and the necessarily related physiology and genetics (Lee, 1978). Winston (1988) studied the perspective of systematists having queried many other systematists of different universities, came to the conclusion that much more alpha taxonomy, collection and description of organisms must be carried out before systematists can get on with the higher systematics of each group and this must be accomplished before the habitats are changed or destroyed. It has been recognized for many years that diversity of species on earth exceeds current taxonomic capacity to inventory it and recent analyses of known and estimated global species diversity approximate that only around 1.75 million species have been described out of, perhaps, 12.5 million to 13.6 million species total (Gordon, 2003). From all the above workers views, it is evident that taxonomy of many groups are still to be explored before we step into the advanced applied part of research.

The critical need for basic research in systematics, so as to upgrade the biodiversity studies of animals, have eventually led to the growing interest in the group Bryozoa, which was in many respects in the 'alpha' stage a few decades ago. Non-specialists and biologists may recognize no more than a few species since they resemble a variety of other organisms, like small corals, hydroids and seaweeds.

The Western Indian Ocean forms a coherent subdivision of the world's largest biogeographic province – the tropical Indo-Pacific. The Indian Ocean as a whole is a more understandable sub region, being bounded by great continental landmasses, but even this is illusory, as on its eastern side tropical water flows continuously to the Pacific Ocean (Sheppard, 2000). Bryozoans are well distributed in the Indian waters. They show exceptional levels of species diversity than any other organisms known today. Systematic study of the group is mainly based on the highly calcified zooecia; even dry material offer excellent specimens for taxonomic investigations. In spite of the enormous amount of progress in various aspects of research, these enigmatic creatures remains unattended. Indeed the current lack of research is surprisingly obvious, of how common they are in the 41 stations investigated in this region; the Indian EEZ. The dredge samples were encrusted to almost 70% by this fascinating group. The present study will definitely throw light on one of the less discovered and ignored part of the benthic community, the bryozoans of the Indian EEZ and will prove to be a continuity of the
previous classical work of Menon (1967) on the Polyzoa of the west coast of India, after a long pause.

The Antarctic Ocean presents unique features in several aspects of its environment. Life of the organisms inhabiting this region were influenced by many factors like the circumpolar currents, the upwelling and the consequent enrichment of the surface waters, the cold climate, the ice cover etc. Above all, the continuous days and nights play a major role in the occurrence and abundance of green matter and animals in this ecosystem. It is hard to imagine what type of marine life could survive in the harsh Antarctic environment. There darkness prevails for half of the year under 2 m of ice, and huge tabular icebergs, sometimes several kilometers long, break up the way across the seafloor in -2 °C water. Unfortunately the Antarctic bryozoan data are too few and scarce though they are diverse from view of a single site dredged in the Southern Ocean. The present work has an account of Antarctic bryozoans, which were available from Dr. Menon’s personal collections, handed to him by Dr. P. A. Thomas.

Biofouling is the undesirable colonization of the submerged structures by aquatic organisms. The significance of biofouling studies has been increasing in the last few decades as the number of vessels invading the waters has tremendously increased. To understand the fouling bryozoans, it is essential to know about species composition, substrate preferences and depth of occurrence. Biofouling studies are carried out in Cochin backwaters with the aid of non-toxic test coupons. The present work gives a clear picture on seasonal and spatial distribution of bryozoans and delineation on the vertical and horizontal settling of the fouling organisms occurring in the Cochin estuary after 40 years of the previously available data. This enables a relative study of these organisms with special attention to bryozoans and its present status as foulers after the introduction of many effective antifouling techniques. The data will definitely aid in improving control of biofouling engineering works, harbour reformations etc.

1.2 Review of Literature

Taxonomists, biologists and paleontologists have done several works on taxonomy of this group from different regions of the world. A convenient presentation on the historical account of the works carried out has been given by Menon (1967) in his work on the Polyzoa of the Indian waters. Regionalized assessment of the relevant past and recent works on the systematics and ecology of phylum Bryozoa carried out worldwide are reviewed here.
Chapter I. Introduction

**The Arctic**

Numerous leading workers have studied the Arctic bryozoans. Nordgaard (1900) published important papers on bryozoans of the Arctic regions. Kluge's (1975) studies on the Bryozoa of the northern seas of the U.S.S.R have revealed much of the bryozoan accounting to 360 species available in this geographic area. Recently Kuklinski and Hayward (2004) described two new species of cheilostome bryozoans *Pentapora boreale* and *Microporella svalbardensis* from the Arctic region. The literature of different works in this region shows that not less than 560 species have been reported as inmates of this polar area. Looking into the environmental conditions of the polar waters, it is evident that this group of animals evolved successfully to inhabit a habitat with extremely hostile environmental conditions, which include extreme hydrographical conditions, limited food supply of choice and total lack of sunlight during a major part of the year.

**The Atlantic regions**

Hincks (1880) observed the British Marine Polyzoa and his report is one of the pioneer works of the British Isles. The British Museum collections were examined and accounted in catalogue of marine Polyzoa by Busk (1852, 1854, 1856, 1858, 1860, 1875). Johnston's (1838, 1847) publications on the history of British Polyzoa is yet another work on the Bryozoa of the Atlantic region. Waters (1909, 1910, 1913) have studied the bryozoans of the Sudanese Red Sea waters. Marcus (1940) is considered to be one of the standard taxonomic references for this region. The contributions of Marcus (1937, 1938a,b, 1939a, 1941, 1942, 1949 and 1953) cover the Brazilian coasts. Notes on Swedish Marine Bryozoa given by Silen (1943, 1951) are rather works after the standard taxonomic study by Marcus (*loc.cit.*). Nair (1961) listed 22 species after his observations on the settlement and distribution of bryozoans in the fjords of Western Norway. Cheetham and Sandberg (1964) have reported on the cheilostome fauna of the Gulf of Mexico and the Caribbean Sea. The West African fauna of the southwest Atlantic belonging to the Coelostegia division has been described by Cook (1964, 1965) and further she gave a detailed explanation of species of Cupuladriidae and its related groups. Maturo and Schopf (1968) had described 23 species from North American east coast. Remarkable works on taxonomy of this region have been compiled by Soule and Soule (1968) and Schopf (1967, 1968). Ryland (1958a, b, 1963, 1965, 1967, 1974b) has done immense work on the species of this area and published many papers on the Bryozoa of Norway reporting several species and is one of the important references for
north Atlantic area. The functional aspects of bryozoans of the North Sea in relation to
temperature, salinity were studied by Menon (1972e, 1973b, 1974b, 1975). Schopf and
Gooch (1971) studied the gene frequencies in a marine ectoproct *S. unicornis* in relation
to sea temperature. Hondt (1974a, b) prepared descriptions of 82 species of bryozoans
from the collections of "Thalassia" in the Atlantic Ocean. The Mediterranean
gymnolaemates have been discussed and studied by Hayward (1974) from a large
collection made during the Chios expedition, yielding 101 species of cheilostome
bryozoans from samples of shallow waters (1-61 m) alone. He remarked about the
report by Harmelin in 1969 of 101 species of which 85 were cheilostomes from the same
area at greater depths of 30-270 m. Schopf and Dutton (1976) and Schopf (1976)
compared the shallow water species and deep sea forms and their genetic causes of
morphological variability within bryozoan colonies. Observations on living colonies of 56
species of marine bryozoans from Florida and Panama were carried out by Winston
(1977b, 1978) and the polypide morphology and feeding in marine ectoprocts was
studied. The author informed that the polypide morphology varied from species to
species and this variation is dependant on the behavioural strategy.

Winston and Eiseman (1980) listed 36 species of bryozoans from algae in the shallow
subtidal and continental shelf area of Florida in which, they have mentioned the
bryozoan-algal association clearly. Dynamics of bryozoan populations, complicated by
their modular construction and growth were studied by Jackson and Winston (1981).
Winston (1982, 1986, 1995) studied the distribution and ecology of bryozoans of the
Indian River along the Atlantic coast of Florida and she obtained 84 species of
bryozoans. A ctenostome family, Mimosellidae was recorded by Winston (1984) for the
first time from the Caribbean, in spite of the relatively well-known bryozoan fauna of this
area. Best and Winston (1984) tested the skeletal strength of calcareous walls of the
cheilostome bryozoans as this was an important factor determining the relative ability to
resist damage. The author reported that those with increased calcification have high
evolutionary success. Winston and Håkansson (1986) have done work on the unique
encrusting bryozoan and they described 34 species, of which 9 were new species to
science.

Hayward and Hansen (1999) recognized three cheilostome bryozoans from the British
sea area, which were poorly characterised before. Winston *et al.* (2000) discussed
marine bryozoan species within an area of the south west Atlantic between 35° S and
56° S and between the coast of Argentina and 50° W. This author has also given a key for identification of *Beania* sp. and reported a new species, *Smittina oblita*, from the same locality. Harmelin (2003) listed 64 species in his paper on the biodiversity of the Marine cryptic habitat from the Mediterranean. Gusso and Soule (2003) reported the first occurrence of the genus *Plesiocleidochasma* from Mediterranean localities though it was previously known only from the western Pacific and Indian Oceans. Morphological and genetic characteristics of erect ctenostome *Alcyonidium diaphanum* using Allozyme Electrophoresis by Porter (2004) revealed that it consisted of two generic types. Winston and Migotto (2005) reported the encrusting interstitial epifauna from Brazil after the same being recorded 20 years hence.

The Pacific regions

The New Zealand Reteora and fenestrate bryozoans was studied by Waters (1887, 1894, 1899). Busk (1952) has given an account on the Polyzoa of the coasts of Australia and the Louisiade Archipelago. Osburn (1950, 1952, 1953), in his outstanding contribution to the Bryozoa of the Pacific coast of America has described not less than 565 species and varieties of ctenostoms. This report is chiefly based on the Bryozoa collected during the Allan Hancock Pacific Expedition off the coast of Mexico, Central America, South America and Galapagos Islands during 1933-1944. Silen (1954) studied and described 51 species from the materials collected by Prof. T. Gislen’s Expedition from Australia during 1951-1952.

The more important studies on the Polyzoa of the Japanese waters are those of Okada and Mawatari (1935a, b, 1937, 1938), Silen (1941, 1942) and Mawatari (1953). Silen (*loc. cit.*) working on the collections of the ctenostoms made during the Sixteen Bock’s Expedition to Japan and the Bonin Islands during the year 1914, described 106 species and varieties from that region. Mawatari (1952), after reviewing his previous works in detail, presented a list of 152 species from the Kei Peninsula. In a check list of the cyclostomatous Bryozoa from the Japanese waters, Mawatari (1955) has listed 78 species. More recently the same author has described 45 species from the Kurile Island and 84 from the eastern shore of Noto Peninsula (Mawatari, 1956, 1963).

Species of *Hippothoa* were studied by Pinter (1973), which was previously described under various names from the California coast and revealed the presence of three species when scanning electronmicrographs were taken. Ryland (1974a) published papers on the Bryozoa of coral reef areas of the Great Barrier Reef. Chronological and
geographic distributions of bryozoan fauna has been studied by Hayami (1973, 1975) in which, a total of 123 species and subspecies distributed among 69 genera, were discriminated. Among them, 31 species and 2 subspecies are described new to science. Extensive collections on the Japanese anascans were carried out by Mawatari and Mawatari (1973, 1974, 1979, 1980, 1981) and have reported more than 150 species of the division Malacostega. Brood (1976) recorded 14 cyclostomatous bryozoans with 7 new species and one new genus from Madagascar. Pouyet and David (1979) established paleobiogeography in bryozoans by studying more than 50 species of Steginoporella, for understanding the recent distribution of this species connected with the great events of earths' evolution.

Gordon (1984, 1985, 1986, 1989a) conducted a series of studies on gymnolaemate Bryozoa from the New Zealand waters and reported a total number of 227 species from the Kermadec ridge. He recorded and described with photographs, the Marine bryozoan fauna of New Zealand and has succeeded in recording more than 325 ascophorine cheilostomes, 132 anascans and 13 species of ctenostomes. The author numbered the New Zealand EEZ bryozoans extraordinarily high as 911 species, which constitute around 15% of the entire world fauna of about 6000 species. Winston (1986) has prepared a checklist, which includes 284 species of bryozoans from coral substrata or reef environments of different areas like Caribbean, Red Sea, East Africa, Indonesia, Great Barrier Reef, Eniwetak, Hawaii and Eastern Pacific. Gordon (1989b) studied the major cryptofaunal species from reef-flat rubble at Sa'aga Island and gave information on 10 species of bryozoans, of which 2 were new species. Gordon (1982, 1992) reconsidered the genera of Chaperiidae and described several species from the New Zealand region and erected a new genus Bryopastor for a recent, deep sea and fossil species from this locality.

The South-Australian bryozoans of the 110 year old Hutton collections, which is still present in Otago Museum collections, were examined and identified by Gordon and Parker (1991) and 23 species have been listed, nine of them accompanied by descriptive annotations. Mawatari et al. (1991) redescribed the original Russian description of Microporella echinata, as he found the original description very brief with poor drawings when compared to the specimens obtained in his survey project conducted by National Science Museum, Tokyo. Hageman et al. (1996) analysed the geographic distribution of 88 modern bryozoan species among 16 sampling localities from the Lacepede Shelf off Southern Australia. Gordon and d'Hondt (1997) again contributed to bryozoan taxonomy by describing 98 species of ascophorine bryozoans
Chapter I. Introduction from the 1989-99 MUSORSTOM cruises, mainly in the EEZ of New Caledonian Island in this region. The phylogeny and systematics of bryozoans are dealt by Hondt (1986, 1997a, b, 2001). Seo (2002) is the only literature available on bryozoans from localities of Korea in which he reported a new parasmittinid species *Parasmittina pyriformis*. Winston and Beaulieu (1999) have found *Striatodoma dorothea*, a new genus and species of cheilostomate bryozoan from off central California. Soule et al. (1995, 2002, 2003, 2004), in the Irene McCulloch Foundation Monograph Series, have published a standard publication of more than 150 species obtained mainly during the Allan Hancock Foundation collections from the eastern Pacific.

Tilbrook *et al.* (2001) studied the subtropical bryozoans of the Vanuatu Island in the southwest Pacific Ocean and a total of 92 species were described, including a new family, three new genera and 20 new species. Tilbrook (1999) also reported 4 species of *Hippopodina* from the Philippines. Taylor (2000, 2001) has identified 23 species of cyclostomes from the Pacific side of Central American Isthmus and the Caribbean. He remarked that study of cyclostomes is very crucial to understand the palaeobiology of the extinct orders. The author also mentioned about the middle Jurassic bryozoans jointly with Wilson (1999) and reported of species of cyclostome bryozoan and one ctenostome. A list of 23 species of Australian lace corals or fenestrate bryozoans belonging to the family Phidoloporidae was described by Hayward (2000). Dea and Okamura (1999, 2000a,b) introduced a new technique for investigating palaeoseasonality based on intra colonial variations in zooid size, which was explained as an effect of temperature, salinity and food. Dea (2003) applied this technique to few encrusting bryozoans from either side of Isthmus and Panama, which were in contrasting seasonal environments. Gordon *et al.* (2002) have described 7 new species of encrusting eurystomellids from New Zealand and Japan and also have assessed their phylogenetic relation. Two erect cyclostomes of the New Zealand benthic fauna were described for the first time by Taylor and Gordon (2003). Hondt (2004) has revised the biological definition of Bryozoa. Hayward (2004) redescribed and illustrated 20 species of Phidoloporidae from the Indo-West Pacific realm. Tilbrook and Cook (2005) reported investigations on 10 species of bryozoans belonging to the family Petralliellidae Harmer 1957 from Queensland, Australia.

The Antarctic region

Busk (1884, 1886) studied the collections obtained from the "Challenger Expeditions" and reported the bryozoans from this region in the 'Report of the Polyzoa'. Kluge (1914), in his report of the South polar Expedition, has described many species of bryozoans
The cyclostomes are well described by Borg (1944) and some species among these have been reviewed and redescribed by Androsova (1968) and Moyano (1966). Hastings' (1943) "Discovery reports" was a comprehensive review of the cellularine Anasca, and membraniporadean, microporadean and cellarioidean species. Rogick (1965) listed not fewer than 158 species considered to be endemic to Antarctic and reported an additional 142 species (including Cyclostomata and Ctenostomata), which are considered to occur in both Antarctic and non-Antarctic regions. The same author has published (1955, 1956, 1959a, b, 1960, 1962) on various bryozoans, the collections of which were made during U.S. Navy's (1947-48) Antarctic Expedition and still continue to be the most important source of reference for the Antarctic ascophoran Bryozoa. Winston (1983) studied the patterns of growth, reproduction and mortality in bryozoans of the Ross Sea in the Antarctic Ocean. The descriptions of Ascophora by Hayward and Thorpe (1989) have nine new species of cheilostome Bryozoa of which five are new to science. The latest work available on the bryozoan fauna of the Antarctic region is that of Hayward (1995). Available information reveals that not less than 600 species have been reported from this area. Hayward and Winston (1994) described 4 new species of cheilostome Bryozoa from the sub-Antarctic, based on the collections of US Antarctic Research Program. Hayward (1996) described the cheilostome genus *Toretocheilum* from the Antarctic after the original description by Rogick, in 1960.

The Indian Ocean region

Harmer (1915, 1926, 1934, 1957) working on the collections made by the Siboga Expedition from the Indo-Australian Archipelago described not less than 527 species of bryozoans. This represents an outstanding contribution to the knowledge of the bryozoan taxonomy. Robertson (1921) worked on the polyzoan fauna of the Indian waters nearly eighty-five years ago. Her report on a collection of Bryozoa from the Bay of Bengal and other eastern seas is an appreciable paper on the Indian Polyzoa. Of the 95 species she described, 9 species and 1 variety were new to science. Another important paper to appear on this subject is that of Hincks (1887) describing 7 species from the Mergui Archipelago. In her report Thornely (1905, 1906, 1907, 1912, 1916) has described and listed 116 species of which 31 had already been recorded from the Indian seas, 32 from the Australian waters, 13 from the China Sea and outlying waters of the east, west and south of the Indian Ocean. In her report, she described 16 species and one variety as new to science. Thornely has given a reasonably complete description of 36 species but no figure has been given of species other than those described as new. The latest works on the Indian waters are the extensive work done by Menon (1967,
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1972a, b, c, 1973a, 1974a, c) and Menon and Nair (1967a, 1969a, b, 1970a, b, 1972b, 1973, 1974a, 1975) on recent bryozoans along the coasts of India. The authors have given detailed description, with clear illustrations of 101 species, which is one of the useful taxonomic references for this area. The morphological variations accompanying environmental variability in marine animals with structures exhibiting rigid calcareous and significant shear strength are established by studying the morphometrics of the widely distributed genus *Steginoporella* by Soja and Menon (2005). A Monograph on the taxonomy of bryozoan from the Indian EEZ, including descriptions and illustration of 128 species of bryozoans, is an ample work on this group from this region by Menon and Menon (2006).

**Fouling bryozoans**

Studies on the various fouling organisms are important to initiate novel antifouling techniques. Annandale's studies (1906, 1907a,b, c, 1908, 1911a,b, 1912) were mainly confined to the fresh water and brackish water forms. Annandale (loc. cit.) described nearly 8 species from the brackish water along the coasts of India. Mawatari (1951a,b), in his paper on the natural history of a common fouling bryozoan *Bugula neritina* has given observations on its embryonic development, larval behavior, metamorphosis, seasons of attachment, rate of growth, reproductive activities, duration of life as well as its resistances in various circumstances. Raft tests were conducted by Mawatari and Kobayashi (1954a,b) in Ago Bay, where pearl culture is active. Skerman (1958, 1959, 1960) investigated on the marine fouling at the Port of Auckland, the factors influencing settlement of individual species and those contributing to qualitative differences and intensity in fouling. A general account on the development of fouling community with seasonal changes in their initial development was presented by Kawahara (1960, 1962, 1963, 1965, 1969). Nair (1962) investigated the vertical zonation of foulers and borers of Western Norway, the effect of temperature on their activity, inhibitive and preservative value of local paint compositions on the resistance of woods against attack by marine borers.

Hayward and Harvey (1974) studied the distribution of larval settlement of two *Alcyonidium* species on *Fucus serratus* and found heterogeneity between areas of each frond. Biofouling happening on the shells of *Nautilus* from three geographic areas and the epizoans on them were studied by Landman et al. (1987) and they reported that the epizoans obtained tend to differ widely. Organization and Isolation of the ciliary locomotory and sensory organs of marine bryozoan larvae were done by Reed (1988),
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Upon exposure to hypotonic seawater and revealed that sensitivity of cilia at osmotic shock is organ specific but not species specific. 40 species of native and exotic marine bryozoans, recognized as foulers on vessels and submerged artificial surfaces in New Zealand ports and harbours, were mentioned and described in the Atlas of marine fouling Bryozoa by Gordon and Mawatari (1992). Stevens et al. (1996) examined bryozoans attached to plastic artifacts, a significant contaminant of all marine surface waters, which they reported, can be an important factor in maintaining, though not expanding, the geographic range of some species. Microbial mats and biofilms represented an important factor influencing bryozoan settlement and distribution as reported by Scholz and Krumbein (1996). Key et al. (1996) examined the intensity, abundance and spatial distribution of fouling bryozoans on blue crab, comparing their prevalence among male and female crabs and found that the females fouled more than males. Zooid size and colony growth of the estuarine bryozoan Conopeum seurati were examined by Dea and Okamura (1999) and results supported the uses of zooid size as an indicator of both long term trends and seasonal variations in temperature. Gutt et al. (1999) investigated 55 stations in Magellan region of South America and biological patterns of occurrence of five species assemblages were explained.

Fouling species of marine bryozoans were observed by Menon and Nair (1967b, 1971) and reported that their seasonal succession corresponded to the salinity of the Cochin estuary. The vertical and horizontal distribution of bryozoan foulers in Cochin backwaters was studied by Menon (1972d). Menon and Nair (1972a) discussed growth rates of 4 species of intertidal bryozoans and in yet another paper (1974b) discussed the salinity tolerance of euryhaline intertidal species, Victorella pavida and Electra crustulenta, which are widely distributed in this area. They found that the two species, when lined under the oligohaline condition in the rainy season, tolerated salinities from 0-10 psu (practical salinity unit) and 0-21 psu respectively, but during summer when the lower reaches of the backwaters exhibit typical marine condition, these animals, which settled on fresh panels tolerated higher salinities ranging 16-22 psu and 16-32 psu respectively. Rao and Ganapati (1975) described and illustrated six species from the intertidal region of Kakinada, Godavari. Katti and Rao (1976) noted the occurrence of Bugula neritina an important fouling bryozoan on a GRP hulled fishing trawler. Menon et al. (1977) compared settling of oysters, hydroids and polychaetes with bryozoans on glass panels in wooden racks in the Mangalore harbour. Weekly and monthly exposure of panels to fouling groups also has been vastly studied and the discussions are well referenced. Meenakumari and Nair (1988) studied the growth of the Barnacle Balanus...
amphitrite communis in Cochin backwaters and reported the relationship between the height and the rostrocardinal diameter at different ages is significantly linear. Daniel (1988) studied biofouling in Madras harbour and the role of biofilm on settlement of organisms. Anil and Wagh (1988) and Alan et al. (1988) studied the biofouling communities at Zuari Estuary, Goa and Ratnagiri coast respectively.

1.3 Basic morphology of a bryozoa

The phylum name, Bryozoa, literally means “moss animals” and refers to the bushy, moss-like colonies of some species. Flat encrusting forms are sometimes called sea mats. Erect, lacy forms are often called lace corals, a name that could also be applied to the thin, lace-like sheets that encrust kelp fronds.

Bryozoans are defined as microscopic, sessile, colonial coelomates that are permanently fastened in exoskeletal cases or gelatinous material of their own secretion, that are provided with a circular or crescentic lophophore and a recurved digestive tract bringing the anus near the mouth, and that lack nephridia and a circulatory system. The colony can be arborescent or frondose or can very often form flat spreading incrustations on objects, or sometimes become adherent or erect by stolons bearing the zooids. The colony is composed of individuals (zooids), each of which is typically enclosed in a secreted exoskeletal case. The case is termed zooecium; the zooecia of a colony has an opening to the exterior called orifice, provided with a closing apparatus called the operculum. The ectoproct individual or zooid consists of two main parts, the tentacular crown or lophophore, protrusible through the orifice, and the trunk, permanently fastened in the zooecium. In the marine forms or gymnolaemates, the
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The lophophore is circular but has the shape of a horseshoe in the fresh-water or phylactolaemate forms. Lophophore always embraces the mouth but never the anus. Retraction and protrusion of the lophophore aids in feeding since they are filter-feeders. The recurved digestive tract hangs freely in the coelom with few attachments to the body wall. The nervous system consists of a main ganglionic mass situated between the mouth and the anus encircles the pharynx. The nerves ascend into the tentacles and descend along the digestive tract and other parts of the trunk. Most ectoprocts are hermaphroditic. Circulatory, respiratory and excretory systems as organic assemblages are wanting. These animals exist as colonies that are typically derived by asexual reproduction from a single progenitor (ancestrula), originating by the metamorphosis of a sexually produced larva.

The gymnolaemate ectoprocts have polymorphic zooids. Coloniality in bryozoans reaches peak of specialization as some are designed to incubate embryos: ovicells, settlement and attachment: stolons, rhizoids etc, chemoreception and defence: avicularia and vibracula, asexual reproduction: brown bodies, statoblasts and feeding and nutrition: functional autozooids. Organically an ectoproct colony resembles a community, which contains individuals with specific functions, which obviously is accompanied by morphologically specialized members suited to perform the functions for the colonial existence. There is no parallel to this system of organismic assemblage in any marine animal so far encountered.

1.4 Habit

The bryozoans are almost always sedentary and sessile animals, erect or encrusting species, normally adhesive to a substratum. The adhesion is assumed according to different modes: fixation of the whole zoarial surface, by an encrusting disc or plate constituted by a small number of basal zooecia, by rhizoid issued from proximal or lateral autozoecia, by a column or a peduncle or erects elongated zooecia. The lunulitiform bryozoans are capable of moving slowly on the substratum, and to turn over if they are reversed with the help of marginal specialized vibracula of the conical zoarium. These organisms demonstrate the most elaborated and advanced case of coordination and integration, involving a whole zoarial response, among the Bryozoa. A few families such as are Terebriporidae, Spathiporidae, Penetrantidae, with colonial morphology are found to bore into molluscan shells. There are free-living bryozoans. The interstitial ctenostomes belonging to the genera Aethozoon Hayward, 1978 and Pachyzoon or Franzenella Hondt, 1983 live in the inter spaces of sand grains. These
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Species are probably mobile, but very slowly, inside the substratum. More peculiar is the case of the Monobryozoon Remane, 1936, constituted only by a functional autozooeia and its replacement bud has been described as motile in the sediment. The mobility of the adhesive basal tubes allows a temporary adherence to the sand grains; but probably also the movements are very slow in the Monobryozoon, and the animals cannot do spacious displacement (Winston, 1988).

1.5 Habitat

The Ectoprocta belonging to the group Gymnolaemata are marine, and one of the most common animals found in collections along ocean shores. They are mostly limited to the littoral zone, although known to descend to depths of nearly 6000 m. The colony is nearly always immovably attached to substrates like shells, seaweeds, pilings, bodies of other animals, and so on, although a few colonies are motile, and manifests a great variety of form. The group Phylactolaemata is limited to fresh water, and its members are sparingly found under stones or on twigs and other objects in clear lakes, reservoirs, ponds and streams. Bryozoans form erect growths that provide structure to seafloor habitats and calcareous encrustations contributing to coral reefs, which increases three-dimensionality and biodiversity.

1.6. Importance of Bryozoan on Evolution, Ecology and Economy

1.6.1 On Evolution

Bryozoans have a very long history spanning from Lower Ordovician (500-430 million years ago) to the Recent. The calcareous skeleton of Bryozoa are extremely durable constituting important component of fossil forms from the Permian, Palaeozoic, Jurassic, Lower Cretaceous and the Recent, thereby, are of great palaeontological significance. Geological informations are well characterized by Bryozoa. The stratigraphic value of these species and their application to economic problems in ecology is an aspect of great sedimentological importance yet to receive scientific attention. Dea and Okamura (2000a) formulated a new technique for investigating palaeoseasonality based on variations in zooid size of fossil cheilostome bryozoans.

1.6.2 Ecology

Many bryozoans are influenced by the ecological factors of their locality and by knowing an indigenous species we can predict the ecological factors, which may have influenced it, as few live only in peculiar situation. Notable among these are the ctenostomate
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families *Terebriporidae*, *Dentranitidae* and *Inmergentidae*. Another well-known example is the lunuliform Bryozoa, *Cupuladria canariensis*, which is distributed within the limits of 14 °C isocryme, are confined typically to warmer waters (Ryland, 1970). They are usually found in sandy bottom area. Calcareous Bryozoa compete with other calcareous algae in growing over and cementing fragile broken coral branches and thereby contribute to the coral reef ecosystems.

1.6.3 Economy

Bryozoans are biochemically important and have been proved to be a rich source of novel compounds or bioactive agents. Bryostatin-1, a compound produced by *Bugula neritina* has been in human Phase I clinical trials for the past 2 years and is a promising anti-tumor agent (Petit, 1994). A draft developed from this has already reached the pharmaceutical markets (September, 2005). Over 20 different bryostatins have been isolated from this particular species (Faulkner, 1984, 1986, 1987, 1988, 1990, 1991, 1992, 1993, 1994). *B. dentate* (Lamouroux) was shown to contain an anti-microbial blue pigment (Matsunaga *et al.*1986). A series of brominated alkaloids have been isolated from *Flustra foliacea* (L.) (Christopher and Carte 1980, 1981; Wright, 1984) of which Flustramines A and B having muscle relaxant activity and Dihydroflustramine exhibiting strong antimicrobial activity. Compounds from *Sessibula translucens* Osburn, inhibits cell division in fertilized sea urchin egg assay and also exhibit antimicrobial properties (Faulkner and Carte 1983). *Chartel/a papyracea* (Ellis and Solander) and *Cribricellina cribraria* are biochemically important for its biological activities including anti tumor and antifungal activities (Princep *et al.*, 1991). The calcium carbonate of these animals is in a highly pure form for the utilisation in dentistry. Chitin extraction from bryozoan is another field that is developing. These chemicals open up an important field in biotechnology research of pharmaceutical importance. The experimental studies to understand cloning and mapping of genes is a recent field of research in which bryozoans are being used extensively by genetic engineers.

1. 7 Objectives of the present study

1. Taxonomic study of bryozoans of the Indian EEZ and the Antarctic waters.
2. Provide detailed description of the bryozoan species collected with a dredge from the Indian EEZ and the Antarctic.
3. Collate data on the distribution of species as well as the influence of environmental condition on distribution and abundance.
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4. Assess the biogeography of the recorded species with the help of secondary data.

5. Test the spatial relations existing between species from Indian EEZ and the Antarctic.

6. Assess endemism in tropical bryozoans.

7. Study exoticism and surface transport relations.

8. Monitor the bioactively proved species availability in Indian waters.

9. Assess the hydrographical conditions of Cochin estuary, a proved abode of bryozoan foulers.

10. Determine the qualitative and quantitative distribution of bryozoans in the Cochin backwaters.

11. Study the incidence of fouling bryozoans on test coupons as a part of biofouling studies.