TAXONOMY, BIONOMICS AND BIOFOULING OF BRYOZOANS FROM THE COASTS OF INDIA AND THE ANTARCTIC WATERS

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CERTIFICATE

This is to certify that the thesis entitled "**Taxonomy, Bionomics and Biofouling of Bryozoans from the Coasts of India and the Antarctic Waters**", is an authentic record of the research work carried out by Smt. Soja Louis, under my scientific supervision and guidance in the School of Marine Sciences, Cochin University of Science and Technology, in partial fulfillment of the requirements for the degree of Doctor of Philosophy of the Cochin University of Science and Technology and that no part thereof has been presented before for the award of any other degree, diploma or associateship in any University.

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Preface

The Study of bryozoans, an important group of coelomates in the marine environment is an integral part of faunistic investigations, since this group controls the quality of animals that would colonize the continental shelf region of the tropical seas. Bryozoans are an ancient, aberrant phylum of microscopic but fascinating and often beautiful animals that build intricate colonies sometimes resembling mini colonies. Watching them alive under a microscope is a wonderful experience. They have a well recorded fossil history due to their zooecial nature and they have been around since the Ordovician era. Bryozoan phylum contains around 6000 recent and 22,000 extinct species. Knowledge of the taxonomy, spatial distribution and dominance in the microbenthos by bryozoans from the Indian continent is very relevant as this aspect has been uniformly neglected by marine biologists in general and benthologists in particular.

Bryozoan morphology is complicated and hence has deterred marine scientist from making attempts to study in detail. This is especially so in the Indian context which is amply testified by the lack of serious work on the taxonomy and biology of this group. These animals have not been explored by any marine biologist since a series of publications appeared in the early seventies. The classical work of Harmer (1926-1957) showed the species abundance of this group in the Indian Ocean. Menon (1967-1974) described in detail numerous species that occurs around the coasts of India. Considering the importance of a study on the biodiversity of microbenthos, which is normally represented by representatives of this group from the benthic realm an enquiry into this, could become a very useful input towards understanding the biodiversity of benthic animals. Therefore, the present work was undertaken in which taxonomy, bionomics, geographical distribution and fouling, an economically relevant aspect of the bryozoans of the Indian EEZ and a locality in the Antarctic was carried out. It is hoped that this work would help the future researchers to devote attention on microbenthos of the continental shelf of India when samples are made available through collections conducted by any ocean going vessel. The present work when published would become an excellent addition to the bryozoan literature.

Part-I

Taxonomy

1. Introduction

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 bio-geographic 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.

The Arctic

Numerous leading workers have studied the Arctic bryozoans. Nordgaard (1900) published important papers on bryozoans of the Artic 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 Coeliostega 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 several northeast Atlantic problematic species. Gappa (2000, 2001, 2002) recorded 246 marine bryozoan species within an area of the south west Atlantic between 35^{o} 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 Retepora 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 ectoprocts. 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 ectoprocts 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 crytofaunal 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 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 from this region. 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, 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 *Nautilius* 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), 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

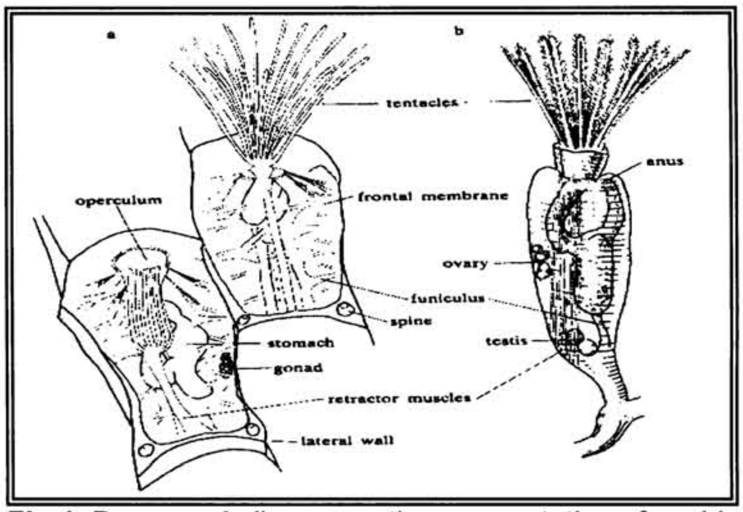


Fig.1. Bryozoa- A diagrammatic representation of zooid.
a. Gymnolaemate zooids. b. Ctenostome zooid.

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 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 autozooecia, 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 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 autozooecia 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 strategraphic 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 families *Terebriporidae, Dentrantidae* and *Inmergentidae.* Another well-known example is the lunilitiform 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.) (Christophersone and Carli, 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). *Chartella 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.

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.

2. Taxonomic account

Bryozoans are colonial animals that look superficially like corals, but have a morphology that is significantly complicated. The group is known taxonomically as the Phylum Bryozoa or the Phylum Ectoprocta. Bryozoa (Erhenberg, 1831), the retained name of the so-called Ectoprocta by Nitcshe (1869) and Polyzoa by Thompson (1830) was raised to the phylum rank by Hatschek in 1888. Although, considered as a minor-phylum and placed in the midst of the phylum Mollusca and phylum Echinodermata, this phylum with animals of variegated morphology needs to be elevated and given a major phyletic rank. Growth in these colonial organisms by repetition of modules inherently provides an increase in complexity relative to their solitary organism (Hageman, 2003). Therefore, the interpretation of the functional or evolutionary significance of complexity, within this group that exhibit modular growth, may need to be considered under a modified criterion from those used to interpret complexity in solitary organisms. Complexity in colonial organisms is often equated with the degree of integration in polymorphs (Jackson, 1985). The morphology of an organism can reflect adaptive evolutionary or phenotypic responses to selected environmental pressures under which the organism lives. Extrinsic and intrinsic factors, physical and biological factors and the interactions of all these are hypothesized to affect bryozoan diversity. These lophophorate coelomates are unnoticed by a naked eye due to the small size of the zooids that comprise the colony and belie the significant complexity of structure. The individual in the colony are at a level of complexity under a microscope and was commented as "exceptionally difficult group" by Hyman (1959) in her scholastic documentation of the invertebrate phyla.

Bryozoans are epibiont on various living and non-living hard substrata like sand grains, rocks, shells, wood and blade of kelps or other algae. Calcified outer armour or structures of attachment are the skeletal characters used in taxonomy and are species specific and differences in them have been directly linked to genetic differences. However, the proliferation of terms and the unique terminology of this group have made assigning a species a laborious task involving careful observation. Scanning Electron Microscopy is the most recent technique employed to identify species.

Differences in names and status of taxa occur throughout the hierarchy even to the phyletic level (Hyman, 1959; Ryland, 1970). The marine forms grouped under gymnolaemates are in a continuing state of revision. However, taxonomists generally agree that there are three major classes in the phylum Bryozoa. These are the Class Phylactolaemata, whose members are found only in fresh water, and two Classes, the Stenolaemata and the Gymnolaemata whose members are wholly marine. Bryozoans are predominantly marine organisms.

The freshwater bryozoans, in the Class Phylactolaemata, differ from their marine counterparts in a number of ways. First, the crown of ciliated tentacles is horse-shoe or "U" shaped instead of being circular. Second, they are never calcified. The colony may be embedded in a gelatinous matrix, but it never has calcified components. Third, there is no polymorphism in the colony, all of the individuals look and act alike; no avicularia or vibracula are found in the freshwater species. Finally, the freshwater forms often produce a small dispersal stage called a statoblast, while gymnolaemates, similar to most invertebrates, pass through a developing dispersal stage called a larva. These animals are widely dispersed in freshwaters, being found in virtually all bodies of freshwater. Additionally, some fresh water colonies are huge, several inches in diameter.

The marine bryozoans, the Gymnolaemata, may or may not be calcified, at least to some extent, this helps in classifying this group, which is subdivided into three living and two extinct orders, based on the complexity involved by the calcification of the exoskeleton. The three living orders are the ctenostomes, cheilostomes and the cyclostomes in the sequential order of the morphological complexity.

- The ctenostomes are the gymnolaemates with a simple, flexible, uncalcified zooecium composed of chitinous cuticle. Usually represented by stoloniferous vase like zooids, which are greatly misunderstood as the coelenterates. The orifice lacks a closing apparatus called the operculum but the diaphragm usually bears a pleated collar which when folded blocks the vestibule.

- The Cheilostomata are the calcified group and the most dominant group in a bryozoan assemblage. The colony usually consists of box-like contiguous zooids arranged as branches, continuous incrustations or lamellate expansions. They are unique in having an operculum, the closing apparatus of the orifice. Polymorphism, a phenomenon of variation in zooidal structure and function within a species reaches its paramount in this group. Based on the extend of calcification of the exoskeleton and the presence or absence of ascopore, they are subdivided into Anasca and Ascophora.

  - Anasca having a less calcified membraneous front which itself regulates the in and out movements of their feeding organ – the lophophore.

  - Ascophora has a distinctly calcified front due to which the in and out movements of the lophophore is facilitated by the possession of a compensation sac – the ascus.

The family Cribrilinidae needs to be mentioned, which is the evolutionary link between the Anascans and Ascophorans, is featured by its calcified costulate armour with partially exposed front and possesses characters of both the classes.

- The cyclostomes are more complex group possessing fully calcified tubular zooids. Lophophore protrusion is by the action of annular muscles and is devoid of avicularia and vibracula but heterozooids occur in the form of gonozooids, nannozooids and kenozooids.

2.2. Materials and methods

The bryozoans from the Indian EEZ were dredge sampled during the FORV Sagar Sampada **[Fig. 3]** cruise No. 177, in October 1999 from transects extending from Cape

Table. 1. FORV Sagar Sampada, Cruise 186 (July 2000): station locations along the East coast of India: Depth and Sediment characteristics

Sl.No.	St. No.	Transect	Latitude(N)	Longitude(E)	Depth (m)	Sediment Nature
1	**620**	**Chennai**	13°15'08"	80°32'15"	118	Silty sand
2	**623**	**Cuddallore**	12°15'00"	80°07'13"	30	Sand silt clay
3	**624**	**Cuddallore**	12°15'00"	80°13'59"	50	Coarse sand
4	**633**	**Krishnapatanam**	14°00'00"	80°22'97"	50	Fine clay
5	**640**	**Kavali**	15°00'00"	80°20'17"	100	Fine clay
6	**653**	**kakinada**	17°00'14"	82°30'27"	48	Clay
7	**660**	**Visakapatanam**	17°50'39"	83°59'97"	98	Coarse sand
8	**661**	**Visakapatanam**	17°51'26"	83°57'02"	65	Sandy clay

Table. 2. FORV Sagar Sampada, Cruise 177 (October 1999): station locations along the West coast of India: Depth and Sediment characteristics

Sl.No.	St. No.	Transect	Latitude(N)	Longitude(E)	Depth (m)	Sediment Nature
1	**1**	**Cape comorin**	08°3'.01"	77°20'68"	35	sand
2	**3**	**Cape comorin**	07°21'.83"	77°20'62"	127	sand
3	**5**	**Trivandrum**	08°27'.58"	76°42'72"	60	sand
4	**6**	**Trivandrum**	08°21'.67"	76°32'.63"	112	sand
5	**8**	**Quilon**	09°00'.27"	76°03'.93"	31	sand
6	**9**	**Quilon**	08°57'.70"	76°19'.40"	50	sand
7	**11**	**Quilon**	08°53'.35"	76°01'.69"	110	sand
8	**12**	**Quilon**	08°54'.77"	75°58'.77"	128	sand
9	**14**	**Cochin**	09°55'.35"	75°53'.92"	49	sand
10	**15**	**Cochin**	09°46'.26"	75°41'.42"	94	sand
11	**16**	**Cochin**	09°42'.73"	75°37'.63"	201	sand silt clay
12	**17**	**Calicut**	11°23'.40"	75°52'.96"	32	clayey silt
13	**18**	**Calicut**	11°20'.12"	75°21'.47"	60	sand
14	**19**	**Calicut**	11°17'.98"	74°57'.08"	87	sand
15	**20**	**Calicut**	11°19'.01"	74°51'.67"	185	sand
16	**21**	**Calicut**	11°43'.25"	74°33'.86"	193	sand
17	**22**	**Cannanore**	11°44'.95"	74°40'.52"	103	sand
18	**23**	**Cannanore**	11°48'.99"	74°52'.10"	66	sand
19	**24**	**Cannanore**	11°56'.42"	75°04'.1"	52	sand
20	**25**	**Cannanore**	11°59'.72"	75°04'.35"	32	sand silty clay
21	**27**	**Mangalore**	12°49'.92"	74°32'.66"	52	sand
22	**28**	**Mangalore**	12°44'.47"	74°14'.78"	97	sand
23	**32**	**Bhatkal**	14°4'.31"	73°48'.46"	69	sand
24	**33**	**Bhatkal**	14°08'.05"	74°04'.86"	53	sand
25	**37**	**Goa**	15°25'.94"	73°17'.35"	73	silty clay
26	**38**	**Goa**	15°26'.07"	73°06'. .17"	100	silty sand
27	**39**	**Goa**	15°25'.56"	72°53'.04"	194	silty sand
28	**42**	**Ratnagiri**	16°38'.18"	72°39'.14"	80	silty sand
29	**43**	**Ratnagiri**	16°36'.40"	72°17'.51"	107	sand
30	**46**	**Off Mumbai**	17°59'.59"	72°21'.82"	54	sandy clay
31	**47**	**Off Mumbai**	17°59'.26"	71°50'.27"	95	sand
32	**48**	**Off Mumbai**	17°59'.38"	71°14'.59"	92	sand
33	**49**	**along Mumbai**	18°23'.25"	70°47'.14"	94	silty sand

Comorin to Dwaraka along the West coast and cruise No. 186 in July 2000 from Karaikal to Paradeep along the East coast **[Fig.2]**. Various stations distributed along the transects were located at various depths **[Table 1 and 2]**.

The material for the study of Antarctic species was obtained from collections made during the Third Antarctic Expedition by ORV Sagar Kanya from December 1983 to March 1984. These specimens were accidentally caught during a vertical haul of a plankton net from a depth of 200m at 1900 hrs on 1st January 1984 off- Prince Astrid Land **[Fig. 5]** close to the Antarctic circle (Lat. 69°54'S and Long.12°49'E). During the hauling the mouth of the net scraped the sides of a gorge and collected the bryozoans growing on the hard rocks.

Sampling gear: Dredges have a heavy metal frame and are designed for breaking off pieces of rock, scraping organisms off hard surfaces, with limited penetration and collection of sediments.

Naturalists dredge: The naturalists or rectangular dredge is a useful instrument for exploratory purposes as it can obtain samples on a variety of grounds **[Fig. 4]**. One of the dredge arms is attached to two ropes, the other being joined to it by few turns of twine, which act as a weak link to release the dredge should it become fast on the sea bed.

The specimens were scraped off the substratum using a surgical blade. They were cleaned with Sodium hypochlorite (0.5%) washed and dried. Coated with gold under vacuum conditions using Agar, UK. and Scanning Electron Micrographs were prepared with a Leo 435 VP Scanning Electron Microscope (Carl Zeiss SMT Ltd, UK). The zooecial dimensions were recorded by means of SEM technology.

2.3 Results

A systematic survey of the marine and estuarine forms grouped under gymnolaemates from the Indian EEZ and the Antarctic waters have been completed with descriptions, SEM photographs and figures. In order to compile information relevant to biodiversity, a species list is an indispensable tool and the species name, is the vocabulary of biodiversity. The present taxonomic work on the Indian EEZ bryozoans accounts the details of 102 species including 39 species of Anascan belonging to 23 genera of 17 families, 54 species of Ascophora belonging to 34 genera of 22 families, 4 species of cyclostomes of 4 genera and 3 families and 5 species of ctenostomes belonging to 5 genera of 4 families.

Of the 24 species of bryozoans from the Antarctic waters, 12 species of Anasca belonging to 10 genera of 5 families, 10 species of Ascophora belonging to 10 genera of 7 families and 2 cyclostomes of 2 genera and 2 families have been identified and described.

A total of 51 Anascans, 64 Ascophorans, 6 Cyclostomes and 5 Ctenostomes are systematically placed. Of these 54 species are first records from the Indian EEZ and 10 species from the Antarctic are premier records from the Antarctic waters. There are 3 new records to science; they are ***Chartella arabica*** from the Cochin estuary, ***Cleidochasma sampada*** from the EEZ of India and ***Iodictyum anomala*** from the Antarctic waters.

2.4 Abbreviations

L_z	Length of the zooid
l_z	Width of the zooid
L_{za}	Length of the 'A' zooid
l_{za}	Width of the 'A' zooid
L_{zb}	Length of the 'B' zooid
l_{zb}	Width of the 'B' zooid
L_a	Length of the avicularia
l_a	Width of the avicularia
L_o	Length of the ovicell
l_o	Width of the ovicell
L_{op}	Length of the operculum
l_{op}	Width of the operculum
EEZ	Exclusive Economic Zone

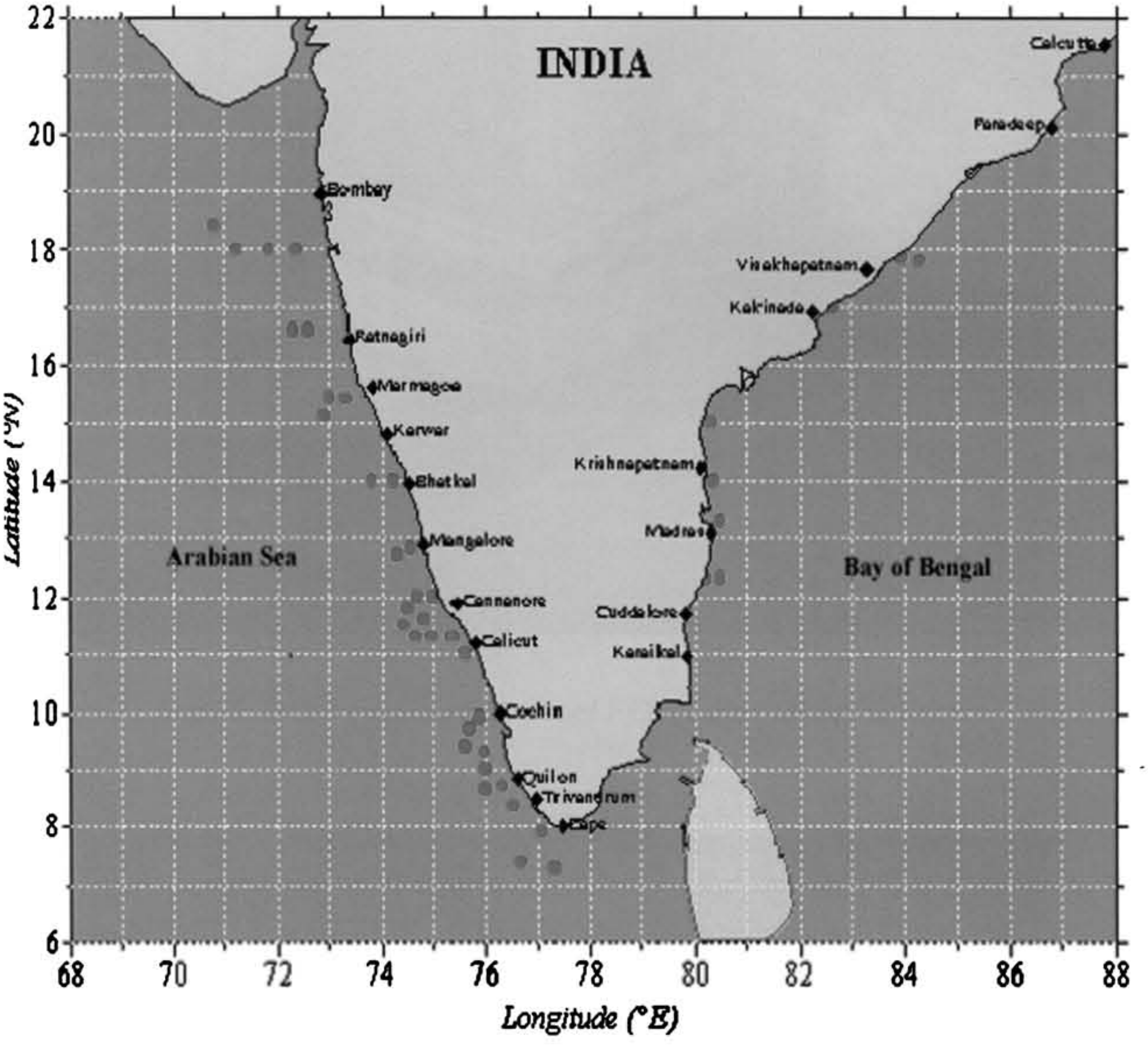


Fig.2. FORV Sagar Sampada stations in the Indian EEZ: locations sampled for bryozoans from the Arabian Sea [Cruise No. 177] and the Bay of Bengal [Cruise No. 186].

Fig. 3 DOD Research vessel FORV Sagar Sampada

Fig. 4 A Naturalists dredge

2. 5. TAXONOMIC LIST OF THE INDIAN EEZ BRYOZOANS

CLASS GYMNOLAEMATA (Allman, 1856)

Order CHEILOSTOMATA Busk, 1852

Suborder ANASCA Levinsen, 1909
Family - *Aeteidae* Smitt, 1867
Genus - *Aetea* Lamouroux, 1812
1 *Aetea anguina* (Linnaeus), 1758

Family - *Membraniporidae* Busk, 1854
Genus - *Acanthodesia* Canu and Bassler, 1919
2 *Acanthodesia* sp.
3 *Acanthodesia savartii* (Audouin), 1826

Family - *Electrinidae* d'Orbginy,1851
Genus - *Electra* Lamouroux, 1816
4 *Electra indica* Menon and Nair,1975
5 *Electra crustulenta* (Pallas), 1766
6 *Electra crustulenta* var. *borgii* Menon and Nair,1975
7 *Electra bengalensis* (Stoliczka), 1869
Genus - *Conopeum* Gray, 1848
8 *Conopeum reticulum* (Linnaeus), 1767

Family - *Calloporidae* Norman, 1903
Genus - *Parellisina* Osburn, 1940
9 *Parellisina curvirostris* (Hincks), 1862
Genus - *Crassimarginatella* Canu, 1900
10 *Crassimarginatella* sp.
Genus - *Cranosina* Canu and Bassler, 1933
11 *Cranosina coronata* (Hincks), 1881
Genus - *Alderina* Norman, 1903
12 *Alderina arabianensis* Menon and Nair, 1975

Family - *Antroporidae* Vigneaux, 1914
Genus - *Antropora* Norman, 1903
13 *Antropora erecta* (Silen,1941)
14 *Antropora granulifera* (Hincks,1880)
15 *Antropora tincta* (Hastings), 1930
16 *Antropora marginella* (Hincks), 1884
17 *Antropora claustracrassa* (Canu and Bassler), 1930
18 *Antropora* sp.

Family - *Calesharidae* Cook and Bock, 2001
Genus - *Caleschara* Mac Gillivray, 1880
19 *Caleschara levinsenii* Harmer, 1926
20 *Caleschara mexicana* Osburn, 1950
Family - *Heliodomidae* Vigneaux 1949
Genus - *Setosellina* Calvet, 1906
21 *Setosellina constricta* Harmer, 1926

Family - *Cupuladriidae* Lagaaij, 1952
Genus - *Cupuladria* Canu and Bassler, 1919
22 *Cupuladria indica* Cook, 1965
23 *Cupuladria guineensis* (Busk), 1854

Family - *Flustridae* Fleming, 1828
Genus - *Chartella* Gray, 1848
24 *Chartella arabica* sp. *novo*

Family - *Quadricellariidae* Gordon 1984
Genus - *Nellia* Busk, 1852
25 *Nellia occulata* Busk,1852

Family - *Bugulidae* Gray, 1848
Genus - *Bugula* Oken, 1815
26 *Bugula neritina* (Linnaeus, 1758)
27 *Bugula cucullata* (Busk, 1867)

Family - *Epistomiidae* Gregory, 1893
Genus - *Synnotum* Pieper, 1881
28 *Synnotum aegyptiacum* (Audouin, 1826)

Family - *Candidae* Busk, 1852
Genus - *Scrupocellaria* van Beneden, 1845
29 *Scrupocellaria ferox* Busk, 1852
Genus - *Caberea* Lamouroux, 1816
30 *Caberea lata* Busk, 1852

Family - *Onychocellidae* Jullien, 1882
Genus - *Smittipora* Jullien, 1882
31 *Smittipora abyssicola* (Smitt, 1873)

Family - *Steginoporellidae* Hincks, 1884
Genus - *Steginoporella* Smitt, 1873
32 *Steginoporella buskii* Harmer, 1900
Genus - *Labioporella* Harmer, 1926

33 *Labioporella sinuosa* (Osburn, 1940)
Family - *Thalamoporellidae* (Levinsen, 1909)
Genus - *Thalamoporella* Hincks, 1887
34 *Thalamoporella gothica* (Busk, 1856)
35 *Thalamoporella hamata* Harmer, 1926
36 *Thalamoporella expansa* Levinsen, 1909
37 *Thalamoporella rozierii* (Audouin,1826)

Family - *Cellariidae* Hincks, 1880
Genus - *Cellaria* Ellis and Solander, 1786
38 *Cellaria johnsoni* Busk, 1858
39 *Cellaria punctata* (Busk), 1852

Family - *Cribrilinidae* (Hincks, 1879)
Genus - *Puellina* Jullien,1886
40 *Puellina vulgaris* Ryland and Hayward, 1992
Genus - *Cribrilaria* Canu and Bassler, 1929
41 *Cribrilaria* sp.

Suborder ASCOPHORA
Family - *Trypostegidae* Gordon and Winston, 2005
Genus -Trypostega Levinsen, 1909
42 *Trypostega venusta* (Norman, 1864)

Family - *Adeonidae* (Busk, 1884)
Genus - *Adeona* Lamouroux, 1812
43 *Adeona foliacea* Lamouroux, 1816
Genus - *Adeonellopsis* Mac Gillivray, 1886
44 *Adeonellopsis arculifera* (Canu and Bassler, 1929)

Family - *Lepraliellidae* Vigneaux, 1949
Genus - *Celleporaria* Lamouroux, 1821
45 *Celleporaria pilaefera* (Lamouroux, 1821)
46 *Celleporaria granulosa* Haswell (1880)
47 *Celleporaria magnifica* Osburn, 1914
Genus - *Drepanophora* Harmer, 1957
48 *Drepanophora incisor* (Thornely), 1905

Family - *Smittinidae* (Levinsen, 1909)
Genus - *Parasmittina* Osburn, 1952
49 *Parasmittina aviculata* (Mawatari, 1952)
50 *Parasmittina egyptiaca* (Waters, 1909)
51 *Parasmittina hastingsae* Soule and Soule, 1973
52 *Parasmittina parsevalii* (Audouin, 1826)

53 *Parasmittina signata* (Waters, 1889)
54 *Parasmittina spathulata* (Smitt), 1873
55 *Parasmittina tubula* (Kirkpatrick, 1888)
Genus - *Smittina* Norman, 1903
56 *Smittina landsborovii* (Johnston), 1847
57 *Smittina torques* Powell, 1967
58 *Smittina acutodentata* Harmer, 1957

Family - *Romancheinidae* Jullien, 1888
Genus - *Escharoides* Edwards, 1836
59 *Escharoides* sp.

Family - *Bitectiporidae* MacGillivray, 1895
Genus - *Metroperiella* Canu and Bassler, 1917
60 *Metroperiella pyriformis* Harmer, 1957
Genus - *Schizomavella* Canu and Bassler, 1917
61 *Schizomavella inclusa* (Thornely, 1905)

Family - *Watersiporidae* Vigneaux, 1949
Genus - *Watersipora* Neviani, 1895
62 *Watersipora subovoidea* (d' Orbigny, 1852)

Family - *Schizoporellidae* Jullien, 1903
Genus - *Schizoporella* Hincks, 1877
63 *Schizoporella cochinensis* Menon and Nair (1967)
64 *Schizoporella inarmata* Hincks (1884)

Family *Margarettidae* Harmer, 1957
Genus - *Margaretta* Gray, 1843
65 *Margaretta watersi* Canu and Bassler, 1930

Family - *Hippopodinidae* Levinsen, 1909
Genus - *Hippopodina* Levinsen, 1909
66 *Hippopodina californica* Osburn, (1952)

Family - *Cryptosulidae* Vigneaux, 1949
Genus - *Cryptosula* Canu and Bassler, 1925
67 *Cryptosula pallasiana* Moll, 1803

Family - *Actisecidae* Harmer, 1957
Genus - *Actisecos* Canu and Bassler, 1927
68 *Actisecos regularis* Canu and Bassler, 1927

Family - *Hippaliosinidae* Gordon and Winston, 2005

Genus - *Hippaliosina* Canu, 1918
69 *Hippaliosina acutirostris* Canu and Bassler (1929)

Family - *Microporellidae* (Hincks, 1879)
Genus - *Microporella* (Hincks, 1877)
70 *Microporella orientalis* Harmer (1957)
Genus - *Microporelloides* Soule, Chaney and Morris, 2003
71 *Microporelloides hawaiiensis* Soule, Chaney and Morris, 2003
Genus - *Fenestrulina* Jullien, 1888
72 *Fenestrulina malusii* (Audouin, 1826)
Genus - *Calloporina* Neviani, 1895
73 *Calloporina sigillata* Canu and Bassler, 1929
74 *Calloporina sculpta* Canu and Bassler, 1929

Family - *Petraliellidae* Harmer, 1957
Genus - *Sinupetraliella* Stach, 1936
75 *Sinupetraliella affinis* Harmer, 1957
Genus - *Hippopetraliella* Stach, 1936
76 *Hippopetraliella magna* (D'Orbginy,1852)
Genus - *Mucropetraliella* Stach, 1936
77 *Mucropetraliella thenardii* (Audouin, 1826)
78 *Mucropetraliella philippinensis* (Canu and Bassler, 1929)

Family - *Crepidacanthidae* Levinsen, 1909
Genus - *Crepidacantha* Levinsen, 1909
79 *Crepidacantha crinispina* (Canu and Bassler, 1929)

Family - *Cleidochasmatidae* Cheetham and Sandberg, 1964
Genus - *Cleidochasma* (Harmer, 1957)
80 *Cleidochasma biavicularium* (Canu and Bassler, 1929)
81 *Cleidochasma fallax* (Canu and Bassler, 1929)
82 *Cleidochasma protrusum* (Thornely),1905
83 *Cleidochasma sampada* sp. novo

Family - *Celleporidae* (Canu and Bassler, 1917)
Genus - *Lagenicella* Cheetham and Sandberg (1964)
84 *Lagenicella marginata* (Canu and Bassler, 1930)
85 *Lagenicella punctulata* (Gabb and Horn, 1862)

Family - *Phidoloporidae* Gabb and Horn, 1862
Genus - *Rhynchozoon* Hincks, 1895
86 *Rhynchozoon compactum* (Thornely, 1905)
87 *Rhynchozoon larreyi* (Audouin, 1826)
88 *Rhynchozoon globosum* Harmer, 1957

Genus - *Metacleidochasma* Soule, Soule and Chaney, 1991

89 *Metacleidochasma planulata* (Canu and Bassler, 1929)

Genus - *Triphyllozoon* Canu and Bassler, 1917

90 *Triphyllozoon tubulatum* (Busk), 1884

91 *Triphyllozoon philippinense* (Busk), 1884

Family - *Conescharellinidae* Levinsen, 1909

Genus - *Conescharellina* d'Orbigny, 1852

92 *Conescharellina jacunda* Canu and Bassler, 1929

Unknown family

Genus - *Escharina* Milne Edwards, 1836

93 *Escharina pesanseris* (Smitt), 1873

<u>**Order CTENOSTOMATA** Busk, 1852</u>

Family - *Alcyonididae* Johnston, 1849

Genus - *Alcyonidium* Lamouroux, 1813

94 *Alcyonidium erectum* (Silen, 1942)

Family - *Victorellidae* Hincks, 1880

Genus - *Victorella* Kent, 1870

95 *Victorella pavida* Kent, 1870

Family - *Nollellidae* Harmer, 1915

Genus - *Nolella* (Gosse, 1855)

96 *Nolella papuensis* (Busk, 1886)

Family – Vesicularidae Johnston, 1838

Genus - *Bowerbankia* Farre, 1837

97 *Bowerbankia gracilis* Leidy, 1855

Family - *Triticellidae* Sars, 1873

Genus *Triticella* (Dalyell, 1848)

98 *Triticella korenii* Sars, 1874

<u>**Order CYCLOSTOMATA** Busk, 1852</u>

Family - *Stomatoporidae* Pregens and Meunier, 1886

Genus - *Stomatopora* Bronn, 1825

99 *Stomatopora granulata* (Milne - Edwards, 1836)

Family - *Oncousoeciedae* Canu, 1918

Genus - *Proboscina* Audouin, 1826

100 *Proboscina lamellifera* Canu and Bassler, 1930

Family - *Crisiidae* Johnston, 1838
Genus - *Crisia* Lamouroux, 1812
101 *Crisia elongata* Milne - Edwards, 1838
Genus - *Filicrisia* d'Orbigny, 1853
102 *Filicrisia* sp.

2.6. TAXONOMIC LIST OF THE ANTARCTIC BRYOZOANS

CLASS GYMNOLAEMATA (Allman, 1856)

Order CHEILOSTOMATA Busk, 1852

Suborder ANASCA Levinsen, 1909

Family - *Calloporidae* Norman, 1903
Genus - *Ellisina* Norman, 1903
103 *Ellisina levata* (Hincks), 1882
Genus - *Amphiblestrum* Gray, 1848
104 *Amphiblestrum inermis* (Kluge), 1914

Family - *Chaperiidae* Jullien, 1881
Genus - *Icelozoon* Gordon, 1982
105 *Icelozoon lepralioides* (Kluge), 1914
Genus - *Chaperia* Jullien, 1881
106 *Chaperia quadrispinosa* Kluge, 1914
Genus - *Clipeochaperia* Uttley and Bullivant, 1972
107 *Clipeochaperia funda* Uttley and Bullivant, 1972

Family - *Onychocellidae* Jullien, 1882
Genus - *Chondriovelum* Hayward and Thorpe, 1988
108 *Chondriovelum adeliense* Hayward and Thorpe, 1988

Family - *Steginoporellidae* Hincks, 1884
Genus - *Steginoporella* Smitt, 1873
109 *Steginoporella magnilabris* (Busk, 1854)

Family - *Cellariidae* Hincks, 1880
Genus - *Cellaria* Ellis and Solander, 1786
110 *Cellaria tecta* Harmer, 1926
111 *Cellaria praelonga* Harmer, 1926
112 *Cellaria aurorae* Livingstone, 1928
Genus - *Swanomia* Hayward and Thorpe, 1989
113 *Swanomia membranacea* Hayward and Thorpe, 1989
Genus - *Melicerita* Edwards, 1836
114 *Melicerita obliqua* Thornely, 1924

Family - *Cribrilinidae* (Hincks, 1879)
Genus - *Reginella* Jullien, 1886
115 *Reginella* sp.

<u>Suborder ASCOPHORA</u>
Family - *Escharellidae* Levinsen, 1909
Genus - *Escharella* Gray, 1848
116 *Escharella mammillata* Hayward and Thorpe, 1989
Genus - *Escharoides* Edwards, 1836
117 *Escharoides praestida* (Waters, 1904)

Family - *Sclerodomidae* Levinsen, 1909
Genus - *Cellarinella* Waters, 1904
118 *Cellarinella laytoni* Rogick, 1956

Family - *Smittinidae* Levinsen, 1909
Genus - *Smittina* Norman, 1903
119 *Smittina favulosa* Hayward and Thorpe, 1989
Genus - *Dakariella* Moyano, 1966
120 *Dakariella concinna* Hayward, 1993

Family - *Lacernidae* Jullien, 1888
Genus - *Lacerna* Jullien, 1888
121 *Lacerna watersi* Hayward and Thorpe, 1989

Family - *Phidoloporidae* Gabb and Horn, 1862
Genus - *Rhychozoon* Hincks, 1895
122 *Rhynchozoon tubulosum* (Hincks, 1880)
Genus - *Iodictyum* Harmer, 1957
123 *Iodictyum anomala* sp. novo
Genus - *Reteporella* Busk, 1884
124 *Reteporella parva* Hayward, 1993

<u>**Order CYCLOSTOMATA** Busk, 1852</u>
Family - *Plagioeciidae* Canu, 1918
Genus - *Plagioecia* Canu, 1918
125 *Plagioecia patina* (Lamarck, 1816)

Family - *Horneridae* Smitt, 1867
Genus - *Hornera* Lamouroux, 1821
126 *Hornera spinigera* Kirkpatrick, 1988

2.7 Description of species from the EEZ of India

ORDER CHEILOSTOMATA (Busk, 1852)

Zooecial walls calcified, opening by a movable opercular valve like a little trap door.

SUB-ORDER ANASCA (Levinsen, 1867)

Cheilostomate without a compensation sac possessing an external frontal membrane.

Family Aeteidae Smitt, 1867

"Zooecia tubular with a sub terminal membranous area, partly erect and free, partly decumbent and adherent, uniserial" (Busk, 1884). Avicularia, vibracula and ovicells of the ordinary cheilostome type wanting.

Genus *Aetea* Lamouroux, 1812

Aetea Lamouroux, 1812: 184; Harmer, 1926: 194; Silen, 1941: 12; Osburn, 1953: 11.
Anguinaria Lamarck 1816: 142.

Zooecia tubular with a sub-terminal membraneous area. Partly erect and free, partly decumbent and adherent. No avicularia, vibracula, spines or permanent ovicell.

1. ***Aetea anguina*** (Linnaeus), 1758 **Plate 23: Fig. 81**

Sertularia anguina Linnaeus, 1758: 816.
Aetea anguina Lamouroux, 1812: 184; Hincks, 1880: 4; Busk, 1884: 2; Thornely, 1905: 108; Osburn, 1912: 220; Waters, 1913: 463; Harmer, 1926: 194; Hastings, 1932: 408; Marcus, 1938b: 199; Silen, 1942: 12; Osburn, 1950: 11; Mawatari, 1956: 115; 1963: 6; Menon and Nair, 1967a:1.

Occurrence: Few colonies were collected attached on the glass test panels immersed in Cochin estuary for biofouling studies.

Salient features: $L_z = 360\mu$; $l_z = 70\mu$

Attached to the substratum by means of the proximal part of the zooecium. Tubular, annulated peristome gradually expands to a non-annulated region. There is a very distinct frontal membrane covering the annulated part. The operculum with slightly thickened rim is distally placed.

Remarks: The specimens collected resemble those described by Waters (1913), Harmer (1926) and Mawatari (1956). No ovicell was noticed. This species has not been recorded from any other part of India. Curiously enough even Indian Museum does not possess these specimens.

Records from Indian waters: Gulf of Mannar, (Harmer, 1926); Off Cochin, west coast of India (Menon and Nair, 1967a).

Distribution: Cosmopolitan except in the polar waters.

Family Membraniporidae Busk, 1854

Frontal membrane fills the aperture, opesia occupying the same area of the frontal membrane or reduced by the development of a cryptocyst. Encrusting in habit. Ovicells are not found in any of these cheilostomes, known to posses a cyphonautes larva, or in which the occurrence of this larva is probable. Hence, Harmer thinks that the presence of cyphonautes larva is of great taxonomic importance.

Genus *Acanthodesia* Canu and Bassler, 1919

Encrusting, hemescharan, cellariform or vincularian. Zooecia without a gymnocyst, the frontal membrane occupying the entire surface. Typical marginal and oral spines wanting. Cryptocyst most developed proximally, narrower distally. Adventitious avicularia, ovicells or pore chamber wanting. The genus appears to be related to *Conopeum* sp. but can be distinguished from it by the absence of gymnocyst and by the greater development of proximal cryptocyst and narrower distal cryptocyst.

2. ***Acanthodesdia*** sp. **Plate 1: Fig. 1**

Occurrence: Few colonies found in the loose sediment from Cape Comorin.

Salient features: L_z = 650 µ; l_z = 480 µ

Colony erect, zooecia arranged alternatively having at least five zooids in a horizontal row. Opesia typically oval. The lateral walls of the zooecium provided with very minute tubercles. Cryptocyst broad, proximally slanting, smooth, practically non-existent distally. Neither spines nor proximal cryptocystal tubercles noticed.

Remarks: The material before me is temporarily assigned to the genus *Acanthodesia* since this appears to be the genus to which the present material resembles quite well. Since electron micrographs could be prepared from the meager sample at disposal, the structure is extremely clear and the zooids were found tolack some of the specific characters exhibited by different species assigned to this genus. The noticeable morphological characters, in the present material such as tubercular thickening, and margin, which demarcate the zooecium. Slight elevation of the distal portion of the zooecium and very well developed proximal cryptocyst, absence of spines and avicularia do not warrant the placement of this material to any specific species of *Acanthodesia*. Only on examination of more material from the locality from which the present specimen was collected, a specific identification of this material will be possible.

3. ***Acanthodesdia savartii*** (Audouin), 1826 **Plate 1: Fig. 2**

Membranipora favus Thornely, 1905: 110.
Membranipora savartii Thornely, 1912: 143; Marcus, 1921: 16; Osburn, 1950: 27; Menon and Nair, 1975: 555.
Acanthodesia savartii Canu and Bassler, 1920: 100; 1923: 31; Harmer, 1926: 213.

Occurrence: This species was obtained attached on bivalve shells in dredge samples taken from Vishakapatanam at a depth of 100 m from the Bay of Bengal.

Salient feature: L_z= 490µ; l_z= 310µ

The species could be hemescharan, escharan, cellariform or vincularian. The material in hand was found encrusting on bivalve shells. Zoaria arranged in longitudinal lines and could be alternate. The breadth and length of the zooecia can vary depending on the position of bifurcation. Basal zooecia from which bifurcations commence could have an oval opesia with broad proximal portion. Gymnocyst present, less developed. Cryptocyst extensive proximally and evanescent laterally and distally. The proximal portion of cryptocyst often provided with denticles. Cryptocyst may have minute tubercles. Operculum distally placed. The distal part of the gymnocyst slightly elevated and may possess tubercles. Opesia typically elongated oval. No distinct demarcation between zooecia. The denticles could be placed at the tip of very moderate cryptocystal extensions, which is evident in at least two zooecia.

Remarks: Previous workers have assigned this species to various genera. Review of the literature shows that the genera were *Flustra, Membranipora, Biflustra* and *Acanthodesia*. The basic difference among these genera is essentially centered around the cryptocystal characteristics and the related denticulations. Since the size and the nature of growth of the colony are highly variable, assigning this species based on this character alone (*Flustra* and *Biflustra*) is taxonomically wrong. Presence of denticles at the proximal extension of the cryptocyst is a very characteristic feature based on which Thornely (1912), Marcus (1921), Silen (1942), Menon (1967) assigned it to *M. savaratii*. However, Harmer (1926) followed Canu and Bassler (1919) and brought it under *Acanthodesia*. A very wide geographic distribution of this species in the tropical Indian and Pacific Ocean and various stations in the Indo-Australian Archipelago has resulted in considerable confusion in the taxonomic placement of this species. Examination of live specimens has seldom occurred but in the case of Harmer (1926), he even discussed the importance of variations in the placement of the retractor muscles at points of bifurcation, zooecial asymmetry seldom occurred. Harmer (1926) even created a variety *A. savartii* var *centrata* because of the vincularian character of the colony, although I did not find conspicuous variations in zooecial characteristics.

Records from Indian waters: Mangalore (Thornely, 1907); Cape Comorin (Menon, 1967).

Distribution: "It is a common species around the world in warmer shallow waters" (Osburn, 1950).

Family Electrinidae d'Orbginy, 1851

Encrusting zoarium could be erected from an encrusting base. Zooecia provided with a well-developed gymnocyst, which could be vestigial. Curiously enough these variations could be noticed in the same colony. No ovicells, no avicularia and no dietellae. Spines usually present around the border of the opesia, may be wanting or could be limited to a single proximal strong medium spine which could be very strong or reduced to a mere tubercle. The characters of the species assigned to this family are simple, but for the spines. Evolutionarily could be very close to the primitive membranipores.

Genus *Electra* Lamouroux, 1816

Electra Lamouroux, 1816: 120; Harmer, 1926: 206; Osburn, 1950: 35.

Encrusting colonies, square shaped or rectangular zooecia. A proximal gymnocyst may be evanescent distally. The frontal membrane covers the opesium, which more or less has the same extent of the zooecial surface. Opesia could be over arched by the marginal spines sometimes single or numerous. Cryptocyst wanting or barely indicated. No avicularia, ovicells or pore chambers. Single ancestrula.

4. ***Electra indica*** Menon and Nair, 1975 **Plate 26: Fig. 98 a, b & c**

Electra indica Menon and Nair, 1975: 562.

Occurrence: This species was seen epizoic on the shell of the bivalve mollusc *Perna indica* collected off-Cochin.

Salient features: L_z= 420µ - 460µ; l_z= 240 - 270µ
Encrusting zoaria growing on algal fronds and bivalve shells. Oval opesia, well developed, porous proximal gymnocyst. Three tubercles occupy the zooecial margin of which one occupy the proximal median point and the other two distal regions on either side of the opercula. Median tubercles in the young zooecia long and spinous. All these tubercles connected with a transparent membrane which has two lateral flanks. The distal extension of this, some times gives the appearance of a hood. Menon and Nair (1975) has followed the advice of Mawatari and decided to place this species under the genus *Electra* since ancestrula is single. The present species resemble *Electra biscuta* described by Osburn (1950). *E. biscuta* has a series of spines occupying the lateral side of the opesium and overarches the proximal gymnocyst. Such spines are however not noticed in the present specimens, although tapering of the spines gives a spinous appearance throughout the colony.

Remarks: This is first record of the species after the original record from Kovalam by Menon and Nair (1975). The occurrence of a peculiar proximal process developed on the gymnocystal margin is a character, which according to Mawatari, partly suggests, the position of the present form near *Electra*. It is evident that the hood-like extension at the distal end of the zooecium is not a forerunner of the ovicell since it is developed even in immature zooecium. The ancestrula is single. Probably this is the only dependable character to distinguish the genus *Electra* from *Membranipora*.

The salient distinguishable features of the present form are the swollen distal part of the zooecium, the large pores of the gymnocyst and the well developed tubercles. From a study of the available literature, it seems that the genus *Electra* established by Lamouroux in 1816, based on the form *Flustra verticillata* Solander, now includes about 14 recent species and varieties. The only species to which the present form resembles is *Electra biscuta* Osburn (1950). Osburn, in his specimens of *E. biscuta* noticed that the gymnocyst usually very limited in extent, could occupy one fourth or more of the zooecial length, cryptocyst smooth or slightly granulated, a strong arching of the distal walls on the dorsal side and spines of three kinds - one set occupying the lateral sides of the operculum over arching the opesia, when fully developed; two stout conical distal spines opposite the distal end of the operculum and a transverse series of short and stout conical spines which project forward in a row proximal to the opesia on the gymnocyst. He found that the number of this kind of spines, vary from 1 to 5. Osburn was doubtful about the generic status of his species, but he wrote "the absence of ooecia and avicularia and the presence of a gymnocyst, mural spines and thin lateral walls without dietellae, suggest the genus *Electra* though there is little resemblance in appearance to any other of that genus". An attempt to treat the form under consideration close to *E. biscuta* is vitiated by the presence of pores on the gymnocyst and the lesser development of the tubercles in this form. Regarding the presence of hood-like structure, Osburn's remark that "the distal wall is strongly arched forward on the dorsal side" suggests a lesser development of a hood-like structure. In the present collection, the proximal gymnocystal tubercles in certain colonies have attained spinous nature as a result of the elongation and tapering of these structures. It seems that this difference of the tubercles is the result of growth and age.

Records from Indian waters: Kovalam, west coast of India, (Menon and Nair, 1975).

Distribution: Arabian Sea (Menon and Nair, 1975).

5. *Electra crustulenta* (Pallas), 1766 — Plate 23: Fig. 82

Electra crustulenta Pallas, 1766: 39; Borg, 1931: 29; Osburn, 1950: 35; Menon and Nair, 1975: 557.

Occurrence: Several colonies were collected from wooden rack and short term and long term glass test panels used for biofouling studies at various stations in the Cochin estuary during the monsoon and post monsoon periods of 2002, 2003.

Salient features: L_z= 460 - 480µ; l_z= 210 - 240µ

Encrusting colonies. Light brownish patches and pinkish dots distinguishes this species from other foulers on glass panels under natural conditions. Zoarium shows a definite pattern of growth even though the pace slackens as the colony becomes older. Zooecia arranged in regular rows but could be affected by overcrowding. The mural rim finally granulated. Gymnocyst present slightly developed. Cryptocyst also granulated and the rim provided with small tubercles. Distal regions of zooecia raised so as to overarch the proximal part of the succeeding one. Elongated, oval opesia. Operculum chitinised. The marginal sclerite brownish in hue. The pharyngeal region with a pink coloured area giving the colony a characteristic spotted appearance.

Remarks: This species has been extensively studied by Menon and Nair (1975). Probably this species shows considerable morphological variations to accompany changes in the environmental conditions. Menon and Nair (*loc.cit.*) opined that these variations are habitat induced. *E. crustulenta* is a species, which enjoys very wide distribution in brackish waters. It is quite likely that the stock of this species regularly encountered on panels used for fouling studies, was originally brought from some other locality and that this is a distinct ecotype of the Cochin backwater system.

Records from Indian waters: Cochin, west coast of India, (Menon and Nair, 1975).

Distribution: Baltic, Germany, Swedish coast, England (Borg, 1931); Yaquina bay, Oregon, California (Osburn, 1950).

6. ***Electra crustulenta* var. *borgii*** Menon and Nair, 1975 **Plate 23: Fig. 83**

Electra crustulenta var. *borgii* Menon and Nair, 1975: 559.

Occurrence: Few colonies attached to glass test panels immersed in Cochin estuary during the pre-monsoon (February – May) period of 2002-2003 were collected.

Salient features: L_z= 400µ; l_z= 230µ

Encrusting. Colonies form thin layers over the glass panels appearing as pale whitish circular patches. Quincuncially arranged zooecia, very slightly calcified. The distal region of the preceeding zooecium slightly over arch the proximal part of the succeeding one. Gymnocyst absent. Cryptocyst vestigial. Operculum chitinised. Cyphonautes larva seems to be present. Ancestrula single.

Remarks: The less calcified zooecia and the vestigial nature of the cryptocyst made the identification of this form rather difficult. The arrangement of the first zooecium developed from the ancestrula was very similar to that found in *E. crustulenta* collected from Cochin. The operculum was well chitinised and could be distinguished as distinct brown structures on dry specimens. The absence of spines of any kind, gymnocystal as well as cryptocystal spines separated this form from *E. crustulenta.* The simplicity of the zooecial structure itself seemed to give the form considerable distinction. It is interesting to recall certain observations made by Borg (1931), while examining the specimens of *Membranipora crustulenta* from Duino. Borg (1931) remarked that the degree of calcification in the specimen he examined was rather moderate, weaker than in any other specimens of *M. crustulenta* he had examined. The slightly elevated border of the apertural area was hardly or not at all granulated. The cryptocyst was often almost entirely lacking, which formed a narrow rim inside the border of the apertural area. There was no trace of any spine or even of any calcareous protuberance proximal to the apertural area. Hence this species was tentatively treated as a new variety of *Electra crustulenta,* querying the identification (Menon and Nair, 1975).

Records from Indian waters: Cochin harbour, west coast of India, (Menon and Nair, 1975).

Distribution: Indian waters (Menon and Nair, 1975).

7. ***Electra bengalensis*** (Stoliczka), 1869 **Plate 26: Fig. 97a, b & c**

Membranipora bengalensis Stoliczka, 1869: 55; Thornely, 1907: 186.
Electra anomala Osburn, 1950: 36.
Electra bengalensis Menon and Nair, 1975: 561.

Occurrence: Few colonies collected, attached to glass test panels immersed in Cochin estuary during the pre-monsoon (February – May) period of 2002-2003.

Salient features: L_z= 600µ; l_z= 250µ
Encrusting colonies, normally white in colour. The undisturbed colonies can grow to bigger dimensions especially in culture tanks, where the seawater is supplied directly from natural sources. Live colonies will have a light brownish hue. Delicate zooecia rectangular, arranged alternatively, separated by distinct grooves. Proximally developed cryptocyst, opesia oval and very minutely developed cryptocyst. There are different types of spines, which could be placed on the operculum, and three on the distal portion of which one is medianly placed and two lateral. Delicate basally joint, slender spines

overarch the frontal membrane. These spines are gymnocystal in origin. Distinct operculum, rather large in size often harbours long forked spines.

Remarks: This species was described earlier from the same locality by Menon and Nair (1975). Osburn (1950) noticed opercular spines of simple nature and has remarked that this can assume longer proportions depicting an anomalous morphology in species assigned to this genus, which resulted in his naming a new species, *Electra anomala.* However, Stoliczka (1869) described *Membranipora bengalensis* and did remark that opercular spines are present which look like those arising from the lower lip. This evidently was a misinterpretation by Stoliczka (*loc.cit.*) who examined specimens with opercula in open position. Numerous colonies of this species examined. Spines on the operculum were invariably present. Osburn (*loc.cit.*) has observed many colonies with and without marginal spines. Menon (*loc.cit.*) after examining the ancestrula of this species clearly grouped this species under genus *Electra* and has synonymised the previous records of *Membranipora bengalensis* and *Electra anomala* under this species.

Records from Indian waters: Bengal, east coast of India (Stoliczka, 1869), Snod Island (Thornely, 1907), Arabian Sea, west coast of India, (Menon and Nair, 1975).

Distribution: Balboa, Pacific coast of Panama (Osburn, 1950), Indian waters (Stoliczka, 1869; Thornely, 1907; Menon and Nair, 1975).

Genus *Conopeum* Gray, 1848

Conopeum Harmer, 1926: 210; Osburn, 1950: 30; Menon and Nair, 1975: 565.

Encrusting zooecia with a gymnocyst possessing two triangular depressions. Sometimes gymnocyst is lacking. Tuberculated cryptocyst extends from the entire margin. No avicularia, ovicells or pore-chambers.

8. *Conopeum reticulum* (Linnaeus), 1767 — **Plate 1: Fig. 3**

Conopeum reticulum Harmer, 1926: 211; Osburn, 1950: 31; Menon and Nair, 1975; 565.

Occurrence: This species was obtained in dredge samples from various depths of 30-150 m from stations at Cape Comorin, Trivandrum, Calicut, Mangalore and Bhatkal in the Arabian Sea.

Salient features: L_z= 650µ; l_z= 350 µ

Quinquncial zooecia encrusted on gastropod shells. The zooecia separated by chitinous margins. The shape of the zooecia variable and could possess highly granulated cryptocyst. A small gymnocyst present, cryptocyst proximally expanding and at times the tubercles project into the opesia. The typical depressions found at the proximal corners of the zooecia is absent in the present material, in which case, these resemble well with that of Harmer (1926) described from Cochin backwaters.

Remarks: The present material was found in dredge collections from various localities from the west coast of India, invariably they were encrusting on molluscan shells. This species was described earlier by Menon and Nair (1975) from the Arabian Sea, although the material was obtained from swimming crabs. Dredge collections were not available to these authors. This species is widely distributed in the tropical belt. Osburn (1950) while examining his material obtained from the Californian Coast was not convinced that the *Conopeum reticulum* described by Harmer (1926) from Indo-Australian Archipelago belonged to this species. He was critical to the comments of Robertson (1908) in that *C. reticulum* is a cosmopolitan species. Osburn (*loc.cit.*) believed that it is a typical tropical form and not found in higher latitudes.

Records from Indian waters: Bay of Bengal, Chilka Lake, Arabian Sea (Annandale, 1912; Menon and Nair, 1975).

Distribution: Alaska, southern California (Robertson,1908); Indo-Australian Archipelago (Harmer, 1926); Monterey Bay, Newport Harbour (Osburn, 1950); Arabian Sea (Annandale, 1912; Menon and Nair, 1975).

Family Calloporidae Norman, 1903

This family has been created to include species coming under various categories. Recently Gordon (2006) in a working list for treatise in bryozoan has brought two well-established genera such as *Ellisina* of Norman and *Parellisina* of Osburn to the family Calloporidae that were previously categorized under family Hincksinidae. The family characters are encrusting colonies, could be erect, bilamellar or vincularian, from an encrusting base. Zooids with frontal membrane. Spines present, occasionally overlapping the frontal membrane. Gymnocyst and cryptocyst present could be vestigial or very prominent. Many species coming under this family can have extensive gymnocyst or cryptocyst also. Avicularia vicarious or adventitious. There are species without avicularia in this family. Ovicell hyperstomial, prominent, ornamental with knobs, ridges, pores or even avicularia of reduced size. Large pore chambers, basal or small and mural.

Genus *Parellisina* Osburn, 1940

Parellisina Osburn, 1940: 361; 1950: 75; Menon and Nair, 1975: 575.

This genus was created by Osburn (1940) to include those species, formerly listed under *Membranipora* and *Callopora,* in which, the avicularia is always associated with a heterozooecium or kenozooecium. The avicularian chamber is proximal to that of the kenozooecium and separated from it by a vertical wall.

9. ***Parellisina curvirostris*** (Hincks), 1862 — **Plate 1: Fig. 4 a & b**

Membranipora curvirostris Hincks, 1862: 29; 1880: 153; Robertson 1921: 46.
Ellisina curvirostris Harmer, 1926: 228.
Parellisina curvirostris Osburn, 1950: 75; Mawatari, 1952: 271; Menon and Nair, 1975: 575.

Occurrence: Many colonies were collected from shell bits, dredged from stations at Trivandrum, Quilon, Cochin, Cannanore, Ratnagiri and Bombay from various depths during Cruise No. 177 along the west coast of India.

Salient feature: L_z= 420µ; l_z= 370µ
Encrusting, the size of zooecia variable. The central zooecia normally smaller than the peripheral ones. Zooecia arranged hazardly with shallow grooves separating them. Gymnocyst less developed. No gymnocystal spines. Well-developed cryptocystal ridge, could reduce in width distally. Opesia normally oval, seldom rounded. Cryptocyst with many granulated ridges, highly calcified. Avicularia present often associated with triangular kenozooecia. The distal portion of the avicularia elevated and highly calcified. The direction of the avicularia variable, commonly distal. A well-developed hyperstomial ovicell with distinct pores provided with calcareous indentations. The proximal part of the ovicell could be thickened, possibly covered by the operculum.

Remarks: This species has been previously described by Osburn (1940) from the collections of Robertson (1921) from the Bay of Bengal, kept in the British Museum. This species has a wide tropical distribution and the present collections from the west coast of India shows that this species is extensively distributed in the EEZ of India. The kenozooecia is separated from the avicularia by a distinct calcareous wall. In the specimen one kenozooecium was found to lack avicularia, which gives it a miniaturized zooecial look. Avicularian cryptocyst is strongly calcified. The ovicell although prominent could be partially immersed.

Records from Indian waters: Ganjam Coast, southwest of Calcutta (Robertson, 1921), Quilon (Menon and Nair, 1975).

Distribution: Cornwall, Brazil, Naples, Cape Verde Island, Morocco, Atlantic, Singapore, (Harmer, 1926), Calcutta (Robertson, 1921), Quilon (Menon and Nair, 1975).

Genus ***Crassimarginatella*** Canu, 1900

Crassimarginatella Harmer, 1926: 222; Silen, 1941: 23.

Frontal membrane fully developed, gymnocyst vestigial or less developed, narrow cryptocyst, spines wanting. Vicarious avicularia present. The mandibles with complete or incomplete calcareous bar. Ovicells hypostomial or vestigial.

10. ***Crassimarginatella*** sp. **Plate 1: Fig. 5**

Occurrence: Few colonies were collected from shell bits dredged from stations at Cape, Cannanore and Bombay from various depths during Cruise No. 177 along the West coast of India and from Chennai in the east coast.

Salient features: L_z= 667µ; l_z= 239µ

Bit of the colony consisting of a few zooecia was obtained from the dredge sample examination. Electron micrographs of the specimens show that these might belong to *Crassimarginatella*. Presence of distinct dietellae noticed in one zooecium. Well developed proximal gymnocyst, corrugated cryptocyst. Lack of enough material was a hindrance in describing this species completely. However, tentatively the specimens are placed under this genus.

Genus ***Cranosina*** Canu and Bassler, 1933

Encrusting zoarium, zooecia large, oval to hexagonal in shape. A well-developed gymnocyst present. Strongly calcified cryptocyst descending distally gives a corrugated appearance. Distal interzooecial vibraculum present, normally transversely positioned.

11. ***Cranosina coronata*** (Hincks), 1881 **Plate 2: Fig. 6a & b**

Membranipora coronata Hincks, 1881: 147; Thornely, 1907: 186.
Cranosina coronata Osburn, 1940: 363; Winston and Heimberg, 1986: 6; Mawatari and Mawatari, 1981: 46; Tilbrook *et al.*, 2001: 44.

Occurrence: Attached to shell bits from dredge samples taken from Quilon, Cochin, Calicut, Cape Comorin, Cannanore and Goa at a depth of 100 m.

Salient features: L_z= 473µ; l_z= 454µ: L_a=180µ; l_a= 91µ
Encrusting zoarium, large zooecia, oval to hexagonal in shape. Gymnocyst present well developed to the proximal area. Strongly calcified cryptocyst, descending distally giving a corrugated appearance. Interzooecial vibraculum present normally transversely positioned, placed at the distal part of the zooecia. Vibracular setae not observed. Pore plates present, three in number, distinctly opening into the adjacent zooecia. The ratio in size of pore plates and lateral walls almost equal. The vibracular chamber proximally oval and distally tapering slightly raised distally, giving a beak-like appearance. Ovicells not found.

Remarks: *C. coronata* is a cheilostome which enjoys wide distribution throughout the Indo-West Pacific region, the Philippines, Indonesia, Sri Lanka, India and Mauritius. The present material came from the west coast of India at a depth of 100m. Ryland and Hayward found that this species is not very common in the Indo-Australian Archipelago. Although Tilbrook *et al.* (2001) recorded this as a very common species in few of the Indopacific Islands with reference to the Indian sub-continent; this species was recorded only from the west coast from Cochin to Goa. The electronmicrographs shows that the septum separating the vibracular chamber from the preceding zooecial chamber is highly calcified and porous. The vibracular chamber is smooth in contrast to opesial walls. Calcification is found to assume a wavy appearance with trough and crests. The rim of the cryptocyst is distinctly uneven although, when merging with the vibracular area it becomes smooth. The interzooecial margins are distinct and hence give a rhombic appearance to a few zooecia in the colony.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Venezuela, Red Sea, Indonesia and Philippines.

Genus *Alderina* Norman, 1903

Alderina Osburn, 1950: 59; Menon and Nair, 1975: 573.

Entirely membranous frontal wall, crenulated sidewalls. Spines absent, modular processes may be present, avicularia absent. Dietellae present. Ovicells usually single ribbed or with a depressed area.

12. *Alderina arabianensis* Menon and Nair, 1975 **Plate 23: Fig. 84**

Alderina arabianensis Menon and Nair, 1975: 574.

Occurrence: Several colonies were collected from glass panels used for the study of fouling organisms in the Cochin estuary.

Salient features: L_z= 520µ; l_z= 240µ

Encrusting, flat and disc like colonies. Elongated zooecia, quadrangular distally, overlaps the proximal portion of the succeeding zooecia. Aperture occupies 3/4th of the front. Gymnocyst present slightly extensive proximally. Cryptocyst with spinules which are prominent proximally. The distolateral corners of the zooecia provided with two triangular areas often bearing spines, which could be forked or variously branched. Hyperstomial ribbed ovicells, ancestrula possess a pair of branched spines.

Remarks: The growth of this species on glass panels was observed and the distolateral spine bearing areas were often found without spine in young colonies. As the zooids mature spines become well developed and could be branched many times, which was especially true in colonies appearing during the highly saline regime of the backwaters. These spines when branched could extend up to the proximal portion of the zooecia. The ovicells are light brown in hue well projected above the frontal plane and looks like helmets with ribs. The ectooecium with two ribs extend distally. A horizontal rib interconnects these ribs. Menon and Nair (1975) placed this species in *Alderina* of Norman since the species resembles well with *Alderina smitti* of Osburn (1950). Mawatari states that "The peculiar ribbed ovicells and distal spines indicate that this form is not identical with *Alderina smitti*". Although this species was created in 1965 and published in 1975, it was not subsequently recorded from any part of India. The present finding from the type locality indicates that this species is prevalent in Cochin area and possibly remains endemic.

Records from Indian waters: Cochin backwaters, west coast of India, (Menon and Nair, 1975).

Distribution: Indian waters (Menon and Nair 1975).

Family Antroporidae Vigneaux, 1914

Zoarium encrusting, calcareous. Zooecia simple, membraniporine with entire membranous front. Gymnocyst reduced or small. Cryptocyst vestigial or present. Avicularia interzooecial. Ooecia endozooecial, narrow, transverse, shallow sometimes immersed.

Genus *Antropora* Norman, 1903

Zoaria encrusting, unilamellar or multilamellar. Zooecia elliptical or oval, with reduced proximal gymnocyst. Aperture occupying almost the entire front. Cryptocyst developed especially proximally to aperture or distally to operculum. Large vicarious avicularia occur in some species and triangular areas occupy the spaces among zooecia. Ooecia endozooecial, shallow as usual. A number of dietellae present.

13. *Antropora erecta* (Silen, 1941) — Plate 2: Fig. 7a & b

Antropora erecta Harmer, 1926: 232; Silen, 1941: 43; Osburn, 1950: 51; Menon and Nair, 1967a: 1; 1975: 571.

Occurrence: Colonies collected were encrusting on molluscan shells in dredge samples from many stations in the east and west coasts of India at various depths.

Salient features: L_z= 460μ; l_z= 260μ

Zooecia were broadest in the middle and slightly tapering both ways. Gymnocyst vestigial or absent. Extensive cryptocyst, highly granular, proximally invading the lateral and distal portion. Opesia depressed, broader basally and tapering distally, often gives a triangular appearance. Vicarious avicularia present, rare. Adventitious avicularia common positioned at the proximal end of the zooecia directed distally. The distal portion is slightly elevated and crowding of zooids gives the impression of placement of this avicularia laterally at the distal portion of the preceding zooecia. Large vicarious avicularia noticed in one with an extensive circular area, to lodge the avicularian mandible. The lateral portion of this is pointed at the loci where it merges with the zooecial margin. The cryptocyst of vicarious avicularium less developed.

Remarks: The specimens at my disposal resemble remarkably with the original descriptions given by Silen (1941). It is to be assumed that ecotypical variations could be present in colonies collected from various latitudes of tropical seas. Silen (*loc.cit.)* collected this specimen from Bonin Island, Pacific. *A. erecta* is a common species in the Indian Ocean. The Indian specimens show variously developed crenulations disto-laterally in which character these differ from that of Silen (*loc.cit.*). The Electron micrographs show that the crenulations could be the elevated rims of the pore-plates. This character is not present in the vicarious avicularia. Silen (*loc.cit.*) has remarked that in the case of zooids the adventitious avicularia could be single or paired and laterally arranged and his assumption was that the adventitious avicularia become vicarious. This particular point did not match with the characters of the present material where the vicarious avicularia had adventitious avicularia at the base. By and large this species is an encrusting form, although Silen has found them growing erect and even tubular in structure. In this connection Mawatari and Mawatari (1981) commented that encrusting mode of growth is quite common in this species since erect colonies are seldom available in collections.

Records from Indian waters: Off Cochin, west coast of India (Menon and Nair, 1967a; 1975).

Distribution: Bonin Island, Pacific (Silen, 1941); Indian waters (Menon and Nair, 1967a; 1975).

14. ***Antropora granulifera*** (Hincks, 1880) **Plate 2: Fig. 8**

Membranipora granulifera Hincks, 1880: 72.
Amphiblestrum granuliferum Thornely, 1912: 110
Antropora granulifera Norman, 1909: 288; Harmer, 1926: 232; Osburn, 1950: 52; Menon and Nair, 1967a: 14; 1975: 573; Mawatari and Mawatari, 1981: 28.

Occurrence: Few colonies were collected, attached to shell bits in dredge samples from Cape Comorin, Trivandrum, Quilon and Calicut at a depth range of 50-100 m.

Salient features: L_z= 420µ; l_z= 270µ

Zoaria encrusting on shells and when fresh they are brownish in hue. Considerable meristic differences are shown by zooecia growing towards the periphery of the colony. Longitudinally arranged zooecia retain regular shapes, when the substratum is non-corrugated. Thin mural rim, mildly denticulate. Heavily calcified walls lack a gymnocyst.

Well developed cryptocyst, highly tuberculated, descending distally invades the proximal borders. The distal part of the zooecia therefore, may be slightly arched. Paired adventitious avicularia positioned distally at the zooidal junctions. Rostrum distally directed in a slanting manner, normally shifted towards the proximal border of the zooecium. The mandibles are pointed. Membraniporine operculum possesses a marginal sclerite. Vicarious avicularia present with rounded rostrum and occupies more than half the length. Two condyles are present to which the strongly calcified mandibular sclerite is attached. Spines wanting.

Remarks: *A. granulifera* from Indian waters have been recorded by Thornely (1912). Harmer (1926) collected two species from the various tropical islands of the Indo-Australian Archipelago. He noticed interzooecial grooves as conspicuous separations but this particular aspect could be influenced by the texture of the substratum on which the colony grew. The vicarious avicularian length also did show variations from those of Harmer. Examination of colonies has shown that the directions assumed by the distal part of the adventitious avicularia could vary and sometimes it could be pointed distally or medianly. Thornely (1912) found that the avicularia were juxtaposed. This morphological variation was noticeable in a few colonies collected from the west coast of India. However, this is not taken as a serious variation so as to place this species in another genus as done by Thornely (*loc.cit.*). Harmer (*loc.cit.*) stated "The avicularia vary in position, some being paired and transverse, especially in the more peripheral zooecia while others occur at the side of the opesia, the rostra having a distal direction.

Records from Indian waters: Off Cochin, west coast of India (Menon and Nair, 1967a, 1975).

Distribution: Osburn (1950) remarks about the distribution of this species in these words "probably distributed around the world in warmer waters". Madeira (Hincks, 1880); Cape Verde Island (Calvet, 1907); Indian ocean (Thornely, 1912); Ceylon (Thornely, 1905); Japan (Mawatari, 1952); Samoa Island, Strait of Makassar, Talaut Island, Kei Island, Sumbawa (Harmer, 1926): Panama, Mexico (Osburn, 1950); Indian waters (Menon and Nair, 1967a; 1975).

15. ***Antropora tincta*** (Hastings), 1930 **Plate 2: Fig. 9a & Plate. 3: Fig. 9b**

Crassimarginatella tincta Hastings, 1930: 708.
Antropora tincta Osburn, 1950: 54; Mawatari and Mawatari, 1981: 31.

Occurrence: Two colonies were collected, attached to bivalve shells in dredge samples from Cochin and Cannanore from a depth of 60 to 100 m.

Salient features: L_z= 325μ; l_z= 210μ

Antropora tincta is found to be distributed along the west coast of India from depths of 60-100 m and along the east coast of India. Zoaria unilaminar when encrusting on shells. Regular to irregular oval in shape. The zooecia depicts heavy calcification especially at zooidal junctions. Triangular, oval areas present in these junctions. However, some of these spaces occupy adventitious avicularia with distinctly triangular shape, occasionally elongated. The cryptocyst is well calcified, wavy in appearance with clear-cut slanting calcareous thickenings. The mandibles are semicircular or slightly triangular distally. The avicularian mandibles are pointed. Dietellae present prominently placed distally. The triangular spaces occupying the zooecial junctions have soft central space, which under electron micrograph gives stunted zooecial structure. Osburn (1950) mistook these areas to those found in certain species of *Conopeum*. However, he corrected this assumption stating that these spaces represent small functional interzooecial avicularia or zooecia placed at points of branching thereby distributed more in number towards the center. Spines totally absent. The mural rims are thin.

Remarks: Electron micrographs of this particular species is not available in the literature but Mawatari and Mawatari (1981) studying the material using simple microscopy have succeeded in identifying very minute characteristics of the cryptocyst, interzooecial avicularia and even a vicarious avicularia, which could be noticed in the present material also. No description is available on the nature of dietellae. The presence of dietellae and its placement is very clearly seen in the present material apart from the characters noticed by the previous workers. A well examined specimen with the aid of electron micrography shows that, the interzooecial spaces can never be considered as micron spaces but as regions as vibrant as that of a normal zooecia. The cryptocyst proximally have distinct tubercles. The thin mural rim also has clear-cut uneven thread like appearance. The present record extends the distribution of the species to the Indian Ocean.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: California, Mexico, Peru, Galapagos Islands, Panama, Brazil, West Africa, Japan (Osburn, 1950).

16. ***Antropora marginella*** (Hincks), 1884 **Plate 3: Fig. 10**

Membranipora marginella Hincks, 1884: 358; Waters, 1898: 658.
Amphiblestrum marginella Thornely, 1905: 110.
Antropora marginella Harmer, 1926: 234.

Occurrence: One colony was collected attached to shell bits in dredge samples taken from Bhatkal from a depth of 70 m.

Salient features: L_z= 525μ; l_z= 400μ

Encrusting zoarium. Zooecia though variable in shape predominantly elongated oval with slightly pointed distal regions. Quinquncial distribution of the zooecia results in very distinct interzooecial grooves. Triangular to rectangular areas where three or four zooecia meet are provided with adventitious avicularia which have rather blunt mandibular region and circular rostral region, giving the whole structure a mounted appearance. Gymnocyst moderately developed and its merger with the adjoining zooecium gives a broader proximal structure. Cryptocyst descending uniformly granulated, receding anteriorly. Vicarious avicularia was not noticed. The proximal part of the avicularian rostrum is nearly rounded.

Remarks: This species is recorded for the first time from the Indian waters. Thornely (1905) recorded this species from Ceylon and assigned to the genus *Amphiblestrum* which was brought under *A. marginella* by Harmer (1926). The present collection was from the west coast of India and only a fragment was available for examination, therefore no comparison could be made on the structure of vicarious avicularia and the ovicell. Notwithstanding this the clarity of the electronic micrograph makes the present assignment valid.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Torres Strait, Malay Peninsula, New Guinea, Strait of Makassar (Harmer, 1926).

17. ***Antropora claustracrassa*** (Canu and Bassler), 1930 **Plate 3: Fig. 11a & b**

Membrendoecium claustracrassum Canu and Bassler, 1930: 7.
Antropora claustracrassa Osburn, 1950: 53.

Occurrence: One colony collected attached to shell bit was collected in dredge samples from Calicut at a depth of 60 m.

Salient features: L_z = 440μ; l_z = 270μ

Zoarium encrusting. The opesia slightly anteriorly placed, basically oval, broad proximally. Gymnocyst conspicuous, smooth in structure. Cryptocyst very broad proximally provided with minute blunt tubercles. Zooids with deeper opesia may possess striated lateral cryptocyst. The colony contains spaces without vicarious or adventitious avicularia, although interzooecial margins invariably house small rounded adventitious avicularia. The avicularian rostrum flared proximally. The size and shape varying in areas where bifurcation of zooid occurs in the colony. In one of the photographs a structure very similar to an adventitious avicularium was noticed although an area with sunken space was noticed on the distal point of the zooecium, which Canu and Bassler (1930) treated as vacant spaces resulting in naming it as *A. claustracrassa.*

Remarks: Curiously enough this species has never been recorded from the Indian Ocean. Previous records are exclusively confined to the west coast of tropical United States and the Galapagos region. The present record of these animals from the Arabian Sea extends the distribution of this species to the Indian Ocean. Absence of good drawings or photographs makes a comparison of the present material with those of Osburn (1950) who brought the species under *Antropora* rather difficult. However, the presence of "vacant" spaces and naming of the species as *A. claustracrassa* by Canu and Bassler (1930) definitely confirms the present identification and probably opens up an area of geographical distributions of benthic animals from a more holistic point of view.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Mexico,La Libertad, Ecuador and the Galapagos Islands (Osburn, 1950).

18. ***Antropora*** sp. **Plate 3: Fig. 12**

Occurrence: One colony attached to shell was collected in dredge samples from Cannanore at a depth of 100 m.

Salient features: L_z= 300μ; l_z= 230μ

Zoarium encrusting on shell. Well defined gymnocyst and cryptocyst. The gymnocyst typically separated from the cryptocyst by a distinct margin. Cryptocyst uniform in thickness and could be seen in the opesia which is typically oval. Well marked calcification of cryptocyst noticed in the other species is not exemplified in the present material. Adventitious avicularia uniformly present which are bigger in size and well defined with large mandibular region. Rostrum is calcified and the avicularia is slightly elevated from the gymnocystal plane. An important feature noticed in the present material is a saucer shaped elevation at the distal regions of the zooecium which makes the interzooecial spaces at this region more pronounced. It looks as if this species is related to *A. claustracrassa* but devoid of the typical vacant spaces noticed in the above species. The absence of spaces and the elevation of the distal portion of the zooecium give the zooid a more or less rhomboid shape which is a deviation from the species hitherto described in this genus. Pending examination of more material, I am not inclined to describe the material before me as a new species.

Family Calescharidae Cook and Bock, 2001

Operculum membraniporine. Spines absent. Extensive cryptocyst tuberculated and extending round the opesia, the proximal regions being produced into a median "steganoporelliform process" (Harmer, 1926), which may be free distally or united with the lateral cryptocyst. Trifoliate opesia. Opesiules complete if the median process unite with the lateral cryptocyst. Avicularia absent. Large endozooecial ovicells. Uniporous septula present .

Genus *Caleschara* Mac Gillivray, 1880

Caleschara Mac Gillivray, 1880: 45; Hincks, 1881: 152; Busk, 1884: 76; Harmer, 1926: 221; Osburn, 1950: 103; Menon and Nair, 1967a: 12; 1975: 567.

Entire surface occupied by frontal membrane. Operculum membraniporine. Spines absent. Extensive cryptocyst tubercular and extending around the opesia, proximal region produced into a median "steganoporelliform process" (Harmer, 1926), which may be free distally or united with the lateral cryptocyst. Trifoliate opesia. Opesiules complete if median process unite with lateral cryptocyst. Avicularia absent. Large endozooecial ovicells. Uniporous septula present.

19. ***Caleschara levinsenii*** Harmer, 1926 **Plate 3: Fig. 13**

Caleschara levinsenii Harmer, 1926: 221; Menon and Nair, 1967a: 1; 1975: 567.

Occurrence: Two colonies encrusting on stones were collected from material dredged from a depth of 30m from Cape Comorin.

Salient features: L_z= 600µ; l_z= 460µ

Encrusting colonies, brownish in hue with longitudinally arranged zooecia. Expansive frontal membranes occupy the entire dorsal surface. Membraneous operculum. No gymnocyst. Tuberculated cryptocyst invade the entire proximal portion of the opesia. The anteriorly invading cryptocyst gives a pyramidine picture and results in creating a trifoliate opesia. In certain specimens the cryptocystal projection is slightly raised, often giving a tubular appearance. Laterally cryptocyst not well developed. The opesiules elongated and extend towards the sides of the median process. Ovicells not noticed.

Remarks: The photomicrographs taken for the first time of Indian species of this genus gives quite a bit of additional information. The lateral margins of zooecia are corrugated. The zooecia are separated by distinct less calcified grooves. Two spinous processes are present anteriorly, extending from the lateral portion of the zooecial margin. The cryptocyst is highly tuberculated and at times gives a porous appearance. Asymmetrical placement of the median process can obliterate the typical trifoliate nature of the opesia. Menon and Nair (1975) felt that, this species resembles to a very great extent to *C. mexicana* created by Osburn (1950). Curiously enough, Osburn's creation was based on the presence of spinous processes on the cryptocystal margins. Both the species are available for examination now and they do have distinct morphological characters. Harmer's (1926) remark that considerable variation occurs in the size of the zooecia in the same colony and the presence of spinules in the proximal cryptocyst is not in conformity with the present material. Osburn (*loc.cit.*) did notice a pair of larger spinules placed very similar to cardelles.

Records from Indian waters: Off Alleppey, west coast of India (Menon and Nair, 1967a; 1975).

Distribution: Kei Island, Mindanao, Halmaheira, Dario's Island, Amirante Island, Japan, Singapore, Seychelles (Harmer, 1926), Indian waters (Menon and Nair, 1967a; 1975).

20. ***Caleschara mexicana*** Osburn, 1950 **Plate 23: Fig. 85**

Caleschara mexicana Osburn, 1950: 104; Menon and Nair, 1967a: 1; 1975: 567.

Occurrence: Same as *Caleschara levinsenii* and also from Vishakapatanam at a depth of 100m.

Salient features: L_z= 500µ; l_z= 360µ

Encrusting zoaria, unilaminar, flat and glistening white. Longitudinally arranged zooecia often elliptical. Gymnocyst wanting, cryptocyst well-developed, extending proximo-medianly. The proximal region extends very near to the aperture and gives the appearance of a horizontal lamina. This portion could be slightly elevated and laterally drawn in a spinous fashion. Here also, two cardelles are present which are not manifested distinctly. The zooecial features, by and large appear very similar to *C. levinsenii*. Weakly developed lateral spines placed at the position of cardelles. The cryptocyst was in general tuberculated. Avicularia and ovicells absent.

Remarks: The spinule-like structures described by Menon and Nair (1975) are present in the present material. The creation of this species was based on the morphometric features given by Harmer (1926). Lack of horizontal spinules in *C. levinsenii* looks to be a more reliable specific difference than morphometrics. Electronmicrograph of *C. levinsenii* does give a better picture of the zooecia. Menon and Nair (*loc.cit.*) who examined both the species did not feel that morphometrics should be given more importance. The sub globular tubercles not noticed by Menon and Nair (*loc.cit.*) are however distinctly present in this material. The present finding extends the distribution of this species to the Bay of Bengal, although Osburn (1950) considers them to be Mexican inhabitants.

Records from Indian waters: Off Quilon, west coast of India (Menon and Nair, 1967a; 1975).

Distribution: Mazatlan, Mexico and Panama (Osburn, 1950), Indian waters (Menon and Nair, 1967a; 1975).

Family Heliodomidae Vigneaux 1949

Free, discoidal cheilostome, saucer-shaped or conical and trochiform. Both fossil and recent forms exist in this family and hence it is difficult to determine the systematic position. However, Vigneaux (1949) felt that the recent species of Cheilostomata coming under the above morphological category should be grouped under a sub family and he proposed a few genera under which *Heliodoma* and *Setosellina* were categorized. But by and large, characters like encrusting nature or sellinarian feature, alternating vibracula reduced, calcification of lamina with aperture occupying the entire front, well developed cryptocyst and absence of ovicells do support the inclusions of these two genera under the same family.

Genus ***Setosellina*** Calvet, 1906

Setosellina Calvet, 1906: 157; Harmer, 1926: 264; Silen, 1942: 3.

The entire front occupied by aperture, gymnocyst absent or vanishing. Cryptocyst usually narrow, well developed, strongly tuberculated with no proximal widening, extending the entire opesia and sometimes evanescent distally. Opesia oval sometimes wide proximally, vibracula vicarious, one at the distal end of the zooecium. Opesia of the vibracula asymmetrical. Pore chambers present or absent. Ovicells present broader than long.

21. ***Setosellina constricta*** Harmer, 1926 — **Plate 4: Fig. 14a (a), 14b & c**

Setosellina constricta Harmer, 1926: 264; Silen, 1942: 4.

Occurrence: Two colonies were collected from dredging conducted at 60 m depth at Cape Comorin and Cannanore in the west coast of India.

Salient features: L_z= 383μ; l_z= 333μ

Encrusting minute zoaria, normally growing on sand grains or shell particles. More or less discoidal, ancestrula surrounded by 7 zooecia. Distinct zooecia separated by narrow grooves, expanded at the angles with slightly raised edges. Proximal gymnocyst present, moderate, evanescent distally. However, enlarged zooecia gives the impression that, the gymnocyst has a more or less uniform region but for the proximal region, aperture occupies almost the entire front. Cryptocyst present, equally developed proximally and laterally but evanescent distally. It possesses transverse crenulations. Tubercles present uniformly and distinctly, developed laterally also. Pore chambers present, may vary in number from 1 to 3. Each zooecium succeeded by vibracula, which judged from the size, could be termed vicarious. The lateral sides of vibraculum raised proximo-laterally. The slight projection of the lateral gymnocyst of the vibracula asymmetrical and sprouting. Vibracula with a distinct depth, prominent. Ovicells not noticed.

Remarks: The genus *Setosellina* was created based on *S. constricta* as the genotype. This is probably the first record of the species from the Indian Ocean as no information is available from this region in any subsequent collections. The fact that the present materials were from the Arabian Sea and sandy bottom, substantiates the theory that lunuliform bryozoans are commonly found established in tropical sandy bottoms of the Indian and Indo-Pacific seas. The wide geographical difference in the locations of the present finding from the home of the holotype, which was the initial tip of the Indo-Australian Archipelago, destroys the theory of larval transport in distribution at least in the case of the genus under consideration. The accurate photographs of the species gives evidences to the fact that, the presence of distal vibracula chamber results in creating a distinct distal elevation of the preceding zooecial tip. This is very evident from the photographs available. Unfortunately, absence of vibracular spines in the colony makes a comparison of this organ with that of Harmer (1926) impossible. Probably this could be possible when more collections are available from the localities.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: New Guinea, Strait of Makassar, Celebes (Harmer, 1926); Gulf of Aden (Silen, 1942).

Family Cupuladriidae Lagaaij, 1952

Anascans with lunulitiform zoaria. Ancestrula surrounded by seven zooecia and a distal vibraculum. Variously developed cryptocyst. Ovicells absent.

Genus *Cupuladria* Canu and Bassler, 1919

Cupuladria Canu and Bassler, 1923: 28; Osburn, 1950; 33; Lagaaij, 1963a: 193.

Discoid and free zoarium with rhomboid zooecia arranged in radial rows. Vibraculum present at distal end of each zooecium. Well developed cryptocyst, depressed opesia which may be oval, round or quadrangular. Opesia sometimes invaded by processes from basal margin of cryptocyst. Ovicells probably wanting.

22. ***Cupuladria indica*** Cook, 1965 **Plate 4: Fig. 14 a (b) & 15**

Cupuladria indica Cook, 1965: 169; Menon and Nair, 1967a: 1; 1975: 570.

Occurrence: Ten colonies were collected from dredgings conducted at 60 m depth at Trivandrum, Quilon, Cochin and Calicut.

Salient features: L_z= 480μ; l_z= 320μ: Whole colony size range=1.5 - 6 mm in diameter. Zoaria flat, saucer shaped with zooecia ornamentally distributed giving the colony a very interesting shape. The colony can therefore be considered as having a convex and concave surface. The zooecia are arranged on the convex side of the zoarium, differential growth rate at the rim of the colony giving it a crenulated appearance, which is an important morphological feature of the species. The colony is formed in such a fashion that the center is occupied by four zooecia of which one becomes the central one. Bifurcation happens in such a fashion that the zoarium will have a stellar appearance. The concave side of the colony is tuberculated bearing these ridges, which radiate from the central point and branch at a region of the basal part of vibracula. A median ridge always extending to the distal tip. Ancestrula single. The first two daughter zooids placed at an obtuse angle to ancestrula, creating a central triaxial architecture. The first axis passing through the distal proximal extension of the ancestrula and the other two axes diverge from the primary axis resulting in a central configuration of eight rayed star. The central zooecia smaller than zooids of the rest of the colony. Gymnocyst present but very small. The zooecia as such looks rhomboid. The lateral axis of the rhombus ordinarily borders the vibraculum. Cryptocyst uniformly tuberculated and descending. However, under high magnification the cryptocyst gives a "pitchy" appearance. The zooecial margins are thin, calcareous structures virtually merging with the cryptocyst thereby totally obscuring the structural feature of the gymnocyst. The vibracular chambers reasonably large and gives a pear-shape because of the lateral extension of the adjoining zooecia termed as auricles. The opesial shape typically oval. Ovicells absent.

Remarks: The genus *Cupuladria* is an enigma in bryozoan taxonomy. Settlement of larvae, originating from alecithal egg into benthic adults, normally ensures clear-cut footage. Settlement of larvae on unstable substratum is one of the main reasons for the absence of sedentary lower marine invertebrates in sandy substrata. This genus contains species, which are exclusively distributed in the areas where sandy bottom exist. Overemphasis on the development of vibracula, in *Cupuladria* could be a reason for the dominance of this group in sandy substratum. An interesting feature noticed regarding the auricle projection was that they always alternate in the succeeding rows of the zooecia starting from the center of the colony.

Records from Indian waters: Off Cochin and Beypore, west coast of India (Menon and Nair, 1967a; 1975).

Distribution: Mergui Archipelago (Hincks, 1887); Gulf of Aden (Silen, 1942) as quoted by Cook (1965); Indian waters (Menon and Nair, 1975).

23. ***Cupuladria guineensis*** (Busk), 1854 — **Plate 4: Fig. 14a(c) & 16**

Cupuladria guineensis Busk, 1854: 98; 1884: 206; Marcus, 1921: 86; Harmer, 1926: 266; Silen 1942: 8; Cook, 1965: 170.

Occurrence: Two colonies were collected from dredge samples from a depth of 60 and 120 m from Trivandrum and Cape Comorin respectively.

Salient features: L_z= 400 - 560μ; l_z= 320 - 420μ

Zoarium large, on an average measuring 12mm, rather flattened, lacks crenulations at the periphery. Basal side of the zoarium concave interrupted by radial grooves in between rows. Normally the surface is imperforate sometimes provided with pores. The concave surface of the colony is with serrated edges created by the protruding vibracula. The frontal surface slightly convex, the ancestrula producing 7 to 8 zooids radially. Aperture full slightly elevated rims of the zooecia giving an oval shape which is distinctly different from the shape of *C. canariensis*. Cryptocyst well-developed granulated and laterally slants towards the opesia. Vibracula comparatively smaller in size and very minute centrally. Ovicells not noticed.

Remarks: The genus *Cupuladria* has received extensive attention from Silen (1942), who studied the spiral growth of zoarium. There are only a few genera where spiral growth is common. Probably *Cupuladria* is the most cardinal genus, which has depicted this mode of growth along with the presence of adventitious zooids represented here by the vibracula. The possibility of vibracula budding an autozooid is unlikely, which makes determination of the growth lines of the colony rather difficult. If it is assumed that kenozooids are incapable of budding, the saucer shape of the colony does not require an explanation. From an ecological stand point, the occurrence of this species in sandy bottom is an interesting phenomenon since the capacity of this species to remain rooted on to the bottom, with the aid of vibracular setae, becomes a tedious action in the part of the colony and also a process which calls for expenditure of energy. This aspect has not been described by any of the authors as all of them took for granted that *Cupuladria* and the related genera grew in an umbrella fashion. The size of the zooids slightly increases towards the periphery of the colony and those at the arch of the dome are distinctly large. From a morphometric stand point, arching must be a forerunner of the colonies behavior to reach the substratum by which time the growth should cease. This must be the reason why very large zoaria are seldom collected from the environment. Probably this disproves the existing theory that bryozoan colonies are capable of continuous growth.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: New Guinea, Philippines (Busk, 1854) Japan as quoted by Cook (1965); Mindanau (Harmer, 1926); Gulf of Aden, Malayan Archipelago, Australia, South China Sea (Silen, 1942).

Family Flustridae Fleming, 1828

Erect, free frondose and flexible zoarium, rarely encrusting. Opesia occupy the entire or nearly the entire front. Avicularia interzooecial. Ovicell when present endozooecial, embedded at the base of the succeeding zooecium or in the avicularian chamber.

Genus *Chartella* Gray, 1848

Chartella Gray, 1848: 147; Harmer, 1923: 304; Silen, 1941: 49; Ryland and Hayward, 1977: 80; Mawatari and Mawatari, 1979: 24.

Bilaminar zoarium, free, erect and frondose. Zoaria really "papyrus". Zooecia rectangular and lack spines and when present reduced in size. Opesia rectangular. Endozooecial ovicells immersed in the distal autozooecia with a distal opening connected with the mother zooecia. Vicarious avicularia present or absent. Two species of *Flustra* namely *Flustra carbasea* and *Flustra papyracea*, the former lacking ovicells and avicularia and the latter having ovicells were grouped together by Gray in 1848 to create a new genus *Chartella*. However, confusion prevails regarding the taxonomic validity of the genus as Busk, Hincks, Levinsen and Silen did not recognize *Chartella* [as quoted by Mawatari and Mawatari (1979)]. Cook, Ryland, Stebbing, and Hayward accepted *Chartella* as a new genus. Notwithstanding the remarks on the occurrence of avicularia it is assumed that the presence of avicularia cannot be taken as an important generic character.

24. ***Chartella arabica*** sp. novo **Plate 4: Fig. 17**

Occurrence: Two large colonies collected attached to wooden rack immersed in the North tanker berth station in the Ernakulam channel for biofouling studies in March (pre-monsoon period) of the year 2002.

Salient features: L_z= 540 – 600μ; l_z= 330 – 350μ

Bilaminar zoaria, free, erect and significantly foliated giving the appearance of silky smooth floating cloth. Zooecia rectangular arranged quinquncial. Gymnocyst narrow, cryptocyst distinct, evanescent distally provided with minute spinules. The distal part of the zooecia distinctly raised and forms an arched calcareous hood-like structure. The simplicity in zoarial structure and very delicate zooecial armature makes this species distinctly different from species of *Chartella* hitherto described.

Remarks: The colonies were collected from a locality situated near the shipping channel of the Cochin port. This tanker berth on to which the racks were suspended is frequented by crude carrying vessels and refined oil transporting vessels, which ply the international waters. The type locality experiences high saline conditions during the hot months of January, February and March. The presence of the shipping channel and the constant tidal effects keeps the whole water column considerably mixed resulting in uniformly aerated alkaline seawater. Marginal dilutions take place in this area during the summer season because of limited forward discharge in the upper reaches of the Cochin estuary where the harbour is located. Two colonies attached to the rack, suspended for the collection of foulers was in a spot, which experienced regular seawater intrusion. It is assumed that the larvae settled on the rack and grew during the high saline period, which would be around 30 days.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Cochin Backwaters- Arabian Sea-Indian Ocean.

Family Quadricellariidae Gordon 1984

Erect, dichotomously branched zoaria. Zooecia arranged longitudinally around an axis formed by the separating walls of the zooecia. Uniporous septulae, frontal avicularia present. Ovicells present, endozooecial.

Genus *Nellia* Busk, 1852

Nellia Busk, 1852: 18; Canu and Bassler, 1920: 195; Harmer, 1926: 240; Silen, 1941: 49; Osburn, 1950: 119; Winston, 1986: 9.

Zoarium erect. Quadriserial branches join at the bifurcation to form algal like structures. Zoarium in alternate pairs, internode with the four sided prism. Zooecia of each pair open on two opposite faces of the internode. The basal surface of the zooecia meet in a spindle shaped area about half the length of the zooecium. Proximally placed cryptocyst, spines wanting. Gymnocyst vestigial present at the proximal end only, though well developed at the internode. Two avicularia vestigial or with pointed mandibles present proximally to the opesia. Ovicells small and endozooecial. Uniporous septula, one terminal and two lateral.

25. ***Nellia occulata*** Busk, 1852 **Plate 5: Fig. 18a, b & c**

Nellia occulata Busk, 1852: 18; Hincks, 1887: 121; Thornely, 1905: 110; 1906: 185; Canu and Bassler, 1920: 489; Harmer, 1926: 240; Silen, 1941: 49; Osburn, 1950: 119; Menon, 1967: 167.

Occurrence: Several colonies were collected attached to gastropod shells from dredge samples from a depth of 120 m from Cape Comorin.

Salient features: L_z= 520μ; l_z= 120μ

Variously branched zoaria. Height of the colony could be as much as 6 cm. Anchored to substratum by rootlets. The lengths of the internodes greater distally than proximally. The distal region of the preceding zooecium overarches the proximal portion of the succeeding zooecium. Frontal membrane occupies the entire front. The mural rim thin slightly raised giving the zooecium the shape of a boat. Operculum large distally placed. Proximal gymnocyst provided with two more or less triangular avicularia, which look like raised knobs. The avicularian base less calcified. Avicularia with two small pores one of which bridged with a horizontal bar. Cryptocyst smooth. Ovicells not evident.

Remarks: The specimens compare well with that of Harmer (1926) and Osburn (1950) however, absence of ovicells is rather conspicuous. The normal habitat of this species is gastropod shells and hydroids. The internodes may contain 10-12 zooecia. The zooecia from which the bifurcation occurs has well developed gymnocyst and the connecting zooecial node is typically circular in shape. The bifurcation looks to be characteristic and is always placed distolaterally.

Records from Indian waters: Andaman Island (Thornely, 1907); Laccadives (Robertson, 1921); Off Cochin (Menon, 1967).

Distribution: Florida (Smitt, 1873); Tortugas Island (Osburn, 1914); Crozet Island, Heard Island (Busk, 1852); Aru Island, Saleyar, Seget, Timer (Harmer, 1926); Victoria (Mac Gillivray, 1880); Queensland (Haswell, 1880); Philippines (Busk, 1884); Siboga stations in the Indo-Australian Archipelago (Harmer, 1926); Ceylon (Thornely, 1905); Indian waters (Thornely, 1907, Robertson, 1921, Menon , 1967).

Family Bugulidae Gray, 1848

The genera included in this family are usually erect, occasionally more or less recumbent or even loosely encrusting, biserial, sometimes uniserial or multiserial. They are usually well chitinised but little calcified. The zooecia take their origin from the dorsal side of the preceding zooecia in the series, so that the distal ends over-lap more or less the bases of the succeeding zooecia. The opesia are usually large, frequently occupying the whole front, though the gymnocyst may be well developed in many cases. The sides of the zooecia are frequently rolled inward (turbinate). Spines, both terminal and lateral, are usually present and pedunculate avicularia are characteristic, though both spines and avicularia may occasionally be wanting" (Osburn, 1950).

Genus *Bugula* (Oken, 1815)

Bugula (pars) Oken, 1815: 89; Harmer, 1926: 432; Okada and Mawatari, 1935a: 133; Silen, 1941: 105; Osburn, 1950:153; Ryland, 1960: 66; Menon and Nair, 1972: 406; Gordon, 1986:45.
Dendrobeania Levinsen 1909: 99.

Unilaminar, erect and branching zoarium. Zooecia alternate, boat-shaped with proximal forking. In frontal view the zooecia usually truncate above and slightly attenuated towards the base. Calcified basal and lateral walls. One or more spines present, a greater number usually occurring at the outer distal angle. Avicularia shaped like a bird's head may be present or absent placed laterally or on the frontal surface. Ovicells hyperstomial, the shape of which range from globular to elliptical.

26. ***Bugula neritina*** (Linnaeus, 1758) **Plate 5: Fig. 19**

Sertularia neritina Linnaeus, 1758: 802.
Bugula neritina Robertson, 1921: 37; Mawatari, 1951b: 49 ; Osburn, 1950:154; Ryland, 1960: 74; Menon and Nair, 1972b: 406; Winston, 1982: 129; Gordon, 1986: 45.

Occurrence: Several colonies were collected attached to glass test panels immersed in Mattancherry wharf in Cochin estuary during the pre-monsoon (February – May) period of 2002-2003.

Salient features: L_z= 870 - 890µ; l_z= 250µ
Live zoarium purplish brown in colour, but preserved ones faded to translucent brown in hue. Colonies grow to small tufts. Zooecia arranged biserially. Bifurcation of type 4, as described by Harmer (1926). No spines or avicularia. The outer distal angle of the zooecia pointed. Opesia occupy the whole front. Large, sub-globular ovicells attached to the inner distal portion in a slanting position to the zooecia.

Remarks: These specimens resemble remarkably *Bugula neritina* (L.) given by Osburn (1950) and Ryland (1960). However, a small difference is noticed between the present form and that of Ryland. Ryland found the average length of zooecia to be 745µ, whereas here it is 890µ. Thornely (1905, 1907, 1912) recorded this species from Palk Bay, Gulf of Mannar and from Ye, Burma. In all the collections she noticed specimens with avicularia. She states (1907) "these specimens have avicularia as in those mentioned in my report on Polyzoa from Ceylon". Harmer (1926) has treated all her records of *B. neritina* as *B. robusta*. Ryland (1960) feels that the absence of avicularia is an important character, which gives specific distinction of this species and in his key to British species of *Bugula* he refers *B. neritina* as the only species without avicularia coming under the genus *Bugula*.

Records from Indian waters: Madras Harbour, Bay of Bengal (Robertson, 1921). Mattancherry and Ernakulam channel of Cochin backwaters, West coast of India (Menon and Nair, 1967a; 1972b).

Distribution: "Widely distributed in the warmer waters of the world" (Ryland, 1960).

27. ***Bugula cucullata*** Busk, 1857 **Plate 27: Fig. 87a & b**

Bugula cucullata Busk, 1857: 241; Maplestone, 1882: 50; Harmer, 1926: 447; Menon and Nair, 1967a: 1; 1972b: 412.

Occurrence: Several colonies collected attached to glass test panels immersed in Mattanchery channel and Ernakulam channel in Cochin estuary during the pre-monsoon (February – May) period of 2002-2003.

Salient features: L_z= 470μ; l_z= 170μ

Zoarium consists of horizontal and vertical stolons, with branches bearing biserial zooids, which arise at regular intervals from the vertical stolons with branching of type 3. Rootlets arise from the horizontal stolons, facilitating attachment to the substratum. Rootlets long, unbranched and opaque with slightly expanded tips. The front is occupied by an opesia equally extensive as a frontal membrane. Gymnocyst present proximally and evanescent. Cryptocyst vestigial. Three distinct jointed spines present distally with 2:1 arrangement. Of the outer two, the more internal one longer than the other. The other two spines very short. Avicularium placed proximally on a rounded tubercle on the lateral side of the zooecium. Rostrum downwardly hooked at the tip. Mandible with a median bar. Cucullate ovicells, placed distally slightly turned towards the median axis of the branches. Developing embryo yellow in colour.

Remarks: While agreeing closely with the description of *B. cucullata* given by Harmer (1926), the present material shows certain points of difference with the figures given by Harmer. The tubercles from which the avicularia arise are shown as quite distinct from the lateral sides of the zooecia in Harmer's figures, but here the tubercles are not so distinct and separate from the lateral zooecial walls. The ovicells are slightly disposed to the side of the zooecia in the present specimens, while Harmer's figure shows them as occupying the distal region. The tentacles are twelve in number in the present specimens. The cucullate ovicells contain developing embryos. Certain remarkable differences have been noticed in the specific characters of the present specimen's collected from the Cochin harbour, less calcified zooecia and in the nature of the rhizoids which are narrow and long. The nature of branching, spines and ovicells are, however, identical in both the cases.

Records from Indian waters: Mattancherry channel and the Ernakulam channel of Cochin Harbour, west coast of India (Menon and Nair, 1967a; 1972b).

Distribution: Victoria (Maplestone, 1882; Mac Gillivray, 1883), Western Australia (Busk, 1857), Kei Island (Harmer, 1926).

Family Epistomiidae (Gregory, 1903)

Zoarium erect or partially prostrate jointed and attached by rootlets. Zooecia paired, extending into three internodes, each of which consists of the distal or largest section of a pair of zooecia, the smaller middle sections of two zooecia of the succeeding internode, and the still smaller proximal sections of two zooecia of the next internode but one. Avicularia sessile or pedunculate, borne by the middle sections of the zooecia, the mandibles acute. Gonozooecia formed by the enlargement of certain individuals, ovicells wanting.

Genus *Synnotum* (Pieper, 1881)

Mononota and *Synnota* Pieper, 188l: 43.
Synnotum Hincks, 1886: 255; Harmer, 1926: 394; Osburn, 1950: 150; Winston, 1982: 127; Gordon, 1984: 43.

Internodes separated by joints. Zooecia arranged back to back in pairs. Each pair connected by tubular prolongations. Sessile lateral avicularia at the distal end, a stalked avicularium occasionally present. Slightly enlarged gonozooecia.

28. *Synnotum aegyptiacum* (Audouin, 1826) — Plate 23: Fig. 86

Loricaria aegyptiaca Audouin, 1826: 243.
Synnotum aviculare Hincks, 1886: 257; Kirkpatrick, 1890: 504; Waters, 1897: 14, 1909: 129; Robertson, 1921: 35.
Synnotum aegyptiacum Harmer, 1926: 398; Osburn, 1950: 151; Menon, 1967: 178; Winston, 1982: 127; Gordon, 1984: 43.

Occurrence: Two colonies were collected from dredge samples from a depth of 50m from Cochin in the west coast of India.

Salient features: L_z= 440 – 500μ; l_z=140 – 150μ
Erect zoarium with prostrate branches at the older parts of the colony, attached by rootlets. Maximum height noticed is 20mm. Rootlets absent in most of the internodes. Zooecia paired with obliquely facing front. A frontal and basal avicularia present at each

internode. Occasionally a pedunculate avicularium takes the place of the frontal one. Enlarged gonozooecium present. Spines absent.

Remarks: Referable to *Synnotum aegyptiacum* (Aud.). A comparison of this with the figures and description of *Synnotum contortum* Waters, shows that these two species show resemblance. The rootlets emerging from almost all internodes characteristic of *Synnotum contortum* are however, not present in *S. aegyptiacum.* Other important distinguishing characters are the presence of sessile avicularia on "one or both the sides" (Waters, 1909) near the distal end of the zooecia and the arrangement of the internodes. Striking difference is seen in the shape of the pedunculate avicularia of these two species. *Synnotum aegyptiacum* is with very delicate zooecia, and with a single basal avicularium at each internode. The production of gonozooecia takes place in *S. aegyptiacum* on normal internodes. The degree of alternate rotation of internodes is less in this species contrary to what is found in *S. contortum.* The pedunculate avicularium has a strongly hooked rostrum and deeply excavated palatal surface, similar to what Harmer noticed in his materials. Gonozooecium is formed out of only one of the pair of zooecia. This character is also in conformity with what Harmer noticed in his specimens.

Records from Indian waters: Palk Strait (Robertson, 1921); Andaman and other localities in the Indian Ocean (Thornely, 1907); Amirante Island (Thornely, 1912); Krusadi Island, Minicoy Island (Menon, 1967).

Distribution: Cosmopolitan. The Mediterranean, the Red sea, South Africa, various localities in the Indian ocean, the Indo-Australian Archipelago; Pacific coast of Japan, and coasts of southern California and Mexico (Hancock stations) and the western side of Atlantic (Osburn, 1950).

Family Candidae Busk, 1852

Colonies erect, unilaminar, branching, usually biserial, with or without joints; attached by rhizoids (rootlets) originating in a septulum or a vibracular chamber. Zooids well calcified except for the frontal membrane usually bordered by well-developed gymnocyst, comparable to opesia. Distal spines usually present, plus a modified spine (scutum) arching over the frontal membrane. Vibracula sometimes on back (ventral) surface.

Avicularia occasionally lateral or frontal on gymnocyst. Ovicells commonly with one or more fenestrae, or imperforate, hyperstomial.

Genus *Scrupocellaria* (Van Beneden, 1845)

Scrupocellaria Van Beneden, 1845: 16; Harmer, 1923: 316, 1926: 364; Okada and Mawatari, 1935a: 134; Osburn, 1950: 130; Menon, 1972a: 914; Winston, 1982: 129; Soule *et al.*, 1995: 94.

Biserial zoarium. Opesia more or less oval, sometimes reduced by the development of a cryptocyst of varying extent on its proximal side. Operculum seldom distinct, scutum present or wanting. On the proximal or inner side of the opesia each zooecium typically provided with a frontal avicularium. A marginal avicularium at its distal end and a basal vibraculum at its proximal end. Avicularia of the pointed type. Vibraculum projects beyond the edge of the branch. Rostrum with two shallow grooves. Seta without lateral branches. Rootlets commonly with barbing spines. Ovicells hyperstomial with or without pores.

29. ***Scrupocellaria ferox*** Busk, 1852 — **Plate 5: Fig. 20a & b**

Scrupocellaria ferox Busk, 1852: 370; Harmer, 1926: 367; Osburn, 1950: 137.

Occurrence: This species was obtained in dredge samples taken from Trivandrum along the west coast of India at a depth of 112 m.

Salient features: L_z= 400µ; l_z= 210µ

Coarse zoarium. Opesia occupies the nearly 3/4th of the front. Scutum absent. Elongated ovicells, distinctly porous and hypostomial. Pore-plates distinctly visible in unfertile zooecia. Vibracula present with slightly curved distal end. Frontal avicularia placed proximally with relatively enlarged distal portion, in which respect, it differs from the avicularia noticed in other species of the genus. Spines present, the number could vary from 3-5 distally and at the sides of the orifice. Only spine bases noticed in the present material. The vibracular curvature is distinct. Frontal avicularia variable in size, the largest normally just after the zooids from where the bifurcations starts. Mandibles not observed but Harmer (1926), who has described this species in detail, stated that, the avicularian rostrum is very aquiline with acute mandibles. The marginal avicularia when present small. Single vibraculum. Pores of the ovicells not tubular.

Remarks: Curiously enough Harmer (1926) has felt that this species is "handsome" and found it intriguing that the species has no scutum. The absence of scutum is of high ecological significance as this would result in very vigorous movement of vibracular spine to avoid settlement of particles on the front. The occurrence of this species at a depth of 112 m distinctly increases the bathymetric distribution of this species, which is normally collected from 0-50 m depth in the Indian Ocean. Previously Menon (1972a) described 9 species of *Scrupocellaria* from Indian Ocean but this species was not recorded from this locality. It is apparently a tropical species widely distributed in the Indian and Pacific Oceans.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Louisiade Archipelago (Busk, 1852), East Indies (Harmer, 1926), Wreck Bay, Chatham Island, Galapagos Islands, Indian and Pacific Oceans (Osburn, 1950).

Genus *Caberea* Lamouroux, 1816

Colony erect, dichotomously branched, generally stiff and fan-shaped, anchored by clustered rhizoids. Zooids in two or more series, alternating. Apparently unjointed, but the chitinous connections covered by calcification. The oval frontal area typically overarched by scutum. Cryptocyst and gymnocyst variable in extent, sometimes well developed. Distal spines present, sometimes inconspicuous. Avicularia sessile; small and lateral; often larger, or occasionally gigantic, avicularia occur sporadically frontally. Basal vibracula well developed, covering much of the surface, each with a long, oblique setal groove; setae long, generally barbed. Ovicell hyperstomial, usually with a broad frontal exposure of ectooecium.

30. *Caberea lata* Busk, 1852 — **Plate 6: Fig. 21a & b**

Caberea lata Busk, 1852: 378; Waters, 1887: 84; Kirkpatrick, 1890: 16; Thornely, 1907: 183; Robertson, 1921: 36; Harmer, 1926: 360.

Occurrence: This species was obtained in dredge samples collected from Vishakapatanam in the Bay of Bengal from a depth of 100 m.

Salient features: L_z= 440µ; l_z= 260µ

Zoaria biserial, zooecia arranged alternatively. Gymnocyst well developed proximally and cryptocyst expansive, evanescent distally. The zooecial margins elevated with lateral bulbous protuberances, giving the zooecia a boat shaped structure when viewed laterally. Frontal avicularia present; only one each zooecia observed in the present specimens. The anterior portion of the opesia has a distinct internal shelf, which is provided with two minute lateral pores to establish organic connections with the succeeding zooecia. Scutum absent. The avicularia is laterally placed and directs proximally, invariably placed at the base of the vibracula, which protrudes into the lateral sides of the zoarium. The presence of well-developed vibracula gives the lateral side of the colony a serrated appearance. The vibracular chamber, which occupies the major portion of the basal side of zooecia, has an elongated morphology with a distal minute pore into which, the vibracular setae would be lodged. However, no seta was observed in the present material. Harmer (1926) has noticed very strong vibracular seta. Ovicells not noticed.

Remarks: The present material compares well with the specimens that Harmer (1926) observed in his collections from various Islands of the Indo-Australian Archipelago. The basic character of the species seems to be the absence of scutum and the presence of highly developed vibracular chamber, which almost occupies $3/4^{th}$ of the lateral front of the zooecium. In the scanning electronmicrograph the strong bulbous nature of the vibracular chamber is very evident. The lateral side of the chamber is slightly elevated and at times, is closely placed so as to give a slit-like appearance. Curiously enough, the frontal avicularia are very minute distally placed giving the impression that over manifestation of the vibracular chamber resulted in minuteness of the vicarious avicularia. Considering the anascan calcification *Caberea* seems to occupy those groups of anascan where calcification is well manifested. This species seems to enjoy a very good bathymetric distribution occurring from the subtidal to 120 m depth.

Records from Indian waters: Madras Presidency, India (Robertson, 1921).

Distribution: Queensland, Japan, Pacific Ocean and the Indian Ocean (Harmer, 1926).

Family Onychocellidae Jullien, 1882

Introduced by Jullien (1882) to include forms with well-developed expansive cryptocyst, anteriorly placed small opesia, inconspicuous or sunk ovicells and characteristic vicarious avicularia. This family is supported to contain rather primitive bryozoans although avicularian mandibles and ovicells are significant evolutionary adaptations.

Genus *Smittipora* Jullien, 1882

Smittipora Jullien, 1882: 284; Canu and Bassler, 1920: 225; Harmer, 1926: 258; Winston, 1986: 11.

More or less hexagonal zooecia with extensive and depressed cryptocyst. Reduced opesia, a little more than the orifice. Sides of the opesia straight or curved may be trifoliate with open opesiules, which may sometimes be indistinct. Various avicularia symmetrical without a distinct rostrum. Mandible symmetrical with large membranous expansions on each side of the rachis.

31. ***Smittipora abyssicola*** (Smitt, 1873) **Plate 6: Fig. 22**

Vincularia abyssicola Smitt, 1873: 6.
Onychocella abyssicola Thornely, 1905: 111.
Smittipora abyssicola Jullien, 1882: 284; Canu and Bassler, 1920: 225; Harmer, 1926: 259; Menon and Nair, 1967a:1.

Occurrence: Colonies collected were encrusting on corals and molluscan shells in dredge samples taken from many stations in the east and west coasts of India at various depths.

Salient features: L_z= 330μ; l_z= 200μ

Encrusting zoaria, nearly hexagonal. Mural rim distinct and contiguous with the cryptocyst but retains specificity by slight elevation. Cryptocyst provided with minute tubercles, more in number and distally elevated slightly. Distolaterally expansive during the appearance of a very inconspicuous bulge. Opesiules distinct basally, trifoliate. The lateral extensions could be very distinct in some zooids. Large avicularia, symmetrical without distinct rostrum. Large opesia slightly expanding distally. Denticulations desirable in some cases. The rostrum though not distinct is profusely tuberculated. Mandibles not noticed. Ovicells absent.

Remarks: This species is very widely distributed and was collected from both the east and west coast of India from depths ranging from 30-150m. Harmer (1926) has noticed the bulging of the cryptocyst in these specimens and hence has remarked that the cryptocyst is concave. The electronmicrographs very clearly shows that the convex feature of cryptocyst is most central and rim smooth, without any tubercles. In this respect, probably this species resemble *Labioporella sinuosa*, which however lacks large avicularium. The zooecial margins are distinct and gymnocyst is remnant. The avicularian cryptocyst is more tuberculated than that of the original zooecia. The lateral extension of the opesiules could be nearly complete in some zooecia probably indicating the forerunner of minute opesiules in related species.

Records from Indian waters: Gulf of Mannar (Menon and Nair, 1967a).

Distribution: Indo-Australian Archipelago (Harmer, 1926), Ceylon (Thornely, 1905), Indian waters (Menon and Nair, 1967a).

Family *Steginoporellidae* Hincks, 1884

Zooecia dithalamic, the cavity more or less divided by a cross wall or partition, with the descending lamina of the cryptocyst, into proximal and distal cavities. The horizontal lamina of the cryptocyst is complete above the proximal cavity; the descending lamina perforated by the polypide tube, which is more or less calcified, sometimes only the roof of the projecting distal portion being calcified. The opesia is confined to the distal cavity and is further limited to a greater or less extent by the surrounding cryptocyst. In the genus *Steginoporella* there are two kinds of zooecia, the "A" zooecia and the "B" zooecia. The "B" zooecia having an enlarged operculum provided with chitinous teeth is apparently an avicularium.

Genus *Steginoporella* Smitt, 1873

Steginoporella Smitt, 1873: 15; Harmer, 1900: 225; Canu and Bassler, 1920: 259; Harmer, 1926: 268; Pouyet and David, 1979: 566; Soja and Menon, 2005: 9.

Zoaria encrusting or erect, zooecia dithalamic, body cavity subdivided by an incomplete descending lamina of the cryptocyst which joins the basal or distal wall leaving a median fenestra prolonged distally into a more or less complete polypide tube which is traversed by the tentacles. In some species prolongation of the frontal wall into flanges form a median process with a frontal depression and the floor of the process formed by the roof of the tube. Gymnocyst wanting or slightly developed. The horizontal part of the cryptocyst merges with the lower part of gymnocyst proximally and laterally. Avicularia present often vicarious and provided with polypides but distinguishable from the normal zooecia by difference in their distal portion and in having a distinct avicularian mandible. There are species under this genus where the avicularia need not possess polypide.

The frontal membrane complete. The presence of avicularian polypide makes *Steginoporella* evolutionarily significant. Majority of the species known today are from the Indo-Australian Archipelago, although they were recorded recently from the Antarctic.

32. ***Steginoporella buskii*** Harmer, 1900 **Plate 6: Fig. 23a & b**

Steginoporella buskii Harmer, 1900: 272; Thornely, 1905: 112; Harmer, 1926: 279; Cook, 1964: 46.
Steginoporella transversalis Canu and Bassler, 1928: 68; Marcus, 1949: 11.
Steginoporella buskii Pouyet and David, 1979: 771; Winston and Heimberg, 1986: 11; Soja and Menon 2005: 9.

Occurrence: Two colonies were collected, attached to shell bits in dredge sample taken from Calicut and Goa in the west coast of India from a depth of 75 to 100 m.

Salient features: L_{za}= 610μ; l_{za}= 545μ: L_{zb}= 843μ; l_{zb}= 657μ
Zoaria encrusting on bivalve shells. The large 'A' zooids are squarish to rectangular in shape slightly developed gymnocyst and slowly descending cryptocyst, raised distally with lateral sides dipping and merging with the zooecial walls. The presence of two ridge- like descending portion of the cryptocyst results in the formation of two fenestrae on either side of the smooth median curved and raised cryptocystal margin. Cryptocyst are provided with pores sometimes numerous at the region where it ascends, by and large granulated, the marginal descending portion is smooth. The semicircular operculum covers almost the entire distal portion of the zooecia. A beaded or moderately thickened ridge of the zooid, gives them a typical hooded appearance and this is the case of both the zooids.

Remarks: This species was created by Harmer (1900) to include those species of *Steginoporella* which has relevantly larger 'B' zooecia with an enormous oral shelf. The presence of conspicuous condyles in 'B' zooecia than those in 'A' type is also a distinguishing feature. Canu and Bassler (1923) remarked that certain species coming under this genus are living fossils. This idea probably was the result of the presence of fully developed polypides, in the vicarious avicularia. This gives significance to the species possessing such avicularia and hence, gives evidence to the archaic nature of at least a few species belonging to the genus *Steginoporella.*

Records from Indian waters: This is the first record of this species from Indian waters. Arabian Sea (Soja and Menon, 2005).

Distribution: Gulf of Guinea, Guinea, Ceylon, Indonesia, Torres Strait (Harmer, 1926); Arabia, South Africa, Australia, Caribbean, Brazil (Cook, 1964); Arabian Sea (Soja and Menon, 2005).

Genus *Labioporella* Harmer, 1926

Labioporella Harmer, 1926: 281; Osburn, 1950: 108; Winston, 1984: 12.

Distinct zooecia arranged in longitudinal rows. Gymnocyst absent. The descending lamina of the cryptocyst meets the basal walls. A complete or incomplete polypide tube present. Porous, horizontal cryptocyst occupies the greater part of the frontal surface. The walls of the lateral recesses join the lateral walls of the zooecium. Large vicarious avicularia present (absent in *L. sinuosa* Osburn). Ovicells absent. Rosette plates multiporous.

33. *Labioporella sinuosa* Osburn, 1940 — Plate 26: Fig. 99

Labioporella sinuosa Osburn, 1940: 377, 1950: 11; Menon and Nair, 1967a: 2.

Occurrence: One colony with five zooecia collected from the sand in the dredge sample at a depth of 35 m from Cape Comorin in the west coast of India.

Salient features: L_z= 390– 420μ; l_z= 300μ

Zooecia arranged in distinct longitudinal rows. Gymnocyst wanting. The descending lamina of the cryptocyst meets the basal walls. Polypide tube present. There are species with complete polypide tube and incomplete form because of the descending lamina not meeting the basal walls. A porous horizontal cryptocyst occupies the greater part of the front. The walls of the lateral recesses join the lateral walls of the zooecia. Large vicarious avicularia present. Ovicells absent. Rosette plates multiporous.

Remarks: In the absence of avicularia, the present form differs from *L. spatula, L. bursaria, L. thornely* and *L. rhomboidalis*. Three species of *Labioporella* are known where the avicularia are either absent or not noticed, namely *L. cornuta, L. elegans* and *L. sinuosa*. In *L. cornuta*, the lateral recesses insert on the basal walls, and this is one of the important characters, which give specific distinction to this species. The lateral insertion of the lateral recesses and the presence of a distinct distal tubercle developed from the proximal part of the distal wall distinguish *L. sinuosa* from other species of *Labioporella*. But among the species known to possess avicularia, *L. spatula* seems to come close to *L. sinuosa*. The occurrence of the distal tubercle characteristic of *L. sinuosa*, found in *L. spatula* also seems to make the specific distinction of these two rather weak, as the only important difference could rather be based on a negative character; the absence of avicularia alone justifies the present placing. The present material resembles closely to the figure and descriptions of *Labioporella sinuosa* Osburn (1950).

Records from Indian waters: Tuticorin, east coast of India (Menon and Nair, 1967a).

Distribution: Tortugas Island (Osburn, 1940), Gulf of California, Clarion Island and Gulf of Panama (Osburn, 1950), Indian waters (Menon and Nair, 1967a).

Family Thalamoporellidae (Levinsen, 1909)

Unique among Cheilostomata in possessing numerous free, calcareous spicules in the body cavity. Median process highly developed and the closed opesiules are asymmetrical. The opesia, situated near the distal end is much reduced. Large, rounded or acute vicarious avicularia present. Ovicells are bivalvular when present.

Genus *Thalamoporella* Hincks, 1887

Thalamoporella Hincks, 1887: 164; Levinsen, 1909: 178; Harmer, 1926: 289; Okada and Mawatari, 1935a: 130; Osburn, 1950: 110; Menon and Nair, 1967a: 1.

Zoaria growing on algae, shell pieces or stones. Zooecia with a depressed porous cryptocyst. Two asymmetrical opesiules present latero-distally, either rounded or hole-like but never slit-like. Opesia and orifice practically co-exist. The opesiules meet either the basal or lateral walls, resulting in a median wall, which merges to form a characteristic polypide tube that terminates beneath the orifice. The cavity between the ectooecium and endooecium divided by a median structure. Spicules present in the body fluid in the form of compasses and calipers or both. Avicularia vicarious rounded or pointed type. Ovicells when present very globose and prominent.

34. ***Thalamoporella gothica*** (Busk), 1856 — **Plate 6: Fig. 24**

Membranipora gothica Busk, 1856:176.
Thalamoporella gothica Harmer, 1926: 302; Cook, 1964: 62.

Occurrence: Many colonies were collected attached to shell bits and stones in dredge samples from Cape Comorin, Quilon and Cochin along the west coast of India at a depth of 115m.

Salient features: L_z= 830μ; l_z= 480μ

Encrusting, adoral area without tubercles, opesia with two big sinuses placed on either side of the polypide tube. Oral shelf well developed. Opesiules variable often symmetrical sometimes, very asymmetrical in frontal view. The basal insertions variable. Avicularia present, acutely pointed mandibles, the distal end of which could be hooked. Operculum complete with a basal sclerite. Ovicells not found.

Remarks: *T. gothica* unfortunately has been bestowed with two varieties namely *T. gothica* var. *indica* and *T. gothica var. prominens* by Harmer (1926). The major variation noticed was in the geographical area of occurrence, size of the zooecia, the shape and structure of the avicularian mandible. Presence or absence of adoral tubercles. The size of the avicularia also has been taken as an important character by Harmer (*loc.cit.*) to describe the Torres Straits specimens as *T.* var. *prominens*. Other species examined by me namely *T. hamata* and *T. expansa* are very distinct and could be distinguished by the blunt nature of the latter from that of the former. Closer examination of the SEM photograph shows that in the case of *T. expansa* the tubercles are larger, closer to the orifice and the distal portion nearly merge with the distal orificial armature so as to give the impression of an overhanging arch. This character I feel is different from *T. gothica* var. *indica* and *T. hamata*. The cryptocystal armature is less calcified and more porous in *T. gothica*. The zooecial margin though elevated is not as strongly desirable as that of *T. hamata*.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Mazatlan, California (Busk, 1856), Africa (Cook, 1964).

35. ***Thalamoporella hamata*** Harmer, 1926 — **Plate 7: Fig. 25**

Thalamoporella hamata Harmer, 1926: 301; Menon and Nair, 1967a: 1.

Occurrence: One colony was collected attached to a shell bit in dredge samples from Cuddallore in the east coast of India from a depth of 30 m.

Salient features: L_z= 630μ; l_z= 430μ

Encrusting zoaria, distinct frontal areas with tubercles. The tubercles are provided with expanding base which occupy both the sides of the orifice or flat calcareous platforms. The tubercles themselves have a rounded opaque distal area, which is very clear in the SEM photographs. The straight proximal margin of the opesia is almost completely covered by the operculum, cryptocyst granular with minute pores. Calcification of the cryptocyst seems to begin from the lateral sides of the front. Opesiules minute and often obliterated by overhanging calcareous cryptocyst. The orifice has a raised, distal margin. Avicularia present, vicarious in structure, they are placed independently along the zooecial growth lines. The vicarious avicularia is pointed, directed distolaterally. Clear-cut marginal gymnocyst present in all zooecia. The zooecia separated by distinct marginal thickenings.

Remarks: *Thalamoporella hamata* was described by Harmer (1926) and Menon and Nair (1967a) after considering various characters of *Thalamoporella* such as size and shape of the sinus, well developed adoral spaces with peculiarly structured tubercles, presence of thin calcareous grooves, avicularian rostrum being narrow which diverges from the sister zooecium. The examination of the present specimen shows the position of the sister zooecium, which interrupts the general array of zooecium. One sister zooecium was noticed with no vicarious avicularia.

Records from Indian waters: The Krusadi Island (Menon and Nair, 1967a).

Distribution: North Ubian, Sulu Archipelago, west of north end of New Guinea (Harmer, 1926), the Krusadi Island (Menon and Nair, 1967a).

36. ***Thalamoporella expansa*** Levinsen, 1909 **Plate 7: Fig. 26**

Thalamoporella expansa Levinsen 1909: 179; Harmer 1926: 300.

Occurrence: One colony was collected attached to a shell bit in dredge samples from Cuddallore in the east coast of India from a depth of 30 m.

Salient features: L_z= 610-728μ; l_z= 280-315μ

Encrusting zoaria, adoral spines very distinct and makes this area of the zooecium very conspicuous. Rounded tubercles on the adoral area might merge with the distal portion of the orifice. Gymnocyst very distinct, tuberculated, calcified with distinct thin line-like margin separating the zooecia. The orifice filled with operculum, which has got a straight proximal margin. By and large, the cryptocyst is highly calcified and opesiules are small and are placed towards the distal part of the zooecium. Dislodgement of the tubercle, creates a sinus space in at least one zooecial photograph. The space between the opesiules and orifice is highly calcified and raised. Slit-like avicularia present but cannot be considered like the normal one found in *Thalamoporella*. The zooecia are separated by distinct calcareous margin.

Remarks: *T. expansa* looks to be a highly calcified species coming under this genus. The Electron micrograph of the specimens of various species at my disposal makes this comparison possible. The size shape and direction of the opesiules of *T. expansa* are variable. The tubercle, the proximal portion of polypide tubes and the marginal area of opesiules, could be highly calcified and might obliterate the shape of the opesiule. The figure given by Harmer (1926) has made this very clear although, when compared with the electron micrographs variations could be noticed. Probably, this character of the species distinguishes it from *T. gothica*. The variable shape of the opesiules and displacement of opesiules towards the proximal portion of zooecia was also noticed by Harmer (*loc.cit.*). This species has not so far been recorded from the Indian Ocean.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Torres Strait (Levinsen, 1909), Unknown locality (Harmer, 1926).

37. ***Thalamoporella rozierii*** (Audouin, 1826) **Plate. 24: Fig. 88**

Flustra rozierii Audouin, 1826: 225.
Steginoporella smittii Hincks, 1880: 178.
Thalamoporella smittii Hincks, 1887: 123; Thornely, 1907: 187.
Thalamoporella rozierii Waters, 1909: 123; Robertson, 1921: 52; Harmer, 1926: 292; Menon, 1967:92.

Occurrence: Few colonies were collected attached to shell bits in dredge samples from Cuddallore in the east coast and Quilon in the west coast of India from a depth of 30 m.

Salient features: L_z= 550μ; l_z = 340μ

Encrusting zoarium. Zooecia elongated and rectangular arranged alternately, separated by raised, thick calcareous margins. Opesia terminal, broad, with large proximal sinus. Opesiules somewhat asymmetrical placed distally. Operculum with rounded distal margin, the proximal region with a complete bar. Cryptocyst granulated and slopes distally, the proximal portions bearing small pores. The median process of the cryptocyst forms the polypide tube, the lateral walls of which form those of the two opesiules. Large adoral tubercles present. Ovicells large and bilobate, with a median septum. The elongated opening of the ovicell occupies the proximal half. Spicules in the form of calipers and compasses, and also a third widely 'V' shaped type present.

Remarks: Harmer (1926) has pointed out the presence of avicularia as an important character in the species of *Thalamoporella* collected during Siboga expedition. It is particularly noteworthy, that the present form does not possess vicarious avicularia. However, Hincks (1880) has distinguished three forms of this species based on the presence or absence of avicularia, tuberosities and ovicells. Those forms with the tuberosities and the ovicells are grouped under the 'form' *'Thalamoporella rozierii'*, those with avicularia and tuberosities under the 'form' *'Thalamoporella gothica'* and a third 'form' *Thalamoporella indica'* with avicularia and ovicells. According to Hincks (1880) the common type is form *Thalamoporella rozierii* with which the present form agrees well since it possesses ooecia and tuberosities but no avicularia. Ovicells are typically bilobate in these specimens. The opening for the escape of embryo is very large. The view that ovicells are modified adoral tuberosities (Harmer, 1926) agrees in the case of the present specimens since in zooecia with ovicells, adoral tuberosities are absent and all the zooecia without ovicells have tuberosities. In addition, the ovicells are found to develop as two valvular extensions from the adoral region, uniting in the middle, forming a calcareous bar characteristic of bivalvate ovicells. It is probable that these valvular structures are modified tuberosities as suggested by Harmer (1926). Tuberosities in the present specimens are large and are with two walls, an outer and an inner with a space in between. In young zooecia the tuberosities are found in the form of two rounded projections opened at the tip and continuous with the wall of the orifice. As growth proceeds the area between the orifice and the tuberosities increases separating the former from the latter. In addition to the two types of internal spicules namely the calipers and the compasses in the developing zooids a third type of spicules is discernible which is widely 'V' shaped. These are found in clusters in the developing zooids together with the other two types of spicules. These probably represent a third type.

Records from Indian waters: Pedro shoal, Indian Ocean (Thornely, 1907), Kovalam, south west coast of India (Menon, 1967).

Distribution: Cornwall, England (Hincks, 1880); Egypt, Red Sea (Audouin, 1826), Indian Ocean (Thornely, 1907; Robertson, 1921; Menon, 1967); Mergui Archipelago, Burma (Hincks, 1887); Makassar Strait, south-west Celebes, Sulu Archipelago, Banda Sea (Harmer, 1926), Cape Verde Island (Waters, 1909).

Family Cellariidae Hincks, 1880

Colonies always erect, which may be jointed or unjointed. Zooids typically have a diamond shape or hexagonal, situated on all sides of the internodes or branches. The lateral walls of the zooids are raised, forming a rim delimiting the frontal area of each zooid. Cryptocyst present depressed and imperforate. Orifice more or less semicircular, the proximal rim of which is either straight or convex usually bearing a pair of condyles laterally. Avicularia are vicarious or absent. Ovicells present and immersed, usually inconspicuous, indicated only by a large pore distal to the aperture.

Genus *Cellaria* Ellis and Solander, 1786

Cellaria Hincks, 1880: 104; Harmer, 1926: 334; Gordon, 1984: 58; 1986: 74.
Erect colonies with or without joints. Zooids are hexagonal or diamond shaped in longitudinal series, usually alternating around an axis. Lateral walls of the zooid raised with depressed cryptocyst. Frontal surface granulated but imperforate. Orifice semicircular with proximal rim straight and possessing condyles. Avicularia usually present and interzooecial. Ovicells immersed, indicated by the presence of a large pore distal to the aperture.

38. ***Cellaria johnsoni*** Busk, 1958 — **Plate 7: Fig. 27a & b**

Nellia johnsoni Busk, 1858: 125.
Cellaria johnsoni Busk, 1858: 65; Hincks, 1880: 112; Thornely, 1905: 109.
Salicornaria johnsoni Busk, 1860: 280.

Occurrence: A single colony was obtained from sand in the dredge samples collected from Vishakapatanam in the east coast of India at a depth of 100m.

Salient features: L_z= 350μ; l_z= 125μ
Slender zoarium looks to be fragile in structure. A distinct feature is the characteristic zooecial margins, which are elevated and ridge-like. The shape of the zooecia varies and the median ones have a distinct elongated basal gymnocyst-like structure, which is separated from the cryptocyst at least in some zooecia by slightly raised smooth

elevations. Cryptocyst is well-developed and the proximal portion of the orifice is slightly flared. The lateral zooecia even gives the appearance of a slightly bulbous cryptocyst, the distal end of which overarches the orifice. The median zooecia which have a different oval shape and a more or less rounded orifice which doesn't look like an artifact or damage since it is repeated twice in a fragment which contained only 11 zooecia. It is not clear, whether this is a modified avicularia of vicarious nature. The lack of description of this species subsequently makes a real comparison rather difficult. Hincks (1880) has tried to compare this species other *Cellarians* and he felt that *C. fistulosa* is a species, which comes very near to *C. johnsoni*. The more or less six-sided nature of the zooecium and the distinct elevation separating the gymnocyst from the cryptocyst gives this species the typical *Cellarian* character. It is not clear that the very expansive gymnocyst of individual zooecia, will accommodate three zooids in the internode and typically one series of zooids in the internode depicts some variations in the shape of the orifice, which looks circular in character.

Remarks: No reference is made by Hincks (*loc.cit.*) regarding the depth from which this animal was collected from the Madeira Islands but this is found to occur in deep waters of Scotland, Madeira and Algiers. The present material came from 100 m off Vishakapatanam. Substratum of this present material was sandy in nature. Describing the avicularia of this species the description given by Hincks (*loc.cit.*) gives the impression that the avicularia was very similar to the normal zooecium but slightly smaller in size and the mandible, a region very similar to the orifice of a normal zooecium. Hincks has been careful in describing this avicularia has "less highly specialized forms" (p.113, British Marine Polyzoa).

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Madeira (Hincks, 1880), Ceylon (Thornely, 1905).

39. ***Cellaria punctata*** (Busk), 1852 **Plate 7: Fig. 28a & b**

Salicornaria punctata Busk, 1852: 366.
Salicornaria gracilis Busk, 1852: 17; 1884: 93.
Cellaria johnsoni Thornely, 1905:109.
Cellaria punctata Harmer, 1926: 337.

Occurrence: Two colonies were obtained from sand in dredge samples collected from off Cochin in the west coast of India at depth of 94 m.

Salient features: L_z= 320μ; l_z= 290μ

Nodular joints with delicate internodes, with anterior portion of the zoarium nearer to substratum containing fertile zooecium. Zooecia rhomboidal, with distinct hexagonal elevations. Gymnocyst less developed and the highly developed cryptocyst elevated, joining the zooecial margins creating distinct elevated ridges. These ridges represent the gymnocyst. Cryptocyst is relatively broad proximally and when approaching orifice it gets slightly elevated. Typically pear-shaped orifice with two distinct enormous condyles, blunt in shape. Ovicells endozooecial. Orifice large armored with proximally placed triangular calcareous thickenings. Cryptocyst at some places looks to be granulated. The orificial margins are ridged and typically semicircular. Some of the zooecia contain minute openings at the laterally elevated cryptocystal margins. Considering the size of the ovicell opening, the ovicell should be enormous in size.

Remarks: Harmer (1926) becomes eloquent while selecting the type specimen of *C. punctata,* has remarked that he was unable to discover any valid motive to reject the original name of Busk (1852) who put specimens under *Salicornaria gracilis.* While selecting the type specimens, Harmer (*loc.cit.*) virtually renouned Busk's "Rattle Snake" specimens in the British Museum from Queensland. Harmer (*loc.cit.*) has synonymised all the species and *Salicornaria* from the Indian Ocean. He also has gave due importance to the endozooecial ovicell provided with characteristic foramen, guarded by a spike-like calcareous structure with a broad base. He has distinctly remarked that this character is typical of other two species of *Cellaria* namely *C. nodosa,* Norman and *C. wasinensis,* Waters. Non-availability of a complete colony with the entire ramification makes further comparison of this species to the ones collected by Harmer (*loc.cit.*) along the Island chains of Eastern Indian Ocean and the Archipelago rather difficult. *Cellaria* though well distributed doesn't contain many species among the different species of *Cellaria. C. punctata* seems to be the most widely distributed one. Regarding the presence of avicularia, Harmer (*loc.cit.*) has the opinion that the avicularia normally found at the base, where it joins the bifurcation. An avicularia like structure is found laterally placed, in one of the internodes examined although this is inconclusive. By and large, *C. punctata* is a very interesting species and Harmer (*loc.cit.*) has even discussed the characteristic growth pattern of this species. The granulation of the cryptocyst is very clear in the photographs, the character which has been noticed by Harmer also.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Island chains of eastern Indian Ocean and the Archipelago (Harmer, 1926), Ceylon (Thornely, 1905).

Family Cribrilinidae (Hincks, 1879)

"This family was created to include all recent and fossil forms in which a frontal shield is produced, by the union of modified spines (costae) over the original frontal membrane" (Harmer, 1926).

Genus *Puellina* Jullien, 1886

This genus was created by Jullien in 1886 to include *C. gatyae*, Busk, which was later on assigned to *Lepralia gatyae* because the species had already been described earlier. However, Ryland and Hayward, 1992 assigned this to the genus *Puellina*. The most important feature of species of this genus is number of oral spines, nature of initiation of costae and the position and structure of avicularia, which are always lateral and small.

40. ***Puellina vulgaris*** Ryland and Hayward, 1992 **Plate 8: Fig. 29a & b**

Puellina vulgaris Ryland and Hayward, 1992: 224; Tilbrook *et al.*, 2001: 58.

Occurrence: This species was collected attached to stones and shell bits in dredge samples from various depths from the east and west coasts of India.

Salient features: L_z=335µ; l_z= 270µ: L_o=110µ; l_o= 130µ
Colonies encrusting. The front highly calcified and when viewed independently, looks like a calcareous armour with radiating costae, which at the periphery merges with the vestigial gymnocyst by means of calcareous bulging. Intercostal pores numerous and the marginal ones placed abutting the gymnocyst, giving the whole front a distinct sinuous margin. Lateral avicularia well developed. Orifice with distinct more or less straight oral thickening and distally rounded. The operculum calcareous and covers the whole orifice. Spinules present, characteristically seven in number. Ovicells present and during the process of growth, invariably displaces the oral spinules and retains them on the frontal less calcified area, resulting in the reduction of oral spinules in fertile zooecia. Avicularia interzooecial, laterally placed, normally one in a zooecium. The avicularia

distally directed and with jointed mandibles. The rostrum has elevated lateral sides and in that respect could be described as interzooecial.

Remarks: Examination of the material shows that the costae originate from the margin of gymnocyst and merges at the center leaving a more or less tuberculated central shield. This was evident from the material in one case, where the costae had not merged at the center but did have well developed lateral structures and intercostal pores. The lateral sides of the rostrum elevated giving it a channel like appearance. This looks to be a very distinguishing feature of *P. vulgaris*, which Ryland and Hayward (1992), found to occur very commonly in the Great Barrier Reef. The present record of *P. vulgaris* from the Arabian Sea and Bay of Bengal in abundance extends the distribution of this species from subtropical and tropical.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Heron Island, Great Barrier Reef (Ryland and Hayward, 1992), Port Villa Harbour (Tilbrook *et al.*, 2001).

Genus *Cribrilaria* Canu and Bassler, 1929

Colony encrusting, gymnocyst extensive proximally or reduced. Frontal shield with pores and costae. Avicularia present, interzooidal in position. Ovicells present, non-porous but with displaced spinous bases.

41. *Cribrilaria* sp. — Plate 24: Fig. 89a & b

Occurrence: This species was collected attached to stones in dredge samples at 30m depth from Cuddallore in the east coast of India.

Salient features: L_z= 140-300µ; l_z= 90-220µ

This cribrimorph has numerous resemblances to *C. radiata* in the main zooecial characteristics. However, the distinct morphological difference is the presence of 10-12 marginal fenestrae, which are separated from each other by well-developed calcareous bars. These bars visibly, gymnocystal in origin merge with the central costae, separated by numerous frontal pores. To some extent, the characteristic feature of merging gives the posterior part of the zooecia and the area where it joins, a disc-like area with minute pores. The operculum is anteriorly drawn out and semi circular in shape, with a distinct proximal calcareous thickening, around which 5 spine bases are found encircling the operculum. Avicularia present, posteriorly directed, placed at the center of a bulbous projection, which has wild calcareous structures connecting the avicularia to the base of the mother zooid. A unique feature of the specimens examined is the presence of dwarf like zooids, resembling the replica of the larger zooecium but without an operculum. There also fenestrae are present, relatively very large, compared to the central part of the zooecium. These dwarf zooecia which are conspicuous in number probably justifies the placement of this particular species under a separate species and probably a new genus.

Remarks: The colonies were found settled on brownish brick-like objects mostly of terrigenous origin, dredged from a depth of 30 m off Cuddallore. Looking into the morphology of bryozoan colonies, the presence of "dwarfs" without a functional zooid raises the question regarding the origin of this dwarf like structures and its functional significance. It is not known whether this is an ontogenic aberration of evolutionary significance. Pending examination of more colonies, the present material is assigned to *Cribrilaria*. The nearest relative of this species is *C. radiata*.

SUB-ORDER ASCOPHORA (Levinsen, 1909)

The frontal area is completely calcified, leaving the aperture. Compensation sac present which opens into the proximal side of the aperture or into the ascopore situated proximal to the aperture. Operculum compound in the case of forms where the compensation sac opens into the aperture, simple in the case of those where an ascopore is present.

Family Tryposteqidae Gordon, Tilbrook and Winston, 2005

Colonies encrusting. Zooids with evenly, minutely porous frontal shield. Orifice with distinct sinuses, the proximal rim with an incipient suture in some taxa, appearing to be derived from vestigial costae. Female zooids with ovicells, the orifice sometimes shaped differently than those of the autozooids. Dwarf zooids or zooeciules located between zooids and on distal ends of the ovicells. Vicarious avicularia present in some taxa.

Genus *Trypostega* Levinsen, 1909

Encrusting, thin walled zooecia with numerous frontal pores. Orifice laterally indented with a distinct sinus. Pore chamber not easily seen. Zooeciules probably representing avicularia at the distal end of many zooecia or ovicells occasionally found between zooecia. Avicularia rarely found interzooecially.

42. ***Trypostega venusta*** (Norman, 1864) **Plate 8: Fig. 30a & b**

Lepralia venusta Norman, 1864: 84.
Schizoporella venusta Smitt, 1873: 37; Hincks, 1880: 276; Kirkpatrick, 1890: 17; Waters, 1899: 440.
Gemellipora glabra form *striatula* Thornely, 1905: 118; 1907: 190.
Trypostega venusta Levinsen, 1909: 281; Waters, 1913: 506; Canu and Bassler, 1920: 330; 1923: 95; 1929: 248; Hastings, 1930: 720; 1932: 426; Marcus, 1938: 213; Osburn, 1952: 280; Harmer, 1957: 953; Winston, 1982: 151, 1984: 18, 1986: 30, 2005: 39.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z= 500μ; l_z= 330μ

Encrusting, quinquncial zooecia, arranged regularly. The shape of the zooecia could be hexagonal or rhomboidal or nearly flat. Longitudinal edentations at the zooecial margins separate them distinctly. Zooeciule, which are miniature zooecia present regularly, accompanying large zooecia. The front of both the zooeciule and the zooecia, highly porous and smooth. Zooecial orifice seems to be slightly elevated from the front. Irregular distribution of zooeciules noticed at the region of bifurcation. Ovicells when developing, bulbous, positioned distal to the orifice.

Remarks: This species enjoys a very wide distribution. The most conspicuous feature is the presence of zooeciules, which gives the appearance of hoods sitting on large zooecia. The secondary orifice is characteristically rounded distally and notched proximally, giving rise to a very clear-cut sinus. At least in a couple of cases among the material examined it was found that the zooeciules could be independent kenozooids.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Cosmopolitan species. Philippines (Canu and Bassler, 1929), Guersey (Norman, 1864), Ceylon (Thornely, 1905), Torres Strait (Kirkpatrick, 1890).

Family Adeonidae (Busk, 1884)

Foliaceous and bilaminar zooecia, rarely encrusting. Zooecia with thick frontal walls traversed by long pore tubes. Usually one or more avicularia present on the front.

Genus *Adeona* Lamouroux, 1812

Adeona Lamouroux, 1812: 188; Harmer, 1957: 789; Menon and Nair, 1967a: 2.

"Zoaria erect, often large, proximally consisting of a branched rootlet system, formed of linear series of stout, short, cylindrical, calcareous segments, connected by bundles of parallel chitinous tubes. Fronds bilaminar, foliaceous, in most species with numerous small fenestrae; or not fenestrate rarely composed of segments united by chitinous tubes. Median pore an ascopore. Operculum not sinuate, having the form of segment of a circle, the proximal margin straight or slightly curved, often wider than long" (Harmer, 1957).

43. ***Adeona foliacea*** Lamouroux, 1816 — **Plate 8: Fig. 31a & b**

Adeona foliacea Lamouroux, 1816: 482; Harmer, 1957: 790; Menon and Nair, 1967a: 2.

Occurrence: Two colonies were collected from dredge samples taken from off-Cochin at 100m depth in the west coast of India.

Salient features: L_z= 420μ; l_z= 280μ

The branch flattened with a median hollow space. Zooecia arranged in regular and more or less transverse rows. Marginal zooecia slightly larger than the central ones. Marginal pores present. Avicularia single, pointed, raised from the zooecial plane and directed distally or proximally. A median ascopore. Raised peristome with a slightly bent distal portion. Vicarious avicularia present.

Remarks: The paucity of material (only a fragment of a colony) made a correct understanding of the zoarial nature difficult. A comparison of this form with the description and figures of *Adeona foliacea* given by Harmer (1957) showed that the present form can be assigned to it. Harmer (*loc.cit.*) in his report has discussed in detail the nature of the zoarium and the zooecia, and has given an elaborate account of the variations noticed in this species. The marginal pores are arranged in a single row in the present material. The peristomes of the lateral zooecia are more raised than those of the median ones. The ascopore is always found to occupy a position proximal to the avicularia. The nature of the adventitious avicularia is very similar to that shown in Harmer's figure.

Records from Indian waters: Off-Cochin, west coast of India (Menon and Nair, 1967a).

Distribution: Australia (Lamouroux, 1816; 1821), Jedan, Aru Island (Harmer, 1957), Indian waters (Menon and Nair, 1967a).

Genus *Adeonellopsis* Mac Gillivray, 1886

Adeonellopsis Mac Gillivray, 1886: 134; Harmer, 1957: 797.

Foliaceous zoarium could be even encrusting. Simple ascopore, circular or multiporous. Large vicarious avicularia sometimes present. The important difference between *Adeona* and this genus is the ascopore, which opens independently and not into the peristome. This is not a common genus of the tropics and Harmer (1957) found the only two species from Indo-Australian Archipelago belonging to this genus.

44. *Adeonellopsis arculifera* (Canu and Bassler, 1929) **Plate. 9: Fig. 32**

Adeonella subsulcata Thornely, 1905: 125, 1907: 194.
Adeona arculifera Canu and Bassler, 1929: 377.
Adeonellopsis arculifera Harmer, 1957: 800.

Occurrence: Two colonies were collected from dredge samples taken from Cannanore in the west coast of India at 30m depth.

Salient features: L_z= 385µ; l_z= 210µ

The colony obtained was around 2 cm long, with zooecia arranged in a fashion so as to bifurcate at the tip of the colony. Distolaterally raised peristome. Flat, tubular except in the marginal zooecia when they are joining. The orifice sub-circular. The central part of the zooecia depressed, so as to give the appearance of lateral calcareous thickening in the form of U-shaped ridges. The lateral margin of this extends to become the secondary orifice. The area, which is not depressed on the lateral sides of the zooecia provided with pores. The septal lines present but not conspicuous. Suboral avicularium with distally directed rostrum, wide proximally and slanting towards the secondary orifice. Tip of the calcareous rostrum raised. No vicarious avicularia noticed. Ascopore circular slightly raised. Ovicells not noticed.

Remarks: Harmer (1957) felt that the younger colonies or the tip of the growing colonies give a correct picture of the nature of the zooecia. Characters such as the lateral pores, ascopore and even the immersed avicularia could get obliterated in older colonies. The ascopore of the younger zooids appears to be placed in calcareous thickenings, which merged with the proximal position of the avicularium in older zooids. The presence of a typical depressed, suboral avicularia and more or less uniserial lateral pores are the conspicuous feature, which allows the present placement of *A. arculifera* along with those recorded by Harmer (*loc.cit.*) from the Indo-Australian Archipelago. Harmer (*loc.cit.*) has explained in detail the variations that could be noticed within the species of the genera *Adeonella* and *Adeonellopsis* based on the work on these genera by authors like Smitt (1873), Thornely (1905, 1907) and Canu and Bassler (1928). This is a common species from Indian waters.

Records from Indian waters: Andaman Islands (Thornely, 1907).

Distribution: Ceylon (Thornely, 1905).

Family Lepraliellidae Vigneaux, 1949

Pleurilaminar zoarium often forms massive encrustations. Tubular zooecia mainly imperforate with few inconspicuous marginal or sub marginal pores. Non-sinuate orifice. Raised peristome. Unilateral sub-oral avicularium often produced into an ascending rostrum which may be a long spike. Frontal avicularia of various sizes, sometimes gigantic. Hyperstomial and imperforate ovicells.

Genus *Celleporaria* Lamouroux, 1821

Celleporaria Lamouroux, 1821: 43; Harmer, 1957: 663; Winston, 1984: 17; 1986: 12.

Characters same as that of the family.

45. ***Celleporaria pilaefera*** (Lamouroux, 1821) **Plate 9: Fig. 33**

Holoporella pilaefera Canu and Bassler, 1929: 422.
Celleporaria pilaefera Harmer, 1957: 679; Menon and Nair, 1967a: 2.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z=400µ; l_z= 300µ

Encrusting. Zooecia small. Front with small marginal pores. Semicircular orifice. No oral spines. Condyles wanting. Median sub-oral rostrum present often long, arises from an expanded base. Sub-oral avicularium not noticed. Large, spatulate vicarious avicularium present with a free raised distal end. Ovicells imperforate and tuberculated with complete frontal wall, pyriform openings facing proximally.

Remarks: Waters (1909) created the genus *Holoporella* to include species of *Cellepora* without sinus. Waters (*loc.cit.*) did not select a genotype for the genus. Canu and Bassler (1917) selected a genotype for Waters' *Holoporella, Cellepora discostilsii* Waters. Unfortunately this species was synonymised by Harmer under *Celleporaria labelligera* Harmer. By this step adopted by Harmer, the genotype became non-available for *Holoporella*. Harmer (1957) synonymised *Holoporella* under *Celleporaria*. Harmer's step is followed here. Even though this material approaches close to *Celleporaria pilaefera,* it does show certain variations from the description and figures of this species given by Harmer (1957). The important distinguishing characters of this species are the conspicuous marginal pores. In the present specimen, marginal pores are seen to be arranged in two rows. In the figure given by Harmer the number of pores shown are few. At certain instances the over development of the base, of the sub-oral rostrum has obscured the proximal regions of the orifice. This is in agreement with Harmer's observation. In the general zooecial characters *Celleporaria pilaefera* resembles *C. tridenticulata*, but the latter is provided with distinct proximal denticles, and lacks marginal pores. *Celleporaria labelligera* is yet another species, which shows similarity to the present species. In *C. labelligera,* Harmer did not notice frontal pores. But in this species the sub-oral rostra are represented by avicularia, which may often be wanting. Harmer remarks about *C. pilaefera* as follows: "this species may be recognized by its conspicuous frontal pores, its frequently massive rostra, its small tuberculated ovicells and its spatulate frontal avicularia".

Records from Indian waters: Mandapam, Gulf of Mannar (Menon and Nair, 1967a).

Distribution: Philippines (Canu and Bassler, 1928), Banda Sea, Timur Island (Harmer, 1957), Indian Ocean (Thornely, 1905), Ghardaqa, Red Sea (Harmer, 1957), Indian waters (Menon and Nair, 1967a).

46. ***Celleporaria granulosa*** Haswell (1880) **Plate 9: Fig. 34a & b**

Cellepora granulosa Haswell, 1880: 40.
Holoporella simplex Thornely, 1912: 155.
Celleporaria granulosa Harmer, 1957: 688; Menon and Nair, 1967a: 2.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken from various depths along the east coast and a few stations in west coast of India.

Salient features: L_z= 550μ; l_z= 380μ

Encrusting, zoarium multilaminar. Distinct calcareous lines present in between young zooecia. Marginal pores present. Orifice orbicular, surrounded by a calcareous border, which sub-orally bears a rounded avicularium placed on a large rounded thickening. The spike-like projection absent. Large, vicarious avicularium expanded distally with a columella rare. Operculum large and with slightly curved proximal border. No ovicells noticed.

Remarks: The form under consideration resembles the figures and descriptions of *Celleporaria granulosa* given by Harmer. Certain differences are, however, noticed. The zoarium here is encrusting, Harmer states that it can be erect. Haswell's materials from Queensland, kept at the British Museum (Natural History) and the Cambridge Museum contain zoaria with erect sub-cylindrical branches. Harmer found that the Torres Strait specimens kept in the B.M (N.H.) possessed numerous vicarious avicularia, but in the present specimen, the number of vicarious avicularia is much less. The vicarious avicularia in these specimens were expanded distally and the distal portions were raised from the zooecial surface. This was in agreement with Harmer's observation.

Records from Indian waters: Mandapam, Gulf of Mannar (Menon and Nair, 1967a).

Distribution: Queensland (Haswell, 1880), Torres Strait (Kirkpatrick, 1890), Mauritius (Thornely, 1912), Indian waters (Menon and Nair, 1967a). This species was not represented in the Siboga collections (Harmer, 1957).

47. *Celleporaria magnifica* Osburn, 1914 — Plate 9: Fig. 35a & b

Celleporaria magnifica Winston, 1986:13.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z= 425μ; l_z= 290μ

Zoaria encrusting, heavily calcified front, nearly raised towards the center giving the zooecium a more or less tubular appearance. The primary orifice flared, provided with a suboral avicularium in some cases. The base of the secondary orifice thickened and provided with mucro like enlargement, which occasionally possess a minute avicularia. The primary orifice is provided with condyles and a distinct sinus. The zooecia are separated by mild less calcified marginal ridges. A conspicuous feature of this species is large vicarious avicularium with a nearly raised, distally invaginated, bulbous rostrum, which is heavily calcified. A typical median ridge is present and the mandible should be flared at the tip so as to close the rostrum properly. Both avicularia and the zooecia are of same size and are separated by minute sparsely distributed marginal pores.

Remarks: *Celleporaria magnifica* is a native of Gulf of Mexico and therefore was not recorded by Harmer (1957) although he has described 13 species of this genus from the Indo-Australian Archipelago. A distinct feature of this genus is the presence of vicarious avicularia with distally flared calcareous rostrum and heavily chitinous flared mandibles. Some species do possess minute chitinous spines or calcareous elongated denticles. Condyles and lyrules are also present in some species. The present specimens were obtained from west coast of India at 70m depth. Relatively smaller zooecia grow in a very haphazard fashion and therefore result in highly variable size range. As in the case of other species, this one also has very fine granulated front provided with minute thickening, created by delicate calcium carbonate crystals. The fact that, this species has been collected from various stations in the Arabian Sea and the Bay of Bengal and that Harmer (*loc. cit.*) did not come across this species either from the Indian Ocean side or the Pacific side of the Indo-Australian Archipelago probably indicates that this species is present only in lower latitudes and not present in the highly coralline area as against majority of the species of this genus. Winston (1986) in her illustrated checklist of coral associated bryozoans has recorded this species from the Gulf of Mexico.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Gulf of Mexico (Winston, 1986).

Genus *Drepanophora* Harmer, 1957

Drepanophora Harmer, 1957: 1078.

Long and tubular peristomes, could be even short. Unilateral, suboral avicularium placed inside the peristome near the orifice. Prolonged peristome could be provided with denticles, invading the space inside the peristome. Other pairs of avicularia wanting. Lyrules and lateral sinuses and condyles wanting. Ovicell with a lateral membraneous area with pore on its sides. Harmer (1957), created this genus mainly to incorporate some collections made by Thornely from Srilanka and described as *Rhyncopora* (sic) *corrugata* and by Waters as *Rhynchozoon corrugatum*. Presence of well-developed peristome and absence of the avicularia other than the suboral ones was also a reason to create this genus.

48. ***Drepanophora incisor*** (Thornely), 1905 — **Plate 10: Fig. 36**

Rhyncopora (sic) *corrugata* Thornely, 1905: 118, 1907: 190, 1912: 149.
Drephonophora incisor Harmer, 1957: 1079; Winston 1986: 16.

Occurrence: Few colonies were collected attached to shells from dredge samples taken from 75-100m depth from Cape Comorin, Mangalore, Bhatkal, off Mumbai in the west and Vishakapatanam in the east coasts of India.

Salient features: L_z= 490-710μ; l_z= 405μ

Convex zooecia with a row of small marginal pores. The zooecia extend upwards in the form of a peristome and hence a major part of the front could be occupied by the peristome. The peristome provided with blunt denticulations in the proximal part, which Harmer (1957) described as tubercles. Secondary orifice circular or oval, without projections and relatively thick margin. The suboral avicularium placed with the peristome, minute in size. No other type of avicularia present. Ovicells placed abutting the peristome, slightly behind and provided with a membrane like structure with lateral pores one each. Ovicell is also provided with small tubercles, nearly merging with the succeeding zooecium.

Remarks: This species was collected by Thornely (1905) from Srilanka and the species was not present in the Siboga collections. Harmer (1957) has depended on Thornely's material to describe this species and even to create a new genus. The characteristic nature of the ovicell and the absence of adventitious avicularia other than the minor ones placed inside the peristome make the species distinct from the rest of the *Celleporaria* species. It is clear from the descriptions of the three species coming under this genus that the nature and size of the peristome could be a very important factor to distinguish this species. The lateral foramen in the ovicell looks to be a very distinctive feature of the species coming under this genus. May be more collections of the species will help in deciding the generic and specific distinction of this group of species which seems to come very close to those assigned to *Rhyncopora* and *Rhynchozoon*.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Ceylon (Thornely, 1905; 1907; 1912).

Family Smittinidae (Levinsen, 1909)

Front an olocyst, pleurocyst or tremocyst. Semicircular primary orifice, usually with cardelles and a lyrula. Oral spines common. Sub-oral or frontal avicularia present. Ovicells hyperstomial.

Genus *Parasmittina* (Osburn, 1952)

Parasmittina Osburn, 1952: 411; Lagaaij, 1963b: 197; Menon, 1972c: 73; Winston, 1982: 142; 1984: 21; 1986: 29; Winston and Heimberg, 1986: 21; Gordon, 1989a: 53; Soule *et al.*, 1995: 237; 2002: 6.

"Avicularia variously distributed on the frontal, but never median, suboral and bilaterally symmetrically, developed around the proximal border of the aperture; they take their origin from areolar pores on one side" (Osburn, 1952). Pleurocyst, with a row of areolar pores. Lyrula and cardelles usually well developed. Variously developed ovicells present. Since all species treated here possess a pleurocystal front and variously placed avicularia without a bilateral chamber, they are placed under *Parasmittina* Osburn (1952). Hence few species described by Harmer (1957) and others under *Smittina* are synonymised under *Parasmittina*. Harmer's work though completed in 1939, was published only in 1957. So naturally Osburn was not able to consult this work before completing his report on Pacific coast of Bryozoa published in 1950-1953. Osburn (1952) assigned species belonging to *Smittina*, with a pleurocystal front and variously placed avicularia without a bilateral chamber, under *Parasmittina* the new genus proposed by him.

49. ***Parasmittina aviculata*** (Mawatari), 1952 **Plate 24: Fig. 90**

Smittina aviculata Mawatari, 1952: 280.

Parasmittina aviculata Menon and Nair, 1967a: 2; Menon, 1972c: 76.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z=475μ; l_z= 275μ; L_a=285μ; l_a= 125μ.

Zoarium encrusting, distinctly whitish in hue. Zooecia arranged in longitudinal rows separated by thin calcareous lines. Front a highly tuberculated pleurocyst, with comparatively small and rounded areolar pores. Peristome with raised proximal and lateral regions. Lyrula broad, condyles slightly pointed. Large spatulate avicularia arranged lateral to the peristome directing proximally. Small lateral avicularia of two types, pointed and circular occupy the lateral sides of the peristome usually directed distally. Two inconspicuous spine bases noticed in young zooecia. Ovicells porous, elevated with an ectooecium occupying the rim.

Remarks: Mawatari (1952) created this species to include forms of *Smittina*, which possessed three types of avicularia. One of the conspicuous features of this species is the presence of the large spatulate avicularia. The nature of ovicell is also important. Even though Mawatari has not mentioned about the ectooecium, his diagrams distinctly show the presence of the ectooecium in the form of a rim. This species shows a very close resemblance to *Smittina protecta* (Thornely). A comparison with the figures and description of *S. protecta* given by Harmer shows that the only important difference to distinguish these two species, is in the presence of an extensive ectooecium rarely mucronated in *S. protecta*. Harmer has stated that the presence of giant avicularia is an important character and in fact the main character which distinguishes *S. protecta* from the other species of *Smittina*. The shape of the tips of the spatulate avicularia shows some difference in *Smittina protecta*. If the tip of the avicularium did not reach the peristome of the preceding zooecium it remains oval, if it touches the peristome, the tip becomes truncate or even concave. If the tip occupies the position in between two zooecia it would have a median acute end. This feature is not noticed in the form collected by Menon (1972c). *Smittina aviculata* shows some relationship to *Smittina parsevalii* and *Smittina egyptiaca*. But the nature of the spatulate avicularia is quite characteristic in the present instance and helps to distinguish this species from the above two.

Few points may be stated here about the generic level of this species. Osburn (1952) created *Parasmittina* to include species of *Smittinidae*, which possess a pleurocystal front and various types of avicularia, which are never median oral. From the figures given by Mawatari, it seems that the front is a pleurocyst with marginal areolae, but he has stated in the description that the front is a tremocyst. Three types of avicularia are present, which are never median oral. So this character also shows similarity towards

Parasmittina. In the present material, the front is a pleurocyst with distinct tuberculation, and small rounded marginal pores. A comparison of the type material with the present material may help to arrive at a definite conclusion regarding the generic status of this interesting species.

Records from Indian waters: Ponnani, Indian waters (Menon and Nair, 1967a; Menon, 1972c).

Distribution: Kei Peninsula, Japan (Mawatari, 1952), Indian waters (Menon and Nair, 1967a; Menon, 1972c).

50. ***Parasmittina egyptiaca*** (Waters, 1909) — **Plate 10: Fig. 37a & b**

Smittia egyptiaca Waters, 1909: 157; Hastings, 1927: 342.
Smittina egyptiaca Harmer, 1957: 937.
Parasmittina egyptiaca Menon and Nair, 1967a: 2; Menon, 1972c: 78.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken at various depths along the west coast of India.

Salient features: L_z= 475µ; l_z= 215µ
Encrusting. Zoaria may consist of zooecia, either separated by deep grooves arranged in longitudinal rows or arranged superposed. Pores small and areolae large. Front slightly convex and tuberculated. Secondary orifice with a narrow or broad sinus, demarcated by two cusps when narrow. Peristome moderate. Primary orifice broad distally, with two small rounded spaces proximo-laterally, created by two small proximally directed pointed cardelles and a median dentate lyrule. Lyrule may be large or moderately sized. Large spatulate parallel-sided avicularia, placed lateral to the orifice pointing proximally. Rostral tip somewhat broad. Avicularia of two types. Avicularia of the pointed type present. Ovicells globose, raised, ectooecium with regularly arranged small pores. Spines wanting.

Remarks: The form under consideration resembles *Smittina egyptiaca* of Waters (1909). Minor differences were however noticed. Harmer (1957) observed small condyles in his specimens and they were present in the present material as well. Even though, Waters (1909) has not noticed them in his type specimens, and therefore, not shown in his figures. Harmer (1957) commented "the condyles vary in size and may be very small". Here the condyles were rather small. Waters (1909) has stated that a small triangular avicularium is present directed proximally. The present form showed closer agreement with this character completely. Spines are not represented in this form.

Records from Indian waters: Quilon, west coast of India, (Menon and Nair, 1967a; Menon, 1972c).

Distribution: Sudanese Red Sea (Waters, 1909); Suez canal region (Hastings, 1927); Sulu Archipelago, Sumbawa, Banda Sea, New Guinea and Aru Island (Harmer, 1957); Indian waters (Menon and Nair, 1967a; Menon, 1972c).

51. ***Parasmittina hastingsae*** Soule and Soule, 1973 **Plate 10: Fig. 38a & b**

Parasmittina hastingsae Soule and Soule, 1973: 417; Winston and Heimberg, 1986: 26; Tilbrook *et al.*, 2001: 76.
Smittina tripinosa var. *spathulata* Hincks, 1884: 284.

Occurrence: Few colonies were collected attached to shell bits and corals from dredge samples taken from Bombay in the west coast of India.

Salient features: L_z= 555μ; l_z= 265μ
Encrusting colony, multilaminar. Zooecia polygonal could be irregular also. Convex front crenulated. Lateral sutures distinct, separates the zooecia. The marginal perforations at times, occupy a larger proportion of the front. Merging of the perforations creates the boundaries on the zooecia, which are not distinct as in many species of this genus. Typically rounded primary orifice, as wide as long. Small lyrula short. Straight edged thin condyles present. Spines not noticed. Secondary orifice with a shared margin. Peristome with well-developed flare produces lateral lappets, which are unique in this species. Avicularia present, lateral, oral, proximally directed sporadically. Rostrum triangular, acute. Gigantic avicularia rare. Ovicells not noticed.

Remarks: *P. hastingsae* is one of the species of the genus *Parasmittina,* which have very prominent marginal pores which should be considered as a distinct feature. The flared peristome is also a character demanding attention. Gigantic avicularia with flared distal portion is a feature found in other species of *Parasmittina*. Paucity of material limits any further remarks on this species.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Komodo, Indonesia (Winston and Heimberg, 1986); Victoria, Australia (Hincks, 1884); Efate (Tilbrook *et al.*, 2001).

52. ***Parasmittina parsevalii*** (Audouin, 1826) **Plate 10: Fig. 39a; Pl. 11: 39b**

Cellepora parsevalii (*Flustra*?) Audouin, 1826: 238.
Smittia trispinosa var. Hincks, 1884: 361.
Smittina obstructa Hastings, 1932: 431.
Smittina parsevalii, Harmer, 1957: 941.
Parasmittina parsevalii Menon, 1972c: 75; Winston and Heimberg, 1986: 24.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z=315 - 400μ; l_z= 300 - 325μ.

Zoarium encrusting, but may occasionally grow into free unilaminar fronds, distinct, whitish in hue. Zooecia arranged in longitudinal lines, separated by thin calcareous lines. Marginal areola conspicuous and large. Zooecia rectangular, but loses the typical shape when superposed. Front convex and in young, zooecia raised. Orifice circular, or slightly triangular proximally. Peristome tubular, moderately developed, smooth. Primary orifice could be seen through the peristome. Lyrules short and truncate, condyles small incurved. Avicularia numerous. Two types of small avicularia, one acute and the other rounded, distributed in almost every zooecium. They could be directing proximally or distally, and in rare cases, transversely. When transverse, usually occupy the lateral side of the peristome. Large spatulate avicularia present, rare, directed proximally or distally, mandible long and with spatulate or rounded tip. Ovicells globose, slightly immersed, ectooecium present at the rim. Peristome may invade the proximal rim. Ovicells porous, pores usually placed on small tubercles.

Remarks: This material agrees well with the figures and descriptions of *Smittina parsevalii* (Audouin) given by Harmer (1957). In the present material, the lateral oral avicularia, which assume a transverse position, invade the lateral side of the peristome, giving the latter a distinct cusped nature. In the absence of the lateral avicularium, the peristomial cusp is also found to be absent. Avicularia are raised slightly from the frontal plane. The number of the large spatulate avicularia was never numerous, as Harmer (1957) had noticed in few of his specimens. But spatulate avicularia were invariably present. The spatulate avicularia were not as much raised as the small avicularia were. Their rostral sides were nearly parallel, with a distinct distal expansion into a spatulate or rounded tip. The globose ovicells may become immersed in the older state. The ectooecium was represented as a thin rim and was never found to invade the porous front of the ovicell. In one instance the rostral tip of a small acute avicularium had been found invading the distal part of a preceding ovicell. From the description of this species given by Harmer (1957) it seems that the range of variations in this species is great and hence differences noticed in the present instance may come under the probable range of variations found in this species.

Records from Indian waters: Harmer (1957) has described this species from the material sent by Thornely from India and Ceylon in 1935 and kept in B.M. (N.H.). Off Cochin, west coast of India, (Menon, 1972c).

Distribution: Egypt (Audouin, 1826), Burma (Hincks, 1884), Sumbawa, Strait of Makassar, Paternoster Island, Sulu Archipelago, Saleyer, south of Celebes, south-east Celebes, West Flores, Banda Sea, Aru Island (Harmer, 1957), Great Barrier Reef (Hastings, 1932), Indian waters (Menon, 1972c).

53. ***Parasmittina signata*** (Waters, 1889) **Plate 11: Fig. 40a & b**

Smittia signata Waters, 1889: 17; Thornely, 1912: 151; Hastings, 1932: 429.
Smittina signata Harmer, 1957: 928.
Parasmittina signata Lagaaij, 1963b: 197; Menon and Nair, 1967a: 2; Menon, 1972c: 73; Winston and Håkansson, 1986: 29.

Occurrence: Several colonies were collected attached to gastropod shells and corals from dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z=360μ; l_z= 180μ.

Encrusting flat zooecia arranged in longitudinal rows. Pleurocyst provided with numerous tubercles, which give it a beaded appearance. Marginal areolae moderately sized. Thin tubular peristome. Spines wanting. A distinct sinus present in the sunk primary aperture. Lyrula absent. Moderately sized avicularia placed proximo-laterally to the orifice. The avicularia occasionally take a slanting position obliquely. Rostrum spatulate, mandible rounded distally. Perforated and slightly convex ovicells, with a narrow basal rim of ectooecium. Semi-circular operculum with a proximal tongue.

Remarks: This form resembles in all general characters the figures and description of *Smittina signata* of Harmer (1957), which however, is considered to belong to another genus *Parasmittina* Osburn 1952, by Lagaaij (1963b). A comparison of the figures given by Harmer (1957) and Lagaaij (1963b), shows that the proximal deep sinus present in Harmer's figure is absent in Lagaaij's figure. The sinus, the shape of which can be noticed by the nature of the secondary orifice is clearly represented in the present specimens. The present form does not possess zooecia with a pair of avicularia, contrary to what Harmer had observed in some of his specimens. Marginal areolae are not as big as shown in Harmer's figures. It is interesting to note that the present material shows resemblance to *Smittina elongata*, the only difference being in the nature of the avicularia, which in *S. elongata* is with "long acute mandible".

Records from Indian waters: Off Cochin, west coast of India, (Menon and Nair, 1967a; Menon, 1972c).

Distribution: *"Parasmittina signata* (Waters), originally described from port Jackson, New south Wales, has a wide distribution in the Indian Ocean and Western Pacific". (Lagaaij, 1963b).

54. ***Parasmittina spathulata*** (Smitt), 1873 **Plate 11: Fig. 41a & b**

Escharella jacontini var. *spathulata* Smitt, 1873: 60.
Smittina tripinosa var. *spathulata* Osburn, 1914: 208, 1940: 435.
Smittina tripinosa spathulata Canu and Bassler, 1928: 114.
Parasmittina spathulata Osburn, 1952: 415; Cheetham and Sandberg, 1964: 1038; Winston, 1982: 142; 1986: 22.

Occurrence: Few colonies were collected attached to shell bits and corals from dredge samples taken from Cape Comorin, Calicut and Cannanore at various depths in the west coast of India.

Salient features: L_z= 375μ; l_z= 225μ

Encrusting colonies multilaminar. Large zooecia with variable shapes. Distinct granular oral surface, with calcareous edentations. Marginal pores well developed, highly calcified. Two types of avicularia present. One type long, slender, proximally directed bilaterally, and placed at the lateroproximal portion of the secondary orifice. Gigantic avicularia also present and when present peristome flared at least on one side. The marginal pores of varying size. Ovicells embedded, highly porous and calcified when present, occupying a major portion of the distal zooecium. Lateral margins indistinct devoid of separating lines.

Remarks: The material under consideration is assigned to this species, since it resembles well with that described by Winston (1982). Conspicuous variation is the presence of gigantic avicularia, which is the enlarged version of the lateral avicularium commonly found in the colony. The granulated, flared nature of the lateral side of the peristome in zooecia possessing gigantic avicularia is distinctly erect and probably, the lateral smaller avicularia is sacrificed during development. Ovicells with numerous pores and crenulated surfaces on it, often results in invasion and merging the front of the succeeding zooid. In one zooid an avicularia was noticed placed close to the proximal margin, which is well in tune with bizarre avicularian distribution in the species of the genus.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Gulf of Mexico and Caribbean, Western Atlantic (Winston, 1986); Cape Hatteras, Brazil.

55. ***Parasmittina tubula*** (Kirkpatrick, 1888) **Plate 26: Fig. 100a & b**

Smittia tubula Kirkpatrick, 1888: 79; Thornely, 1905: 123.
Smittina tubula Harmer, 1957: 940.
Parasmittina tubula Menon and Nair, 1967a: 2; Menon, 1972c: 73.

Occurrence: Few colonies were collected attached to shell bits and corals from dredge samples taken from Cape Comorin, Quilon and Bombay at various depths from the west coast of India.

Salient features: L_z= 390µ; l_z=170µ
Zoarium encrusting. Small zooecia separated by vague calcareous lines. Marginal pores very small. Front coarse and highly tuberculated. A highly raised peristome, proximally with a sinus. Spines present, two to three in number on the distal region of the peristome. A broad lyrule present. Unilateral avicularia, with triangular or rounded tip directing proximally. Ovicell not noticed.

Remarks: This form while resembling the description of *Smittina tubula* (Kirkpatrick) given by Harmer (1957), shows certain differences in the distinct tubular nature and comparatively large size of the peristome, when compared with the size of the zooecia. Yet another difference is in the nature of direction of the avicularia, which in these specimens are directed proximally, as against the distally directed ones in *S. tubula* given by Harmer. Thornely (1905) found the colour of the colonies to be pink, whereas the present material was white. According to Thornely (1905), "there are usually two avicularia, one on either side of the tubular secondary orifice, pointing upwards", but direction and number of the avicularia seems to be not of much importance, when Harmer's observations on these structures are taken into consideration. The avicularia are placed lateral to the peristome and are raised from the surface. The occurrence of avicularia with rounded tips, lateral to the peristome, in certain zooecia of the present specimen is yet another feature of difference noticed from Thornely's specimens. However, Kirkpatrick observed small avicularia with rounded tips in his type material. In the presence of a broad lyrule, the present form resembles Kirkpatrick's forms, even though Harmer was unable to notice this structure in a subsequent examination of the type material. Spine number too shows variations in this species. According to Harmer, the spine number may be six or less and in the form observed by me, the number of spines was two or three. No ovicell was noticed in the present material.

Records from Indian waters: Gulf of Mannar (Thornely, 1905), Krusadi Island (Menon and Nair, 1967a; Menon, 1972c).

Distribution: Madagascar, Ceylon (Thornely, 1905; 1912); Mauritius (Kirkpatrick, 1888), Indian waters (Menon and Nair, 1967a; Menon, 1972c).

Genus *Smittina* Norman, 1903

Tremocystal front with numerous pores. Typically a sub-oral median avicularium. Lyrules well developed, varying in length and breadth. Hyperstomial ovicells, with numerous perforations very similar to that of the front. The suboral avicularium is normally embraced within the peristomial fold often placed quite proximally. The frontal pores are characteristic, could be large and sometimes infundibulate. Often-large frontal avicularia present apart from the typical suboral avicularium.

56. ***Smittina landsborovii*** (Johnston), 1847 **Plate11: Fig. 42a; Pl. 12: 42b**

Lepralia landsborovii Johnston, 1847: 310.
Smittia landsborovii Hincks, 1880: 341; Robertson, 1908: 305.
Smittina landsborovii Osburn, 1952: 400.

Occurrence: Two colonies were collected attached to shells from dredge samples taken from various depths from Cape Comorin and Off Bombay along the west coast of India.

Salient features: L_z= 525-590μ; l_z= 325μ; L_a= 280μ; l_a= 50μ.
Encrusting zoarium, thin and flat. Large zooecia arranged quinquncially. Slightly inflated frontal with numerous pores. The pores seem to be separated by distinct a calcareous thickening, which makes the front crenulated. Marginal pores could be typically enlarged and infundibulate. Rounded primary aperture with small cardelles and broad lyrule. Peristome high, thin, more exemplified distally. Small suboral avicularium typically rounded with circular mandibular portion. Often the suboral avicularium projects over the lyrule making the latter indistinct in the electron micrographs. Large spatulate frontal avicularium present, directed proximally. Numerous avicularia noticed which were conspicuously large. Hyperstomial ovicell present, projecting above the proximal end of the succeeding zooecia.

Remarks: Osburn (1952) opined that "how many other errors have been made in recording *S. landsborovii* from all parts of the world is impossible to judge (pg. 400). Figures of various authors like Osburn (1952) and Hincks (1880) have been examined and a morphological variation in the specific characters of this species is commonplace. Remarks of Osburn (*loc.cit.*) that this species is cosmopolitan probably supports the morphological variations noticed in the specific characteristics of specimens collected from various localities ranging from Alaska to Galapagos and various locations in the Arabian Sea. Curiously enough Harmer (1957) failed to collect this species from the Siboga stations. The present record extends the distribution of this species to the Indian waters.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Cosmopolitan.

57. ***Smittina torques*** Powell, 1967 **Plate 12: Fig. 43a & b**

Smittina torques Powell, 1967: 260; Stevens *et al.*, 1996: 332.

Occurrence: One colony was collected attached to shells from dredge samples taken from 100m depth from Goa in the west coast of India.

Salient features: L_z= 460µ; l_z= 275µ.

Encrusting zoaria, with zooecia arranged quinquncially in regular rows. Front typically porous. Distinctly elevated suborally, with conspicuous chitinous thickening, giving it a bulbous appearance. Tremocystal pores separated by elevated calcareous thickenings. Suboral avicularia small, characteristically placed jutting over the lyrules, which is often indistinct. The peristome elevated distally. Zooecial margins present evidenced by calcareous lines as in the other species of *Smittina,* the marginal pores can merge and assume the shape of large perforations. Ovicells not noticed.

Remarks: A small colony was examined with the ancestrula. The ancestrula structure showed rather distinct difference from the rest of the zooids in that, the tremocystal pores merged to assume a distinct perforated primary zooecium and the growth of the colony taking place in a typical radial fashion from the center. Typical examination of this particular young colony, gives the impression that this species grows in a very systematic order comparable to the primary anascans of the phylum Bryozoa. The presence of obliterated zooecial structures accompanying growth and aging of the colony probably occurs in this species also. It is noteworthy that Harmer (1957) did not record this species from the Indo-Australian Archipelago. Stevens *et al.* (1996) collected this species from New Zealand waters occurring as foulers on plastic debris.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: New Zealand (Powell, 1967; Stevens *et al.*, 1996).

58. ***Smittina acutodentata*** Harmer, 1957 **Plate 12: Fig. 44**

Smittina acutodentata Harmer, 1957: 921.

Occurrence: One colony was collected attached to coral from dredge samples taken from 100m depth from Vishakapatanam in the east coast of India.

Salient features: L_z= 500µ; l_z= 415µ.

Encrusting zoaria, found growing on shell pieces. White or pale yellow. Zooecia of moderate size, hexagonal and with distinct calcareous margins created by the merger of marginal pores. Peristome semicircular or slightly broad at the base. The peristomial flares distinct distally, the peristome and distal lips generally separated by an emargination. Condyles present and lyrules present. Typical adventitious avicularia, posteriorly directed, placed abutting the proximal margin of the peristome or slightly displaced towards the proximal end. The avicularian mandible characteristically tapers accommodated in a flared rostrum. The rostrum is calcified and is elevated from the areolar front. Ovicells present, hyperstomial.

Remarks: This species was created by Harmer (1957), who recorded this species from the Borneo bank, Strait of Makassar, which is the only record from the Siboga collections. Regarding the median position of the avicularium is an important character and there is a distinct separation between the proximal fold of the peristome and the avicularian base. Pointed mandible and elevated rostrum placed on an areolar front could be taken as an important specific character of this species. Harmer (*loc.cit.*) felt that the acute type avicularia are sometimes definitely triangular, the present material shows only triangular pointed avicularia.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Borneo bank, Strait of Makassar (Harmer, 1957).

Family ***Romancheinidae*** Jullien, 1888

Zooidal frontal wall with marginal pores only. Primary orifice typically with lyrula and condyles; enclosed by a well-developed peristome and with conspicuous oral spines. Avicularia present. Ovicells prominent and imperforate. Basal pore-chambers present.

Genus ***Escharoides*** Milne Edwards, 1836

Encrusting colony. The frontal wall with conspicuous marginal areolae. The proximal border of the orifice with denticles or a projection described as "spout-like" peristome (pg. 71 Gordon, 1984). Oral spines present, number variable. Avicularia paired, lateral to the orifice. Prominent ovicells with tatiform ancestrula.

59. ***Escharoides*** sp. — **Plate 12: Fig. 45a & b**

Occurrence: This species was collected attached to stones in dredge samples from 75m depth from Calicut in the west coast of India.

Salient features: L_z= 720µ; l_z= 565µ

Front a well-developed pleurocyst, provided with nearly two rows of areolae, which proceed to calcify towards the peristome but is prevented by the development of well-developed tubercles, which looks to be the termination of marginal calcification. The peristome has a clear-cut centrally placed spout-like projection, which is nearly lateral. Numerous oral spines present sometimes numbering to nine. Lateral avicularia present, distinctly away from the peristome-like projection but having the characteristic thimble-like projection found in this genus. The colonies contain non-fertile zooecia. Another characteristic feature was the presence of minute pores surrounding some of the lateral avicularia. The presence of distinct tubercles, which often ends in an open circular tip probably, gives the impression of spine bases. This is a very characteristic feature in which the present material differs from the species of this genus, the descriptions of which are available to the author. Pending examination of more literature and specimens, the present species is temporarily designed to this genus.

Family *Bitectiporidae* MacGillivray, 1895

Colony encrusting or erect. Zooids with a lepralioid ascus. Frontal shield evenly pseudoporous with marginal areolae, or the pseudopores few to absent. Zooidal orifice without a lyrula, with a narrow to broad sinus, condyles present or absent. Articulated oral spines present or absent. Adventitious and vicarious avicularia present or lacking. Ovicell with endooecium and ectooecium calcified but unfused, the ectooecium with several, relatively large pores.

Genus *Metroperiella* Canu and Bassler, 1917

Metroperiella Canu and Bassler, 1917: 40; Harmer, 1957: 1024.

Front porous with a median, sub oral avicularia. The orifice with a rounded wide sinus. Large globose, porous ovicells, hypostomial. The sinuate orifice distinguishes this genus from *Cadonellina*.

60. ***Metroperiella pyriformis*** Harmer, 1957 — **Plate 13: Fig. 46a & b**

Metroperiella pyriformis Harmer, 1957: 1025.

Occurrence: Few colonies were collected attached to shells and corals from dredge samples taken from 75-100m depth, from Cannanore and Mangalore in the west coast of India.

Salient features: L_z= 450µ; l_z= 320µ

Zoarium encrusting on shells. Rhomboid or elongate zooecium with highly porous front. Zooecia separated by clear-cut interzooecial edentations provided with calcareous sutural line. The secondary orifice placed on slightly elevated peristome, provided within sinus. Zooecial surface provided with finely granulated calcareous structure, interspersed with very minute pores. Electron micrograph gives evidences of layered thickening probably indicating age and growth. Hyperstomial ovicells with the opening nearly merging with the secondary orifice but remains separated. No avicularia noticed.

Remarks: This species was created by Harmer (1957), who recorded the only specimen collected from the collections of Australian museum. Harmer (*loc. cit.*) felt that the characters of the front and the nature of calcification, demands placement of this species as a new one, hitherto not recorded since Harmer's work. The type locality is Queensland and there is no reference of the depth at which these animals lived. The present specimens were obtained off Calicut from a depth of 60 m. This species has not been recorded in other collections examined during the present study. Considering the original locality of the animal this species may also be present in the Andaman Sea and Bay of Bengal, which would connect the present record to the species living in the Indo-Australian Archipelago.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Torres Strait (Harmer, 1957).

Genus *Schizomavella* (Canu and Bassler, 1917)

Schizomavella Canu and Bassler, 1917: 40; 1920: 353; Harmer, 1957: 1027.

Well-chitinised variably sinuate small opercula. Proximally directed sub-median avicularium. Porous ovicells.

61. *Schizomavella inclusa* (Thornely, 1905) — Plate 13: Fig. 47

Schizoporella triangula Thornely, 1905: 115.
Schizoporella avicularis Thornely, 1905: 116.
Schizomavella inclusa Harmer, 1957: 1028; Menon and Nair, 1967a: 2.

Occurrence: Few colonies were collected attached to shells and corals from dredge samples taken from 75-100m depth range from Mangalore in the west coast of India.

Salient features: $L_z= 365\mu$; $l_z= 250\mu$

Unilaminar zoarium encrusting. Zooecia arranged in longitudinal rows separated by thin calcareous lines. Slightly inflated front provided with uniformly distributed pores. Orifice rounded with a distinct sinus limited by two condyles. Avicularium present, placed over a calcareous thickening at a distance from the proximal border of the peristome. Avicularia slightly pointed directing proximally. Small mandibles semi-circular. Ovicells large, slightly immersed, porous. Operculum with a sub-marginal sclerite.

Remarks: This form while agreeing in essential features with the figures and descriptions of *Schizoporella avicularis* given by Thornely (1905) and *Schizomavella inclusa* given by Harmer (1957), does exhibit differences. No vicarious avicularium was noticed in the present material. This may perhaps be owing to the scarcity of the material. Harmer comments about this character "the most striking character of *Schizomavella inclusa* is the occurrence (rare) of large vicarious avicularia of a peculiar type". It is evident that Harmer has noticed that the vicarious avicularia are rare structures in this species. He could notice this structure only in Thornely's specimens kept at the Cambridge museum. The adventitious avicularia were suborally placed, which extend proximally from the lateral border of the peristome. The shape of the avicularium is very similar to that shown by Harmer.The ovicells in the present instance are only slightly immersed.

A scrutiny of the characters of the genera *Schizomavella* and *Codonellina* of the family *Schizoporellidae* has shown that these two genera are very closely allied. From the available literature, it seems that no clear cut character exists to distinguish these two genera from one another, and this aspect becomes more clear when we compare *Schizoporella inclusa* and *Codonella spatulata* Okada and Mawatari (1938).In *Codonella spatulata,* Okada and Mawatari (*loc.cit.*) noticed spatulate avicularia in certain zooecia, their specimen did not, however, possess vicarious avicularia, and this feature was not given importance from a generic point of view. Zooecia with small adventitious avicularia described and drawn by Okada and Mawatari (*loc.cit.*) looks very similar to the present specimens. A comparison of the type materials of these two species of the allied genera may reveal their correct identity.

Records from Indian waters: Off Ponnani, west coast of India (Menon and Nair, 1967a).

Distribution: Madagascar (Thornely, 1912); Ceylon (Thornely, 1905); South of Mindanao, Amboya and New Guinea (Harmer, 1957), Charadaqa (Crossland collections kept at B.M. (N.H.) recorded by Harmer (1957); Indian waters (Menon and Nair, 1967a).

Family *Watersiporidae* Vigneaux, 1949

Colony encrusting or erect, bilamellar. Zooidal frontal shield regularly and evenly perforated, with small areolae. Orifice with or without sinus, condyles present. No oral spines or avicularia. Ovicells absent, embryos brooded internally. Multiporous mural septula present. Ancestrula resembling later zooids.

Genus *Watersipora* Neviani (1895)

Watersipora Neviani, 1895: 231; Osburn, 1952: 471; Menon and Nair, 1971: 303; Ryland, 1974a: 345; Gordon, 1989a: 40; Gordon and Mawatari, 1992: 29.

Tremocyst with numerous pores. Endozooecial ovicells not evident outside. Rounded aperture, usually with a broad rounded sinus and very strong cardelles. Spines and avicularia absent.

62. *Watersipora subovoidea* (d' Orbigny, 1852) — Plate 13: Fig. 48

Lepralia cucullata Busk, 1854: 81.
Watersipora cucullata Jullien and Calvet, 1903: 23; Hastings, 1930:729; Marcus, 1937:118; Mawatari, 1952: 17
Lepralia cucullata Thornely, 1905: 120; 1907: 190; Waters, 1909: 150.
Watersipora subovoidea Ryland 1963: 68; 1974: 345; Menon and Nair 1967a: 2; 1971: 303; Winston and Heimberg, 1986:17; Gordon and Mawatari, 1992: 29.

Occurrence: Several colonies were collected attached to a fishing boat from a dry dock yard in Cochin in the west coast of India.

Salient features: L_z= 360μ; l_z= 250μ

Encrusting, brownish purple in colour. The size of the zooecia varies considerably. The front regularly rounded from side to side in young forms. As growth precedes this feature seems to be lost. Tremocyst smooth with large pores and the ectocyst white in colour with numerous pores. Large rounded primary aperture, broadly arcuate posture, which may even be semicircular. Condyles present, operculum, which is not conspicuously pigmented, clearly covers the aperture. The operculum bears small shining tubercle on each side proximal to the condyles. Peristome highly elevated, elevation greater in the case of mature zooecia possessing embryos. Umbo present.

Remarks: It is noteworthy that Harmer (1957, p.1022) has treated *Watersipora cucullata* (d'Orbigny), and changed the name to *Dakaria subovoidea* (d'Orbigny). Ryland (1965) remarks on this step of Harmer as follows: 'so far as I can ascertain, Harmer's placing of *Dakaria* is unacceptable. However, unfortunately perhaps, Harmer is correct regarding the validity of the specific name *subovoidea*; so, as I understand that, the correct name is *W. subovoidea* (d'Orbigny). Both Mawatari and Ryland agree regarding the conspicuous differences between specimens of this species collected from different localities. Mawatari (1963) remarks thus: "this world wide species may well be studied in the future and if any remarkable variation can be recognised geographically, it may be better to be divided into some sub-species." Pending such a study the present forms are tentatively referred to *Watersipora subovoidea.*

The colour of the colonies is distinctly brownish purple in live condition. But this colour fades away completely as the zooids dry up. Secondary calcification which usually coincides with maturity gives the zoaria a chalky white colour. Osburn (1952) has stated that the front was rounded from side to side; this feature was noticed only in young colonies, as growth proceeds the merging of the sides of different zooecia results in an eventual loss of the regular rounded nature of the sides. An umbo is present in almost all the zooecia proximal to the aperture. The condyles are not highly developed even though a pair of them invariably appears in all the peristomes. Here the orifice is always sub-terminal. Mawatari (1952) noted that the orifice can be terminal or sub-terminal. The cup-shaped inundation just above the condyles on the border of the aperture observed by Osburn was not noticed in the present material.

Records from Indian waters: Arabian Sea (Thornely, 1905); Indian Ocean (Thornely, 1907); Cochin harbour (Menon and Nair, 1967a; 1971).

Distribution: Mediterranean Sea (Hincks, 1886); Red Sea (Waters, 1909); Arabian Sea (Thornely, 1905); Indian Ocean (Thornely, 1907); China Sea (Mawatari, 1952); Pacific Ocean, Japan (Okada and Mawatari, 1935; 1937; 1938; Mawatari, 1952); Pacific Ocean Australia (Allen and Wood, 1950,); Galapagos Island (Osburn, 1952); Gulf of

California (Hastings, 1930); Brazil (Marcus, 1937): eastern Pacific of Mexico (Osburn, 1940) and South Africa (Busk, 1856); Indian waters (Menon and Nair, 1967a; 1971).

Family Schizoporellidae Jullien, 1903

Front a tremocyst. Proximal border of the primary aperture usually with a distinct and moderately deep sinus. Operculum well chitinised. Avicularia usually present. Ovicells hyperstomial.

Genus *Schizoporella* Hincks, (1887)

Schizoporella Hincks 1887: 150; Robertson 1908: 275; Osburn 1952: 317; Menon and Nair, 1970a: 238.

Frontal tremocyst, distally semi-circular aperture, with a slight vibracular arch, a rounded sinus at the proximal border of the aperture, well chitinised operculum, the muscle attachments at some distance from the border. Hyperstomial ovicells, not closed by operculum. Avicularia usually present at the side of the aperture.

63. ***Schizoporella cochinensis*** Menon and Nair, (1967) **Plate 26: Fig. 101a & b**

Schizoporella cochinensis Menon and Nair 1970a: 238.

Occurrence: Several colonies were collected attached to a fishing boat in a dry dock yard at Vypeen in the west coast of India.

Salient features: L_z= 395µ; l_z= 220-250µ

Zoaria encrusting. Colonies form nearly circular, regular patches of unilaminar or multilaminar encrustations. Zooecia arranged in longitudinal rows separated by distinct calcareous lines. Front a tremocyst with moderately sized tremopores. An umbo often present. Aperture rounded with a broad proximal sinus. Thin and smooth peristome. The operculum with a main marginal sclerite. Avicularia present placed lateral to the orifice usually inclined inwards. Mandibles triangular or with a rounded tip. Avicularia not present in many zooecia. Ovicells hyperstomial with large pores. Embryos light red in colour. Ancestrula with five very small spines.

Remarks: A tremocystal front, vestibular arch, the presence of sinus, lateral oral avicularia and hyperstomial ovicells suggest the position of the present form under

Schizoporella. From a review of the available literature, the species to which the present form resembles closely seems to be *Schizoporella unicornis* (Johnston). *Schizoporella unicornis* described by Osburn (1952) from the Pacific coast of America is different from *S. unicornis* (Johnston) described by Ryland (1965). In this work, Ryland has stated that the hyperstomial ovicells are non-porous, and the avicularia directing obliquely outwards are with tapering mandibles. The shape and disposition of the avicularia, and the possession of porous hyperstomial ovicells differentiate the present form from *S. unicornis* (Johnston) described by Ryland (1965). In this specimen, even though pointed avicularia were common, avicularia with rounded mandibles were also common. The colour of the ovicell is characteristic and colonies with fertile zooecia can be easily distinguished by the presence of light reddish spots.

Secondary calcification may obscure many of the zooecial characters and the zooecia may assume the shape of calcareous swellings with marginal pores. Umbonate processes are noticed even in young zooecia. In older colonies the ancestrula do not possess the spines, which evidently are lost as the colony attains age. Certain colonies did not possess avicularia at all. Secondary calcification starts from the centre of the colony towards the periphery and hence characters of marginal zooecia help to identify this species correctly.

Records from Indian waters: Cochin Harbour, south-west coast of India (Menon and Nair, 1970a).

Distribution: Indian waters (Menon and Nair, 1970a).

64. ***Schizoporella inarmata*** Hincks, (1884) **Plate 13: Fig. 49**

Schizoporella linearis form *inarmata* Hincks, 1884: 442.
Schizoporella linearis sub-sp. *inarmata* Robertson, 1908: 291.
Schizoporella linearis var. *inarmata* O'Donoghue and O'Donoghue, 1923: 143; Osburn, 1952: 319; Menon and Nair, 1967a: 2.
Schizoporella linearis inarmata Soule and Duff, 1957: 110.
Schizoporella inarmata Soule, 1961: 10; Soule *et al.*, 1995: 201.

Occurrence: Several colonies were collected attached to shell bits from dredge samples taken from various depths along the east coast and off Mumbai in west coast of India.

Salient features: L_z=460-525μ; l_z=375-700μ

Encrusting colonies thin with glistening zooecia. The size of the zooecia varies considerably ranging from 460μ to 525μ in length and 375μ to 700μ in breadth. Tremocyst with numerous small pores. The presence of small prominences in between the pores gives the tremocyst a granulated appearance. An umbo not present proximal to the aperture. The aperture typically rounded with an arcuate posture. Cardelles present. Ovicell hyperstomial and porous, slightly embedded in the succeeding zooecium. The porous front, bordered by areolar pores and the margins thickly calcified. Avicularia absent.

Remarks: Slight differences in structure are noticed in the present material from *Schizoporella linearis* var. *inarmata* described by Osburn (1952). The sinus of the forms described by Osburn is between 'U' and 'V' - shaped but here it is slightly arcuate. Strong condyles are evident in the present form. The size of the zooecium varies widely as in the specimens studied by both Robertson (1908) and Osburn (1952). Similarly the absence of umbo in the Indian material is also noteworthy. Soule (1961) and Soule *et al.* (1995) have synonymised *Schizoporella linearis* var. *inarmata* under *Schizoporella inarmata.* The present material is placed tentatively under *Schizoporella inarmata* in spite of the differences noticed above. An understanding and assessment of the range of variations within this genus and species may probably help us to classify this more accurately.

Records from Indian waters: Ernakulam and Mattancherry channels, Cochin harbour, south- west coast of India (Menon and Nair, 1967a).

Distribution: Queen Charlotte Island (Hincks, 1884); British Columbia (O'Donoghue and O'Donoghue, 1923; 1926); Santa Catalina Island (Robertson, 1908); west coast of Mexico, Gulf of California, Southern California (Osburn, 1952); Santa Barbara Channel (Soule *et al.*, 1995); Indian waters (Menon and Nair , 1967a).

Family Margarettidae Harmer (1957)

This family was introduced by Harmer (1957) to include *Tubucellaria,* a part of the family *Tubucellariadae,* which he assumed is synonymous to *Margaretta* described by Gray in 1843.

Genus *Margaretta* Gray, 1843

Margaretta Gray, 1843: 293; Harmer, 1957: 824; Winston, 1986: 21; Gordon, 1989a: 64.

Erect zoarium, branches consisting of cylindrical elongated internodes, separated by chitinous joints. Zooecia porous arranged in whorls of 2 to 6 in numbers. Tubular peristome with circular orifice. Peristome could be inflated proximally in fertile zooecia. Ovicells peristomial, avicularia wanting.

65. ***Margaretta watersi*** (Canu and Bassler), 1930 **Plate 13: 50a; Pl.14: 50b & c**

Tubucellaria watersi Canu and Bassler, 1930: 64.
Margaretta watersi Harmer, 1957: 838.

Occurrence: This species was collected from sand obtained in the dredge samples from 100m depth from Vishakapatanam in the east coast of India.

Salient features: L_z= 700μ; l_z= 440μ
The zooecial whorls typically 5 in number, sometimes 4. Internodes stout, straight or curved. Wide base consisting of 3 whorls of zooecia. Zooecia not definitely outlined. Peristomes short and nearly equal length proximally and distally. The orifice slightly denticulate. The point of nodal joints, the composition of the zoarium formed of 5 zooecia distinctly clear, which are separated by clear-cut intermediary walls. Ovicells not noticed.

Remarks: This species probably looks like a porous coral. Absence of clear-cut zooecial margins gives a contiguous external morphology. The proximal end of the internodes shows the foramen. The fact that the internodes are chitinous in nature makes the colony very brittle. The low peristomes and more or less straight position of the orifice distinguishes this species from *Margaretta levinsenii*. Absence of fertile zooecia makes the description of peristome difficult, which normally become ridged and slightly bulbous. The inflated proximal portion of the fertile zooecial peristome is likely to have several circlets of large pores. This particular record seems to be the only one record from the Indian waters although Gardiner has collected this species from the Indian Ocean and the bearings of the station are not known.

Record from Indian waters: This is the first record of this species from Indian waters.

Distribution: The Sulu Archipelago, Kei Island, Indian Ocean, as given by Gardiner (Harmer, 1957).

Family Hippopodinidae (Levinsen, 1909)

Front a thick olocyst or pleurocyst. Usually imperforate but for the marginal areolar pores. Hyperstomial ovicells. Marginally or at some distance within the margin a strong sclerite. Strong cardelles. Avicularia usually present.

Genus *Hippopodina*, Levinsen (1909)

Hippopodina Levinsen, 1909: 353; Canu and Bassler, 1920: 532; Osburn, 1952: 292; Harmer, 1957: 973; Soule, 1961: 7; Menon and Nair, 1967a: 2; 1974a: 113.

Encrusting zoarium. Large, flat and quadrate zooecia arranged in longitudinal rows, bounded by shallow marginal grooves. Front porous. Large orifice, generally longer than wide, parallel sides or indented by the condyles, straight or slightly curved proximal margin limits a wide and shallow sinus. Avicularia acute directing transversely inwards, placed on the distal side of the orifice, tips meeting if paired, occasionally directed proximally or even wanting. Spines absent. Ovicells hyperstomial, large with numerous small pores.

66. ***Hippopodina californica*** Osburn (1952) **Plate 14: Fig. 51**

Hippopodina californica Osburn, 1952: 293; Menon and Nair, 1967a: 2; 1974a: 114.

Occurrence: Few colonies were collected attached to shells from dredge samples taken from 50m depth from Bhatkal in the west coast of India.

Salient features: L_z= 380µ; l_z= 260µ

Zoarium encrusting. Distinct zooecia arranged in longitudinal rows. Arched front a tremocyst. The distal end of the preceding zooecium overarches the proximal end of the succeeding one. Rounded aperture with a shallow sinus. Distinct condyles present. Peristome prominent with flaring lateral borders. Operculum with a main marginal sclerite. Acute, small, avicularia present, occupy the interior of the peristome, lateral in position. No ovicells noticed.

Remarks: The presence of avicularia makes the assignment of the present form under *Hippopodina californica* tentative as this is one of the important differences noticed in the present instance is the occurrence of avicularia. Avicularia are disposed inside the peristome. It is not clear whether the presence of avicularia will justify the creation of a new species. A study of the common species of *Hippopodina* viz. *H. feegeensis,* which does possess avicularia, shows that this structure may be absent in a number of zooecia of the same colony. So it is possible that the presence or absence of avicularia is not of much importance in *H. californica* also. Osburn's figure shows that, an umbonate process may be found in the zooecium. In the present material, the avicularian chamber does give the appearance of a small regular umbonate appearance. The curved sclerite of the operculum, which Osburn noticed in his material, are, however, wanting in the present one. Osburn discovered this species from Southern California and other Hancock stations.

Records from Indian waters: Off Quilon, Indian waters (Menon and Nair, 1967a; 1974a).

Distribution: "The known distribution is from the northern channel Islands off Southern California to San Pedro, Nolasco Island in the Gulf of California" (Osburn, 1952); Indian waters (Menon and Nair, 1967; 1974).

Family Cryptosulidae Vigneaux, 1949

Colony encrusting. Zooids with uniformly but coarsely perforated frontal shield. Orifice large, bell-shaped. No oral spines. Suboral avicularium may be present. Ovicells absent, embryo brooded internally. Multiporous septula present.

Genus *Cryptosula* Canu and Bassler, 1925

Characters same as that of the family.

67. ***Cryptosula pallasiana*** (Moll, 1803) **Plate. 14: Fig. 52**

Eschara pallasiana Moll, 1803: 57.
Cryptosula pallasiana Marcus, 1942: 58; Osburn, 1952: 47; Winston, 1982: 139; Gordon and Mawatari, 1992: 29; Soule *et al.*, 1995:175.

Occurrence: Several colonies were collected attached to shell bits from dredge samples taken from various depths along the east coast and off Calicut at a depth of 50 m in the west coast of India.

Salient features: L_z= 480µ; l_z = 245µ

Few specimens were obtained which resemble the species *Cryptosula pallasiana,* a very common species in higher latitudes and known to enjoy a bipolar distribution. The present specimen contains zooecia with highly porous frontal. A few of the pores looks as if they are provided with fragmented membranous coverings, resembling very much the cryptocystal extension. The proximal region of the peristome-like opening is devoid of pores but is provided with ornamented calcareous edentations. The lateral sides of the orifice are equipped with distinct cavity-like edentations. The peristome in this region is elevated from the front. The zooecia separated by distinct calcareous lines. Avicularia were not noticed and ovicells were absent.

Remarks: The specimen under consideration is tentatively placed in the genus *Cryptosula.* Notwithstanding the similarities of the species assigned to this genus, the present specimens do show some characteristic differences. The presence of distinct minute depression on the front in between the numerous large frontal pores and increased number of such edentations nearer to the peristome have distinguished this form from *C. pallasiana* which looks to be the nearest member of *Cryptosula* from a structural stand point of similiarity. The type locality of this species in the Mediterranean Sea is unknown.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Cosmopolitan.

Family Actisecidae Harmer, 1957

This family was introduced to include the monotypical genus *Actisecos* of Canu and Bassler (1927). The occurrence of hexagonal arrangement of peristomes in *Actisecos regularis* has been taken as the most important character to create this family by Harmer (1957) and he thought the related families like *Chaperiidae, Mamilloporidae, Conescharellinidae*, etc. according to Canu and Bassler (1927) are not interrelated. The genus *Actisecos*, belonging to this family is characterized by the absence of avicularia and they possess long peristomes.

Genus *Actisecos* Canu and Bassler, 1927

Actisecos Canu and Bassler, 1927: 11; Harmer, 1957: 855; Gordon and d'Hondt, 1997: 37.

Selenariiform zoarium, unilaminar, attached by wide delicate rootlets. The zoarium is more or less concave basally. Zooecia thin walled, alternating. The front with small pores produced into a long cylindrical imperforate peristome. Median pores and avicularia wanting. Ovicells globose, porous often opening to the peristome. Operculum thin with out a basal sclerite.

68. *Actisecos regularis* Canu and Bassler, 1927 **Plate 14: Fig. 53a & b**

Actisecos regularis Canu and Bassler, 1927: 11; Harmer, 1957: 856, Gordon and d'Hondt, 1997: 37.

Occurrence: This species was collected from sand in the dredge samples at 100m depth from Vishakapatanam in the east coast of India.

Salient features: L_z= 440μ; l_z= 360μ

Zooecia arranged in regular circlets. The front essentially consists of an elevated peristome. The zooecia are separated by very thin and delicate calcareous thickening. The frontal pores are relatively large and have thin calcareous linings. Calcification seems to be occurring by the addition of thin layers of calcium, superimposing the delicate porous front of the young zooecia. Frontal pores abruptly stop at the base of the peristome. The peristome considerably large, distinctly elevated and provided with finely arranged minute tubercles. The secondary orifice more or less regularly rounded but in one specimen flared laterally. Avicularia are absent. Ovicells not noticed.

Remarks: This species was originally recorded from Philippines; New Caledonia and Java. Subsequently Cook (1966) included this species from among the sand fauna collected from the eastern Africa and northern Indian Ocean. This indicates a very wide distribution of this species latitudinally. The present material was collected from 18°00'N and 84 °00'E, the upper half of the Bay of Bengal. The sandy nature of the bottom seems to be the preferred environment for this species. Harmer (1957) is of the opinion that, the colonies do not grow big and may contain only 18-24 zooecia. This according to him is because of the peculiar nature of attachment of this species in the sandy substratum.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Gulf of Oman (Harmer, 1957); Eastern Africa and northern Indian Ocean (Cook, 1966); Philippines, Java, Indonesia (Gordon and d'Hondt, 1997).

Family Hippaliosinidae Winston, 2005

Colonies encrusting. Zooid with frontal wall imperforate except for a row (or rows) of marginal areolae. Orifice horseshoe shaped distally and proximally with triangular condyles. Orifices of fertile zooids larger and wide than those of autozooids. Adventitious avicularia single or paired, adjacent to orifice. Ovicell endozooidal.

Genus *Hippaliosina* Canu,1918

Hippaliosina Canu, 1918: 88; Canu and Bassler, 1923: 165; Bassler, 1935: 36.

Orifice and opercula typically elongate, with wide sinus; others presumably fertile, larger and of a different shape. The sinus in both kinds limited by minute pointed condyles. Zooecia with a series of marginal pores, continued distally around the orifices. Avicularia oral and lateral, often bilateral; the rostrum without a calcareous bar. Mandibles sometimes setiform or vibraculoid.

69. ***Hippaliosina acutirostris*** Canu and Bassler, (1929) **Plate 15: Fig. 54a & b**

Lepralia depressa Robertson, 1921: 56.
Hippaliosina acutirostris Canu and Bassler, 1929: 391; Harmer, 1957: 1091.

Occurrence: Several colonies were collected attached to shell bits in dredge samples taken from 50 -100m depth from Chennai in the east and Mumbai in west coast of India.

Salient features: L_z= 600μ; l_z= 415μ
Zooecia quadrate, quinquncial, commonly in longitudinal rows. The orifices forming regular oblique series; the surface covered by uniform pearly tubercles. Marginal pores small, uniserial. Orifices slightly raised, generally with a low thin peristome, laterally and distally. The ordinary ones longer than wide, the sinus sub-triangular, limited by minute

condyles. Other orifices, presumably those of fertile zooecia are larger, as wide as long. The sinus wide and shallow. Avicularia mostly paired, on nearly every zooecium, converging on the distal side of the orifice. The mandibles mostly narrow, setiform.

Remarks: Harmer (1957) arranged the specimens into two groups based on the nature of mandibles. In a few specimens, the rostrum of the large avicularia was long and narrow, ending in a pair of upstanding lobes. These were correlated with the form of the trifid mandible, the lateral extensions of which closed on the proximal side of the lateral lobes of the rostrum; the median branch between them. The form of the mandible was noticed by Thornely (1905), Robertson (1921) and Canu and Bassler (1929). In the Siboga specimens, the avicularium of the other side was wanting on zooecia with trifid mandibles; but in those from Ceylon, a smaller avicularium with a shortly vibraculoid mandible was associated with it. The rostrum of the enlarged avicularia of the second group had no terminal lobes. The mandible was vibraculoid, its apex decurved and simply acute. The orifices were generally smaller in this group. Avicularia occurred on practically all the zooecia, in both groups; and they were paired in the great majority. In a few specimens, a large avicularium directed obliquely across the distal part of the orifice, had a long, narrow trifid mandible.

Records from Indian waters: Bay of Bengal, Indian waters (Robertson, 1921; Thornely, 1905).

Distribution: Ceylon, Madras (Thornely, 1905); Bay of Bengal, east coast of India (Robertson, 1921), Philippine Islands (Canu and Bassler, 1929), Borneo bank, Strait of Makassar, Halmaheira, northern end of New Guinea (Harmer, 1957).

Family Microporellidae (Hincks, 1879)

Characterised by the presence of a median ascopore, which varies in form and position, placed proximal to the aperture. Proximal border of the aperture nearly straight, operculum simple without extensions proximal to the cardelles. Avicularia present. Peristome with spine.

Genus *Microporella* (Hincks, 1877)

Semicircular aperture straight proximally. No tremopores between the semilunar or rounded ascopore which occupy a position close to the aperture.

70. ***Microporella orientalis*** Harmer, (1957) **Plate 15: Fig. 55a, b & c**

Microporella orientalis Harmer, 1957: 962; Menon and Nair, 1967a: 2; Gordon, 1984: 103.

Occurrence: Several colonies were collected attached to gastropod shells and corals in dredge samples taken from various depths along the east and west coasts of India.

Salient features: L_z= 500 - 520μ; l_z= 390μ

Encrusting colonies glistening white, spreading over substratum in unilaminar fashion. Zooecia arranged in longitudinal rows, uniformity in growth being lost at places of overcrowding, owing to lack of space. Tremocyst with very minute tremopores. Zooecia separated by grooves. Orifice semicircular with straight proximal border. Short spines present, the number varying from four to six. The places from where spines are dislodged, marked by rounded spots. The secondary orifice of the present specimen is highly calcified and the proximal border calcification, has taken place by the deposition of calcium in a wavy crenulated fashion. The secondary orifice also overlaps the zooecial opening. Ovicells hyperstomial. In fertile zooecia, peristome personate. Operculum not chitinised its main sclerite marginal and proximal border with few denticles. Ascopore reniform with minute teeth. Avicularia single, always placed proximo-laterally to the ascopore. Triangular avicularian mandible long with tip slightly elongated, forming a setiform process. Mandibles with a pair of hooks. Rostrum with a complete bar.

Remarks: This material was collected from the EEZ of India from the east and the west. The electron micrograph of the specimens show at least a few distinct features not noticed by Menon and Nair (1967a) or Harmer (1957). The porous front is interspersed with calcareous deposition giving the impression that the pores are placed at the center of 4-6 such tubercles. The ascopore is provided with a distinct serrated tongue distally, invading into the cavity giving the pore the shape of a highly bent saucer. It is a matter of fact, that the ascopore dips into the front with sides projecting as calcareous rims, similarly the distolaterally directed avicularia has a rostrum, which is characteristically flared at the tip. The avicularia as such fits as a calcareous protuberance on the front. The structure of the rostrum probably gives the impression that the mandible has a filamentous tip, which would fit into the distal portion of the rostrum. The present material is identical to the ones examined by Harmer (1957) who created *M. orientalis,* a native of the Indo-Australian archipelago.

Records from Indian waters: Off-Cochin, west coast of India, (Menon and Nair, 1967a).

Distribution: W. Flores, Sulu Archipelago, Halmaheira, Aru Island (Harmer, 1957), Indian waters (Menon and Nair, 1967a); Victoria, Queens land, Loyalty Islands, Indonesia, Philippines (Gordon, 1984).

Genus *Microporelloides* Soule, Channey and Morris, 2003

This genus was created by Soule, Channey and Morris (2003) to include all *Microporella* species previously and newly described from temperate and tropical north eastern coastal waters of the Pacific Ocean, the Gulf of California and the Hawaiian Islands. This virtually covers the whole of the lower and median latitudes irrespective of the oceans. *Microporella* genus conceived and described by Harmer (1957) includes species from the Indo-Australian Archipelago, part of the tropical Indian Ocean mainly the tropical belt, which directly forces one to include them also. Therefore, this taxonomical group was created by Soule *et al.* (*loc. cit.*) based mainly on geographical distribution. Notwithstanding this, the characteristic of the ovicell was cited as an important distinguishing feature of the species coming under *Microporelloides,* as against those from the Arctic, Atlantic and the Mediterranean. Since *Microporelloides* is a valid genus as compiled by Gordon (2006), one species of *Microporella* described are treated under *Microporelloides.*

71. ***Microporelloides hawaiiensis*** Soule *et al.*, 2003 — **Plate 15: Fig. 56**

Microporelloides hawaiiensis Soule, Channey and Morris, 2003: 30.

Occurrence: Several colonies were collected attached to gastropod shells and corals in dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z= 500 - 520μ; l_z= 390 - 460μ

Encrusting colony multilaminar with abortive frontal zooecia. Hexagonal zooids could be ovate. Aperture semicircular with a straight proximal border without a sinus. The proximal portion of the aperture is highly denticulate. Spines were not noticed but their bases could be discerned by the presence of enlarged pores in the lateral sides of the front or the ovicell. Granulated front with numerous pores. The region between the ascopore and the proximal border of the orifice without pores are marginally elevated. The zooids separated by calcareous lines and the lateral sides can have enlarged pores. The ascopore typically microporelline in character. Avicularia laterally placed, distal portion of the rostrum elevated and the lateral sides flanked. The abortive zooids appear to be a very distinct feature of this species. Ovicells present bulbous, porous.

Remarks: This species was created by Soule and others to include those collected from Hawaii. The authors found that this species has a very wide bathymetric distribution ranging from 80-100 m and the colonies were found attached to shells and corals. Discussing the presence of abortive zooids with various shaped apertures, the authors commented that, this could be because of unstable substrata. This is not a logical explanation for the presence of abortive buds. This should be certainly due to ontogenetic aberrations resulted from variations in either ecological conditions of the habitat or genetically induced variations. Certain variations described by authors between *M. ciliata* and the present are not very convincing. The Indian species was sporadically distributed along the east and west coast of India with bathymetric distribution from 30-100m depth. The temperature varied between 27°C to 18°C showing clear-cut stenothermal behaviour.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Hawaiian Islands (Soule *et al.,* 2003).

Genus *Fenestrulina* Jullien, 1888

This genus differs from *Microporella* by the stellate character of the tremopores, by the more proximal position of the ascopore, so that there are one or two rows of the tremopores between it and the aperture and also by the absence of avicularia.

72. ***Fenestrulina malusii*** (Audouin, 1826) — **Plate 26: Fig. 102a & b**

Cellepora malusii Audouin, 1826: 239.
Microporella malusii Hincks, 1883: 444; Robertson, 1908: 282.
Fenestrulina malusii Canu and Bassler, 1923: 115; Mawatari, 1952: 279; Osburn, 1952: 387; Harmer, 1957: 966; Soule, 1961: 28; Menon and Nair, 1967a: 2.

Occurrence: Several colonies were collected attached to shells from dredge samples taken from various depths from Cochin in the west and Cuddallore and Vishakapatanam in the east coasts of India.

Salient features: $L_z = 520\mu$; $l_z = 310\mu$

Encrusting zoarium, forms white and flat encrustations over the shell. Zooecia separated by deep grooves, arranged alternately in longitudinal rows. Raised front a tremocyst with stellate tremopores, which are large and distributed in a uniform manner. Aperture semicircular with a straight proximal border. Peristome slightly raised. Reniform ascopore with small teeth placed proximal to the aperture and always surrounded by raised walls. Usually two rows of tremopores occupy the space between the ascopore and the aperture. Ovicells hyperstomial, with moderately sized marginal pores separated by calcareous ridges. Ectooecium represented in the form of a calcareous bar placed at the base of the ovicell. Avicularia and spines absent.

Remarks: This material approaches closely to the description of *Fenestrulina malusii* (Audouin) given by Harmer (1957), the only difference noticed being the absence of oral spines. The most characteristic feature of having marginal pores on the ovicells is clearly noticeable. The calcified ectooecium which is represented in the form of a calcareous ridge at the base of the ovicells noticed in the present form is a common feature of the genus *Microporella* Hincks. This character together with the rest support Harmer's statement that "the two genera must be regarded as closely allied". The stellate nature of the tremopores in the present form can be noticed only in those zooecia where the epitheca has been destroyed. In the rest, the tremopores are found as white dots.

Regarding the arrangement of the frontal pores, Harmer (1957) stated that "the frontal pores are very variable; in the simpler condition is uniserial sub-oral and marginal rows, with almost all transitional condition leading to a uniformly perforate frontal surface". From the figures it is evident that these specimens belong to the stage where the whole front is uniformly perforated. This species being a cosmopolitan one, Ryland during a personal communication with Menon (1967) remarked that a good deal of variations can be expected, even though he added "but I have never heard of a form without oral spines". Despite this feature the present form is treated just as an ecotypical variant of F. malusii.

Records from Indian waters: Quilon, west coast of India, (Menon and Nair, 1967a).

Distribution: Cosmopolitan except polar waters (Harmer, 1957), Indian waters (Menon and Nair, 1967a).

Genus *Calloporina* Neviani, 1875

Species belonging to this genus have some of the features of *Microporelloides* such as ascopore, oral spines and acute avicularia. Harmer (1957) felt that the distinct feature of ovicell by itself is sufficient to give those species possibly allied to Microporelloides a different generic status. Hence the ovicells has a crescentic area on the distal and lateral parts, with series of pores and the proximal part was imperforate.

73. ***Calloporina sigillata*** Canu and Bassler, 1929 **Plate 16: Fig. 57a & b**

Calloporina sigillata Canu and Bassler, 1929: 333; Harmer, 1957: 973.

Occurrence: One colony was collected attached to a coral in dredge samples taken from 65m depth from Cannanore in the west coast of India.

Salient features: L_z= 815μ; l_z= 480μ

Zoaria encrusting, zooecia around 20-25% larger than *C.sculpta*. The groove separating the zooids deeper and calcification takes place from the valleys towards the center of the front in such a fashion that the elevated thickenings due to calcification merge on the center. Frontal tubercles large and when arranged around the ascopore, they form a circle of distinct thickenings. Orifice more or less rounded with 8 -10 spine bases. Ascopore slightly elongated laterally. Avicularia could be bilateral also. Ovicells present with a sculptured front.

Remarks: This species was collected at a depth of 65 m from Cannanore. Compares well with the material collected by Harmer from Philippines. The basic differences noticed were in the length of the avicularia. As found by Harmer (1957), the zooecial margins are deep valleys. Circularly arranged tubercles around the ascopore were absent in the present specimen. Since figures of Harmer (*loc.cit.*) are hand drawings, a further comparison of structure is not possible.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Indo-Australian Archipelago (Harmer, 1957), Philippines (Canu and Bassler, 1929).

74. ***Calloporina sculpta*** Canu and Bassler, 1929 **Plate 16: Fig. 58a & b**

Calloporina sculpta Canu and Bassler, 1929: 334; Harmer, 1957: 972.
Microporella decorata Thornely, 1905: 113.

Occurrence: Two colonies were collected attached to corals from dredge samples taken off Mumbai in the west coast of India at 94m depth.

Salient features: L_z=675μ; l_z= 460μ
Encrusting, flat zooecia with distinct frontal pores, which are marginally placed. The secondary orifice elevated with eight to ten spine bases. The lateral spine bases are elevated porous tubercles. Vicarious avicularia normally two in number laterally placed flanking the elevated orifice. The rostrum spatulate with distinct calcareous rim. Ovicell peculiar in character with numerous radial pores and a semicircular flat calcareous flank giving them a typical ridged character. There is a characteristic thickening on the ovicells abutting the distal portion of the elevated secondary orifice. These two features are so characteristic of this species.

Remarks: Only few colonies were obtained from a station located off Mumbai from a depth of 90 m. The frontal pores and the avicularia although very distinctly placed on the front, could be displaced probably depending on the nature of the substratum, on which the colony had encrusted. In at least a few specimens the frontal pores were seen to wander towards the nonporous central portion of the front. By virtue of the peculiar nature and structure of the ovicells, this species stands apart from so many other species of ascophorans placed under various related genera. Merging of the avicularian base with the distal portion of the ovicell has also been noticed in some specimens.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Indo-Australian Archipelago (Harmer, 1957), Ceylon (Thornely, 1905), Philippines (Canu and Bassler, 1929).

Family Petraliellidae Harmer, 1957

Orifices constricted by lateral projections, their inner margins forming wide sinuses, which become the external denticles of the lower lip. This consists medianly of a vestigial lyrula with a minute sinus on each side of it or a plate with several sinuses and denticles. Avicularia large, acute, mostly lateral oral, the mandible sometimes with a median sclerite. Ovicells perforated with minute pores. Suboral avicularium and mucro wanting.

Genus *Sinupetraliella* Stach, 1936

Sinupetraliella Stach, 1936: 378; Harmer, 1957: 705.

Encrusting zoaria, lateral denticles or condyles present. The suboral avicularium nearly median, its palate facing a large lateral sinus on one side of the orifice.

75. ***Sinupetraliella affinis*** Harmer, 1957 — **Plate 16: Fig. 59a & b**

Sinupetraliella affinis Harmer, 1957: 708.

Occurrence: Two bits of colonies were collected from dredge samples taken at 100m depth from Vishakapatanam in the east coast of India.

Salient features: L_z= 800µ; l_z= 630µ

Elongated zooecia, slightly convex. The frontal pores small. Septal lines indistinct, well-developed frontal lobes, which are lateral, meet at the distal end from the orifice. The peristomes slightly raised proximally. The secondary orifice with a large sinuous, median sinus at times with a minute suboral avicularium. Mucro or lyrule wanting. The lateral oral avicularia rounded and sometimes short, oval, small avicularia but not uniformly distributed. The front porous, the pores separated by distinct chitinous thickenings. Ovicells not noticed.

Remarks: This species, which was described from Sulu Archipelago by Harmer in 1957, could be a younger version of *S. gigantea*. Harmer (1957) felt that the differences are distinct, especially with reference to dimensions and total absence of lyrule. The presence of suboral avicularium also seems to be distinct for this species. Increased chitinous thickening of the front gives nearly a secondary layer over the primary wall in this species. The absence of smaller avicularia in all the old zooecia possibly makes this distinct from *S. gigantea*. One of the zooids was noticed to have a relatively large lateral, oval avicularia, directed medianly. This species has not hitherto been recorded from the Indian waters. The present collections came from 100 m depth Vishakapatanam in the Bay of Bengal.

Record from Indian waters: This is the first record of this species from Indian waters.

Distribution: Sulu Archipelago (Harmer, 1957)

Genus *Hippopetraliella* Stach, 1936

Hippopetraliella Stach, 1936: 369; Harmer, 1957: 700; Tilbrook and Cook, 2005: 329.

Orifice constricted at or near the middle by lateral projections, each over hanging a condyle for the articulation of the operculum. Proximal portion of the operculum straight or slightly curved. Lateral oral avicularia one or two, small and oval. The front porous, frontal avicularia present in some species.

76. *Hippopetraliella magna* (D'Orbginy, 1852) **Plate 17: Fig. 60a & b**

Semieschara magna Orbigny, 1852: 367.
Lepralia gigas Kirkpatrick, 1888: 78; Thornely, 1905: 120; 1916: 163.
Petralia japonica Marcus, 1923: 440; Canu and Bassler, 1929: 254; Okada, 1934: 12.
Hippopetraliella magna Harmer, 1957: 701; Cook and Bock, 2002: 1611.
Petralia magna Tilbrook and Cook, 2005: 329.

Occurrence: Two bits of colony were collected from sand in the dredge samples taken from Mangalore at 97m depth from the west coast of India.

Salient features: L_z= 1150µ; l_z= 900µ: L_{op}= 340µ; l_{op}= 415µ
This species is a native of the Indian Ocean. Large zoarium, commonly tubular and hemescharan. Large zooecia arranged longitudinally, separated by distinct marginal thickenings. Flat front reticulate and punctate. Large orifice with distinctly anteriolateral convolutions. Usually widest proximally, condyles present but not visible frontally. No lyrules. The proximal thickened border of the orifice provided with minute denticles and slightly elevated medianly. The front porous, the marginal pores always and size of pores reduces towards centre. The central portion of the front where the pores are small, elevated tubercles can be distinguished, which are more prolific towards the distal portion of the orifice. The lateral oral avicularia typically rounded usually single and placed on the left side of the orifice, a median bar present. Large ovicells immersed, porous, heavily calcified.

Remarks: This particularly large species of bryozoan was never recorded from the west coast of India. The colonies occurred at relatively greater depths and have always been remarked as one of the largest ascophorans encountered in the Indian Ocean. Large size along with heavy calcification and tubular nature of the zoarium probably makes this colony coralline in appearance. The unilateral avicularia is typically rounded in structure, which is a distinct feature of the family Petraliellidae.

Records from Indian waters: India (Thornely, 1916).

Distribution: Japan (Okada, 1934), Mauritius (Kirkpatrick, 1888), Ceylon (Thornely, 1905), Torres Straits, China Sea (Harmer, 1957).

Genus *Mucropetraliella* Stach, 1936

Mucropetraliella Stach, 1936: 363; Harmer, 1957: 709; Tilbrook and Cook, 2005: 331.

Lyrules and lateral denticles often present. Suboral avicularium associated with a mucro is an important character of the genus. Harmer (1957) felt that the generic characters are so variable and hence a universally acceptable definition for the genus is difficult. The bilaterally symmetrical lyrule and sinuses separated from the lateral denticles and suboral avicularia associated with micro are important characters.

77. ***Mucropetraliella thenardii*** (Audouin, 1826) **Plate 17: Fig. 61**

Flustra thenardii Audouin, 1826: 240.
Mucronella thenardii Thornely, 1905: 124.
Petralia laccadivensis Robertson, 1921: 56.
Petralia thenardii Canu and Bassler, 1929: 9.
Mucropetraliella thenardii Harmer, 1957: 714.

Occurrence: Two small colonies were collected from dredge samples taken at 70m depth from Goa in the west and Kakinada in the east coasts of India.

Salient features: L_z= 765µ; l_z= 470µ
Encrusting zoaria. Zooecia long, convex with inconspicuous septal lines. Two spine bases noticed. Orifice circular, wider than long. Narrow lyrules. The most conspicuous feature is the presence of variously shaped mucro with branches. Two lateral avicularia, oral in position, placed at the top of raised platforms. A spatulate suboral avicularia noticed in one zooecium. The mandible placed on the raised rostrum, which forms a part of the mucro. No ovicells noticed. The avicularia are very small and in some cases looks like bases of oral spines.

Remarks: Commenting on the shape and character and nature of variations of this species, Harmer (1957) has remarked that this species is a "Protean" species (pg. 715). No ovicells were noticed in the present case and when present, Harmer has found them to be very small. The common feature of this species looks to be the variation and character of mucro, which assumes sometimes even branched structure. Absence of interzooecial margin in a conspicuous manner gives the colony an appearance of merger of zooecia. The tremopores are very conspicuous and practically occupies the whole front but for the elevated peristome like anterior portion.

Records from Indian waters: Laccadives Islands and Madras (Robertson, 1921); Indian waters (Thornely, 1916).

Distribution: Recorded from Egypt (Audouin, 1826); Port Jackson (Waters, 1887); Ceylon (Thornely, 1905), Strait of Makassar, Celebes Sea (Harmer, 1957)

78. ***Mucropetraliella philippinensis*** (Canu and Bassler, 1929) **Plate 17: Fig. 62**

Petraliella philippinensis Canu and Bassler, 1929: 261.
Mucropetraliella philippinensis Harmer, 1957: 710; Menon and Nair, 1967a: 2.

Occurrence: Two small colonies were collected from dredge samples taken at 100m depth from Quilon in the west coast and Vishakapatanam in the east coast of India.

Salient features: L_z= 510µ; l_z= 380µ

Colony hemescharan. Large and flat zooecia with inconspicuous septal lines. Front with small pores. Distal walls of the peristome thin. Orifices wider than long. Lyrula short and wide with pointed lateral corners. Denticles present, pointed. Sinuses not closed. Majority of avicularia small and rounded. Large lateral avicularia usually present placed slightly away from the lateral sides of the orifice. Sub-oral and lateral frontal avicularia large. Mandibles of small avicularia with denticles. A well developed mucro present often branched and overarches the secondary orifice. No ovicells noticed.

Remarks: This material closely approaches *Mucropetraliella philippinensis* described by Harmer (1957). However, some differences have also been noticed, such as the nature of the lateral avicularia occupying one side of the front, the position of the lateral oral -

avicularia and the nature of the mucro. The lateral frontal avicularia are not spatulate but elongated oval and the sides of the rostrum considerably raised so as to form a low calcareous wall springing from the front. The mucro is found to be rather large and in certain zooecia assume large size. Hence the sub-oral avicularium could be noticed only by removing the mucro. The nature of the lyrule and the lateral denticles are very similar to that given by Harmer in his text. The paucity of material in the present case makes an assessment of the variations occurring in the species impossible.

Records from Indian waters: Gulf of Mannar, India (Menon, 1967).

Distribution: Philippines (Canu and Bassler, 1929); Paternosta Island and Talaut Island (Harmer, 1957).

Family Crepidacanthidae Levinsen, 1909

Encrusting zoarium. Zooecial aperture with strong cardelles; operculum well chitinised. Pore chambers and septulae sometimes alternative. Avicularia long, setose or pediform usually paired at the sides of the aperture; long oral spines usually present and sometimes marginal spines also. The ooecium is hyperstomial and recumbent.

Genus *Crepidacantha* Levinsen, 1909

Encrusting zoarium. Front with marginal pores and peripheral spines. Orifice trifoliate; avicularia small paired, bilateral adjacent to the orifice. Ovicells hyperstomial with frontal pores. Small basal pore chambers present.

79. ***Crepidacantha crinispina*** (Canu and Bassler, 1929) **Plate 17: Fig. 63**

Lepralia setigera Mac Gillivray, 1883: 133.
Lepralia poissonii Thornely, 1907: 190.
Crepidacantha grandis Canu and Bassler, 1929: 411.
Crepidacantha crinispina Canu and Bassler, 1929: 409; Harmer, 1957: 982;
Gordon, 1984: 100; Stevens *et al.*, 1996: 334.

Occurrence: Several colonies were collected attached to shells and corals from dredge samples taken from Kavali in the east coast at a depth of 150m and Cape Comorin, Cannanore, Calicut, Goa and Mumbai at 100–150 m depth in the west coast of India.

Salient features: L_z= 510μ; l_z= 375μ

Encrusting zooecia. The front finely grained with marginal pores, which are fenestra-like. The marginal pores connected with thickened calcareous ridges making the zooid look typically elevated. Marginal spines present on minute bases placed on calcareous ridges. Orifice distinctly trifoliate. The distal portion typically rounded with a calcareous collar. The peristome slightly raised distally. Avicularia placed lateral to the orifice always in pair. Calcareous thickening on the proximal portion of the secondary orifice elevated from the front. Ovicells present, hyperstomial. The ovicells are separated from the succeeding zooids by small fenestrae.

Remarks: The shape of the secondary orifice and the absence of fine grain-like calcareous particles distally give the appearance of a hooded structure to the zooecium, which is raised and having a bulbous appearance. Regarding the size of the zooecia, Gordon (1984) felt that there could be variations but the morphological characters remain constant. The spines and the presence of a suboral "pustule" (Harmer, 1957) are distinct characters. Harmer's thought sufficiently justifies the creation of a species and hence he treated this different from *C. poissonii*. Majority of the material that Harmer (*loc. cit.*) examined were from Mauritius, Philippines and the Andaman's. The present record from both the east and west coasts of India extends the distribution of this species to higher latitudes. Bathymetry remains unchanged.

Records from Indian waters: Madras, east coast of India (Thornely, 1907).

Distribution: Madras, Indian waters (Thornely, 1907); Philippine islands (Canu and Bassler, 1929); Sulu Archipelago, Halmaheira, Aru Island (Harmer, 1957); Three Kings Island, Leigh, Auckland, Totaranui, Cook Strait, Victoria, New Caledonia, Thailand, Indonesia, Philippines (Gordon, 1984).

Family Cleidochasmatidae Cheetham and Sandberg, 1964

Colony encrusting or erect. Zooecia generally with marginal pores. Key hole-shaped elongated orifice. Relatively large sinus, minute condyles generally present. Avicularia present. Globular tuberculated ovicells and sometimes porous, not closed by the operculum.

Genus *Cleidochasma* (Harmer, 1957)

Cleidochasma Harmer, 1957: 1058; Menon, 1974c: 109; Gordon 1984: 124; Winston, 1986: 33.

Key-hole shaped elongated orifice. Relatively large sinus, minute condyles generally present. Zooecia generally with marginal pores. Globular ovicells tuberculated and sometimes porous, not closed by the operculum. Avicularia often two in number, acute or of two kinds.

80. ***Cleidochasma biavicularium*** (Canu and Bassler, 1929) **Plate 17: Fig. 64**

Gemellipora biavicularia Canu and Bassler, 1929: 310.
Cleidochasma biavicularium Harmer, 1957: 1047; Menon and Nair, 1967a: 2; Menon 1974c: 110.

Charcodoma biavicularium Gordon and d' Hondt 1997: 51.

Occurrence: Several colonies were collected attached to gastropod shells and corals in dredge samples taken from various depths along the east and west coasts of India.

Salient features: L_z= 450µ; l_z= 310µ
Zoarium erect, branching and escharan. Zooecia with regularly tuberculated convex front, arranged in longitudinal rows alternately. Zooecia separated by deep grooves. Marginal pores present. Key-hole shaped orifice with slightly narrow sinus. Peristome very low and smooth. Operculum with strong marginal sclerite. Avicularia often paired, placed on swollen projections one of which occupies the lateral sub-oral position and the other one lateral distal or parallel to the orifice. Lateral avicularium with slightly rounded rostrum and with triangular mandible, the sub-oral one with slightly pointed rostrum and long setiform mandible projecting beyond the tip of the rostrum. In both the avicularia, the calcareous bar complete. Globose perforated ovicells, with small tubercles, placed above the operculum. No rootlets noticed.

Remarks: This form agrees fairly well with the figures and description of *Cleidochasma biavicularium* (Canu and Bassler) given by Harmer (1957). Few differences are, however, noticed. The present collection contains several encrusting colonies. The position of the lateral avicularium in the present material is a little above the position of the same shown by Harmer. The marginal pores are comparatively larger here. Single row of pores was observed on either side of the swollen portion of the sub-oral avicularium. This is not shown in Harmer's figure.

Records from Indian waters: Off Cochin, south west coast of India (Menon, 1967, 1974c; Menon and Nair, 1967a).

Distribution: Strait of Makassar (Harmer, 1957); Philippines (Canu and Bassler, 1929); Indian waters (Menon, 1967, 1974c; Menon and Nair, 1967a).

81. ***Cleidochasma fallax*** (Canu and Bassler, 1929) **Plate 18: Fig. 65**

Hippoporina fallax Canu and Bassler, 1929: 320.
Cleidochasma fallax Harmer, 1957: 1043; Menon and Nair, 1967a: 2; Menon, 1974c:110.

Occurrence: Several colonies were collected attached to shell bits and corals in dredge samples taken from various depths along the west coast of India.

Salient features: L_z= 430μ; l_z= 400μ

Encrusting colony, unilaminar. Zooecia tubular distinctly outlined. Front slightly tuberculated with small widely separated marginal pores. Orifice more or less cleithirate with a distinct sinus. Peristome thin. Operculum strongly chitinised with a distinct marginal sclerite. Avicularia lateral oral, may be single or paired directing disto-laterally. Mandible rounded distally. Transversely directed spatulate avicularia placed proximally.

Remarks: The present form approaches closely to *Cleidochasma fallax* described by Harmer (1957). The differences noticed were in the presence of a spatulate avicularium and in the nature of the avicularian mandible. The avicularian mandibles were rounded in the present material whereas Harmer, found them to be acute in his specimens. The occurrence of spatulate avicularia is interesting. Spatulate avicularia were occasionally noticed in some species assigned to this genus. A study of the species based on Harmer's description and figures reveals that the characters such as the marginal pores and lateral avicularia show variations. In the case of *Cleidochasma protrusum* avicularia with spatulate rostra are present with pointed mandibles. In the present form, the mandible is lacking and only few spatulate avicularia has been noticed in the colony. It is, however, not clear whether the presence of this solitary spatulate avicularium in the specimen should be given some importance and considered as a variety of *C. fallax*.

With reference to the nature of the lateral avicularium, Harmer (1957) remarks that this species is characterized by the presence of a unilateral frontal avicularium, directed inwards and more or less proximally. This may frequently be accompanied by a smaller lateral oral avicularium and either of these may be wanting. From these observations, it is evident that the presence, number and position of avicularia show variations in this species. The present specimen shows some resemblance to *C. bassleri* in the position of the avicularia and the nature of the front, but differs clearly in the nature of the operculum, which is simple here.

Records from Indian waters: Off Quilon, south west coast of India, (Menon, 1967; 1974c; Menon and Nair, 1967a).

Distribution: Philippine Island (Canu and Bassler, 1929); Timor and New Guinea (Harmer, 1957); Indian waters (Menon, 1967; 1974c; Menon and Nair, 1967a).

82. ***Cleidochasma protrusum*** (Thornely), 1905 **Plate 18: Fig. 66**

Gemellipora protrusa Thornely, 1905: 119; Waters, 1913: 506.
Cleidochasma protrusum Harmer, 1957: 1040.

Occurrence: Several colonies were collected attached to bivalve shells in the dredge samples taken from various depths along the east and west coasts of India.

Salient features: L_z= 430μ; l_z= 400μ

Encrusting zoarium could become free, spherical, when the zooecia are arranged in concentric layers. Zooecia convex and the surface with calcareous tubercles. Marginal pores present and individual zooecia elevated. Low peristome laterally with short obtuse crust. The sinus typically rounded proximally. The proximal portion of the sinus also slightly elevated and lack calcareous tubercles. Single avicularium present with obtuse rostrum characteristically raised and placed lateral to the secondary orifice. They could be suboral or lateral-oral is disposition. Two damaged ovicells noticed hyperstomial in position. .

Remarks: The only detailed description available of this species is that of Harmer (1957), although Thornely (1905) has created this species and failed to give a detailed description. The colonies examined by Harmer (*loc. cit.*) were spherical with concentric layers of zooids. The present collections had simple encrusting colonies and relatively older spherical ones. The sinuses of the orifices could at times be pointed also as shown by Harmer from a figure of Thornely. The character of the frontal avicularia looks to be uniform. Their position and direction are unchanged. The present records are from numerous stations distributed along the east and west coasts of India.

Record from Indian waters: This is the first record of this species from Indian waters.

Distribution: Ceylon (Thornely, 1905, 1907); East Africa (Waters, 1913); Sulu Archipelago (Harmer, 1957).

83. ***Cleidochasma sampada*** sp. ***novo*** **Plate 18: Fig. 67a & b**

Materials:

Holotype-Two colonies collected from off Trivandrum from a depth of 60 m during FORV Sagar Sampada expedition to study the benthos from the EEZ of India in October 1999. (FORV Sagar Sampada Cruise No. 177). The material will be deposited in CMLRE, MOD, Kochi,

Paratype - From the same locality of the holotype.

Salient features: L_z= 385μ; l_z= 240μ

The zooecia small with an average length of 385μ and width of 240μ. Quinquncially arranged zooecia, separated by clear-cut calcareous margins. The front of the zooecia slightly elevated from these margins and is provided with minute marginal pores. More or less smooth front ornamented with minute spinous projections. A very well-developed lateral flare forming incomplete peristome-like structure nearly overhangs the primary orifice. These elevations become pointed distally mainly in fertile zooecia. Ovicells hyperstomial, porous and provided with two lateral and a median avicularian fenestra. The ovicells open into the distal portion of the primary orifice. Two distinct spines placed distolateral to the orifice. Highly ornamented hyperstomial ovicells. Two type of avicularia, present. The former placed at the base of the secondary orifice on distinct calcareous mounts. The second type of avicularia noticed in one zooecia placed lateral to the orifice directed distally with pointed rostrum.

Remarks: Examination of numerous species of *Ascophora* from the Indian Ocean has convinced me that the material available for study belonging to species hitherto not described from the Indian Ocean. From the structure of the ovicells it becomes clear that the ovicells are calcified from the lateral sides and the calcification meets at the center leaving a proximally directed central fenestrae resembling avicularia. They also harbour two lateral openings and may be assumed that these are covered with ectooecium. The marginal pores are relatively large and in majority of cases they are invariable placed on the distolateral margin of the zooecia. Examination of literature available curiously draws attention to the species *Echinovadoma anceps* described by Tilbrook *et al.*, (2001) from the Vanuatu Islands. The author remarked that "the combined characters of the frontal shield and ovicell produce inclusion of *Echinovadoma* in any known cheilostomate family". The authors have erected a family to include this genus with *E. anceps* as the genotype. This creation is open to question for, hooded ovicell is a very common feature in a few genera of ascophora, especially *Cleidochasma* and *Lepraliella* etc. The authors have said that both avicularia and spines absent in this species. It is not known whether the authors had enough quantities of specimen for examination. It is felt that the creation of a new family to include this species was to some extend outrageous. Pending examination of those materials, no further comments are offered.

Record from Indian waters: This is the first record of this species from Indian waters.

Distribution: Arabian Sea, Indian Ocean.

Family Celleporidae (Canu and Bassler, 1917)

Zoarium erect or encrusting. Vase shaped zooecia. Inflated front a tremocyst. Ovicell small, globular, peristomial, placed about half way down the distal side of the peristome. "The ovicell is recumbent; its orifice is very large and closed by a special operculum". Canu and Bassler (1917).

Genus *Lagenicella* Cheetham and Sandberg, (1964)

Lagenicella Cheetham and Sandberg, 1964: 1041; Soule *et al.,* 1995: 259; Gordon, 1984: 80.

Zoarium erect or encrusting. Vase shaped zooecia. Inflated front a tremocyst. Sub-orbicular orifice may be unmodified or with a broad shallow poorly defined sinus. Secondary orifice sub-orbicular to elliptical, unmodified or having irregular spiniform projections. Small avicularia adventitious and paired placed on the lateral margins of the secondary orifice. Ovicell small, globular, peristomial, placed about half way down the distal side of the peristome. Surface of the ovicell finely perforated.

84. ***Lagenicella marginata*** Canu and Bassler, 1930 **Pl.18: Fig. 68a, b; Pl. 19: 68c**

Lagenicella marginata Canu and Bassler, 1930: 36; Osburn, 1952: 489.

Occurrence: Two uniserial colonies were collected attached to corals in dredge samples taken at 100m depth from Trivandrum, Calicut and Kochi in the west coast of India.

Salient features: L_z= 840 - 940μ; l_z= 260μ

Zoarium uniserial, encrusting on other bryozoans or corals. The zooecia are lageniform, inflated and with tremopores, which are found at the tip of minute calcareous elevations when not marginally placed. High peristome looks to be logical extension of the adnate proximal broad part of the autozooid. The peristome is smooth and at times flares, the flare often crenulated wing-like. Laterobasally, peristome habours two avicularia, which are very small in size. The primary orifice oval. No ovicells noticed.

Remarks: The uniserial zoaria could often contain elongated attached tubular portion without the formation of zooid. This probably indicates a temporary cessation of zooecial growth due to unknown reasons. When the colony has normal growth the zooecia maintains comparable meristic characters.

Record from Indian waters: This is the first record of this species from Indian waters.

Distribution: Gulf of California, Galapagos Island (Osburn, 1952).

85. ***Lagenicella punctulata*** (Gabb and Horn, 1862) **Plate 19: Fig. 69a & b**

Entalophora punctulata Gabb and Horn, 1862: 171.
Lagenipora spinulosa Hincks, 1884: 57; Robertson, 1908: 283.
Lagenipora punctulata Osburn, 1952: 485.
Lagenicella punctulata Menon and Nair, 1967a: 2; Soule *et al.,* 1995: 259

Occurrence: Two colonies were collected in dredge samples taken at 100m depth from Vishakapatanam in the east and Cochin in the west coasts of India.

Salient features: L_z= 840 -1040μ; l_z= 280μ

Zoarium with a small encrusting base, erect and with irregular branches. Zooecia lageniform slightly bent peristome. Front a tremocyst with large tremopores. A pair of minute avicularia occupies the rim of the peristome, latero-medianly. Position of the avicularia demarcated by two pointed calcareous prolongations, placed on the outer face of the avicularia. No ovicells noticed.

Remarks: Cheetham and Sandberg (1964) had created a new genus *Lagenicella*, with *Lagenipora marginata* Canu and Bassler as the genotype. In that paper, the authors had considered *Entalophora punctulata,* Gabb and Horn under the newly proposed genus. A general resemblance shown by the form under consideration to the description and figures of *Lagenipora punctulata* given by Osburn (1952), explains the present placing. Only a fragment of a colony was obtained and hence no detailed comparison was possible with the descriptions and figures of this species given by previous authors. The dimensions of the zooecia, which Osburn thinks to be of some importance, are more or less equal in the present specimen to those observed by Osburn in his material; even though the width of the zooecium is less here in the present specimen. The peristomes are long while one is short. Osburn (1952) states "The peristomial tubes vary in length, occasionally as long as the zooecial body but usually much shorter". The costae of the peristomes are clear and may be even absent. Tubular peristome has ridge-like calcareous thickenings, which proceeds to the main body of the autozooid also. The frontal pores are placed in-between such calcareous thickening, giving the whole autozooid a calcareous lattice structure. In this respect probably the specimens differ from those examined by Menon, 1967.

Records from Indian waters: Off Alleppey; west coast of India (Menon and Nair, 1967a).

Distribution: British Columbia, Monterey Bay, California (Hincks, 1884; Robertson, 1908); Northern California to Lower California, Gulf of California, Galapagos Island (Osburn, 1952); Indian waters (Menon and Nair, 1967a).

Family Phidoloporidae Gabb and Horn, 1862

Colony generally erect, reticulate, forming a lacy network with zooids opening on one side of the branches and with extrazooidal calcification on the basal side; colony attachment by thickened extrazooidal calcification at proximal portion. Zooid frontal with marginal pores only, surface smooth or pustulose. Zooid orifice with a sinuate or orbicular orifice; primary orifice often obscured by thickening frontal calcification. A tubular pseudospiramen may develop on the proximal side of the peristome by coalescence of the marginal processes. Many genera have a denticulate distal margin to the orifice. Ovicells hyperstomial; prominent initially, becoming immersed in secondary calcification. Avicularia generally present, of varied types in different groups; mainly adventitious, with interzooidal avicularia in a few species.

Genus *Rhynchozoon* Hincks, 1895

Rhynchozoon Hincks, 1895: 5; Harmer, 1957: 1062; Osburn, 1952: 454; Menon, 1974a: 115; Menon and Nair, 1967a: 2; Gordon, 1989a:74; Soule *et al.*, 1995: 281; Gordon and d'Hondt, 1997: 59.

Usually encrusting. Marginal zooecia with marginal pores. Superposed zooecia do not resemble marginal ones. Primary orifice denticulate distally. A sinus may generally be present limited by two condyles. Peristome variously developed, but may even be simple. Secondary orifice rarely simple provided with prominent mucros or teeth like projections. Sub-oral avicularia present or absent. Frontal avicularia acute or rounded. Differentiated frontal plate ornaments the ovicell. Opercula strong and with granular thickening.

86. ***Rhynchozoon compactum*** (Thornely, 1905) **Plate 19: Fig. 70**

Cellepora compacta Thornely, 1905: 126.
Rhynchozoon compactum Harmer, 1957: 1076; Menon and Nair, 1967a: 2; Menon, 1974a: 116.

Occurrence: Several colonies were collected attached to shell bits in dredge samples taken from 70m depth at Calicut in the west coast of India.

Salient features: L_z= 500μ; l_z= 325μ

Colony encrusting. Zooecia at the center of the colony semi-recumbent. Primary orifice broadly sinuate with denticulations. Young encrusting zooecia with a single median mucro and marginal pores. Old zooecia with two or three mucros, the lateral ones aviculiferous. The rostrum lying diagonally or distally. The secondary orifice with a median sinus when only two mucros present. The median mucro may be blunt, longer than the lateral ones. Sub-oral avicularia not noticed. Frontal avicularia present, rostra with parallel lateral margins and rounded tips. The calcareous bar complete. No ovicells noticed.

Remarks: These are referable to the description of Rhynchozoon compactum (Thornely) given by Harmer (1957). The presence of aviculiferous lateral mucro seems to be a point of interest. No sub-oral avicularium was noticed in the present material. The zooecia at the center of the colony were always found to be oblique in disposition with the raised distal ends. In this respect they resembled the specimens Harmer collected from Torres Strait. Regarding the number of mucro, Harmer has stated "several may occur on a peristome". This seemed to be not applicable in the present instance, as there were not more than three mucros in any zooecia. Thornely's paratype kept at the Cambridge museum does not possess ovicells or frontal avicularia (see Harmer, 1957, p. 1077). But in the present specimens, the frontal avicularia were represented though not in all zooecia. Harmer states about Japanese specimens kept at the Cambridge Museum "the proximal and occasionally the distal parts of their edge (orifice) have a series of minute teeth". This was applicable in the present case. In the same specimens, Harmer (1957) noticed no sub-oral avicularia at the proximal area, even though he could notice many frontal avicularia. The opercula of the present forms resembled remarkably fig. 25 of plate 70 given by Harmer (1957).

Records from Indian waters: Gulf of Mannar (Thornely, 1905); off Chavara, southwest coast of India (Menon and Nair, 1967a; Menon, 1974a).

Distribution: Ceylon (Thornely, 1905); Japan (Harmer, 1957); Indian waters (Menon and Nair, 1967a; Menon, 1974a).

87. ***Rhynchozoon larreyi*** (Audouin, 1826) **Plate 19: Fig. 71**

Cellepora (?) *larreyi* Audouin, 1826: 239.
Rhynchopora (sic) *bispinosa* Thornely, 1905: 117.
Rhynchozoon larreyi Harmer, 1957: 1074; Menon and Nair, 1967a: 2; Menon, 1974a: 116.

Occurrence: Several colonies were collected attached to gastropod shells and corals in dredge samples taken from various depths along the east and west coasts of India.

Salient features: L_z= 320μ; l_z= 290μ

Zoaria encrusting and multilaminar. Zooecia distinct at the margin of the colony and irregular at the center. Marginal pores present. Front highly tuberculated and the tubercles give the colony a very irregular appearance. Peristome bilabiate, one of the processes aviculiferous. In the older zooecia, small tooth like processes present at the proximal region of the peristome. Small sub-oral avicularia placed obliquely. Frontal avicularia present placed near the distal region proximal to the peristome, triangular and acute. Primary orifice with a distinct sinus, distal portion denticulate. Operculum with a wide circular anter and a distinct poster. Ovicells non-porous and tuberculated.

Remarks: Referable to *Rhynchozoon larreyi* (Audouin) given by Thornely (1905) and Harmer (1957). Harmer has shown that variations do occur in the zooecial characters within this species. He noticed three to four short horizontal digitate mucros in Savigny's material. This feature is noticed in almost all zooecia in the older portions of the colonies. The number of the mucros may be even five and these give the peristome a very characteristic appearance. Harmer (1957) observed denticulate primary orifice with its well-marked sinus in the specimens he collected from West Flores and adds that this feature agrees well with the type material. This feature is easily distinguishable in the present form. In this material the opercula were clearly seen in few zooecia. The shape of the operculum agreed with figures of Harmer (Pl. 70, fig. 20), but here the poster was more triangular than what Harmer has shown in his figure. Harmer shows that the "Sinus of the opercula is bounded by distinct indentation corresponding with the position of the condyles". This was true of the present material as well. In older zooecia, the marginal pores become less conspicuous and only in the younger zooecia the pores can be seen clearly; and in the case of present specimen, only one row of pores had been noticed. The frontal avicularia may be directed proximally or distally and the size may also show variations. In the older regions of the colony the tubercles were enlarged and this would obscure many characters of the zooecia. The tubercles at the margins of the zooecia were larger than those towards the centre. A high tuberculated nature of the front was a very characteristic feature of this species.

Records from Indian waters: Mandapam, Gulf of Mannar, east coast of India (Menon and Nair, 1967a; Menon, 1974a).

Distribution: Ceylon (Thornely, 1905); Indo-Australian Archipelago (Harmer, 1957), Indian waters (Menon and Nair, 1967a; Menon, 1974a).

88. ***Rhynchozoon globosum*** Harmer, 1957 — **Plate 19: Fig. 72**

Rhynchozoon globosum Harmer, 1957: 1072; Menon and Nair, 1967a: 2; Menon, 1974a: 116.

Occurrence: Several colonies were collected attached to shell bits in dredge samples taken from 35m depth from Cape Comorin in the west coast of India.

Salient features: L_z= 580μ; l_z= 415μ

Encrusting. Front finely tuberculated. Peristome with two or three mucros, one of which may be aviculiferous. Sub-oral avicularia present, placed on globular thickenings. Rostrum curved without a uncinate process. Frontal avicularia placed on calcareous thickenings in young zooecia. Mandibles hooked at the tips. Orifice with small sinus. No ovicells noticed.

Remarks: This species was created by Harmer based on the differences he noticed in the nature of the sub-oral avicularia from that of other species of this genus. Harmer (*loc.cit.*) did notice the paucity of this structure in his specimens. Sub-oral avicularia were present, similar to the type which Harmer noticed in his specimens. The marginal zooecia in that form did possess thick circular oral ridge even though, the three processes which Harmer found in his Torres Strait specimens were not represented conspicuously in the present specimens. Harmer's figure shows that the three processes are placed apart, whereas in the present specimens, they were found to be closer. This may be a difference of some importance. A study of Harmer's description of this species shows that the number of mucros shows variations, usually the number being greater in old zooecia, especially in the specimens from Torres Strait. The nature of the mandibles of the Japanese specimens kept in the Cambridge museum and sketched by Harmer is strikingly similar to the ones observed in the present study.

Records from Indian waters: Gulf of Mannar, Indian waters (Menon and Nair, 1967a; Menon, 1974a).

Distribution: Timor; Torres Strait, (Harmer, 1957), Indian waters (Menon and Nair, 1967a; Menon, 1974a).

Genus ***Metacleidochasma*** *Soule et al.*, 1991

Metacleidochasma Soule, Soule and Chaney, 1991: 480; Tilbrook *et al.*, 2001: 97.

Autozooids with spines when young. Marginally placed small lateral frontal pores. Adventitious avicularium may or may not be present. Oral spines present. Hypostomial ovicells. The front highly calcified and plate-like.

89. ***Metacleidochasma planulata*** (Canu and Bassler, 1929) **Plate 20: Fig. 73**

Hippoporina planulata Canu and Bassler, 1929: 321.

Metacleidochasma ovale Soule, Soule and Chaney, 1991: 480.
Metacleidochasma planulata Gordon and d'Hondt, 1997: 59; Tilbrook *et al.,* 2001: 98.

Occurrence: Six zooecia were collected attached to gastropod shells obtained in dredge samples taken at 30m depth from Cuddallore in the east coast of India.

Salient features: L_z= 400µ; l_z= 260µ

A part of a colony was obtained from the east coast of India at Cuddallore from a depth of 30m. Zooecia highly calcified and plate-like. Two distinct ornamented frontal pores present on either side of the front. Orifice with a rounded distal and semicircular proximal portion. The presence of lateral sclerites gives the sinus a typical semicircular shape. Three oral spines present evenly distributed on the distal portion of the orifice. No ovicells or avicularia noticed.

Remarks: The material available was only a bit of a colony consisting of six complete zooecia. When compared with the figures and description of *M. planulata*, Tilbrook *et al.*, (2001) found clear similarity in structure with the specimens collected by them from Vanuatu Islands, which is adjacent to the area covered during Siboga expedition. The only conspicuous change in morphology noticed was the presence of very minute pores apart from the two large ones described by Tilbrook *et al.*, (*loc.cit.*). Curiously enough the electronmicrographs of the material presented by them do show very minute pores. However, inter zooecial margin which is more or less valley-like in the material collected by Tilbrook et al., (*loc.cit.*), seems to be slightly elevated in the present material. Notwithstanding these variations the material is assigned to *M. planulata*, which is a tropical and subtropical bryozoan of the Indo-Australian Archipelago.

Record from Indian waters: This is the first record of this species from Indian waters.

Distribution: Philippines, Hawaii, Maldives, Thailand, Tonga, French Polynesia (Soule *et al.*, 1991); Port Vila Harbour and Iririki Island (Tilbrook *et al.*, 2001).

Genus *Triphyllozoon* Canu and Bassler, 1917

Triphyllozoon Canu and Bassler, 1917: 56; Harmer, 1934: 590.

Zoarium fenestrate. Ovicells with a trifoliate stigma. Peristome may be with a closed labial pore or an open sinus. Generally the operculum with an indefinite border. Large bicuspid avicularia commonly present. Small round and oval avicularia present. Basal vibices few.

90. ***Triphyllozoon tubulatum*** (Busk, 1884) **Plate 20: Fig. 74a, b, c & d**

Retepora tubulata (Pars) Busk, 1884: 121; Thornely, 1905: 125; Hastings, 1932: 442.
Triphyllozoon tubulatum Harmer, 1934: 600; Menon, 1967: 172; Hayward, 2000:118; 2004: 321.

Occurrence: Few colonies were collected from dredge samples taken from 100m depth from Mangalore and Goa in the west coast of India.

Salient features: L_z= 410μ; l_z= 265μ

Tubular zoarium, with delicate tubes and funnels, usually with orifices arranged in the interior face of the funnel. Fenestrae oval. Peristome with a distinct sinus. Labial avicularia present but rare. Numerous sub-median or lateral avicularia invariably present. Infrafenestral avicularia rare may be facing the fenestrae or in an oblique manner frontally with two to four cusps. Large frontal avicularia with rounded rostrum, mandible rounded. Operculum with a marginal sclerite. Delicate ovicells with a trifoliate stigma.

Remarks: Despite the close resemblance of the present form to *T. tubulatum* certain differences are evident. However, a study of the species assigned to this genus shows that in all species, variations in the specific characters can be expected. The typically sinuate nature of the orifice, not visible due to the proximal wall of the peristome, orifices on the inner side of the funnel, large and strongly cusped Infrafenestral avicularia and the rare occurrence of spines were characters which prompted me to place the present form as to *T. tubulatum*. However, the rare occurrence of infrafenestral avicularia, absence of spines in many zooecia, absence of avicularia on the basal side of the zoaria were features in which the present form could be distinguished from *T. tubulatum.* It was not clear whether the differences noticed were sufficiently strong to warrant the creation of a new species. Considering the wide range of variations known to occur in the different species of the genus, the present form is tentatively assigned to *T. tubulatum.*

Records from Indian waters: Harmer (1934) doubts whether *Retepora tubulata* described by Thornely (1907) from east India belongs to the present species. Mandapam, Bay of Bengal (Menon, 1967).

Distribution: Torres Strait (Busk, 1884; Hastings, 1932); Indo-Australian Archipelago (Harmer, 1934); Gulf of Mannar (Thornely, 1905); southwest Pacific (Hayward, 2000).

91. ***Triphyllozoon philippinense*** (Busk) 1884 **Pl. 20: 75a; Pl. 21: 75b, c & d**

Retepora philippiensis Busk 1884: 123.
Triphyllozoon philippinense Harmer 1934: 597.

Occurrence: Few colonies were collected from dredge samples taken from 127m depth from Cape Comorin in the west coast of India.

Salient features: L_z= 450μ; l_z= 300μ

Zoarium reasonably large, tubular and infundibuliform. The orifices are placed on the outer surface of the tubes. Anastomosous of the tubular branches of the zoarium creates fenestrae of elongated oval shape. The peristome sinuate often with a closed labial pore well raised proximally and laterally. Spines typically present, laterally placed one on each side of the orifice. Infrafenestral avicularia more or less slanting, oval in shape, placed on slightly raised calcareous thickenings. The rostral cusps are prominent. The labial avicularia not noticed. Apart from this, small rounded frontal avicularia are found associated with ovicells characteristically placed on the ovicells, by the side of the trifoliate stigma. The ovicells are large and are distinct normally placed in the regions where the bifurcation takes place. A very characteristic trifoliate stigma present, the arm of stigma ending in minute rounded pores.

Remark: The present material agrees very well with those examined by Harmer (1934). Characteristically the dorsal part of the zooecia is incapable of having any autozooid or kenozooid in bryozoans. Contrary to this, in *Triphyllozoon* small avicularia are present which are distributed indiscriminately along the periphery of the fenestra. Distinction between zooids by way of zooecial margins is clearly exemplified only on the ventral basal portion of the zoarium. Merger of zooecia often gives the colonies a fenestrate coralline structure. The relatively well preserved material available for present study shows that variations in geographical bearings do not result in structural modifications. Harmer's materials were collected from the Sulu Archipelago along the Indo-Australian chain of Islands. Busk (1884) also collected them from Philippines. The Indian material came from the west coast of India from a depth of 127 m off Cape Comorin. Hence the present record extends the geographical distribution of this species to the Indian Ocean also.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: The Sulu Archipelago (Harmer, 1934), Philippines (Busk, 1884).

Family Conescharellinidae Levinsen, 1909

Conical zoarium, laminar without distinct attachment. Normally attached by rootlets, which are delicate. Characteristically, the sinuses of primary orifice directed towards the periphery of zoarium. This particular family consists of species which are mainly extinct and do not have any recent relatives. Apical sinuses are present on the secondary orifice. Considerable confusion exists regarding the position of the orifices and nature of placement of zooecium. Harmer (1957) has felt that Canu and Bassler (1929) have misunderstood these aspects.

Genus *Conescharellina* D'Orbigny, 1852

Typically conical zoarium. Normally with a wider base and tapering top without an acute apex, normally discoidal. Composed of a single layer of elongate zooecium surrounding a larger or smaller axial mass of cancelli.

92. ***Conescharellina jacunda*** Canu and Bassler, 1929 **Plate 21: Fig. 76**

Conescharellina jacunda Canu and Bassler, 1929: 95; Harmer, 1957: 735.

Occurrence: This species was collected attached to stones in dredge samples obtained at 30m depth from Cuddallore in the east coast of India.

Salient features: L_z= 295μ; l_z= 260μ

Elongate zoarium, acutely conical about 1½ times as high as wide. Lateral outline nearly in the proximal half. Peristomes in longitudinal rows not on definite costules. Primary orifices relatively large with widely rounded sinus. Conspicuous condyles present. Avicularia in distinct hexagons in a moderately zigzag longitudinal row. Lunoecia not noticed. Basal surface flat. Central surface small with few cancelli.

Remarks: Probably the group *Conescharellinidae* is unique in ascophorans by virtue of their colonial shape, growth and attachment. The presence of hexagonally placed avicularia, among which some are more exemplified and the presence of secondary orifice at the tip of peristomes probably originating from the center of the colony, which in totality is three dimensional and lunuliform, makes this group conspicuously different from any other group of bryozoans. It also has to be noticed that majority of the species coming under family *Conescharellinidae* are extinct indicating lack of improvement in the form of the colony and development of polymorphic organs. There are a group of genera coming under this family, which have retained archaic structure and could easily be misunderstood as cyclostomes, the conspicuous genus showing resemblance being *Agalmatozoum*. All these genera contain species, which are abyssal in distribution.

Record from Indian waters: This is the first record of this species from Indian waters.

Distribution: Philippines (Canu and Bassler, 1929), New Guinea (Harmer, 1957).

Genus *Escharina* Milne Edwards, 1836 (Unplaced family)

Encrusting zoarium, orifice with oral spines. The orifice as such semicircular. The proximal margin straight with a sharp defined sinus, which is narrow and sometimes nearly circular avicularia unilateral or bilateral distally directed. The mandibles either retiform or fan-shaped. Globose ovicells, small thin-walled and imperforate.

93. *Escharina pesanseris* (Smitt), 1873 — Plate 21: Fig. 77a & b

Hippothoa pesanseris Smitt, 1873: 43.
Escharina pesanseris Harmer, 1957: 998; Winston 1984: 26; Gordon 1984: 84; Tilbrook *et al.,* 2001: 80.

Occurrence: Several colonies were collected attached to gastropod shells and corals in dredge samples taken from various depths along the east and west coast of India.

Salient features: L_z= 780μ; l_z= 620μ

Encrusting zoarium. Zooecia distinctly quinquncial, arranged in longitudinal line. The large zooecia provided with conspicuous marginal valleys. The front provided with numerous pores, which are placed on calcareous spinule-like structures. Occlusion of the pores may occur. Exceptionally large condyles sometimes seem to merge at the center to make the sinus nearly circular. Oral spines large and 6 -7 in number. The spines are placed on umbonate elevations. Two lateral avicularia which are distally directed are characteristically merged to the orificial region by the development of smooth calcareous ridge. There are distinct calcareous spaces between the orifice and the frontal elevations. Mandibles of the avicularia are winged and broad distally. This makes the rostrum typically open distally. The operculum has got a clear-cut proximal -

projection, which covers the sinus. Hypostomial ovicells not heavily calcified but seems to be provided with a faint calcified ridge running across the front.

Remarks: This species is well established in the circumtropical areas in the world oceans. The fan shaped mandible is a characteristic feature of the species. Morphological variations between specimens collected from various geographical localities are minimal considering the fact that this species is recorded from the Pleistocene of the Panama Canal Zone, Indian Ocean to Suez to Mauritius to Northeast Madagascar and the Queensland. Harmer (1957) has remarked that young zooecia may remain imperforate and could suggest a different species at times. The oral spines although well developed could often be represented by the umbonate bases.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Widely distributed circumtropical species, Indo-Australian Archipelago (Harmer, 1957), Gulf of Mexico (Winston, 1984), Kermadec ridge (Gordon, 1984), Vanuatu (Tilbrook *et al.,* 2001).

ORDER CTENOSTOMATA Busk, 1852

Chitinous zoaria incrusting, erect, stolonate or burrowing. Aperture simple, closed by inversion of tentacle sheath, or retraction of polypide. Specialized apertures present in some genera, where they may be bilabiate or operculate. No avicularia or true external ovicells. Kenozooecia in the form of stolons in Stolonifera and as spines in Carnosa.

Division Carnosa Gray, 1841

Comparatively heavy calcareous cuticle giving the zoaria a fleshy or leathery nature. Usually encrusting but may rise to thin flabellate, palmate, sac-like, cylindrical or pedunculate expansions.

Family Alcyonididae Johnston, 1849

Zoaria incrusting or erect in sacculate or cylindrical expansions. Aperture closed by simple folds.

Genus *Alcyonidium* Lamouroux, 1813

Alcyonidium Lamouroux, 1813: 85; Harmer, 1915: 36; Silen, 1942: 9; Osburn, 1953:

727; Menon and Nair, 1969b: 439; 1971: 283; Menon, 1972b: 602.

Zoaria gelatinous or coriaceous encrusting as a soft cover over the substratum, or may arise as lobed, sac-like or cylindrical structures. Zooecia closely united, not stolonate. The aperture may either be placed at the centre of a raised papilla or at the distal end of the ventral smooth surface.

94. ***Alcyonidium erectum*** (Silen, 1942) **Plate 25: Fig. 92**

Alcyonidium erectum Silen, 1942: 12; Mawatari, 1953: 214; Menon and Nair, 1969b: 439; Menon, 1972b: 602; Hondt, 1983: 35.

Occurrence: Few colonies were collected attached to the glass test panels immersed in the Cochin estuary in Mattanchery channel for biofouling studies.

Salient features: L_z= 765µ; l_z= 225µ

Zoaria with erect zooids, arranged uniserially or biserially, growing into sac-like expansions from a basal encrusting portion, which spreads over the substratum in sponge-like fashion. Colour of the fresh colonies brown with a greenish tinge which become paler in material preserved in formalin. The erect portion develops from the center of the encrusting part of the colony. The shape of the zooids varies considerably. Zooecia of the encrusting region usually somewhat rectangular in outline becoming much more elongate and at times hexagonal. Inter-zooecial walls thicker in the encrusting zooids and thinner in the erect ones. The frontal wall thin, translucent and even. Aperture placed at the distal end of the zooecia giving the appearance of being placed at the tip of a papilla when the tentacle sheath is not completely withdrawn. In the uniserial and biserial regions of the colony the aperture is placed at the tip of a small papilla marked with two or three wrinkles. The lophophore is placed at an angle with the frontal membrane, bearing sixteen tentacles. The pleated collar funnel-shaped. Parietal muscles consist of about eleven pairs.

Remarks: Silen (1942) has classified the forms coming under the genus *Alcyonidium* into three groups based on their mode of growth, namely encrusting forms, erect forms without raised apertures and erect forms with apertures placed at the tip of papillae where the zooid rows are often disconnected. It is noteworthy that the present form showed similarities to *Alcyonidium erectum* of Silen (1942) and Mawatari (1953). The present material available at my disposal was found mostly encrusting on the glass panels. The zooecia of the proximal part of the erect portion connecting the encrusting part, possessed small papillae with apertures at their tips. Silen's (1942) observations were based on a specimen, which was the "torn off tip-end of a zoarium". The uniserial or biserial arrangement of the zooids in the proximal part of the erect portion and the structure of the flabellate region is in conformity with what Silen (1942) and Mawatari (1953) have observed. The funnel shaped nature of the pleated collar in the present specimen was not mentioned by the above authors. The proximal region of the flabellate part contained empty zooecia giving the appearance of small glass boxes. Brown bodies were noticeable in between the empty and functional zooids of the flabellate part.

Records from Indian waters: Epizoic on the carapace of a crab, off Cochin, south west coast of India (Menon and Nair, 1969b; Menon, 1967; 1972b).

Distribution: Japan, Pacific (Silen, 1942; Mawatari, 1953), India (Menon and Nair, 1969b; Menon, 1967; 1972b).

Division Stolonifera Ehlers, 1876

Zoaria with delicate creeping stolons. From the expanded portion of the stolons, where a diaphragm occurs, either stolonal or zooecial branches may arise. A gizzard may or may not be present.

Family Nolellidae Harmer, 1915

Characterized by the great development of the peristomial part of the zooecium. Adnate part of the zooecium represented by a delicate stolon-like tube and by the base of the peristome into which the tube usually passes abruptly. Branching of the cruciform type. Gizzard wanting.

Genus *Victorella* Kent, 1870

Victorella Kent, 1870: 34; Hincks, 1880: 559; Annandale 1911: 194; Harmer, 1915: 44; Carrada, 1963: 2; Menon, 1972b: 606; 1972d: 160; Menon and Nair, 1971: 285; 1974b: 419; Hondt, 1983: 52.

Pleated collar present. Budding point not localised. Resting buds present.

95. ***Victorella pavida*** Kent, 1870 **Plate 25: Fig. 93a; Pl. 26: Fig. 93b, c & d**

Victorella pavida Kent 1870: 34; Annandale 1907: 200; 1911: 196; Menon, 1972b: 606; 1972d: 160; Menon and Nair, 1971: 285; 1974b: 419; Hondt 1983: 53.

Occurrence: Numerous colonies were collected attached to the glass test panels immersed in the Ernakulam channel of the Cochin estuary for biofouling studies.

Salient features: L_z= 510 - 1420μ; l_z= 160 - 240μ

Pale brown colonies usually spreading out from a central point. Depending on the age of the colony the colour might range between translucent to deep earth brown. Zooecium typically composed of a proximal adnate tubular portion, a median broad adnate part and an erect cylindrical distal region. The proximal adnate tubular portion of the zooecium varies in colour, length and in thickness. Orifice squarish but in resting zooids as well as in zooecia without polypides rounded. Tentacles 8 in number. The pleated collar well developed provided with thin chitinous rods.

Remarks: The British material based on which this species was described by Kent in 1870 does show variations from Indian material as described by Annandale (1907). He felt that there could be differences between the Bengal and the British races. However, the study of Menon and Nair (1971) has shown that there could be considerable variation in the structure of the zooid and the nature of the colony. Bousfield (1885) observed that the specimens he found in England during spring having zooecia, which were "solitary semi erect, colourless and in shape much like a violin with a straight, elongated neck", but on the specimens collected during the month of September he made the following remarks: "The polypide consists of slender yellowish or brownish tubes on which at intervals are situated swellings in each of which a zooid is developed. From each swelling arise two branches at right angles, always branching in a rectangular direction, so that a mated ball results". Specimens collected by Annandale during winter from ponds at Port Canning represented, a phase similar to that found in September in England with a single difference of colourlessness of the zoarium. In specimens collected earlier in the seasons, the zooecia were "partially recumbent as of the same form as those of the specimens taken by Bousfield in England in spring".

The first character was regarding "the small size of the swelling from which the zooecial arise". During the present study zooids have been observed where the length of the adnate tubular part has been reduced very much and the zooids were arranged in groups, together with a diminished size of the swelling. The second feature he noticed was that a "considerable numbers of zooecia are frequently grouped together with very short intervening stola". This seems to be a character that depends on age and competition. In the present study it was noticed that a luxuriant growth occurred only on panels, which were under water for more than twenty days, when they covered the panel like a thick coat of fur and the branching deviated from normal type.

The fourth character, which gave specific distinction for *V. bengalensis* was "the distal part of some of the adult zooecia is approximately circular in cross section". It was observed that the quadrate nature of the distal ends is maintained by many zooecia, though rarely in the old ones the distal part becomes typically rounded and in zooecia without polypides the distal ends are always rounded. More luxuriant growth was noticed in *V. pavida* colonies in Cochin backwaters during the monsoon period when the salinity of the medium falls considerably. Buds at the distal region of the zooecia are never usual even though colonies collected during the month of December possessed individuals with distal buds.

Records from Indian waters: Lower Bengal (Annandale, 1907 a, b; 1908, 1911); Madras (Henderson and Mathai, 1910); Cochin backwaters (Menon, 1972b; 1972d; Menon and Nair, 1971; 1974b).

Distribution: England (Kent, 1870; Bousfield, 1885; Rousselet, 1907); France (Poisson and Remy, 1927; Hondt, 1983); Norway (Brattstrom, 1954); Belgium (Lopenns, 1910); Netherlands (Vortsman, 1935; Lacourt, 1949); Germany (Krapelin, 1887; Braem, 1951); Poland (Luther, 1927); Bulgaria (Valkanow, 1936); Italy (Carrada and Sacchi, 1964; Carrada, 1963); Egypt (Braem, 1951); India (Annandale, 1906, 1907 a, b, c, 1908, 1911, 1912; Henderson and Mathai, 1910; Menon, 1972b; 1972d; Menon and Nair, 1971; 1974b); Japan (Toriumi, 1956); Salton Sea (Soule and Soule, 1968); Chesapeake Bay (Osburn, 1932); Porto Novo, Canal Sao Sebastiao (Marcus, 1953).

Genus *Nolella* (Gosse, 1855)

Nolella Gosse, 1855: 35; Harmer, 1915: 52; Osburn, 1953: 737; Menon and Nair 1967a: 2; Menon, 1972b: 610.

"Zooecia cylindrical, elongate, with considerable variation in size within the same zoarium. Proximal ends of the zooecia are prolonged, narrowed to form connecting tubular extensions. The cuticle may on occasion, be covered by a very fine argillaceous coat" (Osburn, 1953).

96. ***Nolella papuensis*** (Busk, 1886) **Plate 26: Fig. 96a, b & c**

Cylindroecuim papuense Busk, 1886: 38.
Nolella papuensis Harmer, 1915: 53; Menon and Nair, 1967a: 2; Menon, 1972b: 610.

Occurrence: Colonies were collected attached to glass test panels, which were used for the study of fouling organisms in the Cochin estuary.

Salient features: L_z= 1200μ; l_z= 190μ
Variations in meristic characters occur depending on the age of the colony. The striated ectocyst often has adsorbed silt particles. The stolon-like proximal portion represents adnate part and the erect portion the peristome. The distal end of fertile zooecia often harbours embryos. This species could be confused with *Victorella pavida* if the basic characters are not properly understood. Distal end of fertile zooecia often with embryos.

Remarks: Variations in zooecial character have been documented by Harmer (1915). The same colony might possess zooecia of varying dimensions especially length. One might encounter empty zooecia in shrunken stage often brownish in hue. This probably indicates that on degeneration the polypide reduces to a brown-body. Old colonies may contain regenerated zooids, which might depict varied surface structures. Mature zooids possess two or three embryos at their tips. Very long zooids are noticed, longer than 1mm usually varies from 1.2mm to 1.5mm.

Records from Indian waters: Cochin backwaters (Menon and Nair, 1967a; Menon, 1972b).

Distribution: Indo-Australian Archipelago (Harmer, 1915); Indian waters (Menon and Nair, 1967b; Menon, 1972b).

Family Vesicularidae Johnston, 1838

Zoarium repent or erect. Proximally contracted zooecia not closely united to the stem at the base. Zooecia deciduous, without membraneous area.

Genus *Bowerbankia* Farre, 1837

Bowerbankia Farre, 1837: 391; Hincks, 1880: 518; Waters, 1910: 240; Harmer, 1915: 70; Osburn, 1953: 743; Menon 1972b: 619; 1972d: 158; Menon and Nair, 1967a: 2; 1971: 302; Gordon and Mawatari, 1992: 13; Hondt, 1983: 63.

"Zooecia arising irregularly from an erect or creeping axis, commonly in definite groups. Tentacles 8-10. Gizzard present" Harmer (1915).

97. ***Bowerbankia gracilis*** Leidy, 1855 **Plate 25: Fig. 94a; Pl. 26: 94b & c**

Bowerbankia gracilis Leidy 1855: 135; Mawatari 1952: 262; Osburn 1953: 743; Menon 1972b: 619; 1972d: 158; Menon and Nair, 1967a: 2; 1971: 302; Gordon and Mawatari 1992: 13; Hondt 1983: 63.

Occurrence: Several colonies were found attached on the glass panels employed for biofouling studies.

Salient features: L_z= 1140µ; l_z=195 µ

The colonies look like irregular, tangled, grey masses of stolons and zooecia. Zoaria could be repent. Normally the stolons and zooecia gets entangled due to irregular branching. Long zooecia tubular, tapering proximally and distally. Tentacles 10 in number, Gizzard present. Zooecia sometimes provided with caudate ends occurring singularly or in pair. Brownish stolon with irregular internodes separated by diaphragm.

Remarks: As a rule the length of the zooecia varies considerably. Zooecia with a maximum length of 1140µ are present in one colony. The region of the zooecial in connection with the stolon is provided with a plate, and the constriction between the stolon and zooecia is quite distinct showing similarity towards *B. imbricata* (Adams). The parietal muscles in the present form are arranged in two separate bundles, this aspect is not mentioned in Osburn's text (1953) even though it is distinctly shown in the figure. The caudate process is noticed in a few instances and is in conformity with Osburn's observations on the Pacific material.

Records from Indian waters: Cochin backwaters (Menon 1972b; 1972d, Menon and Nair, 1967a; 1971).

Distribution: Pacific coast of North America (Osburn, 1953); Japan (Mawatari, 1953); Indian waters (Menon 1972b; 1972d, Menon and Nair, 1967; 1971); New Zealand (Gordon and Mawatari, 1992).

Family Triticellidae Sars, 1873"

Stolon delicate without free branches, zooecia erect with a long slender base-like pedicel, with a flattened frontal area and without spines at the distal end around the oral aperture" (Osburn, 1944).

Genus *Triticella* (Dalyell, 1848)

Triticella Harmer, 1915: 90; Silen 1935: 5; Osburn, 1952: 748; Menon, 1972b: 620; Hondt, 1983: 70.

Creeping, stolonate zoaria with pedicellate, erect zooecia. Zooecia attached to the stolon by means of movable joints. Zooecia elongate and ovoid with membraneous frontal areas.

98. ***Triticella korenii*** Sars, 1873 **Plate 25: Fig. 95a & b; Pl. 26: 95c**

Triticella korenii Sars, 1873: 84; Harmer 1915: 90; Menon and Nair 1967a: 2; Menon 1972b: 621; Hondt 1983: 70.

Occurrence: Several colonies were found attached on the glass panels employed for biofouling studies.

Salient features: L_z= 1160µ; l_z= 25 µ

Colonies consist of brown branching stolon creeping over the substrata and the zooecia arise solitarily from short internodes of the stolon. Zooecia with long, slender pedicel connected to the stolon by simple movable joints. Frontal surface entirely membranous. At the point where the pedicel joins the zooecium proper, it becomes slightly wrinkled. Zooecia are elongate and elliptical. Pleated collar funnel-shaped. Tentacles 24 in number.

Remarks: This form agrees well with the description of *Triticella boeckii* given by Harmer (1915), treated as a synonym of *T. korenii* Sars, by Silen (1935). The form distinguishes itself from *Triticella elongata* (Osburn), by the comparatively long pedicel, which has got an average length of 1150µ; and by the reduced length of the zooecium proper. It differs from *T. pedicellata* (Alder) in the simple nature of the joints. The zooecia in the present form arose from slightly expanded portions of the stolon. Many regenerating zooecia were noticed. In the regenerating zooecium the pedicel assumed a wrinkled nature at the point of regeneration even though the zooecium proper developed away from the area of regeneration, the regenerating point being marked by the presence of a small dilation. Silen (1935) has given a detailed account of the various specific characters of this interesting species.

Records from Indian waters: Epizoic on the carapace of a crab, off Cochin (Menon and Nair 1967a; Menon 1972b).

Distribution: Oslo (Sars, 1874); Ireland (Duerden, 1893); Indian waters (Menon and Nair 1967a; Menon 1972b).

ORDER CYCLOSTOMATA Busk, 1852

Zooecium calcified, its opening circular, not closed by an operculum.

Family Stomatoporidae Pregens and Meunier, 1886

This family was created in 1886 and the genus *Stomatopora,* which was described in 1825, was assigned to this family. The family Oncousoecidae looks to be a super family envisaged by Canu in 1918 into which, he incorporated three genera such as *Stomatopora, Proboscina* and *Oncousoecia*. Subsequently, this family was split into two to incorporate Stomatoporidae. The important genus, *Stomatopora*, coming under this family was originally genus *Alecto* created by Lamouroux in 1821, but *Alecto* was preoccupied and hence became invalid and Brann in 1825 named the genus *Stomatopora* to incorporate species of *Alecto* including the genotype *Alecto dichotomo* of Lamouroux (1812). The family consists of genera, which includes species having the general character of uniserial zoarium throughout the colony except in places where the ovicells are developed. The presence of tubes on either side of the ovicells is an important feature of this family. Highly lobate nature of the ovicells and the terminal disposition of ooeciostome are characters of importance to this family.

Genus *Stomatopora* Bronn, 1825

Species are uniserial, adnate and branching. Biserial zooids recorded only in the fertile region of the colony. Ovicells inflated may be slightly lobate. The ooeciostome placed terminally.

99. ***Stomatopora granulata*** (Milne-Edwards), 1836 **Plate 25; Fig.91**

Alecto granulata Milne-Edwards, 1836: 205; Busk, 1875: 24.
Stomatopora granulata Hincks, 1880: 425; Borg, 1926: 359; Osburn, 1953; 619.

Occurrence: Few colonies were collected attached to gastropod shells and corals in dredge samples taken from a depth of 48m from Kakinada in the east coast of India.

Salient features: L_z= 450-660μ; l_z= 220μ

Adnate zoarium, uniserial except in the region where mature zooids are present. The branches straight or curved. Certain degree of anastomoses takes place where the branches merge. The peristome virtually grows as a curvature from the adnate bulbous part of the zooecia. The erect peristomial dimensions depending on the rate of calcification. Peristomial aperture provided with minute projections and often small edentations giving the appearance of minute pores. Old peristome may have crenulations. Ovicells not noticed.

Remarks: The present material was collected from a locality off Kakinada at a depth of 48 m. This species has hitherto not been recorded from the Indian waters. However, Osburn (1953) has remarked that this is a widely distributed species and is found abundantly as fossils from New Zealand indicating wide latitudinal distribution.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Widely distributed in the northern hemisphere, California, Norway, Mediterranean Sea, Japan, New Zealand (Osburn, 1953).

Family Oncousoeciedae Canu, 1918

Zoarium adnate and flat. The peristomes flush the surface of the zoarium, slightly raised, distributed irregularly but could be quinquncial or in transverse linear series. A very well developed ooecium is present at the end of the branches of the bifurcated colony.

Genus *Proboscina* Audouin, 1826

The zoarium consists of multiserial elongated bands which can be simple or branched and they are always adnate and flat. Zooecia cylindrical and narrow. The peristomes flush the surface of the zoarium, slightly raised, distributed irregularly but could be quinquncial or in transverse linear series.

100. ***Proboscina lamellifera*** Canu and Bassler, 1930 **Plate 22; Fig. 78a & b**

Proboscina lamellifera Canu and Bassler, 1930:46; Osburn 1953: 623.

Occurrence: Two colonies were collected attached to gastropod shells from dredge samples taken at 60 m depth from Calicut and Cannanore in the west coast of India.

Salient features: l_z= 150µ

Encrusting zoaria usually spreads over shells formed of sinuous branches joined by calcareous lamella. The zooecial tubes are indistinct, short, serrated, terminating in comparatively long erect peristome. The number of peristomes indicating the number of closely joined zooecia could vary from 2 to 4 indicating biserial to quadriserial arrangement of zooids. A very well developed ooecium is present at the tip of one of the branches of the bifurcated colony, as customary in the case of cyclostomes. The ooecium merges with the other peristomes of the accompanying zooids making a distinction difficult. However, the ooeciopore tends to be the central pore, where the typical peristomial erection is absent.

Remarks: Description of the ovicell and the nature of the peristome are sufficient to distinguish this species. However, the connecting lamella is indistinguishable although, it spreads sideways and lacks peristomial projections. The peristome as such could be rounded or elongated oval and when broken shows two layers with a very faint edentations separating it. Although this species has been recorded from lower latitudes, the present finding of this species from a depth of 60 m off Cannanore and Calicut is significant since the distribution of this species extends to the Indian Ocean by this record.

Records from Indian waters: This is the first record of this species from Indian waters.

Distribution: Galapagos Islands (Osburn, 1953).

Family Crisiidae Johnston, 1838

Erect and jointed zoarium, with zooecia arranged in single series or alternating in two series. Ovicell a gonozooid, with an ooeciostome.

Genus *Crisia* Lamouroux, 1812

Crisia (pars) Lamouroux, 1812:183.

Crisia Harmer, 1915: 96; Osburn, 1953: 678; Menon and Nair, 1967a: 2; Soule *et al.*, 1995: 314.

Long internodes. Zooecia arranged symmetrically in two alternating series, the projecting peristome giving the edges a serrated appearance. Gonozooids usually placed in the median line between the zooid rows.

101. ***Crisia elongata*** Milne Edwards, 1838 — **Plate 22; Fig.79a & b**

Crisia elongata Milne Edwards, 1838: 203; Busk, 1886: 50; Waters, 1914: 838; Harmer, 1915: 96; Osburn, 1953: 684; Menon and Nair, 1967a:2.

Occurrence: Several colonies were collected from sand in the dredge samples taken at 100m depth from Vishakapatanam in the east coast of India.

Salient features: L_z= 450-500μ; l_z= 75μ

Delicate zoarium. Projecting peristomes give the branches a serrated appearance. Zooecia long and adnate, the peristome placed obliquely directing forwards. No ovicells noticed.

Remarks: Only few fragments of a colony were available for study. So no detailed comparison with the figures and descriptions given by different authors was possible. But the close similarity shown by the present form with the figures and descriptions of *Crisia elongata* given by Waters (1914), Harmer (1915) and Osburn (1953) made it possible to assign the form to *C. elongata.* The colonies tend to break easily at the internode, so even though complete internode was represented in the fragment it could not be stated about the number of zooecia occupying the internode. But it was evident from the fragment that the width of the internode was considerable because of the extension of the proximal ends of the zooecia along the median sides of the preceding zooecia.

Records from Indian waters: Off Mandapam, east coast of India (Menon and Nair, 1967a).

Distribution: Naples (Waters, 1879); Red Sea (Milne Edwards, 1838); Africa (Waters, 1914); Ceylon (Thornely, 1905); the Indo-Australian Archipelago (Harmer, 1915); west of Fiji Island (Busk, 1886); Gulf of California (Osburn, 1953); Indian waters (Menon and Nair, 1967a).

Genus *Filicrisia* d'Orbigny, 1853

Spinous structures absent. Colonies adnate or erect. Ovicells develop as jointed black bulbous structures.

102. ***Filicrisia*** sp. **Plate 22; Fig. 80a & b**

Occurrence: One colony was collected from the sand in the dredge samples taken from 100m depth at Vishakapatanam in the east coast of India.

Salient features: L_z= 400 -500μ; l_z= 190 -290μ

A bit of a colony was obtained from Vishakapatanam at a depth of 100 m. The basic difference between the present material and those described under this genus is the bulbous nature of the zooecia and less number of internodal zooids. The distal portion of the zooecia looks as if it is a projection from the massive internodal zoarial branch. The area where the bifurcation was noticed, a clear-cut merger of the zooecial base is indicated. This should be incorporated in the character of the genus *Filicrisia*. The erect peristomial portion looks to be a clear-cut extension of the branches. The internodal zooecial number may be 1 or 2. Merger of zooecia at the internode may happen without a less calcareous internodal junction.

2.8 Description of species from the Antarctic waters

ORDER CHEILOSTOMATA (Busk, 1852)

Characters given in Sec. 2.7, p. 31.

SUB-ORDER ANASCA (Levinsen, 1867)

Characters given in Sec. 2.7, p. 31.

Family Calloporidae Norman, 1903

Family characters as given in Sec. 2.7, p. 40.

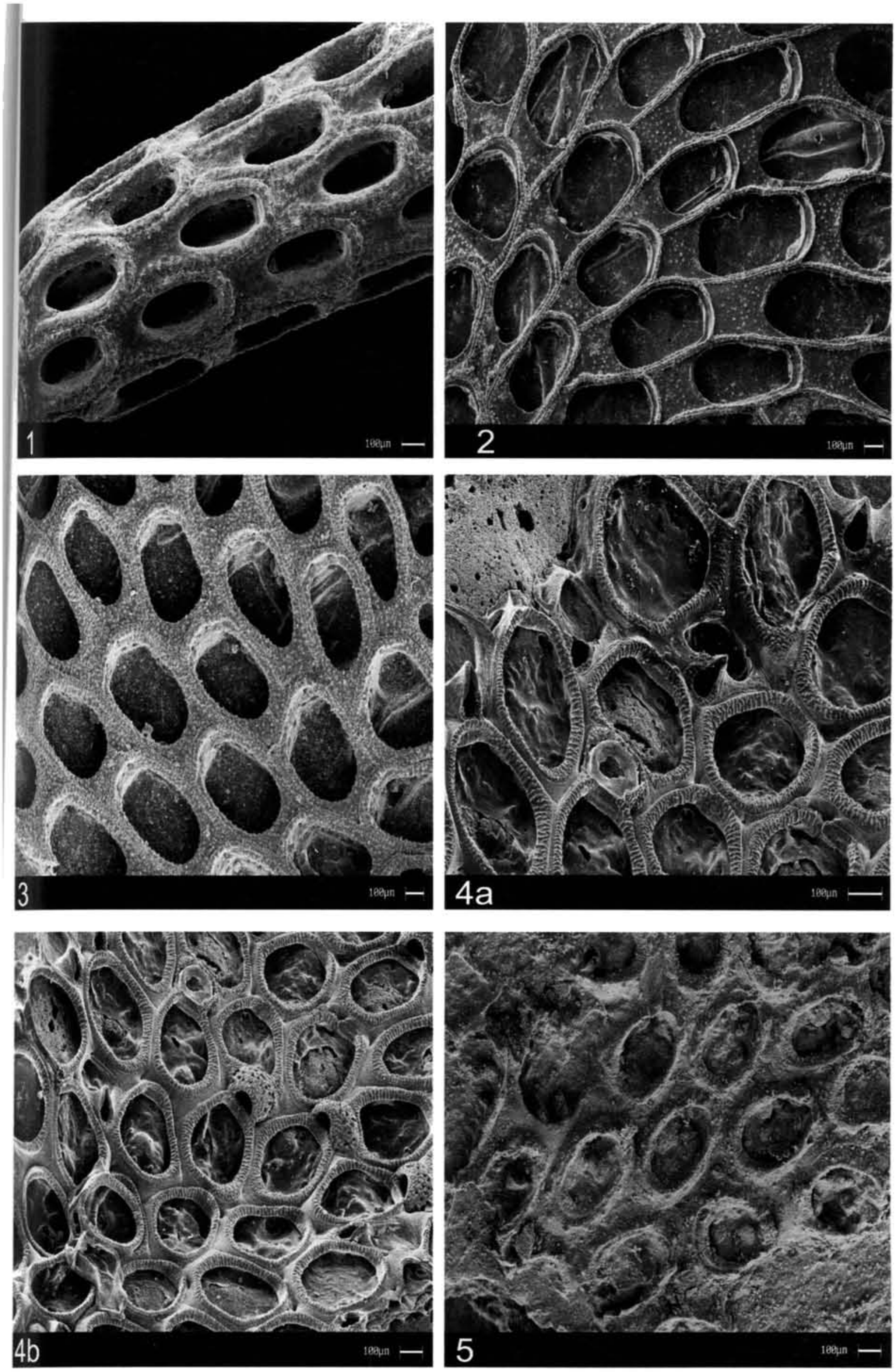


Plate 1. 1. *Acanthodesia* sp., Portion of a colony showing the cellariform nature and details of the zooecia. 2.*Acanthodesia savartii* (Audouin). 3.*Conopeum reticulum* (Linnaeus). 4a, b. *Parellisina curvirostris* (Hincks), colony showing ovicells and avicularia. 5. *Crassimarginatella* sp..

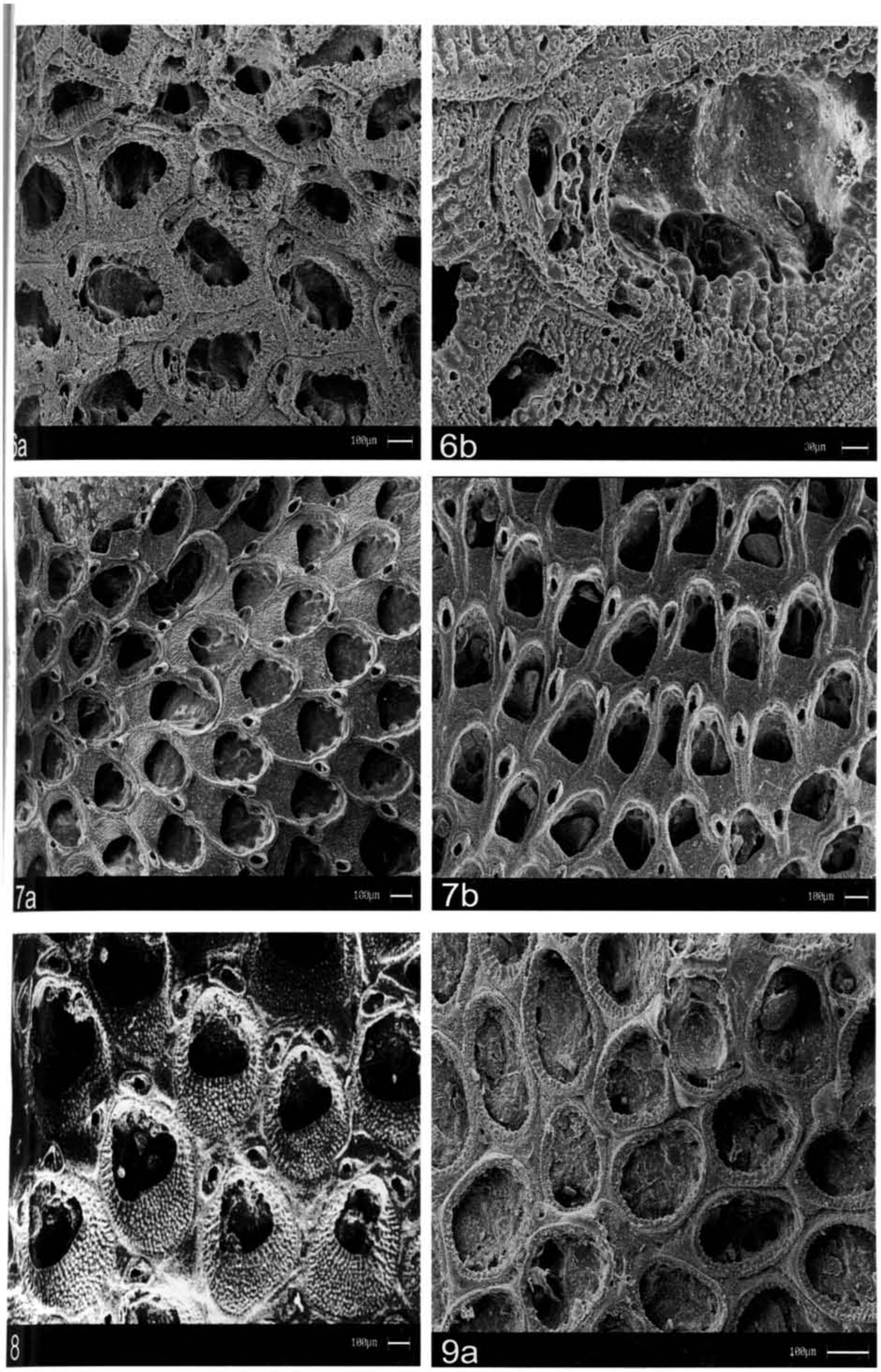


Plate 2. 6. *Cranosina coronata* (Hincks), a. Portion of a zoaria showing the details of zooecium, b. enlarged view of a zooecia. 7a, b. *Antropora erecta* (Silen), view of the zoaria with a vicarious avicularia. 8. *Antropora granulifera* (Hincks). 9a. *Antropora tincta* (Hastings), A view of the zoaria.

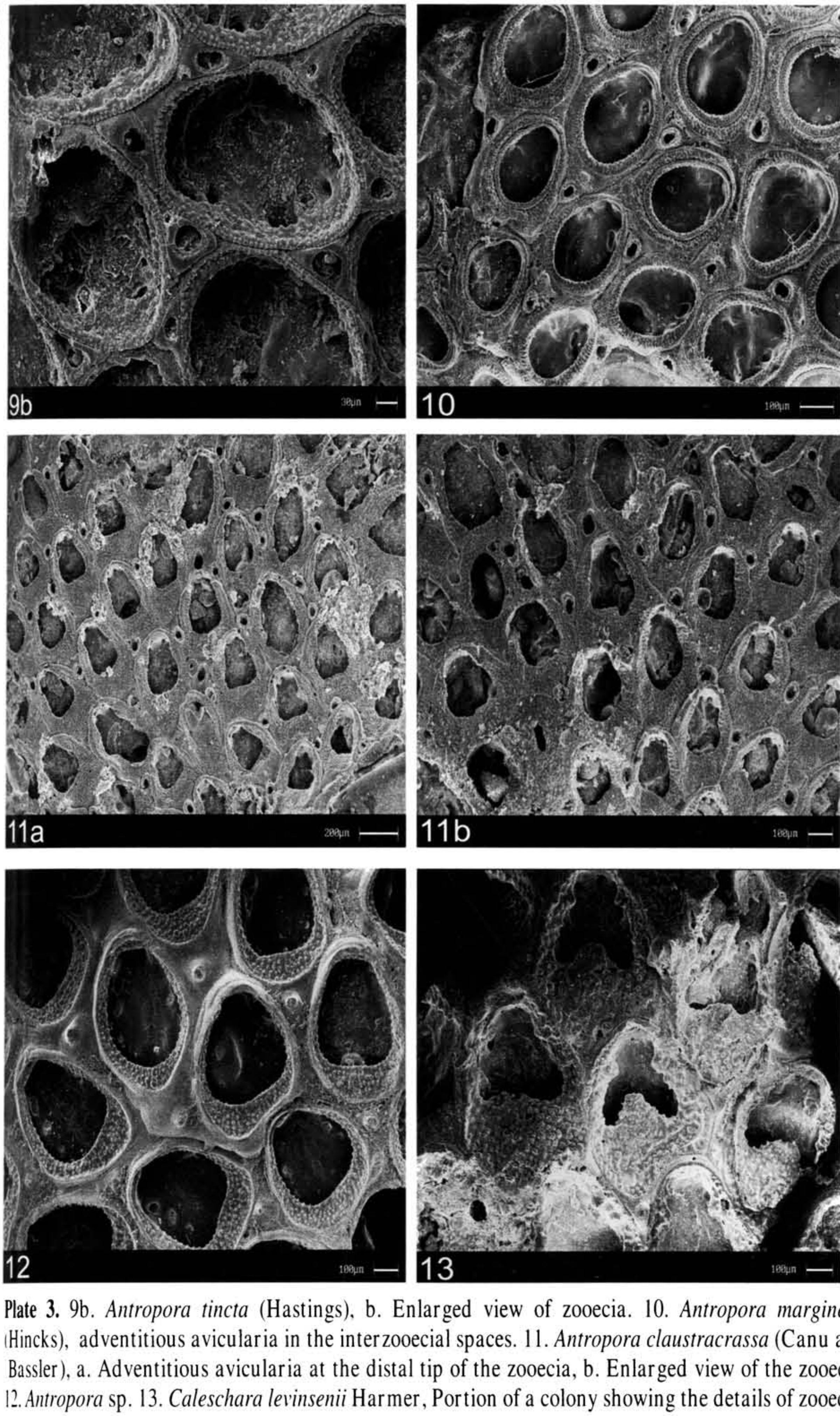


Plate 3. 9b. *Antropora tincta* (Hastings), b. Enlarged view of zooecia. 10. *Antropora marginella* (Hincks), adventitious avicularia in the interzooecial spaces. 11. *Antropora claustracrassa* (Canu and Bassler), a. Adventitious avicularia at the distal tip of the zooecia, b. Enlarged view of the zooecia. 12. *Antropora* sp. 13. *Caleschara levinsenii* Harmer, Portion of a colony showing the details of zooecia.

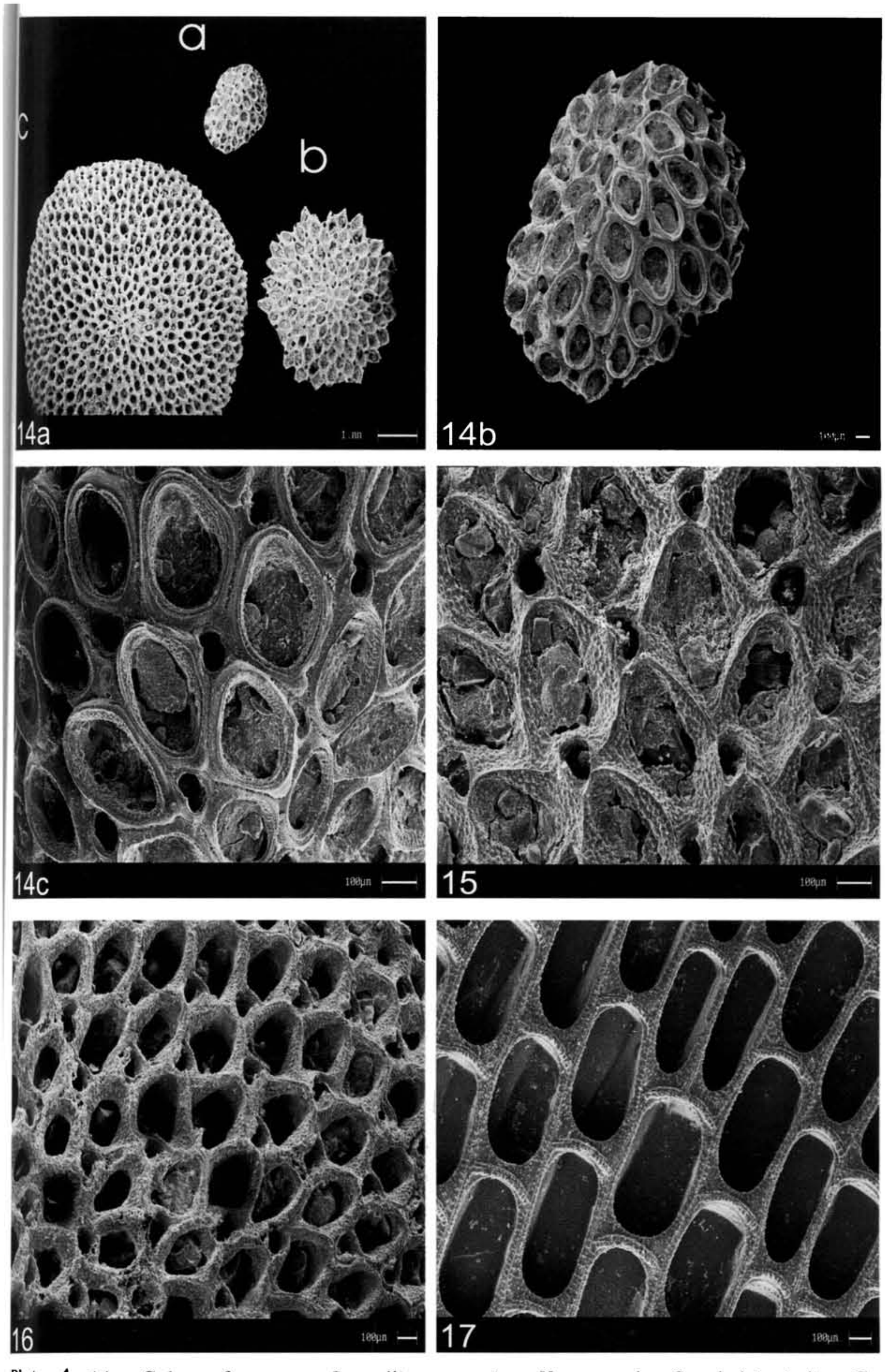


Plate 4. 14a. Colony forms: a. *Setosellina constricta* Harmer; b. *Cupuladria indica* Cook; c. *Cupuladria guineensis* (Busk). 14b, *Setosellina constricta* Harmer, 14c. Enlarged view of a zooecia showing vibracular chamber. 15. *Cupuladria indica* Cook, Enlarged view of a colony. 16. *Cupuladria guineensis* (Busk). 17. *Chartella arabica* sp. novo, A view of asexual reproduction by budding..

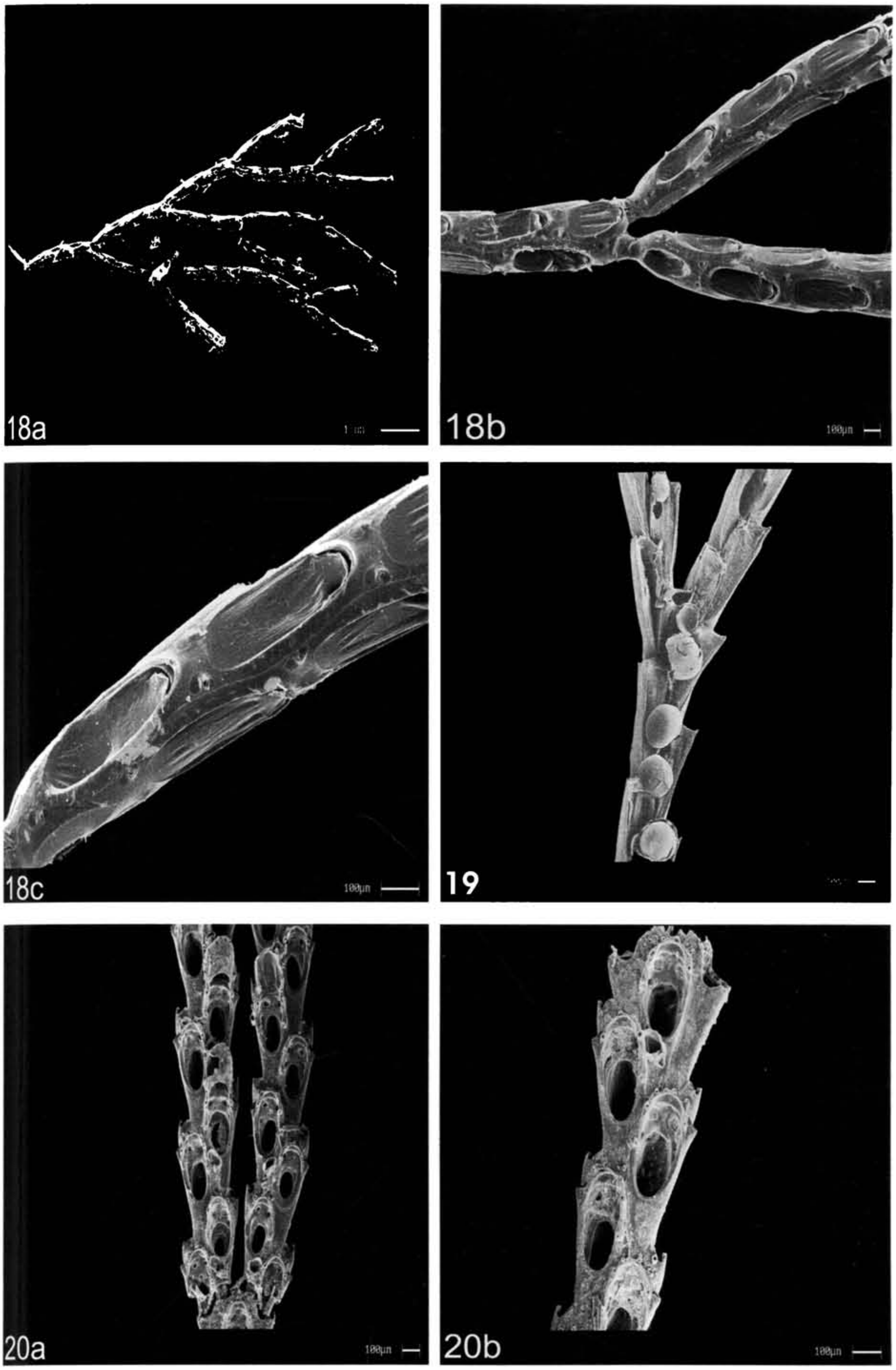


Plate 5. 18. *Nellia occulata* Busk, a, Form of the colony, b. Nature of bifurcation, c. Enlarged view of a colony showing the details of zooecia. 19. *Bugula neritina* (Linnaeus), A colony with fertile zooecia. 20. *Scrupocellaria ferox* Busk, a. Nature of bifurcation, b. Portion of a colony showing the details of zooecia.

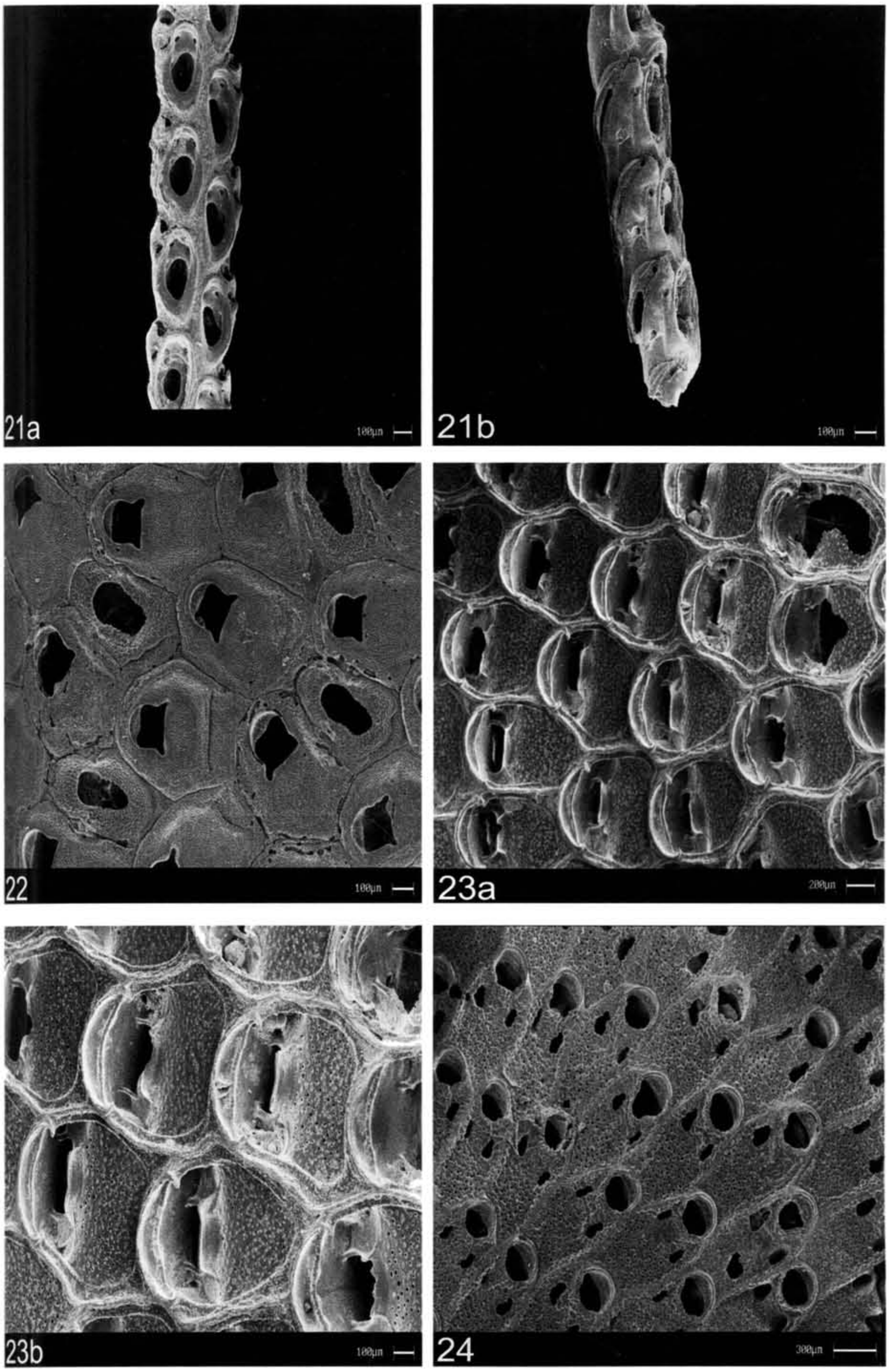


Plate 6. 21. *Caberea lata* Busk, a. Zooecia of a young colony frontal view, b. Lateral view. 22. *Smittipora abyssicola* Smitt, Zooecia with the trifoliate operculum and the avicularian rostrum. 23. *Steginoporella buskii* Harmer, a. Part of a zooecium, b. Enlarged view of the zooids. 24. *Thalamporella gothica* (Busk).

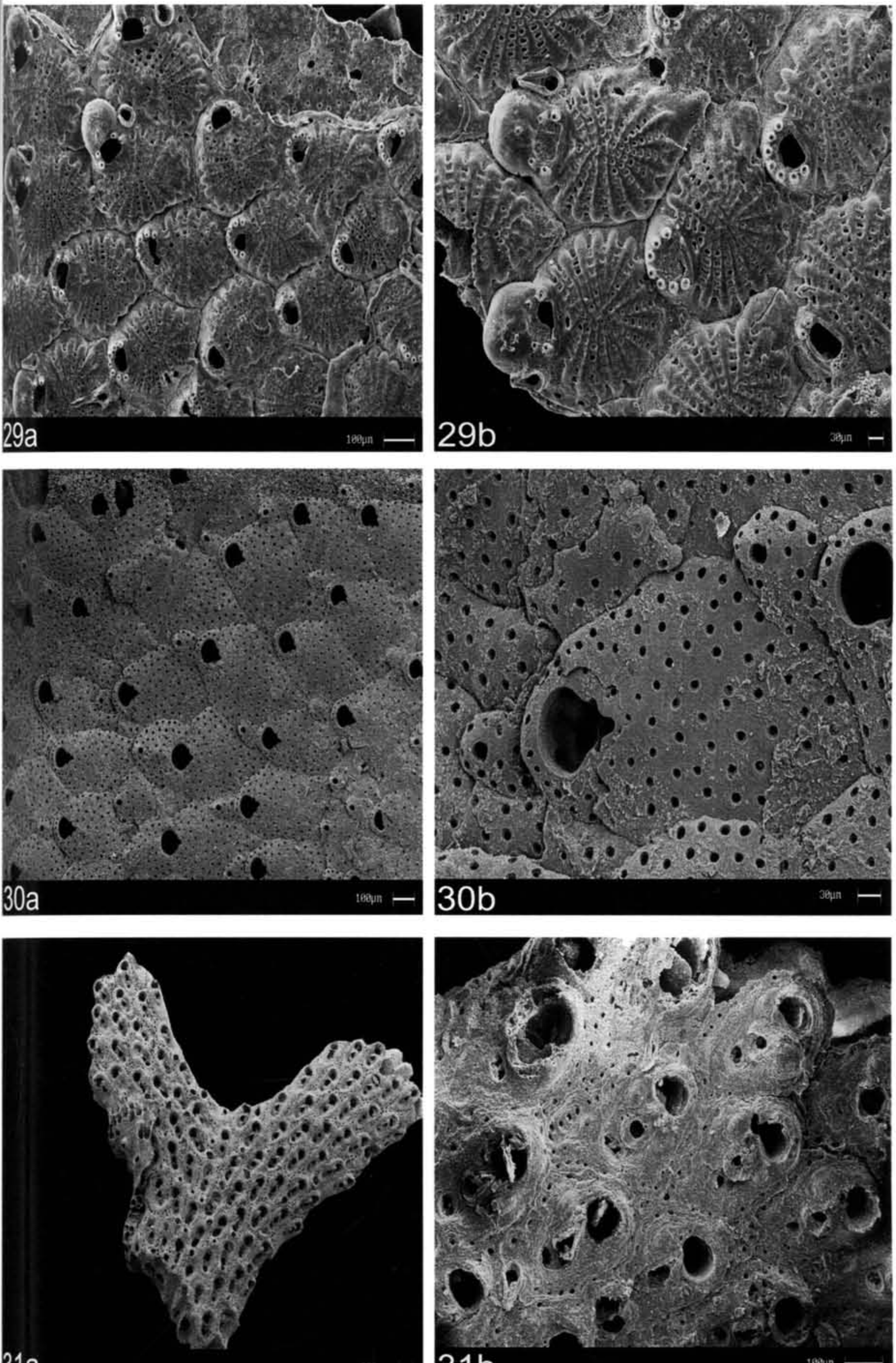


Plate 8. 29. *Puellina vulgaris* Ryland and Hayward, a. Portion of a colony showing the details of zooecia and the interzooecial avicularia, b. Enlarged view of a zooecia. 30. *Trypostega venusta* (Norman), a. Zoarial view, b. Enlarged view of a zooecia with kenozooecia. 31. *Adeona foliacea* Lamouroux, a. Compressed cellariform colony, b. Enlarged view of zooecia.

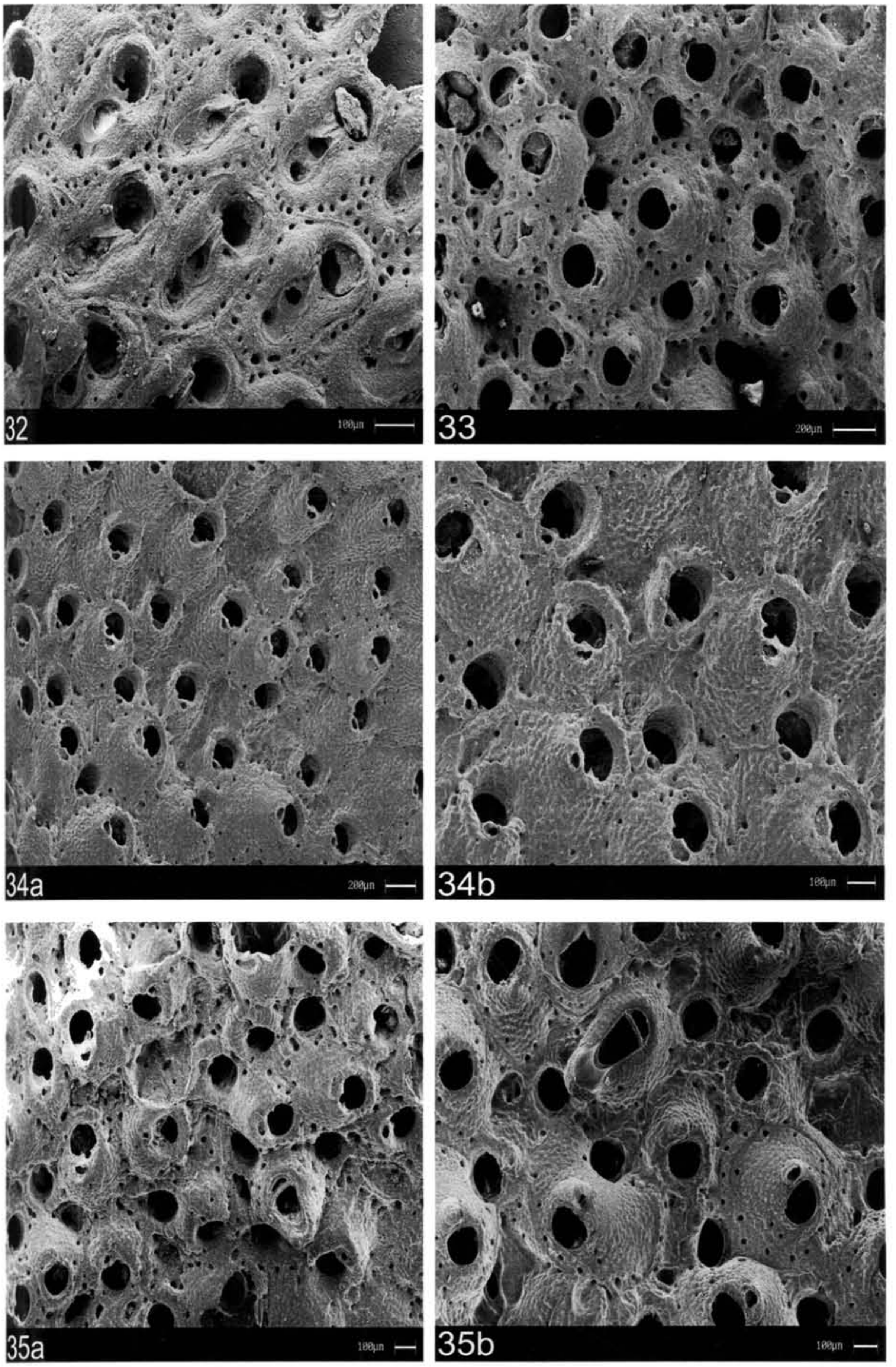


Plate 9. 32. *Adeonellopsis arculifera* (Canu and Bassler), Zooecia and avicularia. 33. *Celleporaria pilaefera* (Lamouroux, 1821), Zooecium with a avicularium and rostrum. 34. *Celleporaria granulosa* Haswell, a. Zoarial view. b. Enlarged view of the zooecia. 35. *Celleporaria magnifica* Osburn, a. Portions of a colony showing the details of zooecia, b. View of the bulbous vicarious avicularia.

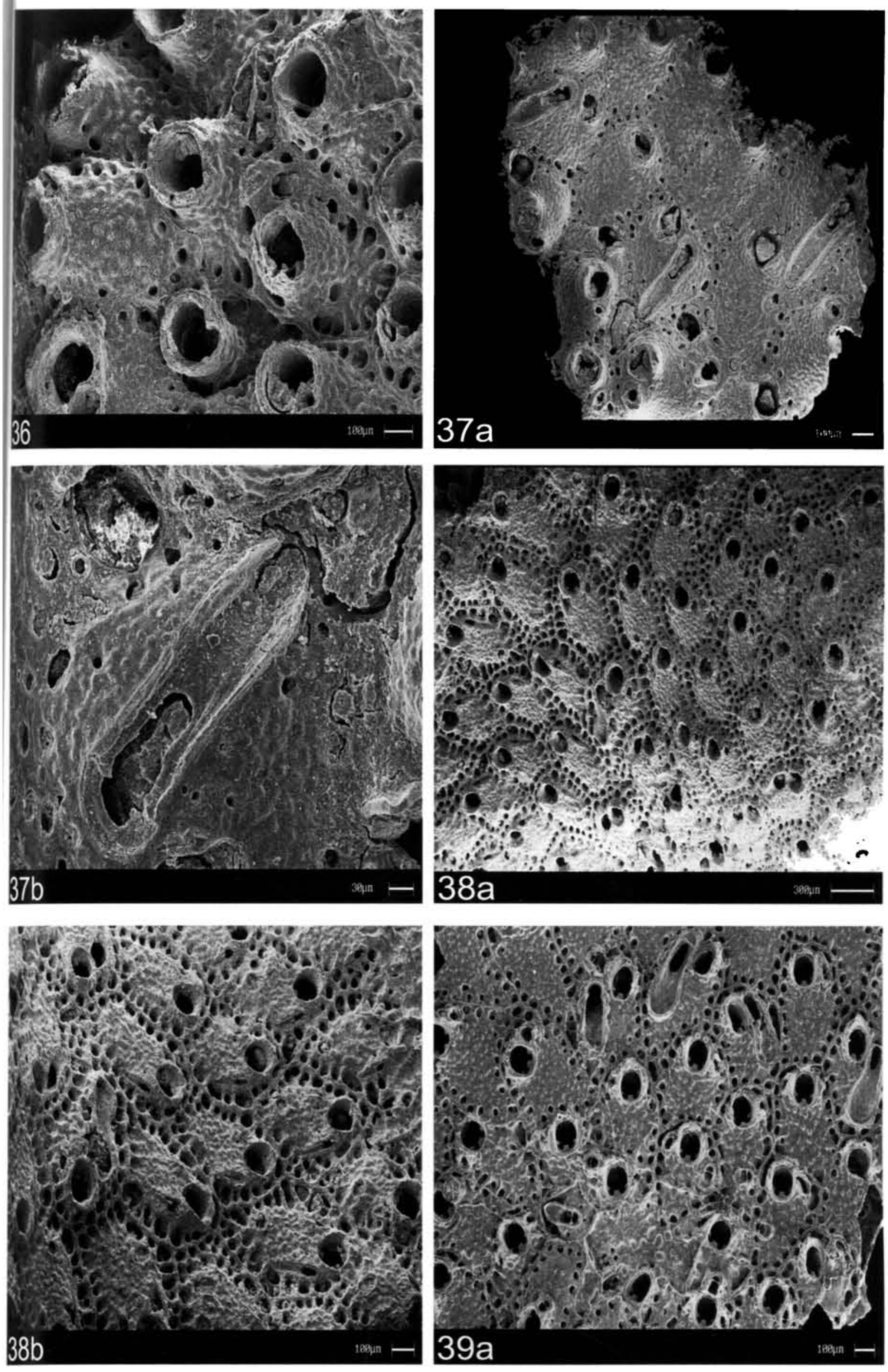


Plate 10. 36. *Drepanophora incisor* (Thornely). 37. *Parasmittina egyptiaca* (Waters), a. Portion of a colony showing the details of zooecia, b. An avicularium enlarged. 38. *Parasmittina hastingae* Soule and Soule, a. A view of the polygonal zooecia. b. Enlarged view showing the acute triangular avicularium. 39. *Parasmittina parsevalii* (Audouin), a. A view of the colony with various avicularia.

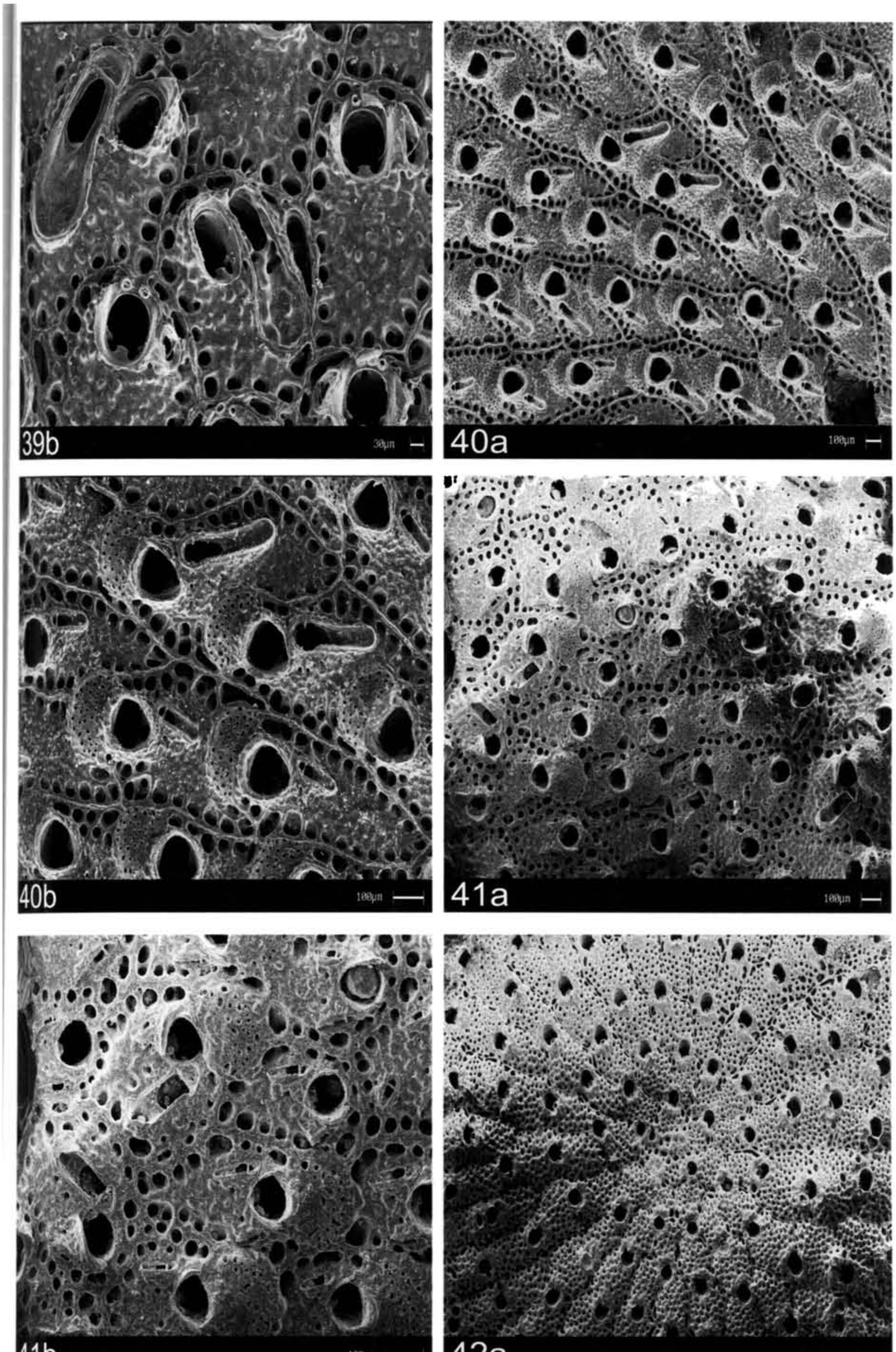


Plate 11. 39. *Parasmittina parsevalii* (Audouin), b. Magnified view of a spatulate avicularium. 40. *Parasmittina signata* (Waters), a. Portion of a colony showing the details of zooecium, b. Zooecium with avicularium and ovicells enlarged. 41. *Parasmittina spatulata* (Smitt), a. Portion of a colony showing the details of zooecium, b. Zooecium with avicularium and ovicells enlarged. 42. *Smittina landsborovii* (Johnston), a. A view of the zoarium.

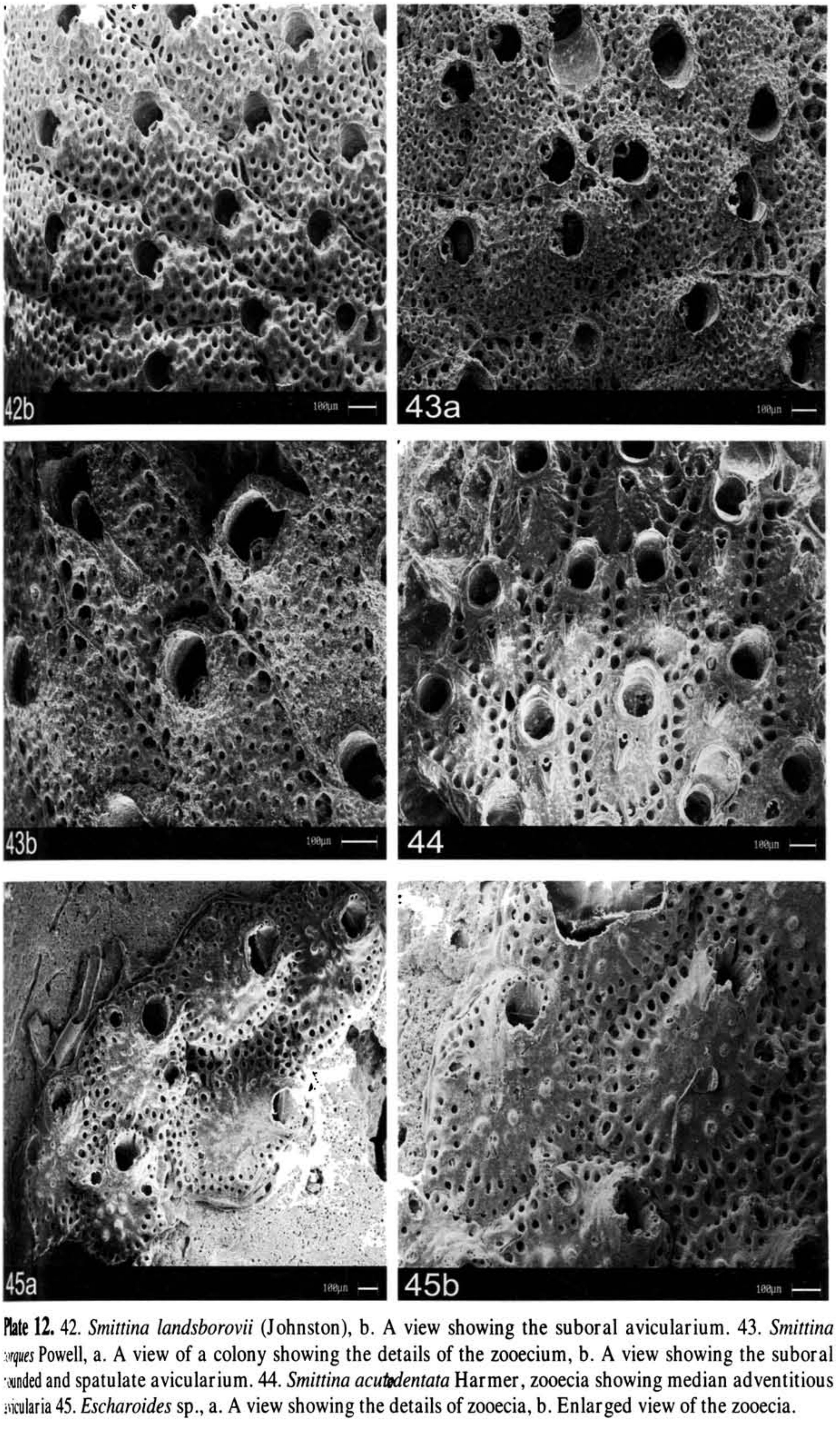


Plate 12. 42. *Smittina landsborovii* (Johnston), b. A view showing the suboral avicularium. 43. *Smittina torques* Powell, a. A view of a colony showing the details of the zooecium, b. A view showing the suboral rounded and spatulate avicularium. 44. *Smittina acutodentata* Harmer, zooecia showing median adventitious avicularia 45. *Escharoides* sp., a. A view showing the details of zooecia, b. Enlarged view of the zooecia.

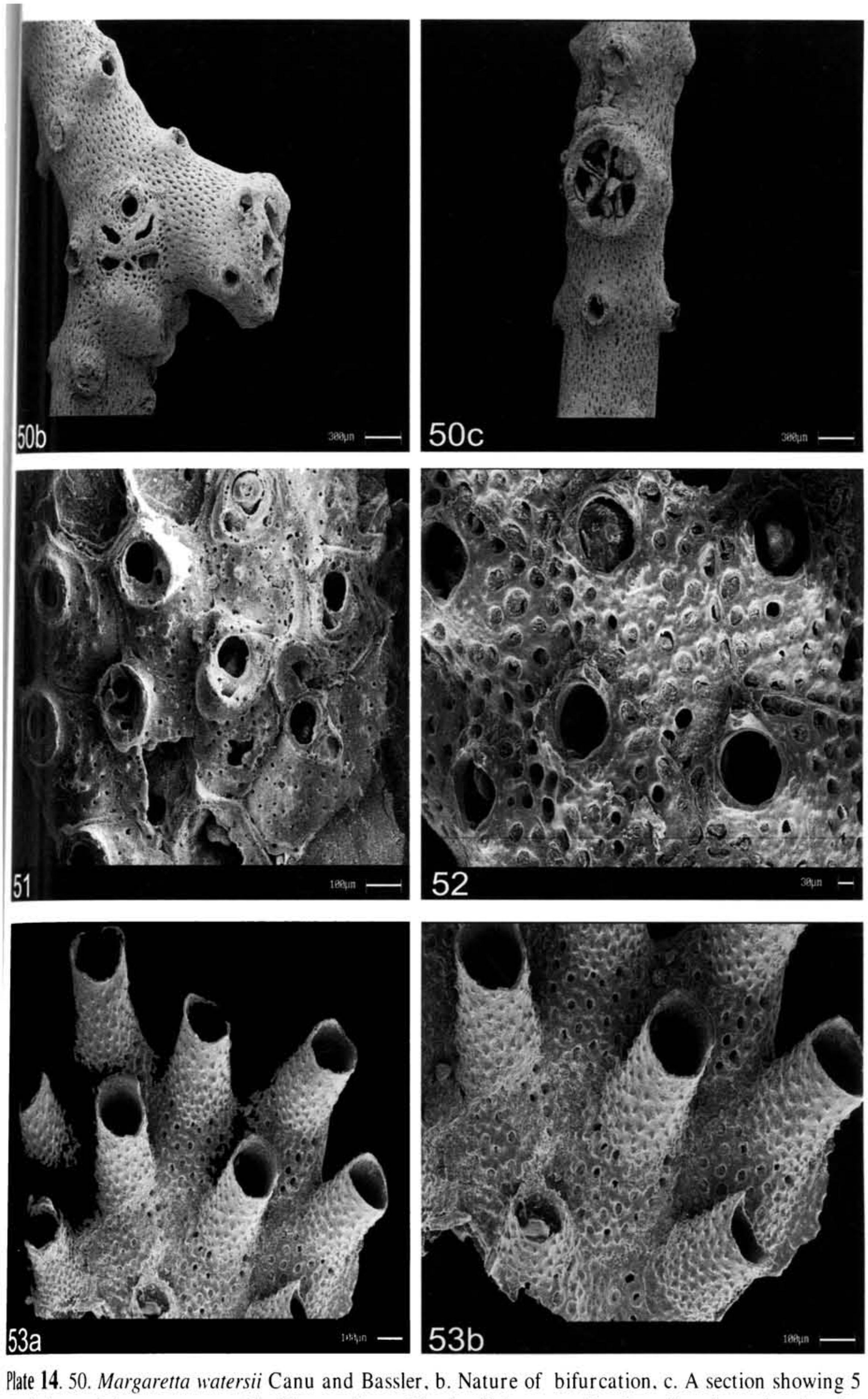


Plate 14. 50. *Margaretta watersii* Canu and Bassler, b. Nature of bifurcation, c. A section showing 5 whorled zooecial arrangement. 51. *Hippopodina californica* Osburn, a. Portion of a colony showing the details of primary orifices and avicularia. 52. *Cryptosula pallasiana* Moll, 53. *Actisecos regularis* Canu and Bassler, a. A view of the zoarium with tubular peristome, b. Enlarged view of the zooecia.

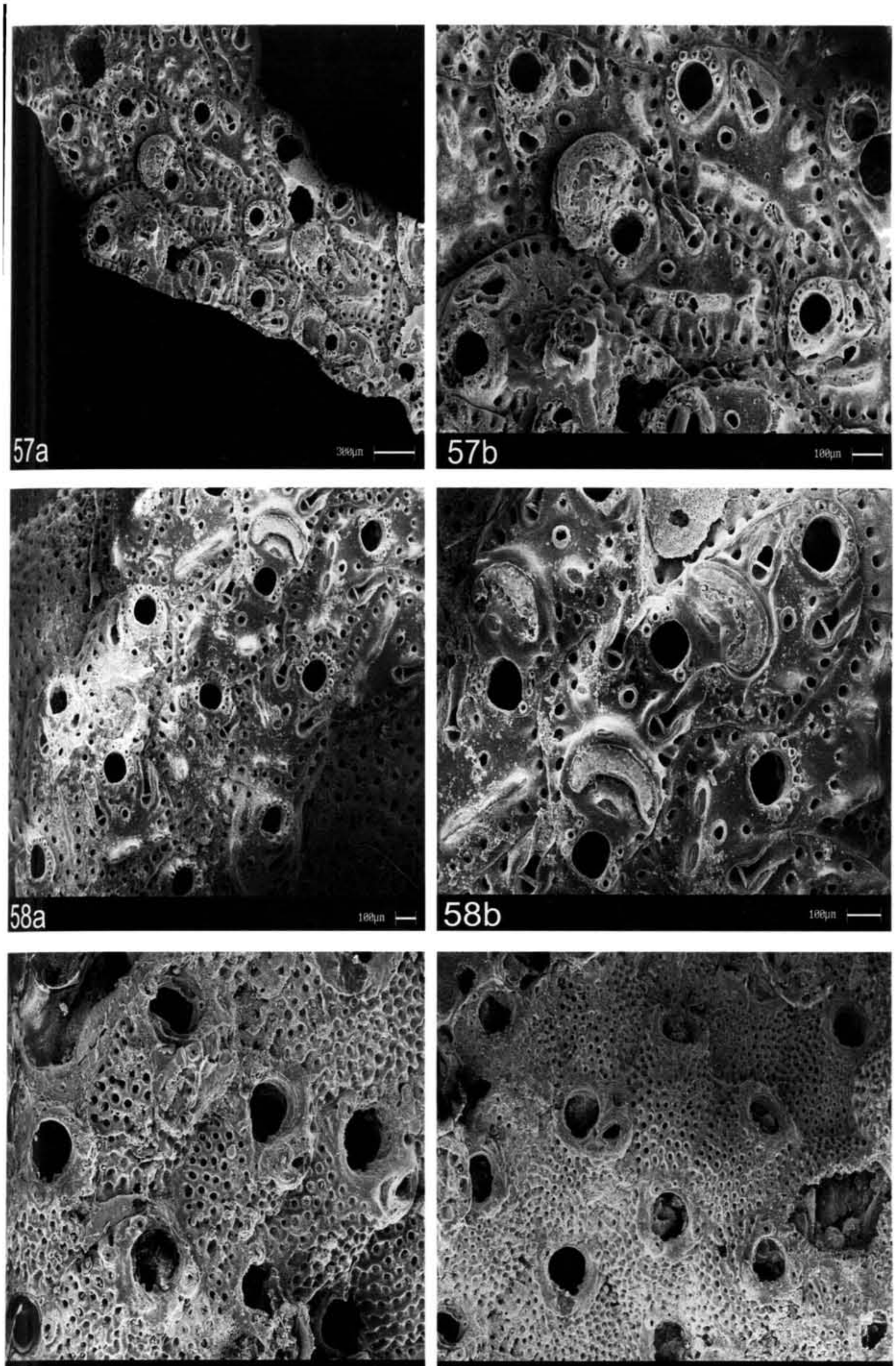


Plate 16. 57. *Calloporina sigillata* Canu and Bassler, a. A fertile zoarium, b. Enlarged view of the zooecia. 58. *Calloporina sculpta* Canu and Bassler, a. A view of the zoarium with ovicells, b. Enlarged view of the zooecia. 59. *Sinupetraliella affinis* Harmer, a. Portion of a colony showing the details of primary orifices and minute lateral avicularia, b. Zoarial veiw.

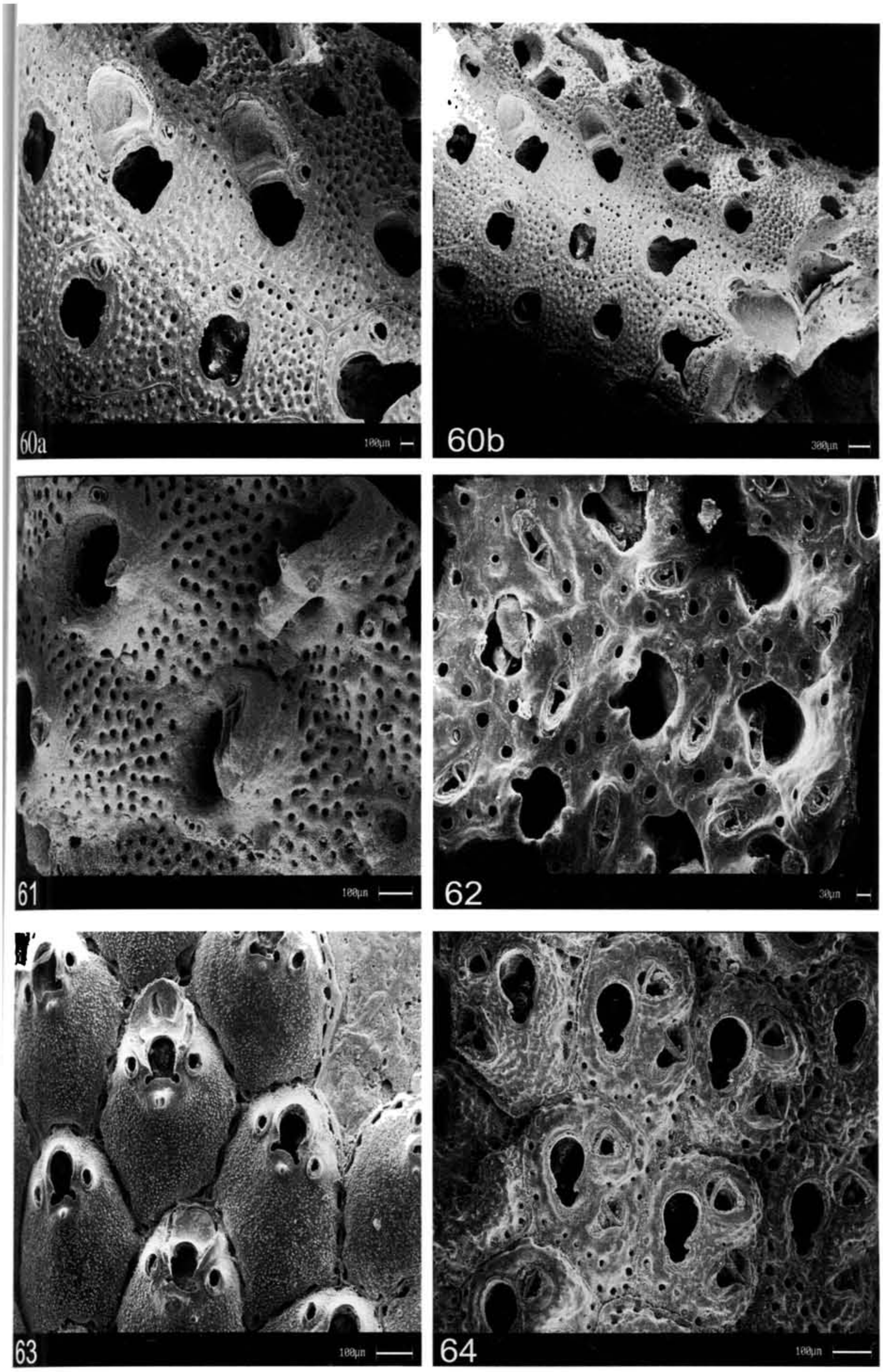


Plate 17. 60. *Hippopetraliella magna* (D'Orbginy), a. Form of the colony, b. Enlarged view of a colony showing the details of zooecia. 61. *Mucropetraliella thenardii* (Audouin), A view showing the branching mucro. 62. *Mucropetraliella phillipinensis* (Canu and Bassler). 63. *Crepidacantha crinispina* (Canu and Bassler). 64. *Cleidochasma biavicularium* (Canu and Bassler).

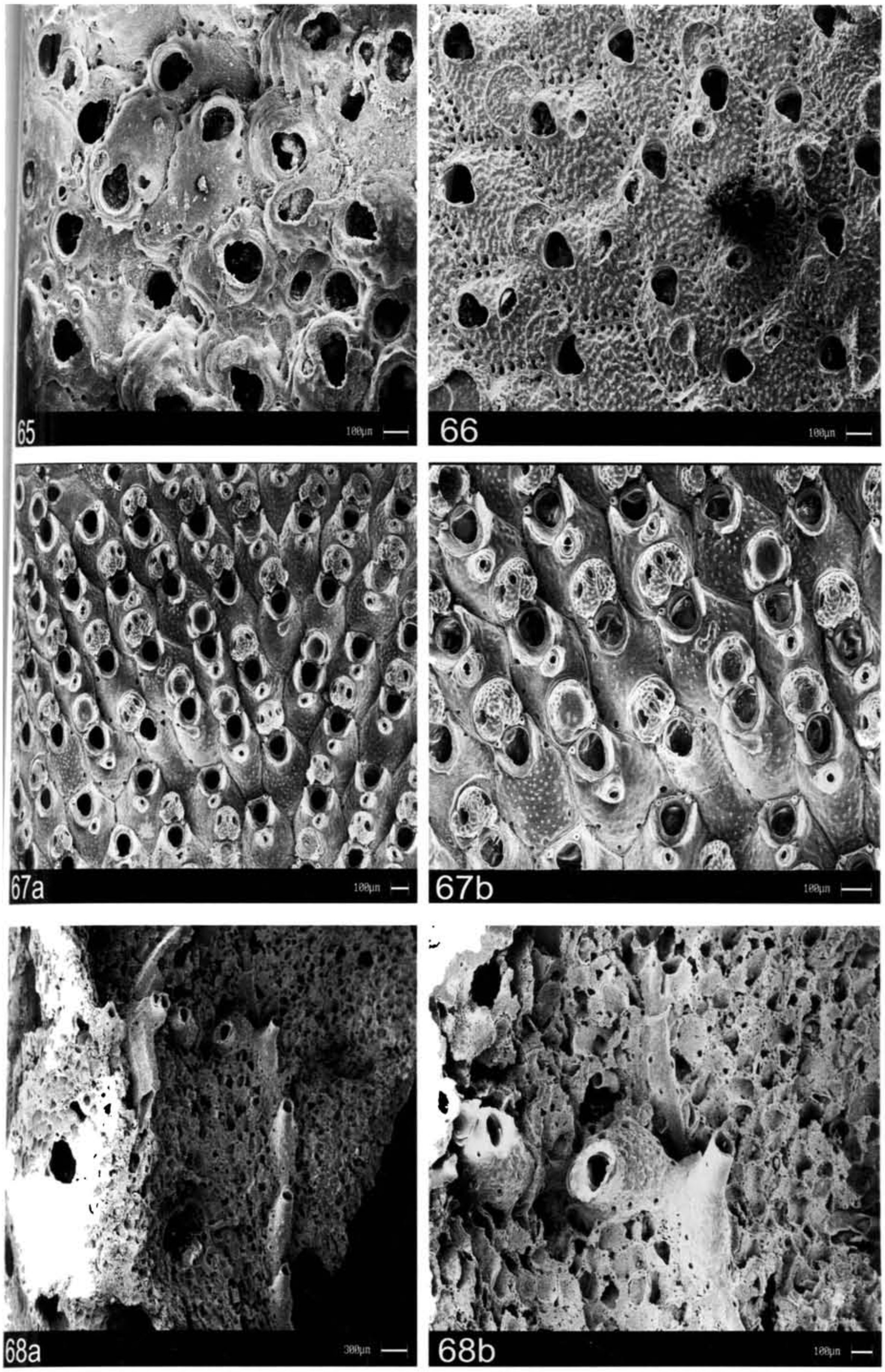


Plate 18. 65. *Cleidochasma fallax* Canu and Bassler. Portion of a colony showing the details of zooecia and a spatulate avicularium. 66. *Cleidochasma protrusa* (Thornely). 67. *Cleidochasma sampada* sp. *novo.* a. Zoarial view, b. Enlarged view of a colony showing the details of zooecia, avicularia and ovicells. 68. *Lagenicella marginata* (Canu and Bassler), a. Form of the colony, b. Flared peristome.

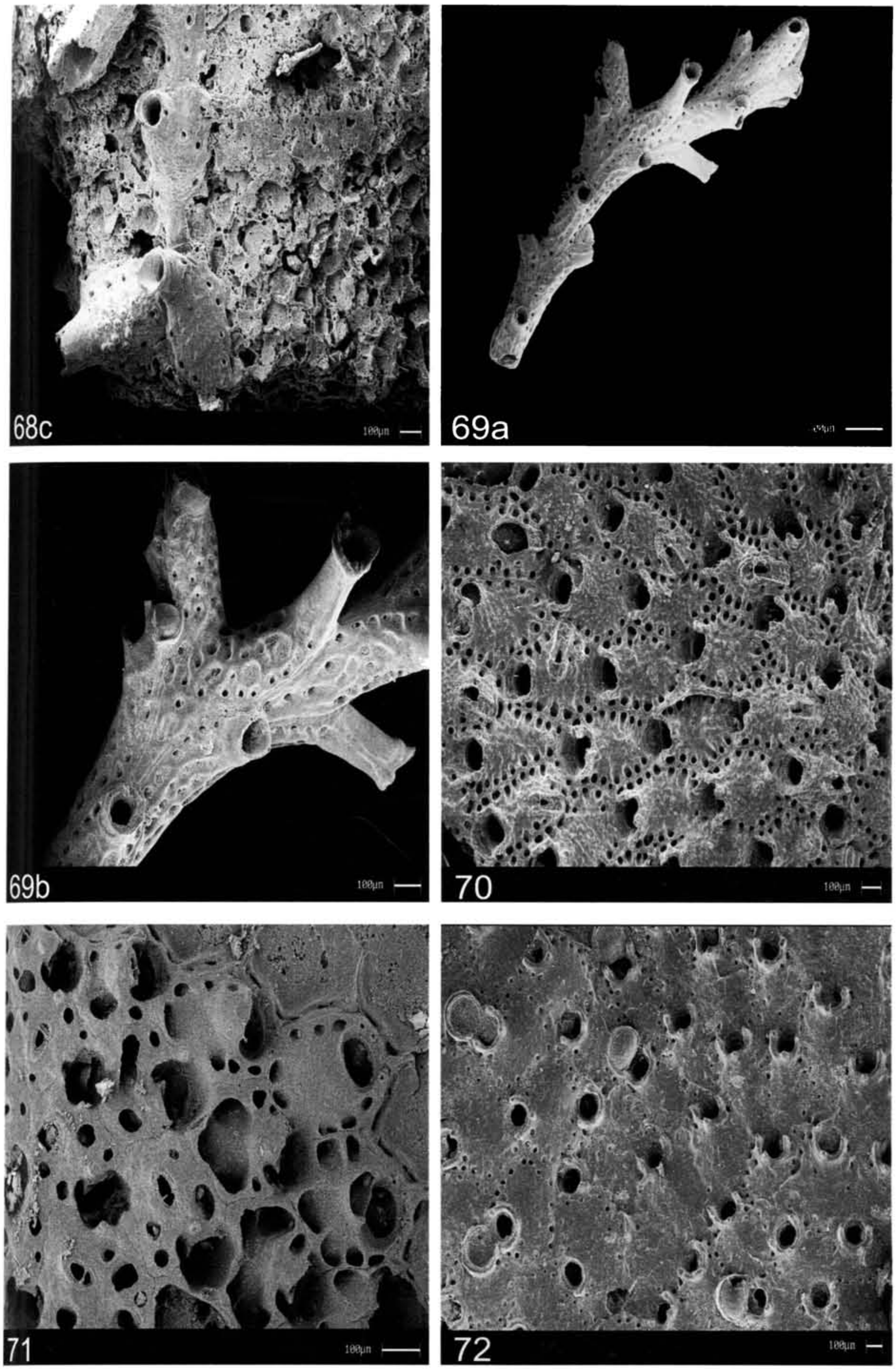


Plate 19. 68. *Lagenicella marginata* (Canu and Bassler), c. Zooecia with two minute lateral avicularia. 69. *Lagenicella punctulata* (Gabb and Horn), a. Zoarial view, b. Enlarged view of the zooecia with tubular peristome and two minute lateral avicularia. 70. *Rhynchozoon compactum* (Thornely).71. *Rhychozoon larreyi* (Audouin). 72. *Rhynchozoon globosum* Harmer. A mature colony.

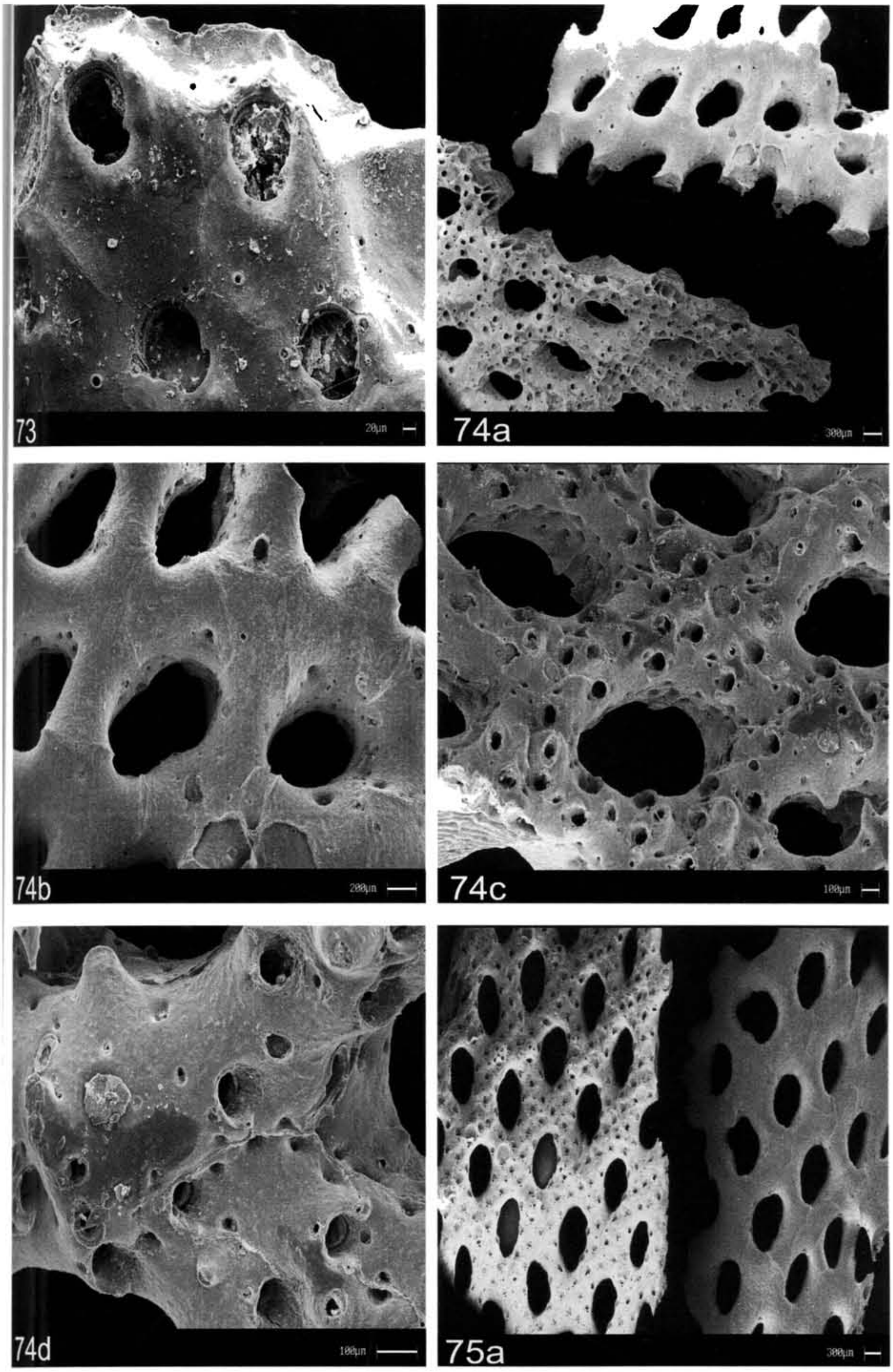


Plate 20. 73. *Metacleidochasma planulata* (Canu and Bassler), Portion of a colony showing the details of zooecia. 74. *Triphyllozoon tubulatum* (Busk), a. Frontal and ventral view of the colony, b. Ventral view enlarged, c. Frontal view, d. Frontal view enlarged showing the details of zooecia. 75. a. *Triphyllozoon philippiensis* (Busk), a. Frontal and ventral view of the colony.

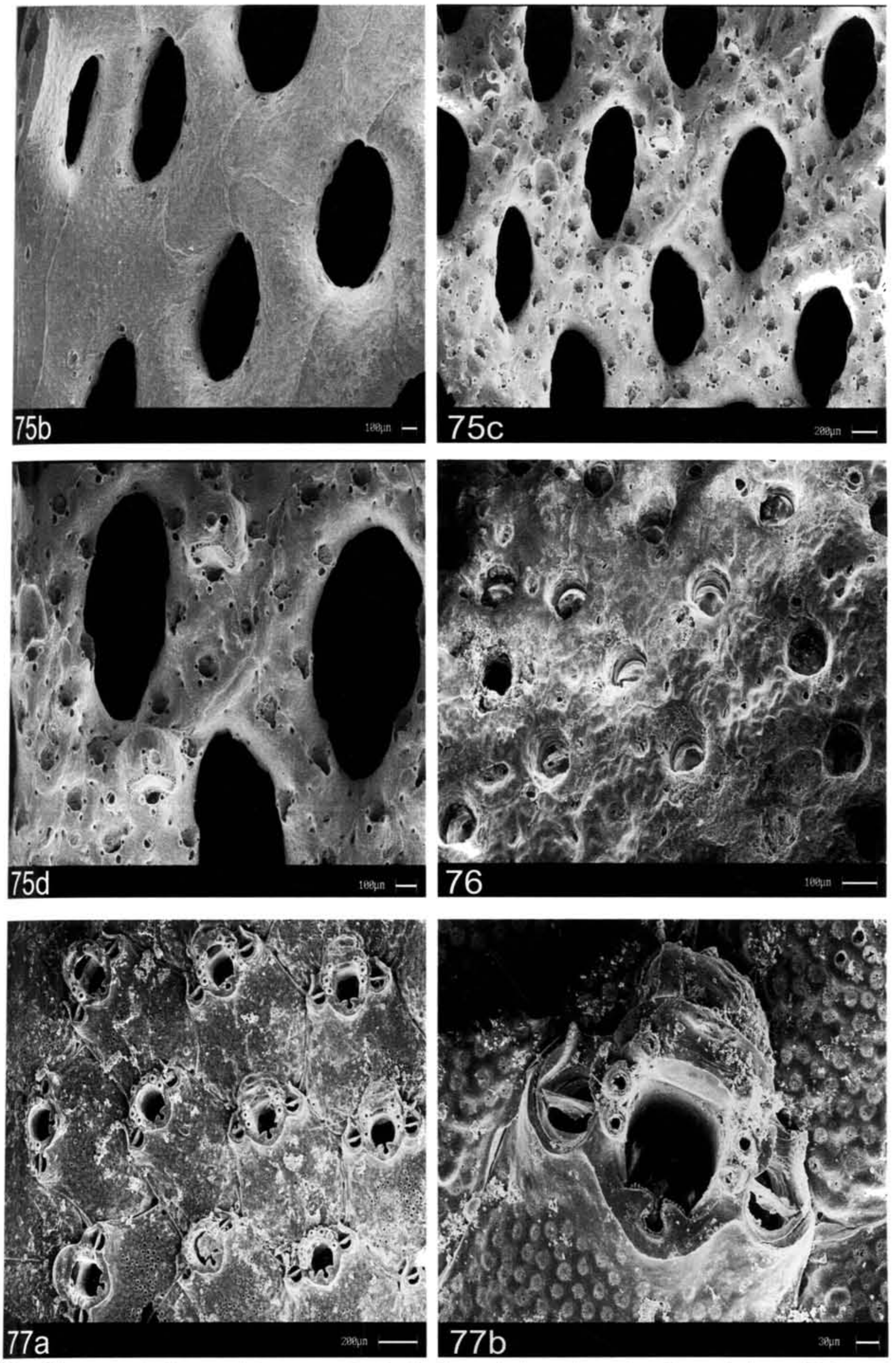


Plate 21. 75. *Triphyllozoon philippiensis* (Busk), b. Ventral view enlarged, c. Frontal view, d.Enlarged frontal view of a mature colony. 76. *Conescharellina jacunda* Canu and Bassler,77. *Escharina pesanseris* (Smitt). a. Portion of a mature colony showing the details of zooecia , b. Enlarged view of the orifice and avicularia.

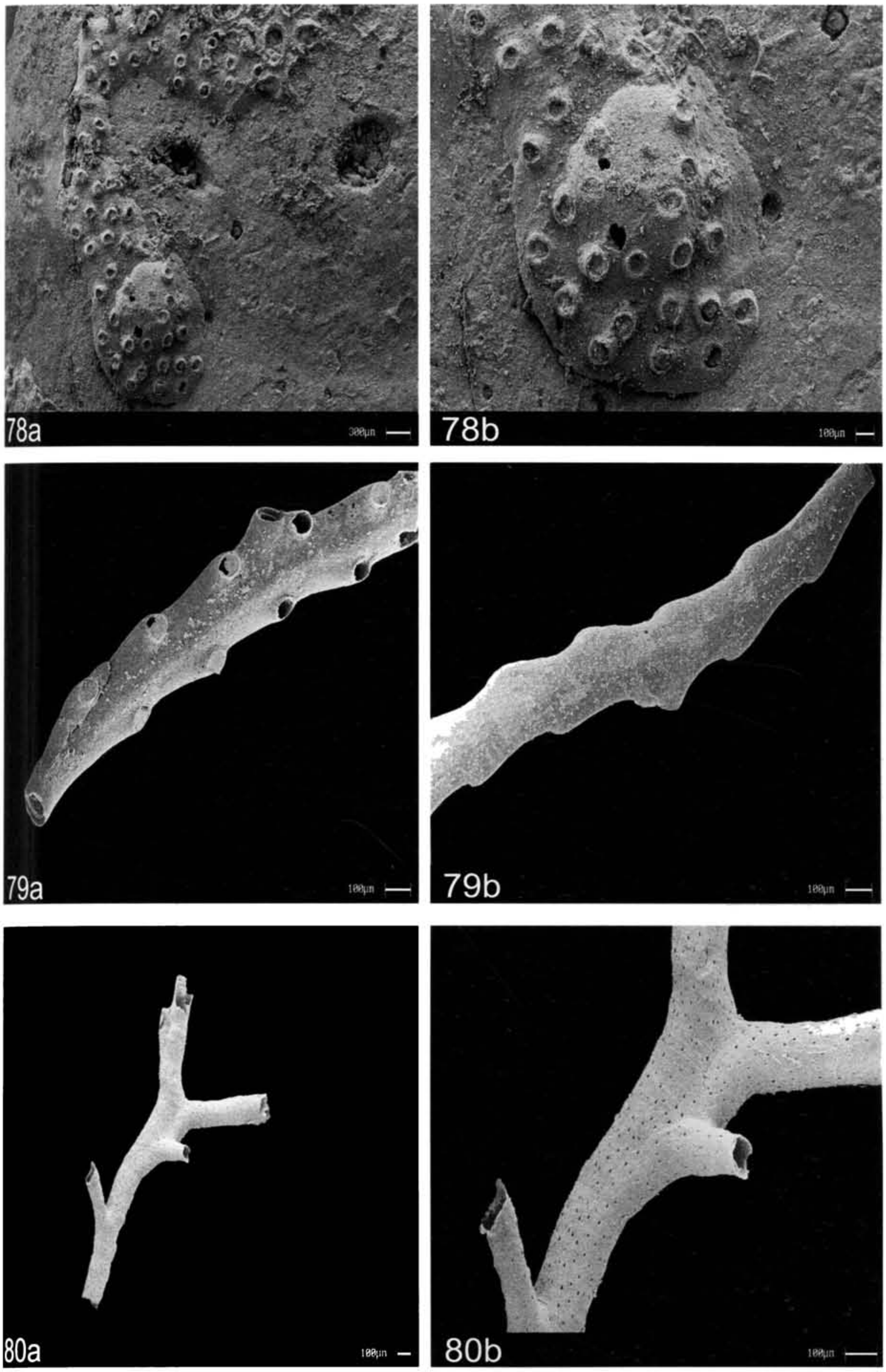


Plate 22. 78. *Proboscina lamellifera* Canu and Bassler. a. Form of the colony. b. Enlarged view of the oecium. 79. *Crisia elongata* Milne Edwards. Form of the colony. a. Frontal view. b. Ventral view. 80. *Filicrisia* sp. a. Form of the colony. b. Enlarged view of the colony.

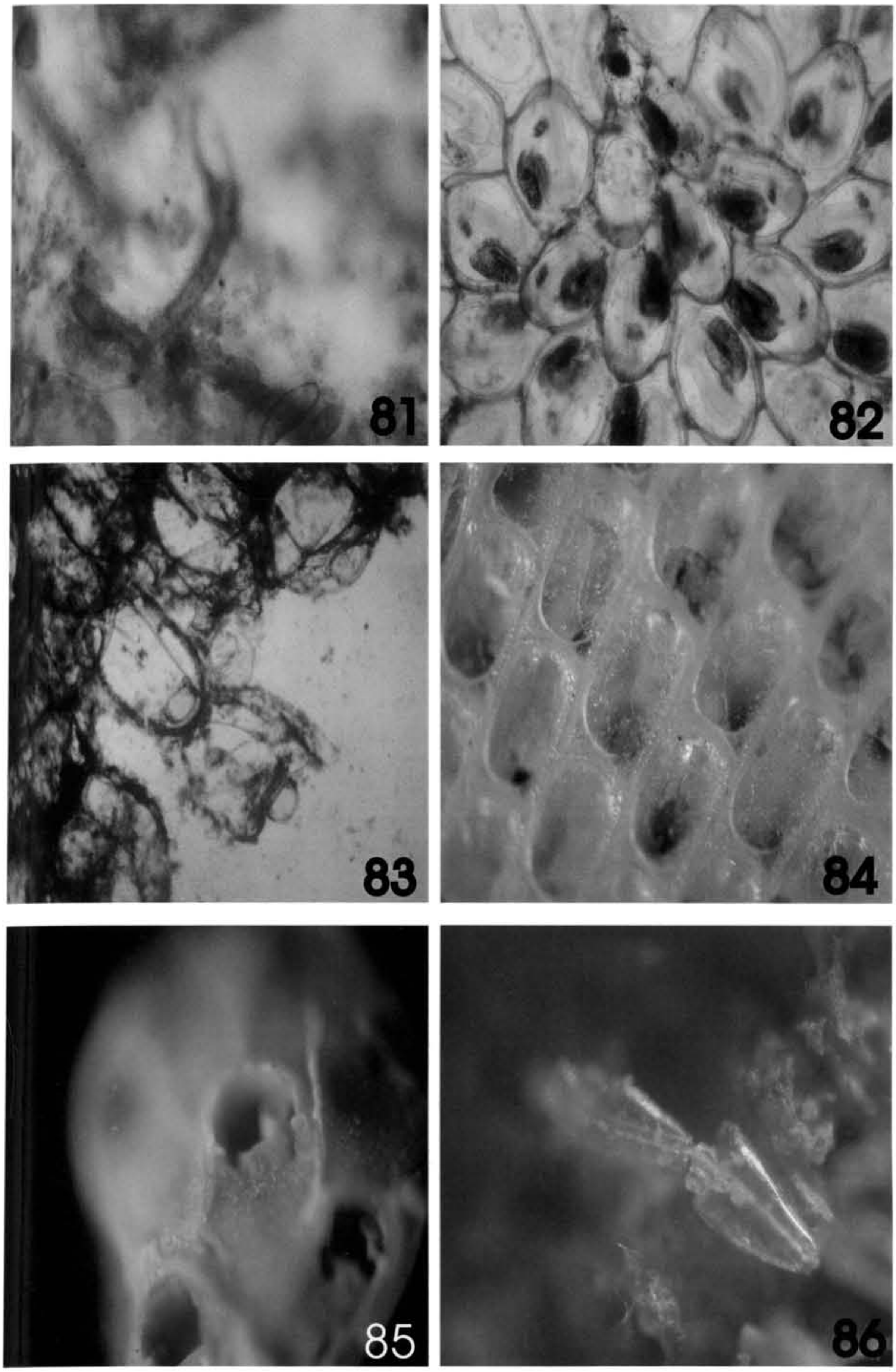


Plate 23. 81. *Aetea anguina* (Linnaeus), Form of the colony. 82. *Electra crustulenta* (Pallas), Portion of a live colony showing details of the zooecia. 83. *Electra crustulenta* var. *borgii* Menon and Nair, Rim of a colony showing the simple nature of the less calcified zooecial walls. 84. *Alderina arabianensis* Menon and Nair, 85 *Caleschara mexicana* Osburn. 86. *Synnotum aegyptiacum* (Audouin).

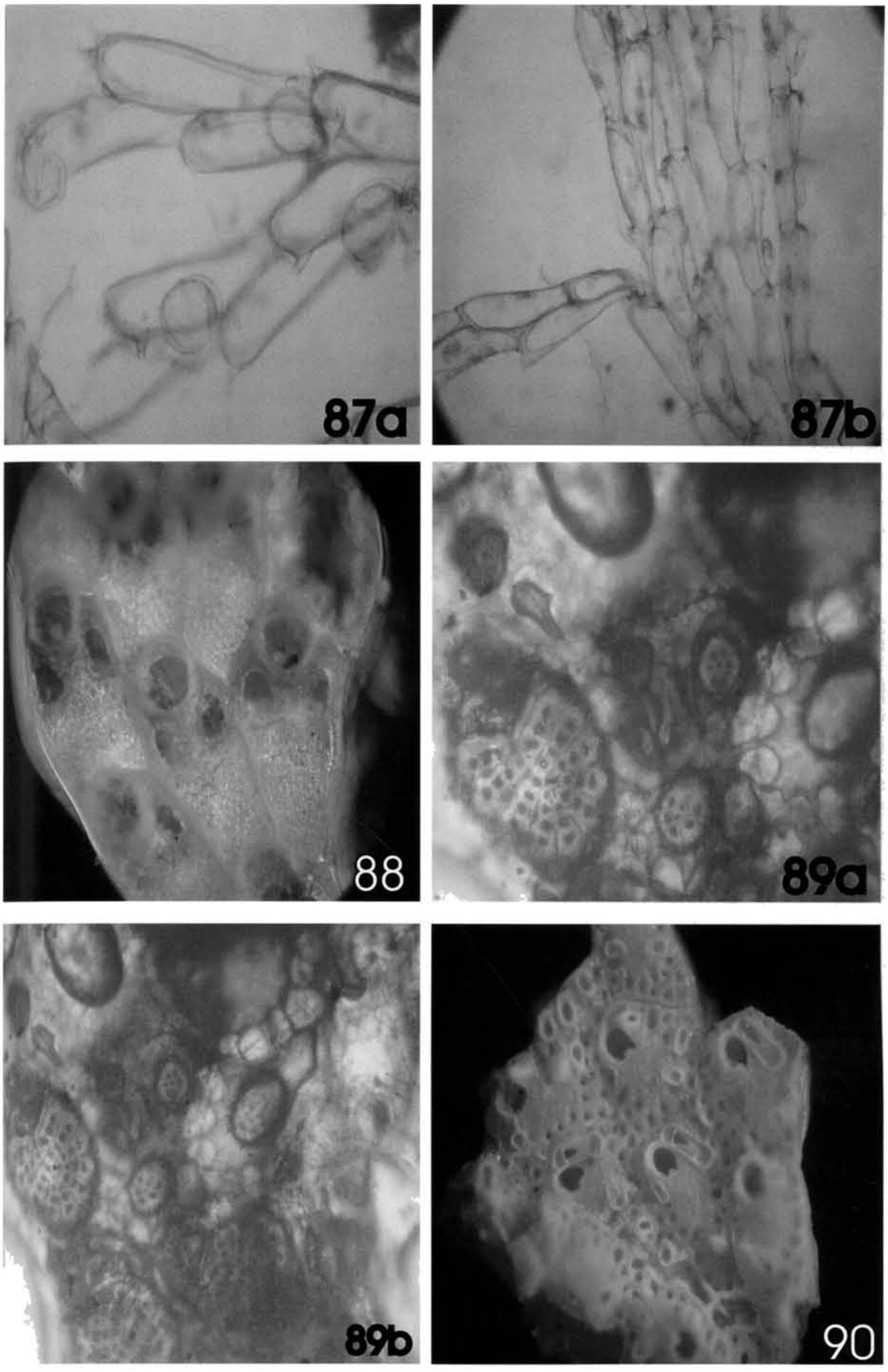


Plate 24. 87. *Bugula cucullata* Busk. a. Avicularia, ovicell, b Portion of a colony showing the details of zooecia. 88. *Thalamoporella rozierii* (Audouin). 89. *Cribriliaria* sp., a. Zooecia at different stages of growth, b. Interzooecial spaces. 90. *Parasmittina aviculata* (Mawatari).

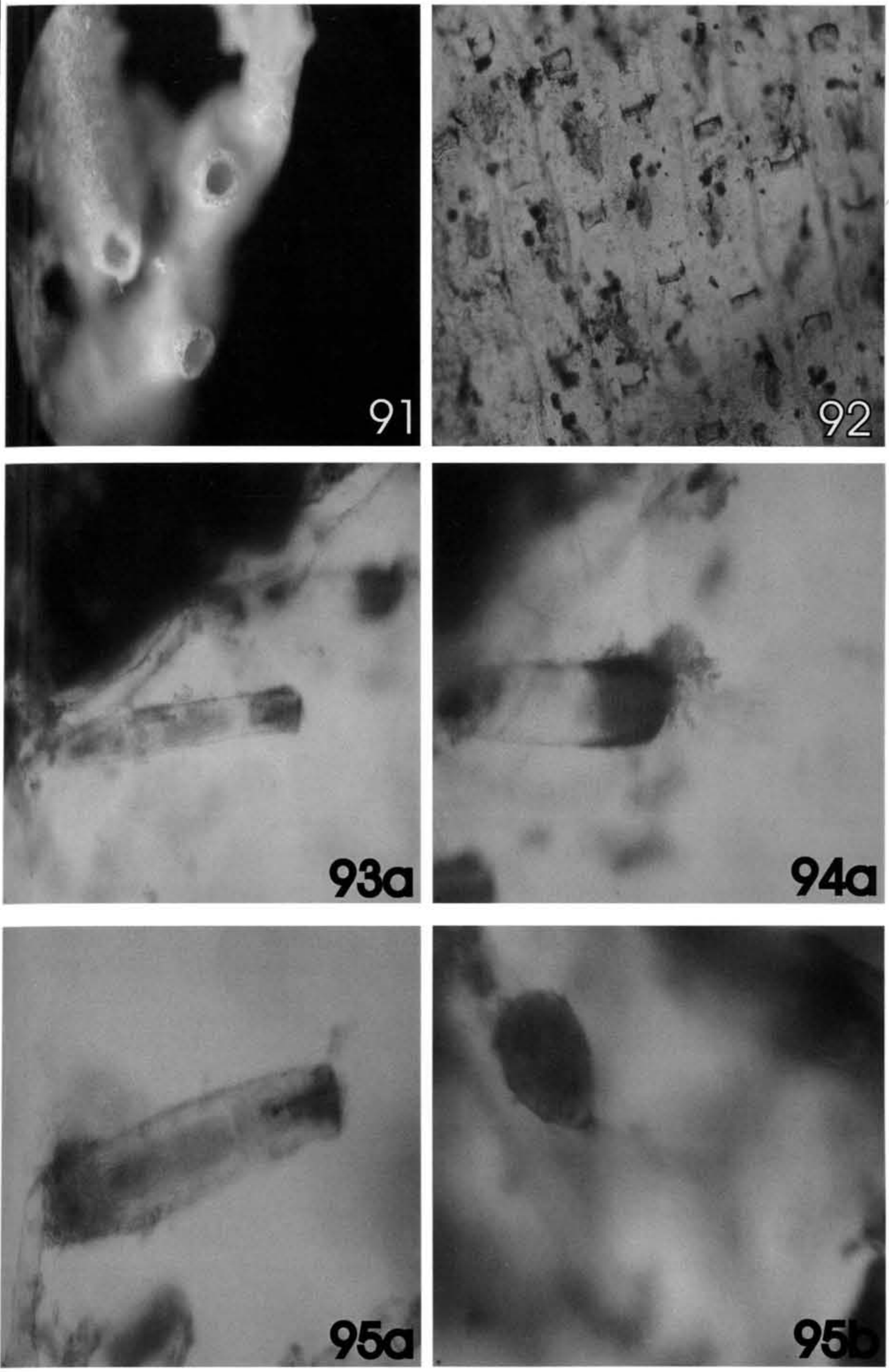


Plate 25. 91. *Stomatopora granulata* (Milne-Edwards), Portion of a colony showing the uniserial zooecia. 92. *Alcyonidium erectum* (Silen). 93. *Victorella pavida* Kent, a. A simple zooid. 94. *Bowerbankia gracilis* Leidy, a. Zooecium with protruded lophophore 95. *Triticella korenii* Sars, a. A single zooid, b. A bud.

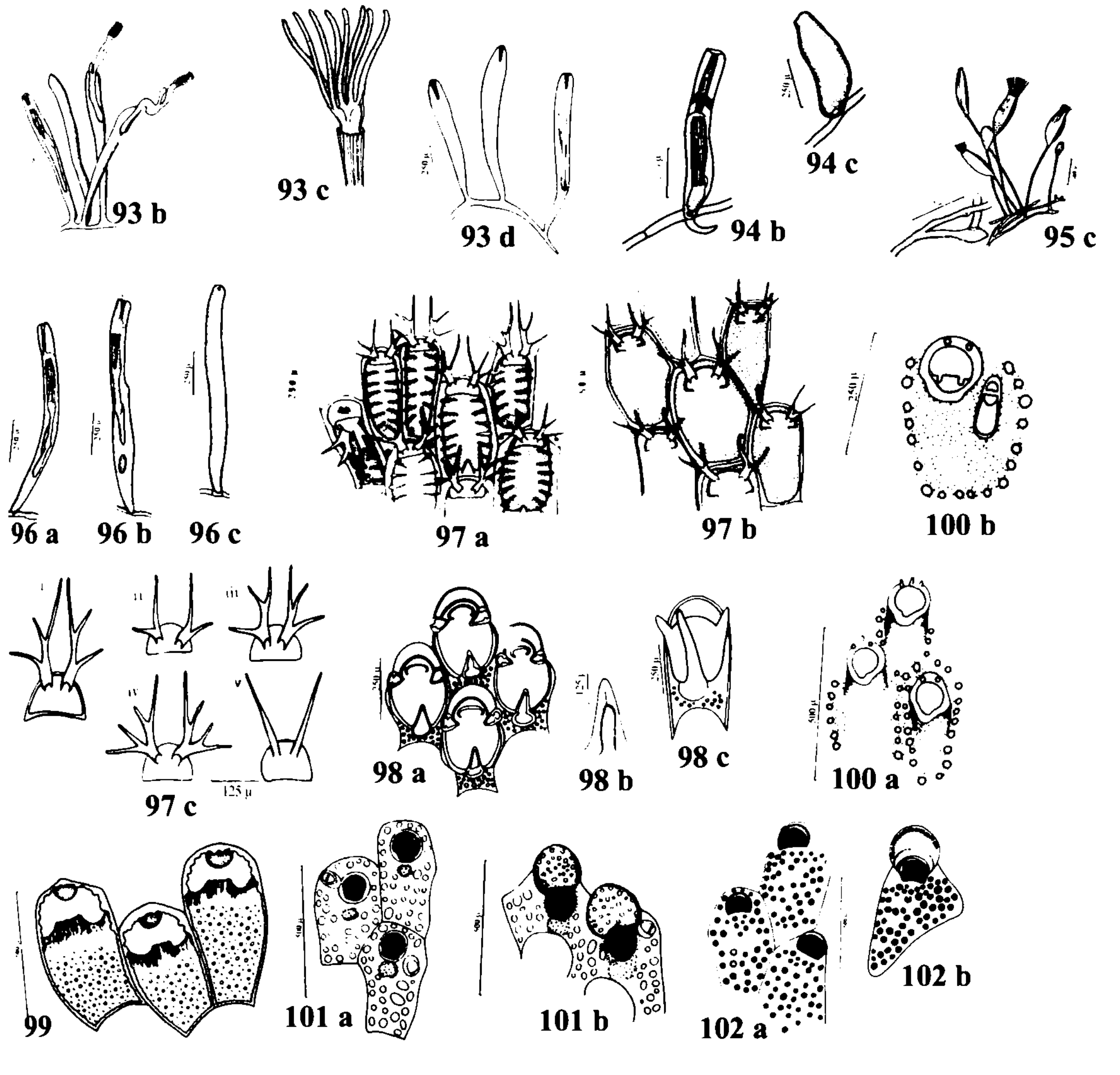


Plate 26. **93**. *Victorella pavida* Kent, b. Zooecium with protruded lophophore, c. Lophophore, d. Disintegrated polypide. **94**. *Bowerbankia gracilis* Leidy, b. A zooid with a caudate end, c. An empty zooid. **95**. *Triticella korenii* Sars, c. A portion of the colony. **96.** *Nolella papuensis* (Busk), a. A single zooid. b. A zooid with a brown body. c. An empty zooid. **97.** *Electra bengalensis* Menon and Nair, a. Portion of a colony showing the details of zooecia, b. Zooecia without marginal spines, c. Operculum; i-v. Opercula with varied spines. **98.** *Electra indica* Menon and Nair, a. Portion of a colony showing the details of zooecia, b. Lateral tubercle, proximal tubercle, c. A zooecium with an elongated tubercle. **99**. *Labioporella sinuosa* (Osburn). **100**. *Parasmittina tubula* (Kirkpatrick), a. Portion of a colony showing the details of zooecia, b. A zooecium with the avicularium (see the Lyrule and the cardelles). **101**. *Schizoporella cochinensis* Menon and Nair, a. Portion of a colony showing the details of zooecia, b. Two fertile zooecia. **102.** *Fenestrulina malusii* Audouin, a. Portions of a colony showing the details of zooecia, b. A fertile zooecium. (Courtesy Menon, 1967; 1972 b, c and Menon and Nair, 1970 a)

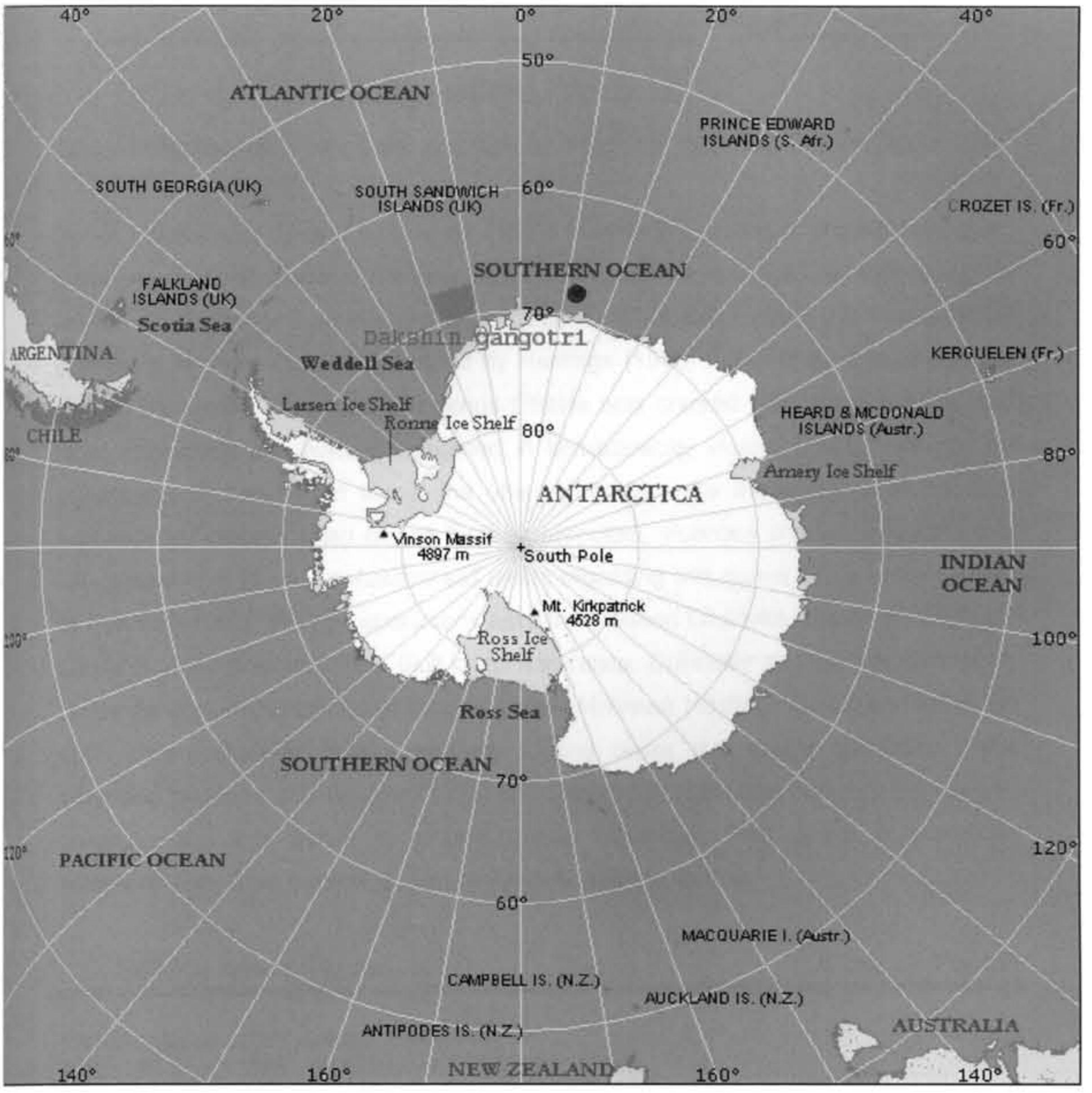


Fig. 5 ORV Sagar Kanya : Antarctic Station: Dakshin Gangothri

Genus *Ellisina* Norman, 1903

Ellisina Norman, 1903: 596; Canu and Bassler, 1917: 19; 1920: 84; Osburn, 1950: 104.

Genus *Ellisina* was created by Norman (1903) to include specimens originally assigned to the genus *Membranipora*. The species described by Hincks in 1882 as *Membranipora levata* was designated as the genotype. Osburn (1950) has quoted the distinguishing characters of three species described by Hastings (1945) under *Ellisina* to assign the generic character. Therefore, the genus *Ellisina* was created from three species and those characters are ovicells immersed in kenozooecia, vicarious avicularia and an autozooecium. Apart from these, the other characters are membraniporine zooecia; endozooecial ovicells often closed by the operculum, vicarious pointed avicularia and lateral pore chambers. Confusions still exists regarding this genus since when erected by Norman (1903), the type specimens were from Queen Charlotte Islands although the diagrams were prepared from Gulf of St. Lawrence. Curiously enough the Gulf of St. Lawrence specimens belong to another genus. However Hastings (1945) corrected this error. Examination of various species coming under this genus especially those described by Canu and Bassler (1923) has resulted in assigning some of the species coming under this genus to a new genus *Ellisinidra*. This genus is noted for representations from tropical, subtropical and temperate waters.

103. ***Ellisina levata*** (Hincks), 1882 — **Plate 27: Fig.103**

Membranipora levata Hincks, 1882: 249.
Ellisinidra levata Canu and Bassler, 1933: 18.
Ellisina levata Hastings, 1945: 87; Osburn, 1950: 104.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 965 µ; l_z=550 µ

Encrusting zoaria although showing smooth surface under simple microscope is provided with distinct gymnozooecial and cryptozooecial tubercles. The size of the zooecia varies between 900 to 1000µ and 500 to 600 µ. The zooecia are separated by conspicuous wedges. Gymnocyst is very narrow and should be manifested clearly laterally. Cryptocyst is tuberculated and broad proximally. Opesial chamber could be elliptical, oval or sometimes elongated. Zooecia at the area of branching, possess broadened gymnocyst. The ratio between opesial area and the calcareous zooecial walls is very high. Interzooecial avicularia are invariably present and are laterally directed. There are distinct calcareous protuberances separating the proximal part of the avicularia from the distal portion. The distal part of the avicularia is slightly elevated and the mandibular tip is triangular. Pore chambers are present with porous dietellae. The elevation of the rostral part of the avicularium is provided with smooth calcareous deposits. The ooecium is embedded in between zooecia. The proximal portion of the ovicell is not calcified. The margin between the zooecia and ovicell is not frontally visible. The position of the ovicell on the proximal part of the zooecia enables opercular closure of the zooids.

Remarks: The present record of this species from Antarctica extends the distributional domain of this species to the Southern Ocean. A very interesting feature is the conspicuous difference in the dimensions of the zooecium. While Hastings (1945) and Osburn (1950) found colonies of moderately smaller zooecium. The material under observation here is distinctly large, although morphologically similar. This probably indicates the possibility of extended growth of the colony before attaining sexual maturity. It is not clear whether changes in morphometrics could substantiate placement of the material under a new variety. Not withstanding this it looks logical to assign them to the already existing species and possibly look into the reasons for enlargement of the zooecium. The bulbous kenozooecia harbouring the ovicell is typical and probably Hastings (*loc.cit.*) demands the creation of a new species, which she named as *E. antarctica* under *E. levata* by Osburn.

Records from the Antarctic waters: This is the first record of this species from the Antarctic.

Distribution: Houston Stewart Channel, Cumshaw, British Columbia (Hastings, 1945); Santa Barbara Islands, California (Osburn, 1950).

Genus *Amphiblestrum* Gray, 1848

Amphiblestrum Gray, 1848: 660.

Encrusting zoaria, opesia trifoliate.

104. ***Amphiblestrum inermis*** (Kluge), 1914 **Plate 27: Fig.104**

Membranipora inermis Kluge, 1914: 663.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 720 - 900μ; l_z= 420μ

Encrusting zoaria, with large hexagonal either narrow or broad zooecia. The margins of the zooecia are raised and typically rounded and minutely denticulate giving a distinct margin, separating the adjacent zooecia. The cryptocyst proximally granulated and distally smooth. The opesia is trapezoid. The varied development of the cryptocyst and bilateral projections into the opesia in distinct manner at four locations give the opesium a very characteristic trifoliate structure. There are well-developed ovicells, which have distinct, median, less calcified and proximodistally raised margins giving them typical hooded appearance. The vicarious avicularia superimposes the proximal region of the zooid and the greater development of the rostral structure gives them a bulbous appearance. The pointed mandibles have a medium sclerite with a distinct triangular distal portion and a rounded proximal end. The zooids are characteristically calcified. Very minute adventitious avicularia could be noticed in some zooids. Pore plates present.

Remarks: The present finding of substantially grown, sexually mature specimens from the Antarctic is of immense distributional importance. Harmer who has done intensive work on distribution of bryozoans of the Indo-Australian Archipelago has not come across *A. inermis.* The bathymetry of this particular species is of interest since they are normally found in deeper waters ranging from 20-300 m where the bottom characteristics have been described basically formed of stone, gravel or silt. The present material was collected from a depth of 200 m were the temperature was –2°C and possibly below 1% light depth. The nature of calcification in the present material is of interest in that, the zooecia are very delicate in structure and possibly contain more refined calcium carbonate which would be having a greater shear strength once the skeleton is incorporated with chitinous material. The presence of ovicells with “miter-like” shape, which is less calcified probably, is due to replacement of the operculum, which normally shields the opening of hyperstomial ovicell. *M. inermis* was described by Kluge (1914), as a new species from the collections of German south polar expedition 1901-1903 and any further comment would be made after inspecting the specimens of Kluge deposited in the Berlin museum.

Records from the Antarctic waters: Gauss station, Antarctica (Kluge, 1914).

Distribution: Antarctic waters (Kluge, 1914).

Family Chaperiidae Jullien, 1881

Family *Chaperiidae* has been given new diagnosis and has resulted in the inclusion of numerous species majority of which were made by Gordon 1982. Though Jullien established the family in 1881, Canu (1900) erected a new genus based on an extinct genus *Marginaria* that was also grouped under *Chaperiidae* by Jullien. Canu (*loc.cit.*) placed the specimens referred by Jullien in a different family resulting in a single genus for the family *Chaperiidae*. Jullien (*loc.cit.*) emphasises the size of opesia and occlussor laminae associated with the insertion of occlussor muscles. However, Waters (1898) realized that certain genera or species assigned to *Membranipora* (sensu lato*)*, belonged to *Chaperia*. However he had to stick to the basic characters of *Membranipora*, especially the absence of ovicells and avicularia, when he included the additional genera or species. Levinsen (1909) recognized the importance "of occlussor laminae" although unfortunately, placed *Chaperia* in *Bicellariidae*. Canu and Bassler (1923) followed by Harmer (1926) retained *Chaperia* under *Membraniporidae*. Notwithstanding the above reasons Canu and Bassler (1923) recognized two groups of species under *Chaperia.* Those lacking ovicells and avicularia and those with hypostomial ovicells and avicularia. Harmer (1926) however, felt that the above characters should help in subdividing genus should that happen. Now Gordon (1982) has assigned around 50 species both recent and fossil falling into two groups as indicated by Canu and Bassler (*loc.cit.*). Uttley (1949) proposed a new genus *Chaperiopsis* to include those groups which has got avicularian ovicells. Brown (1952), however, rejected this classification. The findings of Uttley and Bullivant (1972) introduced three new generas with species which has ovicells, avicularia and variously developed orificial laminae.

Genus *Icelozoon* Gordon, 1982

Zoaria encrusting, uniserial, dichotomous. Extensive cryptocyst granular typically delimited from the smooth bordering gymnocyst. Occlussor laminae conspicuously well developed. Oral spines present. Avicularia lacking. Ovicell hood-like with a narrow proximo-frontal fenestra. Multiporous mural septula present.

105. ***Icelozoon lepralioides*** (Kluge), 1914 **Plate 27: Fig.105**

Chaperia dichotoma Kluge, 1914: 668.
Icelozoon lepraloides Gordon, 1982: 16.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 550 – 640μ; l_z= 330 - 510μ

Colony encrusting, uniserial, dichotomously branched. Opesia transversely oval, encircled by a smooth narrow rim, which is slightly elevated. Cryptocyst broad, granular distinctly delimited by the narrow, smooth gymnocyst. Spines not found but the zooecia provided with eight circular bases from which the spines would have been dislodged. Well-developed occlussor laminae with a very distinct broad, distal base, which gives the structure a characteristic flat shelf like appearance. Ovicells and avicularia not noticed.

Remarks: Gordon (1982) has basically used the species described by Kluge (1914) to create this genus and used *Chaperia dichotoma* as the type species. He has also brought *C. lepralioides* under the genus *Icelozoon* and has remarked that this species is very similar to *C. dichotoma* but for variations noticed in the mode of branching. These characters were considered by Uttley (1949) to split the genus *Chaperia* into two genera. Brown (1952) rejected this idea "If one accepts Brown's contention that *Chaperia* includes Kluges' species as well as those considered here to be referable to *Chaperiopsis*, then we have a genus-group-taxon considerably more heterogeneous than most other cheilostome genera" (p.16 Gordon, 1982). Convincingly the name *Icelozoon* means 'similar animals' aptly coined by Gordon.

Records from the Antarctic waters: Wilhelm II coast (Kluge, 1914).

Distribution: Antarctic waters (Kluge, 1914).

Genus *Chaperia* Jullien, 1881

Colony encrusting. Opesia large, cryptocyst narrow to a distinct shelf. Negligible gymnocyst. Avicularian chambers may obliterate the gymnocyst. Occlussor laminae present variously developed. Spines present bordering the opesia. Avicularia present on the gymnocyst, at times absent. A typical median distal avicularia present. Vicarious avicularia occasional. Hyperstomial ovicells with frontal ridges could be mounted by an avicularia.

106. ***Chaperia quadrispinosa*** Kluge, 1914 **Plate 27: Fig.106**

Chaperia quadrispinosa Kluge 1914: 668.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 800 - 1025μ; l_z= 600 - 650μ

Colony encrusting pyriform zooids, truncated proximally. Large opesia circular, bordered by a smooth narrow cryptocyst, bounded on both sides by a thin raised mural rim. Gymnocyst slightly developed and smooth. Four spines present, two each latero-distally placed. The nature of the spine not fully known as majority of them was dislodged from the colony during processing. Occlussor lamina well developed, the lateral part of which is slanting and joining distally in such a fashion that two paired laterodistal concavities are formed. A distinct tapered small avicularium present on the distal ends of the zooecium while a large median bulbous avicularia present at the proximal region of some zooids. However, the raised rostral portions of these avicularia are not found probably, dislodged during processing. The rostral portion of the median avicularium is at the tip. There are no pivot bars although the foramen is considerably large. Vicarious avicularia rare not encountered in the process of photography. Hyperstomial ovicell small.

Remarks: Kluge's (1914) original description of the species based on the material collected from the Gauss station of South Antarctic shows median bulbous avicularia he considered the centrally placed and distally directed avicularium are adventitious based on the size and contiguity with the mother zooid. He has even suggested that these avicularia can be considered as separate group showing distinct proximally smooth mandibles. The spines that has been described and figured are stout. He found three distinct pore-plates laterally which contained 8-14 pores. The ovicells, which were hyperstomial, was provided with a distinct opening that was strengthened by its rim.

Records from the Antarctic waters: Gauss station (Kluge, 1914).

Distribution: Antarctic waters (Kluge, 1914).

Genus *Clipeochaperia* Uttley and Bullivant, 1972

Clipeochaperia Uttley and Bullivant 1972: 19.

This genus was created to include those genera of *Chaperiidae,* which have a frontal shield form of 2 to 4 avicularia bearing processes which are anchored to the gymnocyst proximally and fusing distally. Two oral spines present, possibly as part of the avicularia. Occlusor lamina not distinctly developed. Grooved oral rim. Vicarious avicularia present. Ovicells with a foramen.

107. *Clipeochaperia funda* Uttley and Bullivant, 1972 — Plate 27: Fig.107

Clipeochaperia funda Uttley and Bullivant, 1972:19; Gordon, 1984: 37.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 1015 -1160µ; l_z= 615 - 620µ
Encrusting colony very small in size. Small zooids with a completely hidden opesia due to a frontal calcareous shield formed by the fusion of the basal portions of the rostra of 2-4 avicularia. This fusion has produced a bizarre looking frontal area for the zooecia and often the rising tips of the avicularia give a characteristic rugged appearance to the front. The fusion of the avicularian bases and the extension up to the orifice gives the species probably characteristic ascophoran morphology.

Remarks: The electronmicrographs very clearly indicate the obliterated front of the zooecium. The randomly distributed minute avicularia gives the surface of the colony a macrotuberculated appearance. Calcification seems to have occurred in different stages resulting in small concavities, which are so characteristic of ascophorans. The hyperstomial ovicell very clearly seen in the figure has a median finely granulated portion as in the case of *Amphiblestrum* and the rim beginning from the proximal lateral portion of the ovicells and ending in a distal tip giving it a typical inverted V-shape.

Records from the Antarctic waters: This is the first record of this species from the Antarctic.

Distribution: New Zealand (Uttley and Bullivant, 1972); Otago Shelf (Gordon, 1984).

Family Onychocellidae Jullien, 1882

Family characters given in Sec. 2.7, p. 67.

Genus *Chondriovelum* Hayward and Thorpe, 1988

Chondriovelum Hayward and Thorpe 1988: 6.

Species coming under this genus have thick well-defined marginal gymnocyst, well-developed cryptocyst reduced opesia, characteristic vicarious avicularia with well-developed rostral cryptocyst. Ovicells merged.

108. ***Chondriovelum adeliense*** Hayward and Thorpe, 1988 **Plate 27: Fig.108**

Labioporella adeliense Livingstone 1928: 41.
Chondriovelum adeliense Hayward and Thorpe 1988: 6.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: $L_z = 900\mu$; $l_z = 480\mu$

Zoaria bilaminar and frondose. Dry colonies very white in colour. Dimorphism apparent with enlarged vicarious avicularia with a characteristic bend. Tubercles present. Opesia very much proximal in position and relatively reduced in size. Pore-plate present on the distolateral walls. The vicarious avicularium has a porous rostrum bearing characterized trifoliate calcareous ridges, which forms a relative depression at the distal end of the vicarious avicularium. Mandibles not noticed but could be asymmetrical when judged from the shape of the large vicarious avicularia. Typically Antarctic in distribution. The opesial margin in the distal portion mildly crenulated.

Remarks: No material is available with the author for comparison. Similarly no description of the species could be found in recent literature available. This species has been described by Hayward and Thorpe (1988) [personal communication Gordon]: The characteristic shape of the vicarious avicularium and the distal structure of the cryptocyst are characters, which might help distinguishing the species from the other species of selected genera coming under family *Onychocellidae*. Cryptocyst well developed but distally less calcified. In that respect this comes very close to *Ogivalia elegans*.

Records from the Antarctic waters: Adelie Land, Antarctic (Hayward and Thorpe 1988).

Distribution: Antarctic waters (Hayward and Thorpe 1988).

Family Steginoporellidae Hincks, 1884

Family characters given in Sec. 2.7, p. 69.

Genus *Steginoporella* Smitt, 1873

Generic characters given in Sec. 2.7, p. 69.

109. ***Steginoporella magnilabris*** (Busk, 1854) **Plate 28: Fig.109a & b**

Membranipora magnilabris Busk, 1854: 62.
Steginoporella magnilabris (Busk) Hincks, 1882: 123; Busk, 1884: 75; Harmer, 1900: 279; Thornely, 1912: 145; Osburn, 1914: 196; Harmer, 1926: 277; Cook, 1964: 53; Pouyet and David, 1979: 784; Winston, 1984: 10; Soja and Menon, 2005: 11.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_{za}= 844μ; l_{za}= 555μ: L_{zb}= 1150μ; l_{zb}= 615μ.

Colonies encrusting. Alcohol preserved material brownish in hue. Large zooecia dimorphic with smaller 'A' type zooids and larger 'B' type zooids, which are commonly interspersed. Elongated zooecia has raised granular proximal margins with a distinct round distal rim, separating the zooecium from the succeeding one. The orifice, which is distally placed, has a distinct Λ- shape which is due to the presence of the strikingly flared cryptocystal armature. Elevated distal rim of the zooecia gives a very characteristic appearance to the species. Apart from the meristic differences between the 'A' and 'B' zooid, there are structural variations like semicircular operculum in 'A' zooids reinforced by '∪' shaped sclerite and bordered by a rake-like chitinous teeth. The 'B' zooid on the other hand have larger opercula and are more rounded, sclerite with Λ-shaped and the marginal teeth larger. Ovicells absent.

Remarks: *Steginoporella* is a genus, which has received enormous attention from bryozoologists. Steginoporellids from the Caribbean according to Winston (1984) contain more than one species. Cook (1964) and Pouyet and David (1979) thought that these species especially *S. magnilabris* is tropical and sub-tropical in distribution. In an excellent treatise of the anatomy of this species, Harmer (1900) has gone into dimorphism and its relation to reproductive organs, structure of opercula, mandibles, associated muscles and pore-plates. In fact, there are at least 7 species of this genera distributed in the Indo-Australian Archipelago. The present material was obtained from 69°54'00"S and 12°49'00"E at a depth of 200 m where the temperature was -2°C, which is highly significant. Previous records of this species have all been from either tropical or subtropical areas. No clear-cut morphological difference between the present and that of Winston (1984) who got this material from the Caribbean, the second largest reef of the world. It is surprising that two populations of the same species, which are so wide apart geographically, exhibit the same morphological characteristics irrespective of contrasting environmental situations.

Records from the Antarctic waters: This is the first record of this species from the Antarctic.

Distribution: Cosmopolitan in tropical waters. Antarctic waters (Soja and Menon, 2005).

Family Cellariidae Hincks, 1880

Family characters given in Sec. 2.7, p. 77.

Genus *Cellaria* Ellis and Solander, 1786

Generic characters given in Sec. 2.7, p. 77.

110. ***Cellaria tecta*** Harmer, 1926 **Plate 28: Fig.110**

Cellaria tecta Harmer, 1926: 340.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 800μ; l_z= 320μ

Zoarium formed of branches connected at nodes. The internodes moderately stout and may contain 10-11 zooecial rows. A colony is formed of straight or slightly sinuous forked branches. Zooecia five serial, pentagonal with rounded distal angles. The opesia distal, a small median process protrudes into the opesia. This process is highly calcified, rounded broad tubercle-like, sometimes giving two lateral drawn-out spaces. The proximal horizontal portion occupies the greater part of the front. The front is depressed often inverted arch-like producing a clear-cut depression centrally. The cryptocyst is surrounded by a pair of ridges, which has a groove in the center. The proximal part of the cryptocyst rugged and does not give any clear-cut prominent calcareous tubercles. The avicularia latero-distally directed with no conspicuous median process. The distal portion of the avicularia tapers and the lateral sides elevated giving a typical arched nature. Ovicell present, inconspicuous, represented by the presence of openings at the distal part of the zooecia.

Remarks: The basic difference noticed between *C. tecta* described by Harmer (1926) from the Indo-Australian Archipelago Islands and the present material from the Antarctic is the variation in the shape of the avicularia and the direction. The figures given by Harmer (*loc.cit.*) shows avicularia, which are distally directed. However, the absence of a complete median process is a common feature in both the materials. Harmer (*loc.cit.)* has not given serious reference in the direction of the avicularium. The common comparable feature is the triangular mandible, which is broad at the base and tapers distally. Harmer (*loc.cit.*) has examined colonies, which had rootlets. The present material consists of only fragments and hence does not give any indication of having rootlets. But the presence of fragmented internodes probably indicates the possibility of having rootlets to help anchorage as in the case of any cellariform bryozoans. An important feature to be noticed here is the presence of this species as south as 69°54'00"S near the Antarctic Circle. The relatively heavier calcification is another factor to reckon with.

Records from the Antarctic waters: This is the first record of this species from the Antarctic.

Distribution: Celebes (Harmer, 1926).

111. ***Cellaria praelonga*** Harmer, 1926 **Plate 28: Fig.111**

Cellaria praelonga Harmer, 1926: 342.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 880μ; l_z= 320μ

Delicate zoarium with nodular joints branched, attached by basal bundle of rootlets, cylindrical internode with quinquncially arranged zooids. Zooecia triserial and two zooids on the frontal area widely spaced. The median zooecia deciding the distance between the opesia of the succeeding zooecia. A distinct median ridge facilitates joining of the zooecia. This median ridge is slightly raised and distinctly calcified. The proximal cryptocyst convex except at the base of the distal median elevation where it could be slightly depressed. The opesia very near to the distal end with two distinct proximal teeth placed laterally. The opesial margin raised throughout with distinct calcification. Nonporous cryptocyst with spinule-like elevations, which gives it a distinct puckered appearance. The electronmicrographs of the lateral view of the cryptocyst also reveals that the median separation distinctly raised and could be provided with these spinule-like structures. Neither ovicell nor avicularia were noticed.

Remarks: This species of *Cellaria* appears to have a clear-cut difference from the rest of the Cellarids collected from the Antarctica. Harmer (1926) created this species to incorporate long and narrow triserially arranged zooecia with opesia, which is almost distally placed. The presence of spinules on the cryptocyst was not noticed by Harmer (*loc.cit.*) probably due to the absence of facilities for higher magnification. Curiously enough, he has not mentioned this in his descriptions also. The specimens were collected from south Celebes by Harmer and the present material came from Antarctica thereby, extending the distribution to typical Antarctic boreal waters.

Records from the Antarctic waters: This is the first record of this species from the Antarctic.

Distribution: Celebes (Harmer, 1926).

112. ***Cellaria aurorae*** Livingstone, 1928 **Plate 28: Fig.112a & b**

Cellaria aurorae Rogick, 1965: 404; Hayward and Thorpe, 1988: 12.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 750μ; l_z= 600μ

Moderately slender zoarium with hexagonal zooecia arranged quinquncially. Zooecial margins separated by distinct calcareous walls, which are slightly elevated so as to give the appearance of calcareous ridges. Gymnocyst virtually absent. Cryptocyst well developed with marginal minute pores and provided with small tubercles, which gives the front a distinct rugged appearance. The orifice is squarish with the proximal margin distinctly raised and arched. Two minute tubercles present on the lateral sides of the proximal margin. The thickened ridge of the orifice seems to be a distinct feature of the species. The proximal portion of the orifice has an elevated hump like structure, which could be reinforced calcareous thickening of the cryptocyst. Two small fenestrae on both sides of this hump were noticed. Ovicells endozooecial with openings touching the distal zooecial margin. Vicarious avicularia not noticed in the material available for examination.

Remarks: No material is available with the author for comparison. Similarly no description of the species could be found in recent literature. This species has been described by Hayward and Thorpe (1988) [personal communication Gordon]: The characteristic shape of the zooecia and structure of the cryptocyst are characters, which might help to distinguish the species from the other species of selected genera coming under family *Cellariidae*.

Records from the Antarctic waters: Antarctic (Hayward and Thorpe 1988).

Distribution: Antarctic waters (Hayward and Thorpe 1988).

Genus *Swanomia* Hayward and Thorpe, 1989

This genus was created by Hayward and Thorpe (1989) to include species, which are Cellariform and has zooecial characters comparable to other species of the genus. Profusely distributed and relatively large sized vicarious avicularia and distinct zooecial margins exemplified by deep grooves. At present this genus represents only Antarctic species.

113. ***Swanomia membranacea*** (Hayward and Thorpe), 1989 **Plate 29: Fig.113**

Cellaria membranacea Thornely 1924: 12.
Swanomia membranacea Hayward and Thorpe 1989: 16.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 680µ; l_z= 500µ: L_a= 750µ; l_a= 400µ

Zoaria cellariform. Tubular branches of the colony contains 8-10 jointed zooecia giving it a circular shape. Zooids are more or less squarish in shape and difference between the length and the width of the zooecia not as different as those found in other cellarids. This itself makes the present form under consideration unique. Gymnocyst not well developed although the zooecial margins are considerably calcified and raised. Cryptocyst broad proximally and is provided with minute granule-like elevations and not tuberculated. The opesia is relatively deep and more or less oval in shape with relatively broader proximal region. Vicarious avicularia characteristic, numerous and the mandibular portion triangular, relatively extended, proximally raised. The rostrum having a structure and shape not normally found in cellariforms. The proximal portion of the avicularia seems to be edentate so as to create, a typical triangular area, which gives this portion the structure and nature of an elevated process. This phenomenon gives the impression that the proximal part of avicularia is immersed in the interzooecial space. The margins of the zooecia are very distinct. No ovicells noticed.

Remarks: The specimens were collected from Antarctica but not from the type locality. Distribution of bryozoans is rather abundant towards the Australian region of the Antarctic and the present finding of this species very near to the Antarctican continent significantly enhances the distributional area of this species. The genus *Swanomia* is not represented in the Indian Ocean. The vicarious avicularia looks to be gigantic and in this respect supports the assumption that these structures may be involved in capturing larger particles, which must be a rarity in the deeper part of the Antarctic Ocean. This character could be described as anomalous since gigantism in vicarious avicularia seldom occurs in cellariforms.

Records from the Antarctic waters*:* Antarctic (Hayward and Thorpe 1989).

Distribution: Antarctic waters (Hayward and Thorpe 1989).

<u>**Genus *Melicerita*** Milne-Edwards, 1836</u>

Melicerita Winston 1983: 690.

"Zoarium compressed, bilaminar, rigid, lobate, ligulate or foliaceous, articulated or continuous. Zooecia usually dispersed in transverse rows, surface areolated, and area rhomboid or hexagonal. Orifice sub-central, semicircular or oblong, border entire with two articular teeth below and sometimes also above" Busk (1884).

114. ***Melicerita obliqua*** Thornely, 1924 **Plate 29: Fig.114**

Melicerita obliqua Winston, 1983: 690.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 720μ; l_z= 480μ

Colonies are flattened, straight or curved reaching around 10 cm length and to 1 to 1.5 cm in width. Colonies tend to be broader distally and rather pointed proximally getting attached by rootlets. Zooecia are hexagonal in shape. The frontal pores are numerous and those located centrally tend to get enlarged in size. Hexagonal zooids are arranged in longitudinal rows. The zooidal boundaries are distinct and the separation could be detected by the presence of thin calcareous margins. The presence of distinct rows of zooids and their longitudinal distribution give the colony a fascicled appearance. The ascopores are within the orificial margin and are not discernible externally. Operculum when dislodged by crushing gives a typical orificial shape. The ovicells are embedded.

Remarks: This species is found in abundant number in Antarctic waters. Silen (1980) while considering the mode of attachment of bryozoan *Scrupocellaria*, where the attachment is ephemeral mainly attained by the ancestrular rhizoids noticed that subsequent attachment is effected by rhizoids developed from each zooid. Attachment in the case of erect colonies with highly calcified zooids is important since lack of calcification would result in breakage of colonies by water movements. It may be assumed that in the case of Antarctic benthic bryozoans, the presence of highly calcified colonies necessitates the development of rhizoids. In the case of *Melicerita*, which have large colonies, the capacity for the formation of rhizoids is limited to the basal portion of the colony. This would help them to oscillate under water currents. However, dislodgement would result in the death of the colony, since regaining perpendicular posture would be difficult without the help of lateral rhizoids. The colonies examined in the present instance were found to have over growth of other bryozoans like *Lacerna* sp. and *Reginella* sp. This might be an indication of partial mortality of the colony.

Records from the Antarctic waters: Ross Sea and Adelie Land (Rogick, 1965; Androsova, 1972; Winston 1983).

Distribution: Antarctic waters (Rogick, 1965; Androsova, 1972; Winston, 1983, Geetha, 1994)

Family Cribrilinidae (Hincks, 1879)

Family characters given in Sec. 2.7, p. 80.

Genus *Reginella* Jullien, 1886

Zooecia with the front formed by voluminous ribs on the exterior surface, with the pores diminishing in size from the talon of the rib to its extremity. These intercostal furrows traverse over the entire zooecium and each pair of ribs separated transversely. Orifice arched with the inferior lip mucronated, marginal spines may or may not be present on the proximal arch. Avicularia unknown.

115. ***Reginella*** sp. **Plate 29: Fig.115**

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 1080 -1300µ; l_z= 800 - 880µ

One colony consisting of 20 zooecia was obtained from the Antarctic waters. The front with numerous costae of very minute size exemplifies the costal character only in the margins. Numerous minute intercostal pores, which even tends to merge at the center in some zooecia. The orifice is elevated with 2 distinct spinules placed proximolaterally and provided with slight calcareous thickening. Apart from the proximal protuberances very minute calcareous tubercles present on the distal portion of the circular vase-like orifice. Presence of avicularia is a distinct feature and they seem to be placed at the tip of minute extended calcareous peduncles. Avicularia variously placed and with minute pointed mandible. No ovicells noticed. Until the time when fresh material is obtained, the present colony is retained in the genus *Reginella*.

SUB-ORDER ASCOPHORA (Levinsen, 1909)

Characters given in Sec. 2.7, p. 82.

Family Romancheinidae Jullien, 1888

Zooidal frontal wall with marginal pores only. Primary orifice typically with lyrula and condyles; enclosed by a well-developed peristome and with conspicuous oral spines. Avicularia present. Ovicell prominent, imperforate. Basal pore-chambers present.

Genus *Escharella* Gray, 1848

This includes species having a frontal wall with marginal pores only. The primary aperture typically with lyrula and condyles, which are enclosed by a peristome and provided with oral spines. Avicularia absent. Prominent ovicells, non-porous.

116. ***Escharella mammillata*** Hayward and Thorpe, 1989 — **Plate 29: Fig. 116**

Escharella mammillata Hayward and Thorpe, 1989: 371.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 1650µ; l_z= 825µ

Encrusting zoaria like coherent sheets. The colony can also be in the form of narrow lobes consisting of one or two series of autozooids. These lobes could merge to form irregular sheets with varying orientation. Zooecia are large broadly rounded, distally often tapering to give a volcanic appearance. The proximal portion of the raised area may have varying calcareous thickenings. Interzooecial borders are well defined with deep ridges because of the mammillate shape of the zooecia. Coarsely granulated front provided with two or three series of minute marginal pores. The primary orifice broader than long with an indistinct lyrule. Typically oral spines are absent but one or two spine bases present in zooecia. Ovicells not noticed.

Remarks: The mammillate appearance of the zooecia according to Hayward and Thorpe (1989) can become distally tapered in later ontogeny. The zooecia are very large as long as 1.6 mm and as broad as 0.82 mm. The species was collected from the Antarctic from a locality, which recorded a temperature of –2°C indicating extreme thermal tolerance by the species. This species, which was created by Hayward and Thorpe in 1989 were mainly from the Clarence Island collected by the Discovery

Expedition. The present material was collected by Sagar Kanya during the 3rd Indian Antarctic Expedition.

Records from the Antarctic waters: Clarence Island (Hayward and Thorpe, 1989).

Distribution: Antarctic waters (Hayward and Thorpe, 1989).

Genus *Escharoides* Milne Edwards 1836

Encrusting colony. The frontal wall with conspicuous marginal areolae. The proximal border of the orifice with denticles or a projection described as "spout-like" (pg. 71 Gordon, 1984) peristome. Oral spines present, number variable. Avicularia paired lateral to the orifice. Prominent ovicells with tatiform ancestrula.

117. ***Escharoides praestida*** (Waters), 1904 **Plate 29: Fig. 117a; Pl. 30: 117 b**

Smittina praestida Waters, 1904: 67.
Escharoides praestida Rogick, 1955: 444.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z =720 μ; l_z= 565 μ
Encrusting zoarium with areolate pleurocyst. Convex frontal often converging towards the primary orifice projecting onto a non-areolate peristome. Conspicuous short oral spines characteristically four in number, these dislodged spines having distinct areolate tubercle. Ovicells present and when present the oral spine reduced to two. Ovicell globose with lateral areolae. Oval avicularia when present placed high up at either or both sides of the peristome. There is a distinct beak in the peristome which is laterally placed. Mandible broad typically thimble shaped. Lyrules and cardelles absent.

Remarks: This species was collected from the Antarctic waters and a well-preserved colony was available for examination. The scanning electronmicrographs at lower magnification gives the impression that the zooecia has a front which is shaped like a tent terminating in distinct porous marginally elevated areolae. It seems that calcification increases, as a function of age and older zooids will possess valley-like calcareous thickening ending in areolae. Slight raising of the tip of the rostrum has resulted in the development of a thimble like mandible. Reduction in the number of spines in the case of fertile zooecia probably indicates dislodgement of the spine or involvement of the spines in the formation of ovicell. Rogick (1955) had given an extensive description of this species, which she redescribed from the materials collected by Waters (1904). A character of the species that she observed was the laterally placed avicularia on the peristome, which she felt as the shoulder of the zooecia. Indirectly referring to the tent-like shape of zooecia she has remarked that the orifice is terminal, which is not in confirmative with the vocabulary used to describe ascophorans. This species looks to be typically Antarctic in character collected from deep stations where the temperature was nearer to 0°. The present specimens were recorded from a station where the temperature maintained was -2 °C which seems ideal for delicate calcification.

Records from the Antarctic waters: Ross Sea (Rogick, 1955; 1965).

Distribution: Antarctic waters (Rogick, 1955; 1965).

Family Sclerodomidae Levinsen, 1909

Cellarinella, is one of the most abundant bryozoan species of this family present abundantly in Ross Sea. The most striking feature of the species is the lack of operculum. Sexual reproduction is minimal and increase in number is known to be effective by fragmentation and subsequent growth by asexual reproduction. Some species have colonies formed of delicate tube like branches, assuming a height of a few centimeters. There are species with stout flattened branches. The zooids have a thick calcified front with large pores. They lack external boundaries, which are evidences of separation or demarcation of individuals. Extensive calcification below the orifice creates bumpy protuberances on the surface of the colony. The Cellarinellids are totally different from other cheilostomes in that they lack operculum. Open orifice leads to a long curved passage with extensive calcification and internal avicularia. Embryos develop inside the ovicells that are embedded frontally.

Genus *Cellarinella* Waters, 1904

Cellarinella Winston, 1983: 689.

This genus is characterized by massive colonies which are erect. The zooids are arranged as fascicles. The highly umbonated orifice facing both the sides. Vicarious avicularia or avicularia embedded in the peristome may be present or absent. Highly porous tremocyst gives the colony coralline structure. Avicularia when present placed on an umbo. This genus is exclusively distributed in the Antarctic.

118. ***Cellarinella laytoni*** Rogick, 1956 **Plate 30: Fig. 118a & b**

Cellarinella laytoni Rogick, 1965: 405; Winston, 1983, 689.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 1080µ; l_z= 540µ

Erect colonies formed of zooids arranged multiserially in a circular fashion give the colony fascicled appearance. Zooid rows may vary from three to six at areas of bifurcation. A conspicuous feature of this species is the drawn out umbonal structure. The orifice deeply embedded and not visible on superficial examination. The tremocyst highly perforated. Vicarious avicularia placed frontally with their mandibles directed laterally. Normally single avicularia placed at the umbonal projection, therefore, hidden. Avicularian mandibles triangular in shape with pointed tip. Highly porous tremocyst has uniformly arranged tremopores. These tremopores give serial sequences at the points of bifurcation. No ovicells noticed.

Remarks: This genus represents an important member of the family *Sclerodomidae*. The species of this genus had a wide bathymetry and are known to reach physical diversity at great depths. The reasons for wide benthic distribution may be due to the lack of uniform hydrographical features of the benthic regions. It is known that broad depth zonations of the species of *Cellarinella* occur covering several hundreds of meters in the Antarctic waters *C.laytoni* is having a restricted spatial distribution. Moyano (1978) estimated that cyclostome bryozoans share about 50% of species with the Antarctican bryozoans. However, among the cheilostomatous bryozoan of the Antarctic *Cellarinella* occupies a very important position.

Records from the Antarctic waters: Ross Sea (Rogick, 1965; Winston, 1983).

Distribution: Antarctic waters (Rogick, 1965; Winston, 1983).

119. ***Smittina favulosa*** Hayward and Thorpe, 1989 **Plate 30: Fig.119**

Smittina favulosa Hayward and Thorpe, 1989: 365.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 1200μ; l_z= 720μ

Erect colony whitish in hue, could be encrusting also in habit. Zooecia nearly oval with the distal portion distinctly raised in the form of secondary orifice. Zooecial margin distinct, canaliculated and' provided with conspicuous calcareous thickening. Tremopores highly porous. The marginal pores merging to form larger concavities, this is especially so in the area where the peristomial elevation occurs. Peristome with calcareous thickening and a distal flare elevated from the succeeding zooecia. A clear-cut suboral avicularium present occupying either the lower portion of the peristome or slightly displaced depending on the axis of growth of zooid.

Remarks: This species was created by Hayward and Thorpe from Terra Nova material collected from St.No.339 from the Ross Sea. They have opined that this species resembles *S. punctata* of Powell but lacks avicularia. The present material differs from *S. favulosa* described by Hayward and Thorpe (*loc.cit.*) in the absence of ovicells which invades into the succeeding zooecium. The ovicells described by the authors was found to have 4-6 irregular frontal foramina. The material at hand was collected from off Prince Astrid Land at 200 m. The depth of sampling of the Terra Nova material from the Ross Sea was 256 m and the present material came from a station further north located at 69° 54'S and 12°49'E . Probably this species is a typical representative of the Antarctic waters. The meristic characters of the present specimens are very similar to that of those examined by Hayward and Thorpe (1989).

Records from the Antarctic waters: Ross Sea (Hayward and Thorpe, 1989).

Distribution: Ross Sea (Hayward and Thorpe, 1989).

120. ***Dakariella concinna*** Hayward, 1993 **Plate 30: Fig.120**

Dakariella concinna Hayward, 1993:1410.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 1800 -2100μ; l_z= 900 -1050 μ

Colony foliaceous, unilaminar, probably detached from substratum on which the encrusting part of the colony grows. The zooecia of enormous size often achieving a length of 2000μ and a width of 1000μ. Characteristically marginal pores enlarged. The rest of the front provided with median size to minute pores. The zooecial margins separated by thin calcareous thickenings. Orifice with a characteristic sinus. The laterodistal portion of the orifice elevated and slightly flared. Avicularia not noticed. The absence of pores in this region of the zooecia gives the secondary orifice a distinct bedecked appearance.

Remarks: This species was originally described from the Antarctic waters by Hayward in 1993. It is assumed that this species is very common in the higher latitudes. The present material collected in copious quantities came from the Antarctic at a latitude of 60°54'00"S but the lack of literature regarding this species makes further comparison difficult.

Records from the Antarctic waters: Ross Sea (Hayward, 1993).

Distribution: Antarctic waters (Hayward, 1993).

Family Lacernidae Jullien, 1888

Front a pleurocyst with numerous areolar pores. The aperture is rounded with a furrowed narrow sinus. A vestibular arch present, suboral or lateral avicularia near the aperture. Peristome with stout oral spines. Hemispherical, hyperstomial ovicells, not closed by the operculum.

Genus *Lacerna* Jullien, 1888

Characters same as that of the family.

121. ***Lacerna watersi*** Hayward and Thorpe, 1989 **Plate 30: Fig.121**

Lacerna watersi Hayward and Thorpe 1989: 371.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 745 - 875μ; l_z= 630 - 690μ

Encrusting colony distinctly whitish in hue. When not disturbed grows into broad flat sheets. Hexagonal autozooids, typically rounded, broad and flat. Interzooecial demarcation by means of distinct grooves formed by channel-like calcareous thickenings. The front with minute calcareous tubercles giving a distinct shape of hills and valleys. Pores are absent at the central portion of the zooids. The margin provided with regular stellate pores characteristically placed on the marginal space adjacent to the interzooecial grooves. Primary orifice wide with a characteristic sinus. The median sinus and the raised lateral proximal margins obliterate the condyles, which are otherwise not distinguishable. The orifice gives the shape of the English alphabet 'D'. The horizontal bar of the 'D' occupying the center proximal portion with centrally placed 'U' shape sinus. Ovicells well developed typically placed distally, highly calcified and provided with stellate marginal pores very similar to those found in the autozooids. The placement of the ovicell is such that the operculum is snuggly closed by the orificial openings. The globose ovicell very common in mature zooids. Spines absent.

Remarks: This species according to Hayward and Thorpe (1989) is endemic to the Antarctic. *L.watersii* was created by these authors as they found that this was different from the well established *L.hosteensis*, which has short primary orifice and ridged condyles. The nodular calcification of the front was also considered as a distinct specific character of this species by these authors. The species described by Levinsen in 1928 as *L.hosteensis* therefore was considered as a synonym of this species mainly because of the concept that this species is endemic to the Antarctic. The present collection is from a locality further north of Ross Sea which looks to be the main geographical area of distribution.

Records from the Antarctic waters: Ross Sea (Hayward and Thorpe, 1989).

Distribution: Antarctic waters (Hayward and Thorpe, 1989).

122. ***Rhynchozoon tubulosum*** (Harmer, 1957) **Plate 31: Fig.122**

Mucronella tubulosa Hincks, 1880: 383.
Rhynchopora longirostris Hincks, 1881:125.
Mucronella tubulosa Thornely, 1905: 124.
Rhynchozoon longirostris Hastings, 1930: 729; 1932: 439.
Rhynchozoon tubulosum Harmer, 1957: 1064; Menon and Nair, 1967a: 2; 1974a: 117; Gordon and d'Hondt, 1997: 59.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 1500µ; l_z= 675 µ

Encrusting with the distal ends of zooecia raised from surface in the young condition. Zooecia arranged in quincunx, convex, separated by distinct grooves. Peristome, conceals the primary orifice, which is rounded with a slightly arched proximal border. Sinus wide and shallow. Conspicuous mucros present, usually three in number but in some, there may be only two. Mucros very conspicuous, usually long, the median one associated with the two lateral ones when the number of mucros is three. The median mucro may be flat or knob like, while the lateral ones comparatively shorter than the median one. Sub-oral avicularia rarely represented. Frontal avicularium large placed horizontally, the tip directed proximally, rostrum with a rounded tip. Ovicells hyperstomial, the ectooecium calcified and imperforate, represented as a narrow rim. The exposed frontal surface of the ovicell bears tubercles.

Remarks: These specimens though resembling Rhynchozoon tubulosum do show variations. Harmer (1957) noticed that the median mucro in his specimens was minutely denticulate and recurved, but in the present form the median mucro does not possess any denticulation. The recurring of the median mucro was noticed in cases where the same has grown long. The number of the mucro was more or less constant. The nature of the zooecia placed at the centre of the colony and towards the periphery showed minor variations. Areolar pores are noticed in the zooecia placed at the rim of the colony whereas they are inconspicuous in the regions where high calcification has taken place. The sinuation of the secondary orifice was noticed in few cases where the number of mucros was only two. The number of frontal avicularia was much less, sometimes even absent in few colonies examined. Harmer (*loc.cit.*) reports the same feature in the colonies collected from Siboga station 81D. The ovicells are similar to the descriptions and figures given by Harmer. From the descriptions of R. tubulosum it seems that characters like the nature of ,spreading, the sub-oral avicularia and mucros may show variations. The differences noticed in the present instance may probably be considered as those that come within the range of variations that occur in this species. Detailed examination of more material and comparison with the type material are essential before reaching a final conclusion.

Records from Antarctic waters: This is the first record of this species from the Antarctic.

Distribution: South Africa (O'Donoghue and Watteville, 1935); Indian Ocean (Thornely, 1912); Ceylon (Thornely, 1905); Sulu Archipelago and Kei Island (Harmer, 1957); Australia (Hincks, 1880); Great Barrier reef (Thornely, 1912); Victoria (Mac Gillivray, 1883; 1890); Bass Strait (Hincks, 1880; Hastings, 1930).

Family Phidoloporidae Gabb and Horn, 1862

Family characters given in Sec. 2.7, p. 136.

Genus *Iodictyum* Harmer 1957

Fenestrate zoarium, calcareous part brilliantly coloured or white. Peristome dimorphic. At first projecting their orifices with more or less distinct teeth and denticles. Spines absent. Descending lamina of ovicells produced into a labellum with a median keel, generally terminating distally in a minute pore, which is the stigma. Avicularia present.

123. ***Iodictyum anomala*** sp. ***novo*** — **Plate 31: Fig. 123a, b, c, d & e**

Material:

Holotype: MOD: Reg. No: 2006.98.123, Third Antarctic Expedition, Station bearings Lat. 69°54'00"S and Long.12°49'00"E.

Paratype: Third Antarctic expedition, Station bearings Lat. 69°54'00"S and Long.12°49'00"E.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 780 µ; l_z= 425 µ

Zoarium lattice like. Whitish in hue and merger of zoarial branches results in the formation of fenestrae of varying size although typically it is elongated oval. Zooecia arranged quinquncially on the branches, the merger of which forms the lattice. Various type of avicularia profusely distributed on the frontal and basal surface. Essentially based on the shape and size, three types of avicularia are very common. Two types are elongated oval and the third one is adventitious. The elongated oval avicularia are of two types, larger one usually placed proximal to a blunt umbonate structure. Some zooecia will harbour a second avicularia, which will then be invariable smaller. The direction of the rostrum of the avicularia could either be towards the proximal portion or distal. As a rule every zooid harbours one avicularia frontally. The frontal umbonate part is placed on the proximal portion of the secondary orifice. These structures are distinct calcareous elevations which may be pointed though with a semicircular blunt frontal portion in the scanning electronmicrographs. The more or less straight part of the umbo descends into the secondary orifice, which is compressed spatulate in shape. There are two ill-defined condyles and very mild lyrules. Frontal pores are present and are placed normally on either side of the avicularia near the base of the umbonate structure. The adventitious avicularia of which a few have been noticed are placed on the sides of the fenestrae they are huge and, are provided with a tapering mandible and rostrum. The adventitious avicularia are elevated and in size more or less equal to that of the zooecia. The zooecial margins are delineated by thin calcareous crenulations. The distal portion of the secondary orifice is relatively sunk into the proximal part of the succeeding one. The basal portion is characteristically provided with numerous avicularia of 2 types and shape. Minute pores are also present. The presence of these avicularia makes the material a unique one.

Remarks: Harmer (1934) who created this genus under the family Reteporidae based on the character of the ovicells, which he found having keeled labellum. He also created two groups of species in this genus. He has described 12 species belonging to both the group among which four where new to science. The material before me can be placed under the genus *Iodictyum* mainly by virtue of shape and number of avicularia, the shape of the orifice and the presence of sinus but no ovicell was noticed in the present material. Among the species described by Harmer (*loc.cit.*) under this genus, the present material come very near to *I.sanguineum* but differs clearly by virtue of the possession of a stout flat umbonate structure often bigger than the secondary orifice and more or less placed like a wall in the proximal portion of the orifice giving the orifice a sunken posture. It is convinced that the present material has not been described by anybody and the fact that it came from Antarctic waters helps me in placing this under a new species. The material was dried and has therefore lost colour.

Records from the Antarctic waters: This is the first record of this species from the Antarctic waters.

Distribution: Antarctic waters.

Genus *Reteporella* Busk, 1884

Zoarium typically ramose or fenestrate. The zoarial branches anatomizing to form narrow slit-like fenestrae. Frontal pores present normally two in number. Peristome with a closed labial pore with labial avicularia on one side of it. Spines could be represented by spine bases. Ovicells immersed and usually persisting as a narrow median fissure and the descending lamina.

124. *Reteporella parva* Hayward, 1993 — **Plate 32: Fig. 124a, b & c**

Reteporella parva Hayward, 1993: 1424.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 1050µ; l_z= 325 µ

Zoarium reticulate, fenestrae formed by anastomosing branches. Junction where the anastomosing takes place there could be 7 to 8 serially arranged zooecia. Zooecial front is more or less smooth with 2 marginal pores, which could be variously placed. Wide primary orifice with less conspicuous denticulations. Sinus typically circular formed by the fusion of the lateral walls of secondary orifice. This could be displaced to sides depending on the mode of growth of zooecium. When laterally placed invariably the front will be slightly elevated at that part of the zooecium to give it a cylindrical posture. Oral spines represented by two spine bases. A minute avicularian structure noticed in one zooecia. Ovicells sunk and represented by a semicircular flat calcareous disc. In zooecia where the ovicells are not developed the portion is represented by elongated slit with a minute pore. Probably this could be also a denuded fertile zooecia. Two types of avicularia present basally. Variously directed avicularia, could be small or large. Horizontal rostral septum present in all types of avicularia. The avicularian mandible distinct frontally and specifically demarcated basally by thin calcareous ridges.

Remarks: The species under observation can be placed under *R.parva* described by Hayward (1993). The material used by Hayward is the Discovery collection from the Antarctic and Sub-Antarctic region. The material examined did not have the large marginal fenestral avicularia, which are seen in figure given by Hayward. The elevation of the front giving the secondary orifice a peristome like structure with tuberculation, where the reasons for the creation of this species by Hayward. He did notice small avicularia with oval rostrum with conspicuous pores on the basal side of the zoarium. However, his material did not have ovicells and he remarked that ovicells unknown which is not the case in the present materials where the typical reteporelline ovicells were observed. Since the type locality is very near to the place from where the present material was collected they are assigned to this species.

Records from the Antarctic waters: Ross Sea (Hayward, 1993).

Distribution: Antarctic waters (Hayward, 1993).

Family *Plagioeciidae* Canu, 1918

This family includes species of various genera mainly here marked by the nature of the ovicell. The ovicell is oblong transverse sac obliterating a specific number of zooecial tubes and it tends to develop nearby zooecial margins. The ooeciostome is small equal to or less than the zooecial diameter. The zoarial tubes are distinct and there are no adventitious tubes.

Genus *Plagioecia* Canu, 1918

The ovicell long transverse sac obliterating a certain number of zooecial tubes. Usually developed in the vicinity of the zoarial margins. The ooeciostome is smaller than the zooecial diameter. The peristomes are isolated from each other.

125. ***Plagioecia patina*** (Lamarck, 1816) — **Plate 32: Fig. 125**

Tubulipora patina Lamarck, 1816: 163.
Diastopora patina Hincks, 1880: 458; O' Donoghue and O' Donoghue, 1923: 14.
Plagioecia patina O' Donoghue and O' Donoghue, 1926: 21; Osburn, 1953: 631.

Occurrence: Found encrusting on other bryozoans collected from Antarctic waters at a depth of 200 m.

Salient features: L_z= 750µ; l_z= 125 µ

The zoarium variable in form rounded or lobate totally encrusting or partially free. The zooids are embedded through most of their length but vertically erected by short peristomes. Minute pores present throughout the zooecial front. The peristomial aperture not circular could be elongated oval or irregular. The tip of the peristome is thin but the damaged ones exhibit the layered porous nature of the peristome. Ovicells not noticed.

Remarks: The material was collected from the Antarctic and the examined colonies did not possess ovicells. The peristome also did possess minute pores at the base. Only the distal tip was devoid of these pores. Lack of fertile colony makes any further comparison difficult.

Records from the Antarctic waters: This is the first record of this species from the Antarctic waters.

Distribution: Chatham Island, Galapagos, Lower California (Osburn, 1953).

Family Horneridae Smitt, 1867

Zoarium erect branching like a tree with rounded stem and branches. Zooids opening on the frontal side. Inflated gonozooid. Ovicell on the frontal side. Inflated gonozooid.

Genus *Hornera* Lamouroux, 1821

Characters same as that of the family. There is moderate sized encrusting base, branching similar to that of the tree but the girth of the branch significantly reduced in successive branches. The species of this genus are highly coloured, red or purple.

126. ***Hornera spinigera*** Kirkpatrick, 1888 — **Plate 32: Fig. 126a & b**

Hornera spinigera Kirkpatrick, 1888: 80; Harmer, 1915:178.

Occurrence: Specimens obtained from collections made at a depth of 200 m during the Third Antarctic Expedition.

Salient features: L_z= 850μ; l_z= 300 μ

Zoaria branching without clear-cut internodal separations. The zooecia completely merged to forma a clear-cut stem like structure for the colony. The interzooecial margins evidenced by very inconspicuous calcareous lines. The frontal pores present variously distributed. The lateral side of the branches evinces more number of longitudinal pores. The peristome bent and elevated, in younger branches projecting out of margin of the branch. Minute spinules present at the tip of the peristome of colonies belonging to the old part of the zoarium. The preserved material did not show any clear-cut colour differences. The peristomial lumen has minute denticles jutting into the lumen.

Remarks: One conspicuous difference noticed between the present specimens, collected from the Antarctic and those described from Harmer (1915) from the Celebes was the produced tips of the peristome in younger colonies; Harmer (*loc. cit.*) has remarked that such spine like structure need not be present in the peristome of older zooids. The broadest area of the present material had quadriserial arrangement of zooids, though this was disrupted at the area where the branches emerge. Clear-cut edendations has been noticed in the axis of a branch, which probably represents a damaged ovicell. Not withstanding some morphological variations, the material is assigned to *H.spinigera*.

Records from the Antarctic waters: This is the first record of this species from the Antarctic.

Distribution: Sulu Archipelago, Celebes (Harmer, 1915).

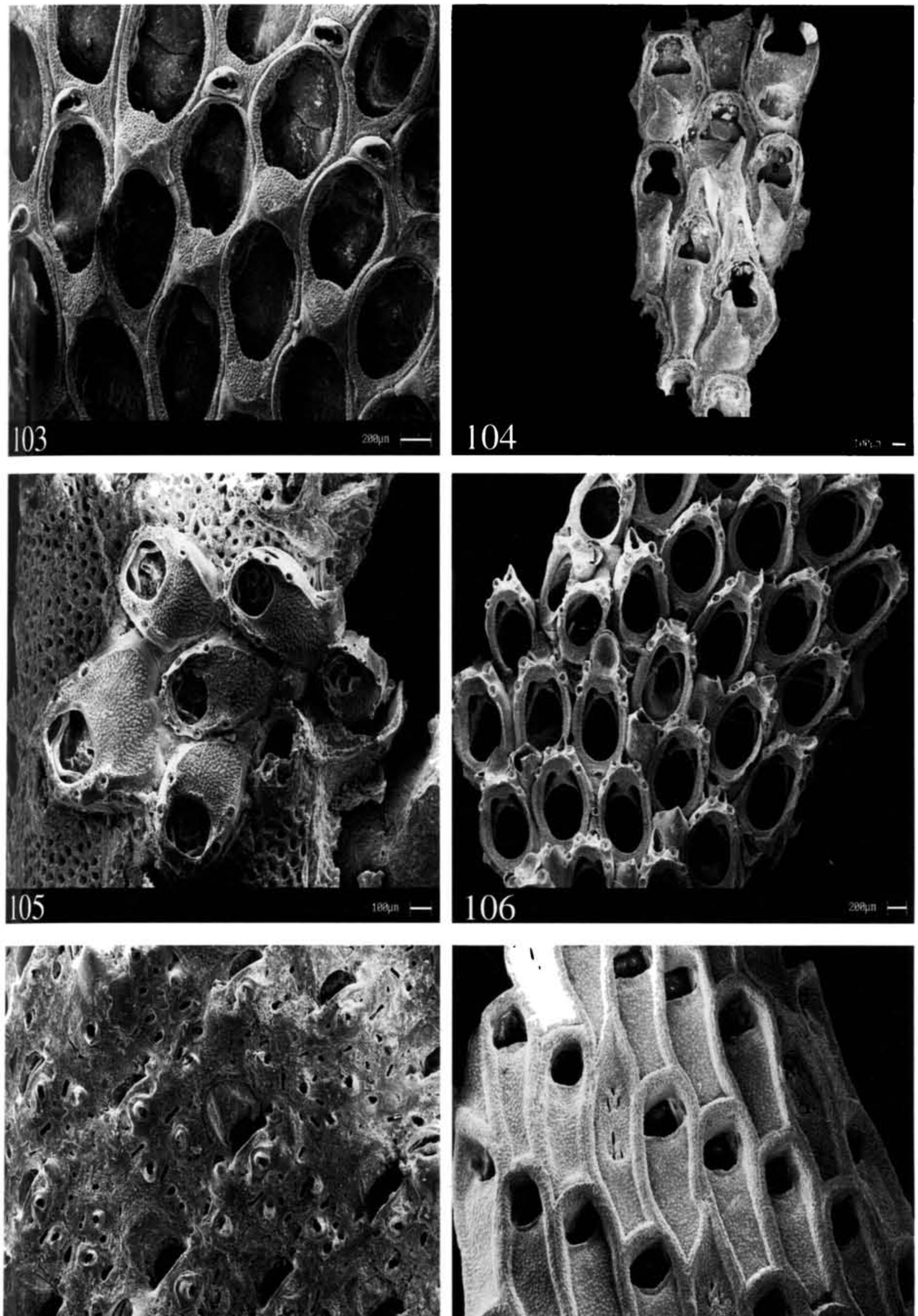


Plate 27. 103. *Ellisina levata* (Hincks), A fertile zooecia. 104. *Amphiblestrum inermis* (Kluge), Portion of a colony showing the proximal gaint avicularia. 105. *Icelozoon lepralioides* (Kluge), A young colony. 106. *Chaperia quadrispinosa* Kluge, A mature colony with two type of avicularia. 107. *Cleipochaperia iunda* Uttley and Bullivant, 108. *Chondriovelum adeliense* Hayward and Thorpe, Portion of a colony showing vicarious avicularia.

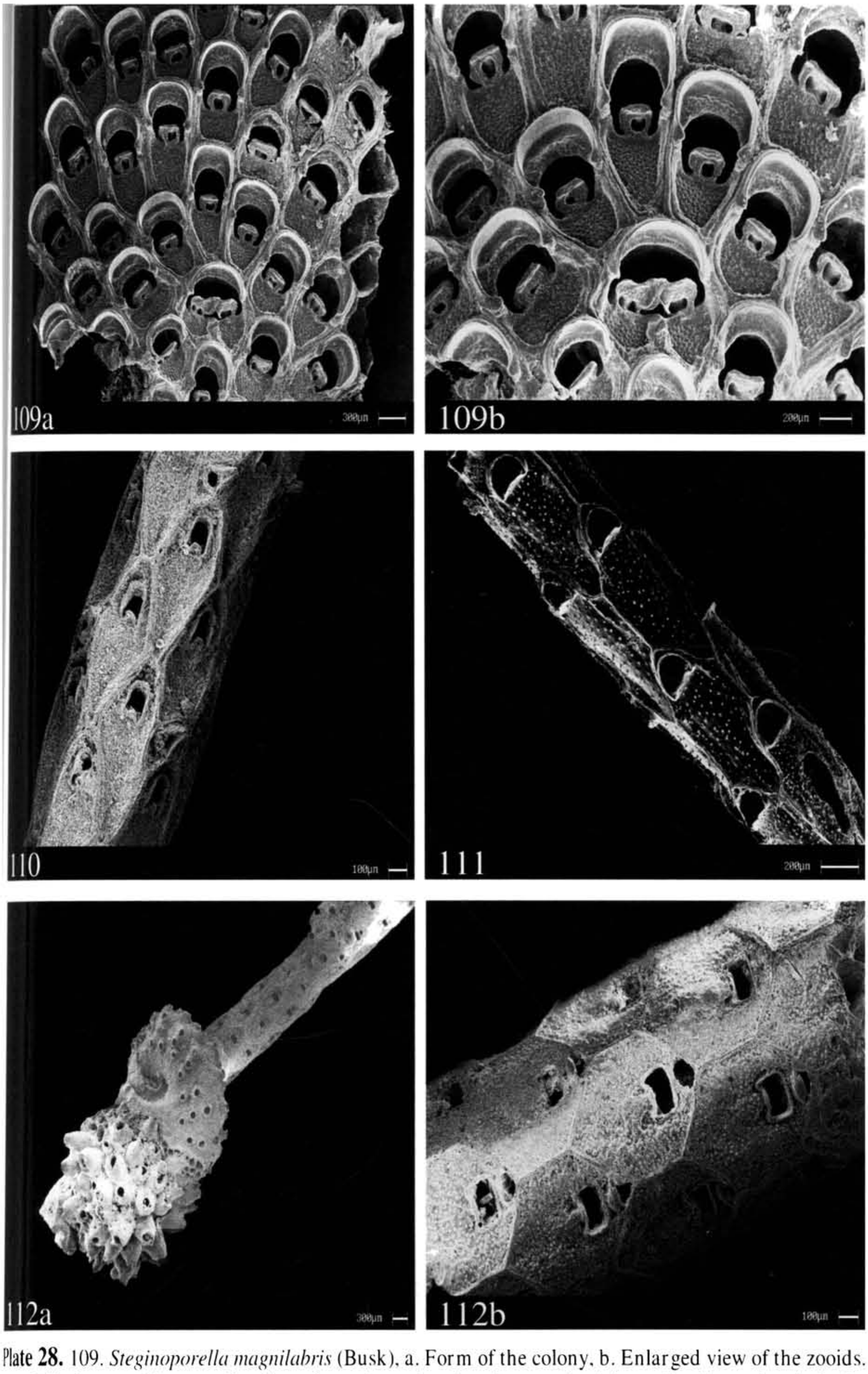


Plate 28. 109. *Steginoporella magnilabris* (Busk), a. Form of the colony, b. Enlarged view of the zooids. 110. *Cellaria tecta* Harmer. Portion of a colony showing the proximal laterally directed avicularia. 111. *Cellaria prealonga* Harmer. 112. *Cellaria aurorae* Livingstone. a. Form of the colony, with other bryozoans attached on it, b. Enlarged view of the zooids.

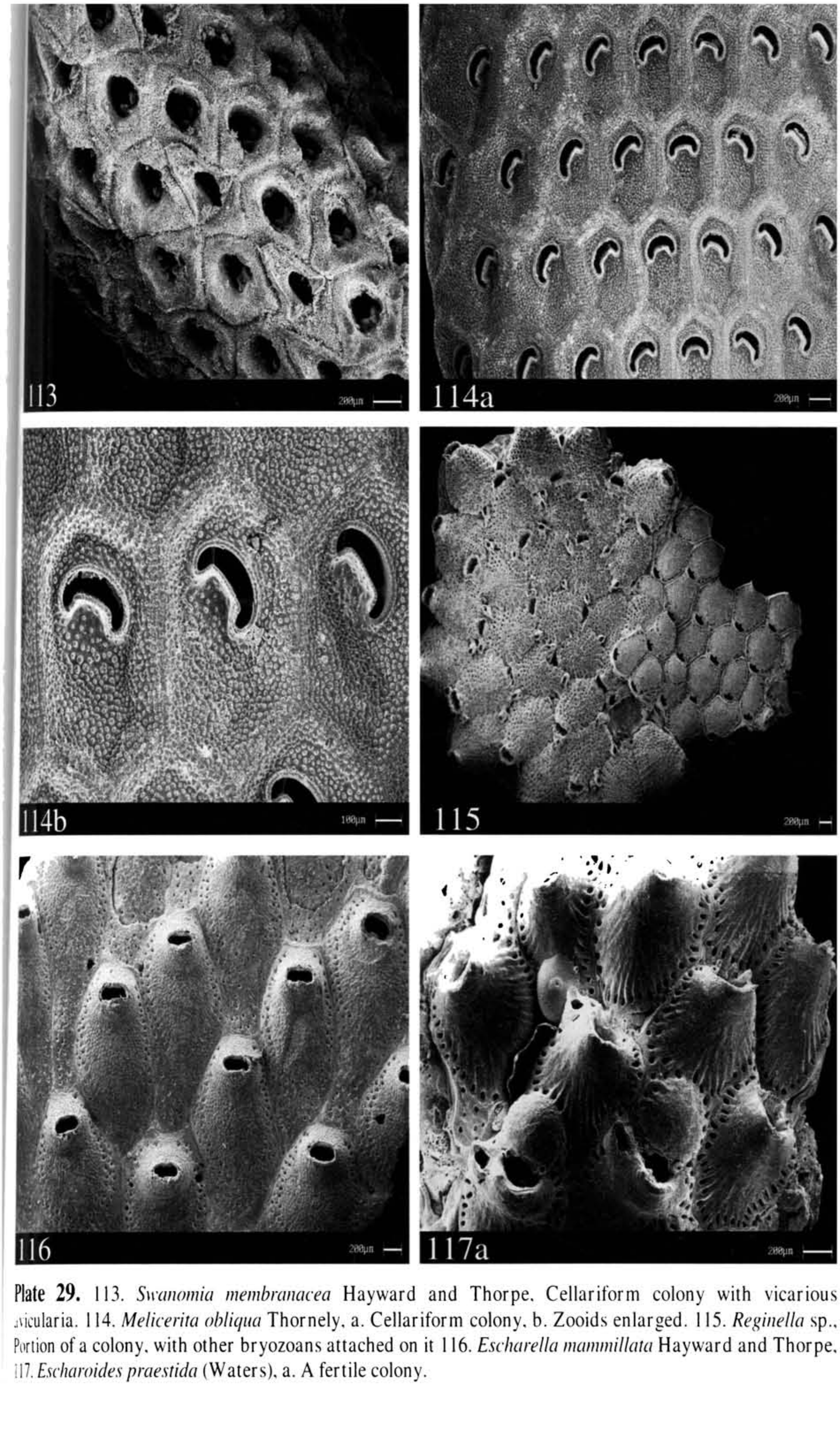


Plate 29. 113. *Swanomia membranacea* Hayward and Thorpe. Cellariform colony with vicarious avicularia. 114. *Melicerita obliqua* Thornely. a. Cellariform colony. b. Zooids enlarged. 115. *Reginella* sp., Portion of a colony, with other bryozoans attached on it 116. *Escharella mammillata* Hayward and Thorpe. 117. *Escharoides praestida* (Waters). a. A fertile colony.

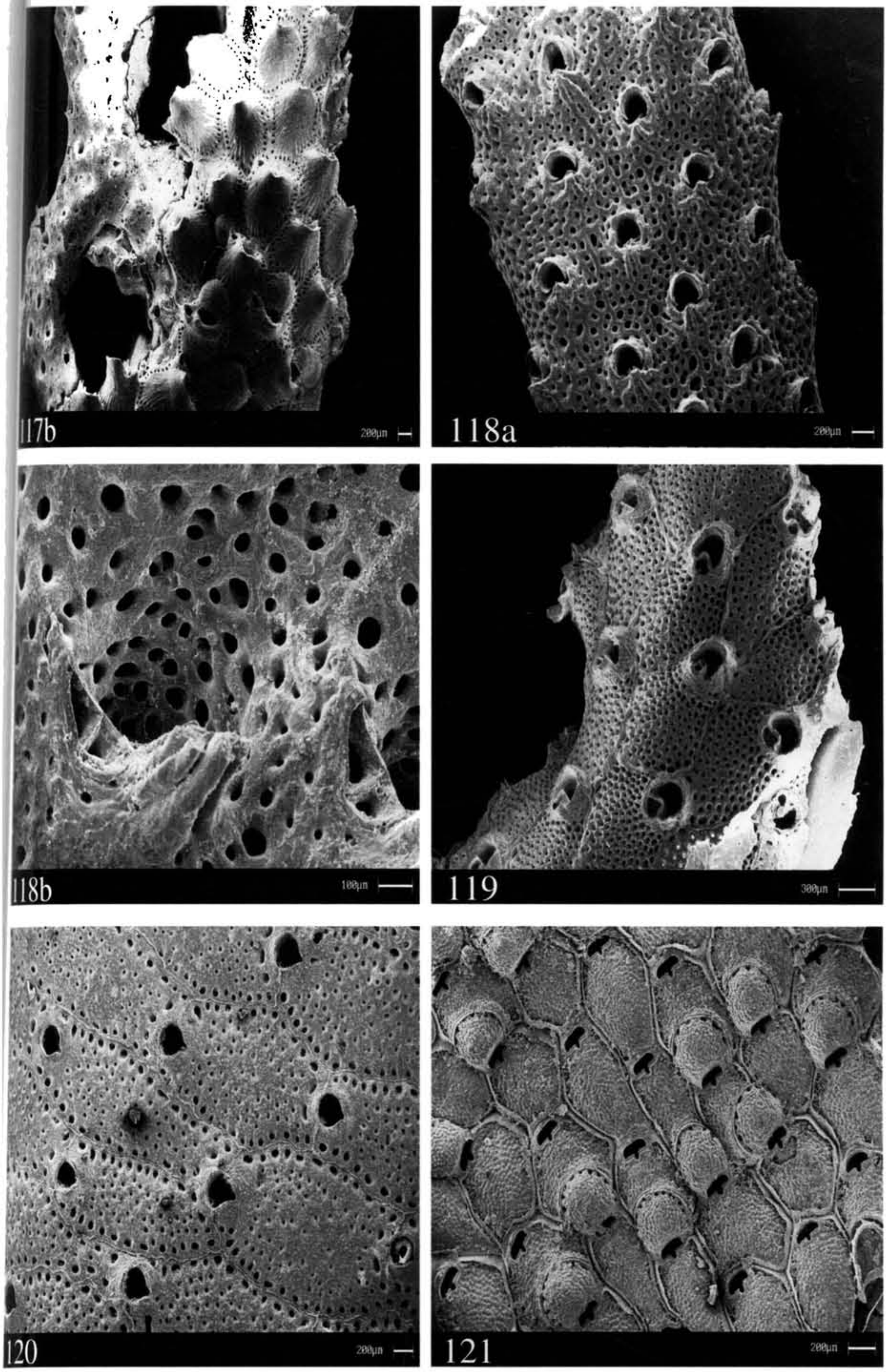


Plate 30. 117. *Escharoides praestida* (Waters), b. Colony attached on other bryozoans. 118. *Cellarinella* *toni* Rogick, a. Cellariform colony, b. Zooids enlarged showing orificial avicularia. 119. *Smittina favulosa* Hayward and Thorpe, Zooids enlarged showing medianly placed avicularia. 120. *Dakariella concinna* Hayward, 121. *Lacerna watersii* Hayward and Thorpe, A fertile colony.

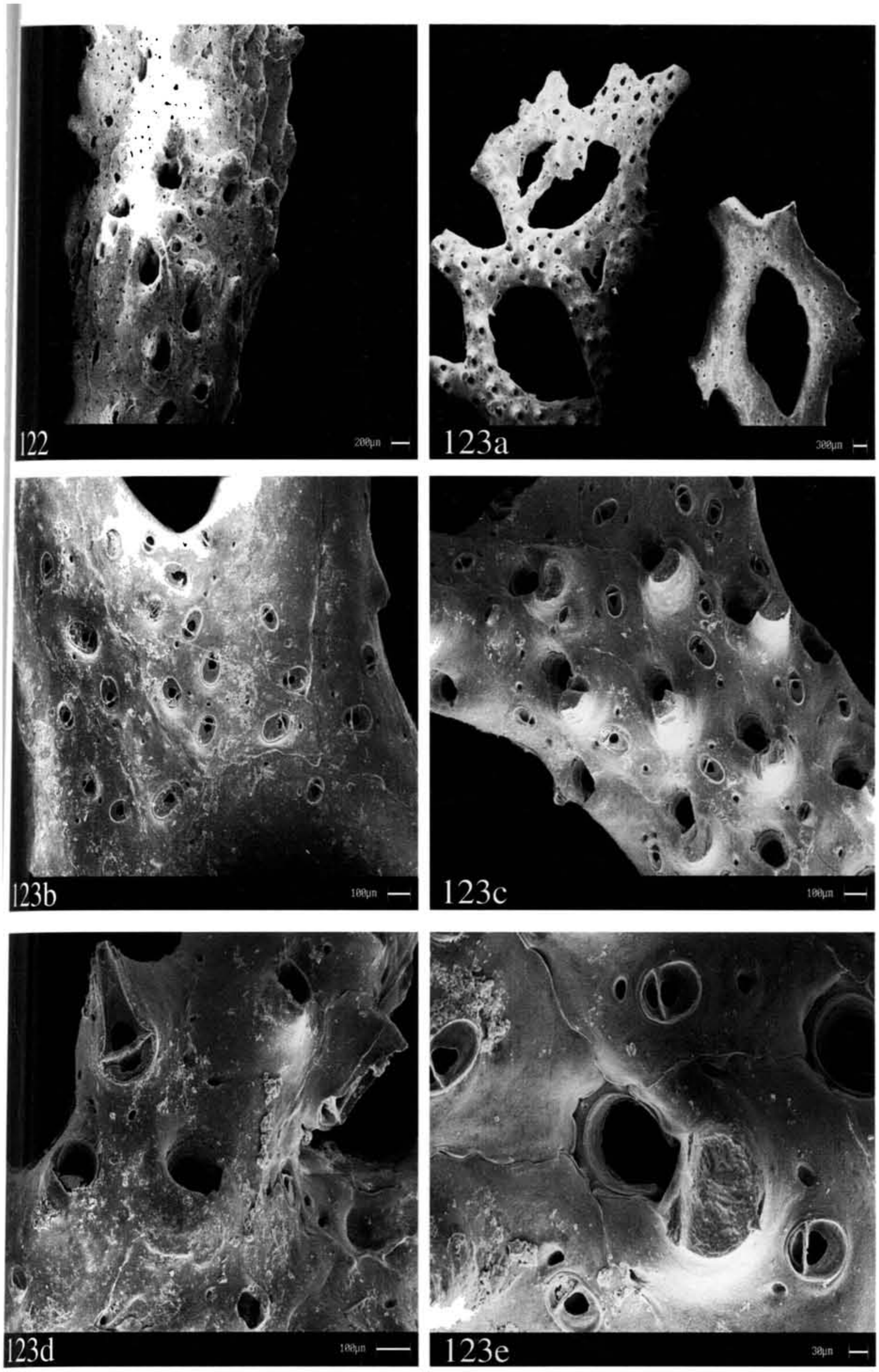


Plate 31. 122. *Rhynchozoon tubulosum* (Hincks). 123. *Iodictyum anomala* sp. novo., a. Frontal and ventral view of the colony, b. Ventral view enlarged, c. Frontal view enlarged, d. Pointed avicularia at the rim of the fenestrae, e. Frontal view enlarged showing the details of orifice and rounded avicularia.

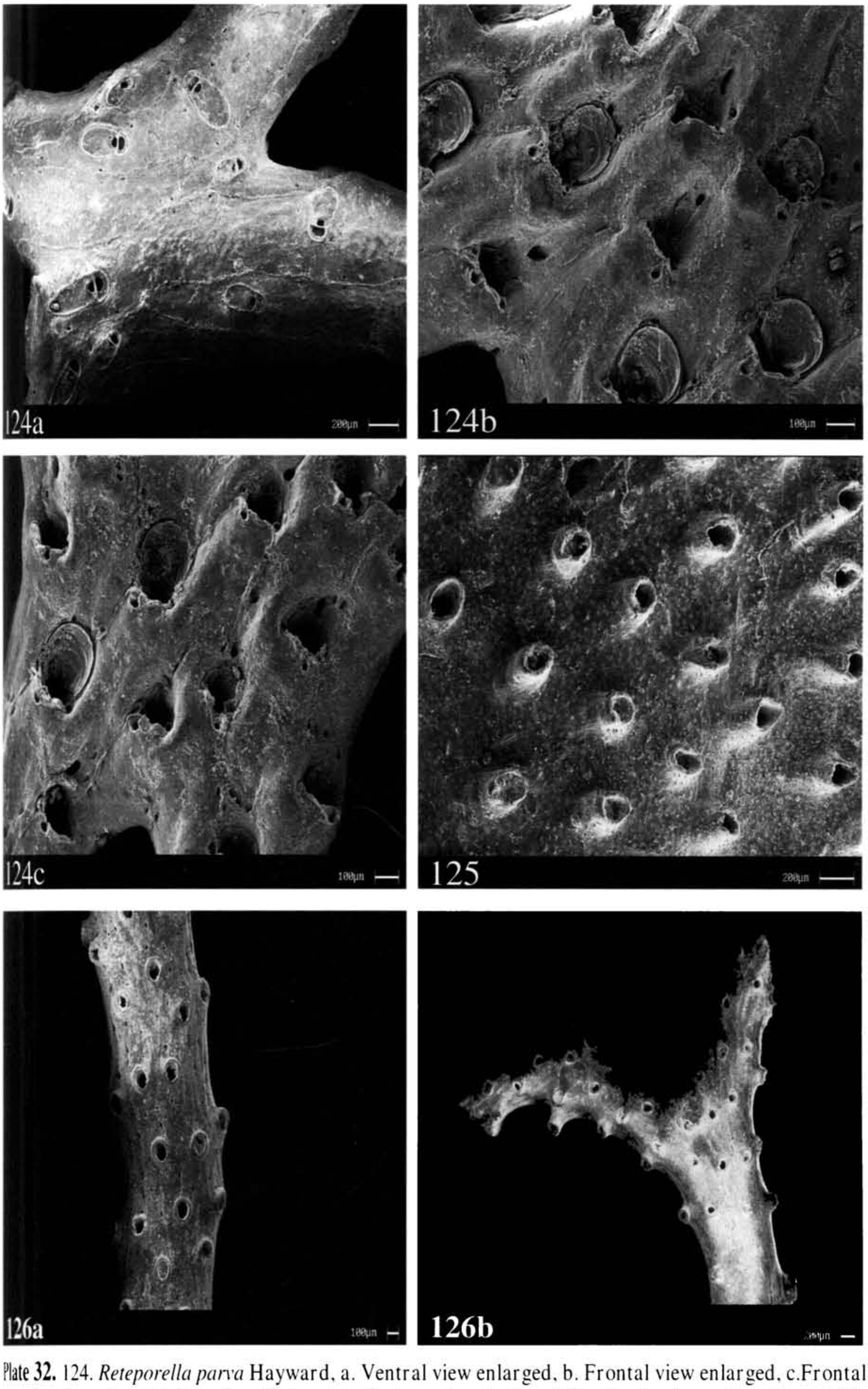


Plate 32. 124. *Reteporella parva* Hayward, a. Ventral view enlarged, b. Frontal view enlarged, c.Frontal :a showing the details of orificial avicularia and ovicells. 125. *Plagioecia patina* (Lamarck). :: *Hornera spinigera* Kirkpatrick, a. Form of the colony, b. Portion of a colony showing branching.

3. Biodiversity and geographical linkage of bryozoans

Bryozoans are a widely distributed taxa. However, its abundance and diversity vary geographically and seasonally according to the environmental conditions. The inherent capacity of many bryozoans to tolerate wide range of abiotic variables has also favoured its geographical distributions. The tolerance to environmental factors may either be genetic or non-genetic. An aspect adding to the wide distribution of this group is its potential to withstand physical abrasion due to water-transported particles and rubbles. Evolutionary success of this group has been explained in terms of the ways in which they have solved the problem by increasing calcification and thereby support and protection of soft tissues and feeding organs without sacrificing the hydrostatic method of lophophore protrusion (Cheetham, 1971; Schopf, 1977).The compressive strength of bryozoan walls both frontal and lateral (Best and Winston, 1984) and their contribution to overall colony protection revealed that compressive strength of bryozoan walls is comparable to that of corals, bivalve shells, echinoid spine and vertebrate bone. The capacity of the animal to tolerate the high pressure at greater depths has helped in expanding the bathymetric distribution of this group to a depth of 6000m.

The capacity to adapt varying environmental conditions by the ancient cheilostome bryozoan species is indicated by their presence as fossils in limestones and shales deposited in shallow and deep waters. This group has a very impressive palaeogeological history and the distributional patterns would be essentially controlled by larval transport. The assumption that latitudinal discontinuity in distribution in microbenthos is basically mode of reproduction dependant, could be cited as an example for the absence of bryozoans in all latitudinal boundaries, notwithstanding the uniqueness in environmental characteristics. Characteristic faunal assemblages have been recognized in various geographical locations, very clearly exemplified by the assemblages in Galapagos Islands, Baja California, Indo-Australian archipelago, the Great Barrier Reef region, the European Mediterranean, various Pacific Islands, the Antarctica etc.

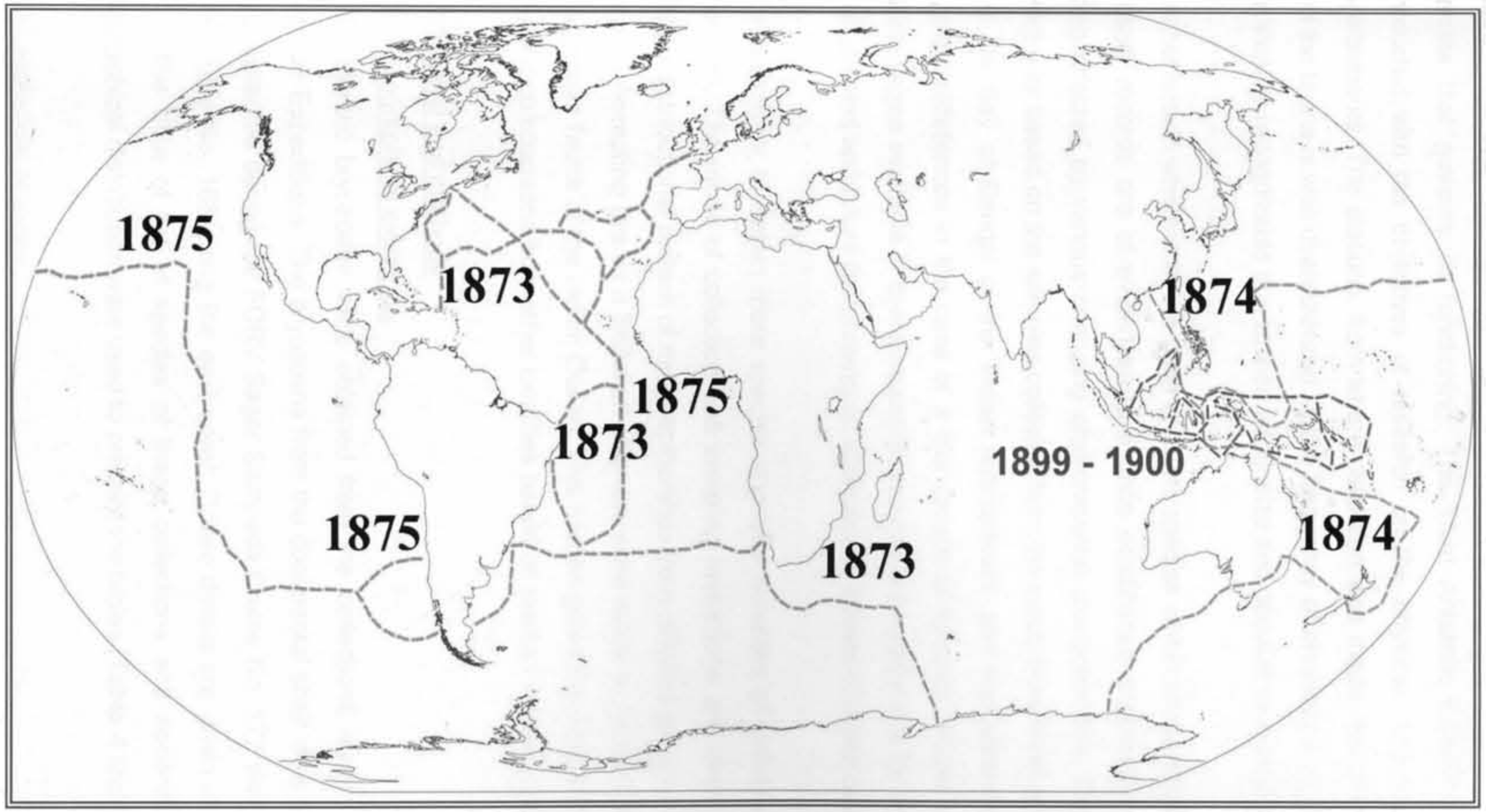
Ekman (1953) felt that the ultimate aim of zoogeography was not only the understanding of the present regional system by revealing the history, but also the way which led to the establishment of the present faunistic systems. The goals of zoogeographic research can generally be applied for the study of (1) delineation and characterization of each distinct faunal area (2) tracing the history of the fauna and (3) using zoogeographic data to augment our knowledge about the course of evolution. Researchers, who have had the privilege of working on the systematics of marine animals that are widespread, have found a close relationship between distributional and evolutionary patterns. This means that the accumulation of detailed knowledge about the distribution of species and higher categories can often be very useful in reconstructing the path of evolutionary change within a given group. Zoogeographers are interested in the various faunal areas of the world and in the distributional patterns of individual animal groups. Studies along these lines are rewarding, since they lead to a better understanding of the faunal areas, their history, and perhaps - most important of all – the phylogeny of certain widespread groups of animals (Briggs, 1974).

The landmass that now forms the continent of Antarctica is formed of two unequally sized fragments that were once part of the large continental landmass of Gondwana. In the early Cretaceous, about 120 million years ago, the southern hemisphere was dominated by Gondwana, with the Tethys Sea to the north and the proto-Pacific to the south. By the early Cenozoic, Gondwana had fragmented significantly and South America, Africa and India had all moved well away from Antarctica and Australia. Many of the details of the break-up of Gondwana are still unknown (Clarke and Crame, 1997). Evidences demonstrated by the distribution of fossil and extinct plants and animals say that South America, Africa, Antarctica, New Zealand and Australia were formerly part of the super continent Gondwana (Moyano, 1996). Marine invertebrates and vertebrates also show zoogeographical links between these very isolated lands. Bryozoans, due to their highly calcareous exoskeleton, offer an excellent material for the study of zoogeographical links.

The Indian Ocean is the third largest of the world oceans. The boundaries of the Indian Ocean are roughly defined from the African coast at 20°E to the Australian and Indonesian coasts in the west and from being landlocked in the north by the Indian subcontinent to 60° S, where it meets the Southern ocean. It is defined to include the Red Sea, Andaman Sea, Arabian Sea, Flores Sea, Gulf of Aden, Gulf of Oman, Java Sea, Persian Gulf, Savu Sea and Strait of Malacca, with 38 countries making up the coastal states of the Indian Ocean Region. The principal bathymetric features of this ocean are the Southwest Indian Ridge and Mid-Indian Ridge in the west and the Southeast Indian Ocean Ridge and Ninety east Ridge in the east. The Indian Ocean region's climate is dominated by the northeast monsoon (December to April) and southwest monsoon (June to October) and the currents that these monsoons generate (Keesing and Irvine, 2005).

The Indian EEZ is home to a diverse array of ancient and unique faunal assemblages. The dissimilarities between the west and east coasts are remarkable. The west coast is generally exposed with heavy surf and rocky shores and headlands whereas the east coast is generally shelving with beaches, lagoons, deltas and marshes. The west coast is a region of intense upwelling associated with southwest monsoon whereas the east coast experiences only a weak upwelling associated with the northeast monsoon, resulting in marked differences in hydrographic regimes, productivity patterns and qualitative and quantitative faunal composition. The Bay of Bengal, which receives enormous quantities of freshwater from the rivers emptying into it from the Indian subcontinent, essentially has a relatively less saline upper layer, limiting conventional mixing of waters form greater depths.

Zonation of the Antarctic bryozoans is greatly linked to the presence of ice, both along the coastline, where scouring ice action prevents the colonization of shallower depths as well as offshore and deeper water, due to the input of fine and coarse sediments discharged by ice melting. These inputs interact with the currents creating a large-scale mosaic of environmental situations, which in turn cause patchiness in the distribution of benthic assemblages. Though several expeditions have been exclusively devoted to research on the marine ecology of the Ross Sea and Weddell Sea regions, "The Challenger Expedition" (1873-1875) is one of the pioneer efforts to study the faunal



Route of the **Siboga** Expedition

Route of the HMS Challenger Expedition.

Fig. 6 Expedition route of **Siboga** and the **HMS Challenger**

compositions of this secluded hostile environment [**Fig. 6**]. Studies on the physical environment and the flora and fauna have helped to understand the physiological process that governs its functioning. The Third Antarctic Expedition by India was conducted with the objectives of research on the physical, chemical and biological environments. The stations, from where collection was made, fall within a coastal belt and the fauna is well characterized by the frequency of bryozoans. All these specimens were easily recognizable due to their larger size and peculiar morphologies.

It is not known whether in the case of those species which show cosmopolitanism, the present records are of evidences to a once established continuous distribution, not being affected by various changing environmental characteristics. The present study, which was based on the samples collected from the continental shelf of the Arabian Sea and the Bay of Bengal of the Indian subcontinent and the Antarctic, has indicated regional differences in the case of a few groups of species. These unique bryozoan assemblages available in dredge samples provide a powerful tool for understanding the past, present and future by focusing on a taxonomic subset of these organisms.

It is customary to obtain more species and less numbers of individuals in a benthic collection. The mode of collection and sampling restrictions are clear-cut limitations to explain distributional pattern of micro-epibenthos from different geographical locations in the sea. Accepting this as a limitation attempts were made to explain the zoogeography of bryozoan fauna of the Indian Ocean. This section gives the details of distribution and faunistic comparisons from other localities based on primary and secondary data.

3.2 Material and methods

3.2.1 Geographical existence

The Antarctic bryozoans were obtained from the collections made during the Third Antarctic Expeditions. The bryozoans from the continental shelf area of the Indian EEZ were collected during the FORV Sagar Sampada Cruise No. 177 along the west coast and Cruise No. 186 along the east coast. Cruise details are given in Chapter 2 (Sec. 2.2). The data of list of species of these collections and secondary data of their geographical distribution were used to prepare the tables [**Table 4** and **5**].

3.2.2 Statistical analysis

Statistical data helps to simplify massive data for clear interpretation. The data of the list of species and the numerical abundance of each species from three stations were selected for PRIMER (Plymouth Routines In Multivariate Ecological Research) analysis. The stations selected were:

1. Station No. 623; at a location of 12°15'00" N latitude and 80 °07'13"E longitude in the east coast of India.
2. Station No. 15; at a location of 09°46'26" N latitude and 75 °41'42" E longitude in the west coast of India.
3. Antarctic station; at a location of 69°54'00" S latitude and 12°49'00" E longitude beyond the Antarctic Circle.

Similarity between these stations with respect to bryozoan species was calculated using PRIMER 5 for windows (version 5.2.8). For this Bray-Curtis similarity index with square root transformation was opted. Dendrogram was plotted using the group average cluster mode for grouping stations with respect to bryozoan species

3.3. Results

3.3.1 Similarity Index

The similarity in percentages showed that the species number and abundance within two localities comparable latitudinally in the Arabian Sea and the Bay of Bengal ranged between 40-60 % **[Fig. 7**]. On the other hand, these two assemblages qualitatively depicted no similarity with the Antarctic fauna (<5%).

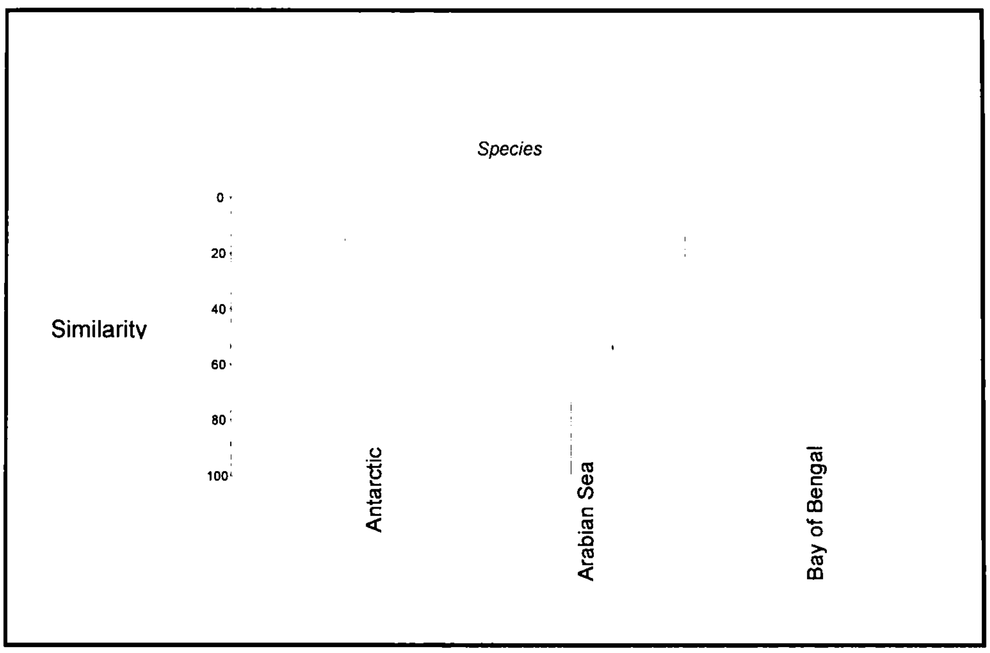


Fig. 7. Dendrogram showing similarity (%) in bryozoans from Arabian Sea, Bay of Bengal and the Antarctic

Table 3: Species of bryozoans and their numerical abundance from the Antarctic, Arabian Sea and the Bay of Bengal for statistical analysis

Species	No. of species		
	Antarctic waters	**Arabian Sea**	**Bay of Bengal**
Ellisina levata	1	0	0
Amphiblestrum inermis	1	0	0
Electra crustulenta	0	6	0
Parellisina curvirostris	0	6	1
Antropora erecta	0	0	5
Antropora granulifera	0	0	1
Antropora tincta	0	1	1
Cupuladria indica	0	3	0
Nellia occulata	0	0	1
Icelozoon lepralioides	8	0	0
Chaperia quadrispinosa	10	0	0
Cleipochaperia funda	11	0	0
Smittipora abyssicola	0	3	1
Chodriovelum adeliense	10	0	0
Steginoporella magnilabris	4	0	0
Thalamporella rozierii	0	1	4
Thalamporella hamata	0	1	0
Cellaria tecta	9	0	0
Cellaria praelonga	7	0	0
Cellaria aurorae	10	0	0
Cellaria punctata	0	1	0
Melicerita obliqua	15	0	0
Puellina vulgaris	0	0	3
Cribriliaria sp.	2	1	0
Reginella sp.	0	1	1
Trypostega venusta	0	1	6
Adeona foliacea	0	1	0
Celleporaria granulosa	0	1	2
Celleporaria pilaefera	0	0	1
Parasmittina aviculata	0	0	1
Parasmittina parsevalii	0	1	3
Parasmittina signata	0	2	0
Smittina favulosa	4	0	0
Escharella mammillata	17	0	0
Escharoides praestida	14	0	0
Cellarinella laytoni	14	0	0
Schizomavella inclusa	0	2	0
Dakariella concinno	5	0	0
Schizoporella cochinensis	0	1	0
Schizoporella inarmata	0	0	2
Lacerna watersi	16	0	0
Microporella orientalis	0	0	3
Microporelloides hawaiiensis	0	1	0
Fenustrulina malusii	0	2	1
Cleidochasma fallax	0	6	1
Cleidochasma biavicularium	0	0	1
Lagenicella marginata	0	1	0
Rhychozoon larreyi	0	4	1
Rhychozoon tubulosum	6	0	0
Iodictyum anomala sp. novo	3	0	0
Reteporella parva	5	0	0
Plagioecia patina	1	0	0
Hornera spinigera	5	0	0

Table 4 : Geographical distribution of Bryozoa recorded from the EEZ of India

Sl.No.	Species	Cosmopolitan except polar waters	Circumtropical	Arctic(Lat. 70oN)	European Atlantic	Mediterranean	Red Sea	East coast of Africa and Persian Gulf	Indian Waters (Lat.8oN - 18oN)	Srilanka	Indo-Australian Archipelago	Australian waters	N.W. Pacific (Japanese waters and Hawai)	N.W. Pacific (Pacific Coast of America)	S.W. Pacific (Pacific coast of S. America and	N.W. Atlantic (Atlantic coast of N.America)	Gulf of Mexico and Carribean	S.W. Atlantic (Atlantic Coast of S.America)	Atlantic Coast of Africa and Maderia	Antarctica (Lat. 69o54'S)
1	*Aetea anguina*	+							+											
2	*Acanthodesia* sp.								+											
3	*Acanthodesia savartii*	+							+											
4	*Electra indica*								+											
5	*Electra crustulenta*			+	+				+				+	+					+	
6	*Electra crustulenta* var *borgii*								+											
7	*Electra bengalensis*						-		+					+		-				
8	*Conopeum reticulum*			+	+				+		+	+		+		+			+	
9	*Parellisina curvirostris*	+			+				+		+				+		+			
10	*Crassimarginatella* sp.								+											
11	*Cranosina coronata*						+	+	+				+			+				
12	*Alderina arabianensis*								+											
13	*Antropora erecta*								+				+							
14	*Antropora granulifera*	+		+					+	+			+	+					+	
15	*Antropora tincta*								+				+	+	+		+			
16	*Antropora marginella*								+			+								
17	*Antropora claustracrassa*								+					+	+					
18	*Antropora* sp.								+											
19	*Caleschara levinsenii*							+	+		+									
20	*Caleschara mexicana*								+								+			
21	*Setosellina constricta*							+	+		+									
22	*Cupuladria indica*						+		+		+								+	
23	*Cupuladria guineensis*							+	+		+	+	+							
24	*Chartella arabica* sp.novo								+											

Sl.No.	Species	Cosmopolitan except polar waters	Circumtropical	Arctic(Lat. 70oN)	European Atlantic	Mediterranean	Red Sea	East coast of Africa and Persian Gulf	Indian Waters (Lat.8oN - 18oN)	Srilanka	Indo-Australian Archipelago	Australian waters	N.W. Pacific (Japanese waters and Hawai)	N.W. Pacific (Pacific Coast of America)	S.W. Pacific (Pacific coast of S. America and	N.W. Atlantic (Atlantic coast of N.America)	Gulf of Mexico and Carribean	S.W. Atlantic (Atlantic Coast of S.America)	Atlantic Coast of Africa and Maderia	Antarctica (Lat. 69o54'S)
25	*Nellia occulata*								+	+	+	+				+	+			
26	*Bugula neritina*	+							+											
27	*Bugula cucullata*								+	+		+								
28	*Synnotum aegyptiacum*	+							+		+			+		+	+			
29	*Scrupocellaria ferox*		+						+		+		+	+	+					
30	*Caberea lata*								+		+	+	+							
31	*Smittipora abyssicola*								+			+								
32	*Steginoporella buskii*							+	+		+	+								
33	*Labioporella sinuosa*								+					+			+			
34	*Thalamoporella gothica*								+	+		+	+	+					+	
35	*Thalamoporella hamata*								+		+									
36	*Thalamoporella expansa*								+			+								
37	*Thalamoporella rozierii*				+		+		+		+									
38	*Cellaria johnsoni*								+										+	
39	*Cellaria punctata*								+	+	+									
40	*Puellina vulgaris*								+			+								
41	*Cribriliaria* sp.								+											
42	*Trypostega venusta*	+							+	+		+	+			+				
43	*Adeona foliacea*								+		+	+								
44	*Adeonellopsis arculifera*								+	+			+							
45	*Celleporaria pilaefera*						+		+		+									
46	*Celleporaria granulosa*								+		+	+								
47	*Celleporaria magnifica*								+								+			
48	*Drepanophora incisor*								+	+										
49	*Parasmittina aviculata*								+				+							
50	*Parasmittina egyptiaca*							+	+		+									

Sl.No.	Species	Cosmopolitan except polar waters	Circumtropical	Arctic(Lat. 70oN)	European Atlantic	Mediterranean	Red Sea	East coast of Africa and Persian Gulf	Indian Waters (Lat.8oN - 18oN)	Srilanka	Indo-Australian Archipelago	Australian waters	N.W. Pacific (Japanese waters and Hawai)	N.W. Pacific (Pacific Coast of America)	S.W. Pacific (Pacific coast of S. America and	N.W. Atlantic (Atlantic coast of N.America)	Gulf of Mexico and Carribean	S.W. Atlantic (Atlantic Coast of S.America)	Atlantic Coast of Africa and Maderia	Antarctica (Lat. 69o54'S)
51	*Parasmittina hastingsae*								+		+	+	+							
52	*Parasmittina parsevalii*					+	+		+		+	+								
53	*Parasmittina signata*		+		+			+	+											
54	*Parasmittina spathulata*								+							+	+	+		
55	*Parasmittina tubula*								+	+										
56	*Smittina landsborovii*	+							+					+		+				
57	*Smittina torques*								+			+								
58	*Smittina acutodentata*								+		+									
59	*Escharoides* sp.								+											
60	*Metroperiella pyriformis*								+			+								
61	*Schizomavella inclusa*								+	+	+									
62	*Watersipora subovoidea*	+				+	+		+		+	+	+		+		+		+	
63	*Schizoporella cochinensis*								+											
64	*Schizoporella inarmata*								+					+			+			
65	*Margaretta watersi*								+		+	+								
66	*Hippopodina california*								+					+						
67	*Cryptosula palliasina*	+				+			+			+								
68	*Actisecos regularis*							+	+		+		+							
69	*Hippaliosina acutirostris*								+	+	+		+							
70	*Microporella orientalis*								+		+	+	+							
71	*Microporelloides hawaiiensis*								+				+	+						
72	*Fenestrulina malusii*	+							+											
73	*Calloporina sigillata*								+		+		+							
74	*Calloporina sculpta*								+	+	+		+							
75	*Sinupetraliella affinis*								+		+									
76	*Hippopetralliella magna*						+		+	+	+	+	+						+	

Sl.No.	Species	Cosmopolitan except polar waters	Circumtropical	Arctic(Lat. 70oN)	European Atlantic	Mediterranean	Red Sea	East coast of Africa and Persian Gulf	Indian Waters (Lat.8°N - 18°N)	Srilanka	Indo-Australian Archipelago	Australian waters	N.W. Pacific (Japanese waters and Hawai)	N.W. Pacific (Pacific Coast of America)	S.W. Pacific (Pacific coast of S. America and	N.W. Atlantic (Atlantic coast of N.America)	Gulf of Mexico and Carribean	S.W. Atlantic (Atlantic Coast of S.America)	Atlantic Coast of Africa and Maderia	Antarctica (Lat. 69o54'S)
77	*Mucropetraliella thenardii*					+	+		+	+	+	+								
78	*Mucropetraliella philippinensis*								+		+		+							
79	*Crepidacantha crinispina*								+		+	+	+							
80	*Cleidochasma biavicularium*								+		+		+							
81	*Cleidochasma fallax*								+		+									
82	*Cleidochasma protrusum*								+	+	+								+	
83	*Cleidochasma sampada* sp.novo								+											
84	*Lagenicella marginata*								+					+	+					
85	*Lagenicella punctulata*								+					+	+					
86	*Rhynchozoon compactum*						-		+	+			+			-				
87	*Rhychozoon larreyi*					+			+	+	+	+								
88	*Rhychozoon globosum*								+		+	+								
89	*Metacleidochasma planulata*								+			+	+		+					
90	*Tryphyllozoon tubulatum*								+		+	+								
91	*Tryphyllozoon philipinense*								+		+		+							
92	*Conescharellina jacunda*								+		+		+							
93	*Escharina pesanseris*	+							+	+	+	+	+		+		+			
94	*Alcyonidium erectum*	+							+											
95	*Victorella pavida*	+							+											
96	*Nollela papuensis*								+		+									
97	*Bowerbankia gracilis*	+							+				+	+						
98	*Triticella korenii*				+				+											
99	*Stomatopora granulata*				+	+			+			+	+							
100	*Proboscina lamellifera*								+						+					
101	*Crisia elongata*					+	+		+	+	+		+						+	
102	*Filicrisia* sp.								+											

Table 5 : Geographical distribution of Bryozoa recorded from the Antarctic waters

Sl.No.	Species	Cosmopolitan except polar waters	Circumtropical	Arctic(Lat. 70°N)	European Atlantic	Mediterranean	Red Sea	East coast of Africa and Persian Gulf	Indian Waters (Lat.8°N - 18°N)	Srilanka	Indo-Australian Archipelago	Australian waters	N.W. Pacific (Japanese waters and Hawai)	N.W. Pacific (Pacific Coast of America)	S.W. Pacific (Pacific coast of S. America and	N.W. Atlantic (Atlantic coast of N.America)	Gulf of Mexico and Carribean	S.W. Atlantic (Atlantic Coast of S.America)	Atlantic Coast of Africa and Maderia	Antarctica (Lat. 69°54'S)
1	*Ellisina levata*													+						+
2	*Amphiblestrum inermis*																			+
3	*Icelozoon lepralioides*											+								+
4	*Chaperia quadrispinata*																			+
5	*Cleipochaperia funda*											+								+
6	*Chondriovelum adeliense*																			+
7	*Steginoporella magnilabris*	+		-								+	+				+			+
8	*Cellaria tecta*										+									+
9	*Cellaria prealonga*										+									+
10	*Cellaria aurorae*																			+
11	*Swanomia membranacea*																			+
12	*Melicerita obliqua*																			+
13	*Reginella* sp.																			+
14	*Escharella mammillata*																			+
15	*Escharoides praestida*											+								+
16	*Cellarinella laytoni*																			+
17	*Smittina favulosa*																			+
18	*Dakariella concinno*											+								+
19	*Lacerna watersi*																			+
20	*Rhychozoon tubulosum*								+	+	+							+		+
21	*Iodictyum anomala* sp.novo																			+
22	*Reteporella parva*																			+
23	*Plagioecia patina*																			+
24	*Hornera spinigera*										+			+						+

3.3.2 Geographical distributions of bryozoans from the Indian EEZ and the Antarctic

The pattern of distribution of Bryozoa in the various seas is tabulated and presented in **Table 4 and 5**. Although a total of 126 species were examined and described in this study, hardly 15 species were found to enjoy cosmopolitan distribution except the polar waters. Of these, 7 species are well established marine foulers. This evidently indicates the role of various methods of transport of adult colonies by way of shipping, driftwood etc. to the subtidal and littoral areas of the oceans. Three species were found to be present in the arctic and they are often recorded as epizoic on crabs, turtles etc. The European arctic also had representation from among the species recorded from the Indian waters. By and large, the major number of species recorded in the present studies was confined to areas of Indian EEZ, the Indo-Australian archipelago and the Pacific and Australian waters. Only two species was found to occur in the south-west Atlantic and one species in the Antarctic.

3.5. Discussion

Investigation on the species abundance of various benthic regions in tropical seas is an important aspect of faunistic distribution. It is well known that the pattern of species abundance is controlled by various features, both biotic and abiotic, in the benthos. This has triggered studies on the benthic community structure to analyse changes that could occur due to recognized variables. Warwick and Clarke (1991) did some pioneering work on this aspect and opined that the temporal or spatial similarities of regions need not reflect on the species distribution and it is necessary to analyse various subsets of environmental data to recognize changes in community structure. This field of enquiry was essentially the product of necessity that arose out of situations which demanded explanations on biodiversity variabilities observed in geographically comparable areas subjected to anthropogenic influences. The studies were essentially directed towards understanding the faunistic composition and its variations in polluted and unpolluted benthic regions. This methodology can be a useful tool even to assess the nature of variabilities in level bottom benthic communities.

Bryozoans are important components of the microbenthos of the world oceans. The present investigation has shown that variabilities could occur in species composition of latitudinally comparable localities. To test this, analysis was made on the distribution of species from two comparable localities and a non comparable locality. Warwick (1988), in his studies to determine effects of pollution at the community level, selected and used benthic assemblages of subtropical waters from various sub littoral areas, macrofauna of Norwegian waters, meiofauna of the Belgium and microfauna of Canada. He felt that macrofauna and meiofauna could be compared and utilized for this study since sampling regimes and species concepts were similar. In majority of cases, studies based on Primer analysis were to indicate increase in variability as a symptom of stress in marine communities. Stress from a biological stand point could be due to numerous factors experienced by a benthic marine invertebrate among which anthropogenic effects are the major reason (Warwick and Clarke, 1993). In the literature, the aspect of variability in the structure of marine benthic populations and communities are many. The causes, however, for such variabilities have generally been not looked into. The main reason for this is lack of information regarding the physicochemical and biological factors of the area of collection. Since this is site specific, generalization normally becomes rather difficult. Notwithstanding this, the species that inhabited three regions in the marine environment were analysed using multivariate diversity indices. The number of species was within 20-23. Among the stations considered one station was experiencing conditions totally different from those prevailing in the other two.

Thorson (1964) and Remane and Schlieper (1971) have studied extensively the nature of level bottom communities. They conceptualized the existence of similarities between communities living in the same latitude irrespective of difference in geographical regions. The similarity percentage of 40-60 support, the broad theory that latitudinally bryozoan species occurring in the benthic realm of Bay of Bengal and the Arabian Sea exhibit similarity. It would be interesting to compare this with the distribution picture of other benthic species from these two seas as well. Probably this would help us to hypothesize parallel level bottom community concepts more explicitly.

A clear cut endemism was discernable with reference to Antarctic waters. The northern extend of distribution of the Antarctic species was found to culminate on the Indo-Australian Archipelago area. The Indian fauna represented species from almost all the tropical regions of both the Indian Ocean and the Pacific Ocean. Faunistic information available on the Bryozoa of the Indian waters is limited. While considerable efforts have been made to study the Atlantic Pacific, the Arctic and the Antarctic, only limited attempts were made to study this group from the Indian Ocean. Therefore, "the patchiness" may be more an indication of lack of information than nature of distribution. This should necessarily be so since, various authors have commented that bryozoans are an important group lophophorates enjoying of wide distribution in the world oceans. A luxurious fossil history of both extinct and recent bryozoan supports this assumption. It was attempted to find out the extend of distribution and the causative factors by selecting a few species. This examination showed that the ctenostomes and the anascans seem to enjoy wider range of distribution except *Rhynchozoon tubulosum,* an ascophoran, which was found to be present in the Indian waters as well as the Antarctic. Structurally the genus *Rhynchozoon* possesses hard skeleton with a variable calcareous thickenings. The warmer conditions of tropical and subtropical seas are found to support a wide range of bryozoan species. There are geographical areas, for example, N. Zealand waters, the Indo-Australian Archipelago, the Great Barrier Reef and the Antarctic, where rich bryozoan fauna exist. The present study added 54 species to the already described 130 species from the Indian Ocean (Menon and Menon, 2006). The new records from the Indian Ocean were essentially from the benthic regions of the Indian EEZ obtained from the collections of FORV Sagar Sampada cruises during 1998-2002.

A study on the zoogeography of benthic invertebrates can be carried out by various methods. Since the samples are obtained from shallow to greater depths, the pattern of distribution can vary from taxa to taxa. The distribution patterns seem to be strongly affected by physico-chemical and edaphic factors. Among these, substratum morphology and exposure heavily affect shallow water rocky biotopes (Barnes and Clarke, 1995) while depth, bathymetry and edaphic factors produce larger variations on bryozoan assemblages. Assuming that eurybathy and stenothermy are the common feature of epibenthos of greater depths, wider distribution of such species is a possibility since pressure and temperature pattern of the deep Sea are more or less universal in the world oceans. Biotic factors, such as the local presence of other organisms also largely influence benthic assemblages.

There is a tendency for many ecological studies to subordinate the effects of pressure to those of other variables perhaps on the misleading assumption that pressure is important to only animals, which have compressible gas bladder or bubbles. However, hydrostatic pressure has profound influence on many physiologic systems and to the kinetics and stereospecificity of physiological biochemistry (Kinne, 1975). Most of the benthic invertebrates showing distinct vertical zonation that might be due to pressure effect also possess larval dispersal stages. Many physical variables change with depth, preventing the attribution of any changes in fauna to simple hydrostatic pressure. Since pressure, light, temperature and nature of benthic deposits vary with changing depth, it is rather difficult to assign any particular physical feature accompanying depth variations to changes in biotic characteristics based on a single factor. The distribution of microbenthos with well developed planktonic larvae with all the positive attributes could be the result of various reasons hitherto not properly explained by marine biologists. In the Antarctic, where there is very little temperature variation with depth changes, there is still marked vertical zonation of the benthic fauna. Similar zonation is found in lower latitudes where there is a marked temperature changes (Hedgepeth, 1957).

Bryozoans are almost absent from the mesolittoral and upper infralittoral zones of the Antarctic down to ca 4m, because of the ice action preventing their settlement (Barnes and Clarke, 1995; Rosso and Sanfilippo, 2000). Hard bottoms of the lower infralittoral zone (4 to 35 m) are heavily colonized by macroalgae, encrusted by sessile epibionts, among which bryozoans are very abundant. Circalittoral and upper pseudobathyal zones comprise of rocky and soft bottoms, normally colonized by dense populations of bryozoans. Sandy and muddy coverings occur at depths ranging from about 60 to 140 m of rocky bottoms and here species richness is higher than that in the infralittoral bottoms.

The method of feeding and mode of reproduction are two important factors which control the distribution of microbenthos especially epibenthos. Therefore, it is logical to consider factors like filter feeding, suspension feeding, feeding on detritus and dissolved organic matter when distributional patterns are assessed. Possible relations between turbulence and faunal distribution in deeper regions have not been explored in detail. But this need not indicate the irrelevance of turbulence on distribution. Even as far down as the abyssal-hadal boundary of hard substrate the presence of filter and suspension feeding organisms would suggest that differing levels of turbulence must be important in all submarine positions.

The high correlation between substrate grain size and fauna indicates that ecology was important in the past as evidenced by the distribution of bryozoans during the different geological era. Rough water morphologies for colonial organisms are notable in this regard. Thomsen (1977) describes the thicker-walled bryozoan colony from a high current-velocity situation as contrasted with thinner walled forms of the same species in a lower current velocity situation. Thomsen (*loc.cit.*) also deals with the relevant sedimentary parameters with the distribution of bryozoans.

Any community concept must account for the commonly encountered patchy distribution so characteristic of benthic communities. In the case of marine organisms occupying relatively greater depths, a real uniform dispersion over any extensive tract is rather difficult. Patchiness could be due to gregariousness, reproductive behaviour (so typical of bryozoans) or owing to heterogeneity of the habitat. In the polar extremes, organisms capable of surviving will occur in environments where they would be outnumbered elsewhere by more capable species. Thus the patch size tends to increase with proximity to the poles and patch kind decreases. (Boucot, 1981).

Analysis of bryozoan fauna during the Holocene (before 11,000 years) to understand links between Australia, New Zealand, south America and Antarctica have shown that clear-cut links do exist between the bryozoan fauna of these regions although the richness per serfs varied between regions. This has affected the quantum of taxonomic units represented in these different geographical areas. Commenting on this feature Moyano (1996) remarked that species richness and genus richness are normally encountered in lower latitudes within the bryozoan group itself. The genus *Smittina,* which exhibits the highest diversity in the Antarctica, exhibits remarkable comparability in the distribution of *Smittina* genera in the various geographical areas including the Indo-Australian Archipelago. This necessitates a look into the causative factors affecting zoogeographical distribution and the possible links between widely separated fauna. Some species, which indicate links between bryozoan fauna of widely separated areas and certain species of cyclostomes belonging to the genera *Crisia*, *Hornera, Lichenopora* and *Tubulipora,* have shown links between Antarctica and S. America. Clear cut zoogeographical connections have been recognized in the case of cyclostomes of Antarctica and the Magellanic area. The contrasting result from the above assumptions if obtained could normally be connected to temperature effects (Soja and Menon, 2005). If Eurythermy is an accepted quality of benthic bryozoans, we should expect similarities in the bryozoan of the hadal regions of the Indian Ocean with the Antarctic. Unfortunately no attempt has so far been made to connect the benthic bryozoan distribution of the Indian Ocean with that of the Antarctic notwithstanding the "hydrological proximity" of the two major oceans with no land mass restricting distribution of animals between these two oceans. This aspect is of importance because no well defined guyots, submarine volcanoes, archipelagos or submarine ridges exist between these two oceans but for the enormity of physical distance. Contiguity in distribution of bryozoans between the Indian Ocean and the southern oceans if proved to exist would necessitate explaining the mode of larval transport that would have affected the distribution.

A valuable discussion of the gymnolaemates of high southern latitudes from the zoogeographical point of view was given by Hastings (1943), who pointed out that the gymnolaemates of sub Antarctic and Antarctic zones are in general distinct. Curiously enough the distribution of bryozoan fauna of many discontinuous geographical regions has shown certain degrees of similarities. Studies have shown that there are some basic resemblances between the Indo-Australian and the Pacific bryozoan fauna at least latitudinally (Menon, 1972e). Another aspect, which could be brought in as a causative factor for variations in patterns of distribution between the world oceans, could be discontinuity in faunal assemblages during the geological periods.

In terms of taxic diversity and modifications, there is a normal fauna for every time interval. It is difficult to define what 'normal' means. Part of the meaning is implicit in the presence of widely distributed taxa as the phylum Bryozoa. If one deduces that phanerozoic marine organisms had their origin in the sea, in a medium possessing properties little different from those of modern tropical- subtropical sea water, it is reasonable to conclude that any deviation in seawater composition from the average will have a faunistically restrictive effect. Of the 126 odd species described here, many enjoy a very extensive paleontological distribution. This probably indicates that cheilostomatous bryozoans, which are essentially marine in origin, enjoyed a very wide-ranging distribution from the early geological era itself.

Part-II

Bryozoan foulers of Cochin estuary

4. Environment of fouling bryozoans

Cochin backwater, situated in the northward extensions of the Vembanad Lake, having an area of 300 km^2, is the largest estuarine water body on the southwest coast of India. Cochin harbour (Lat. 9°58'N and Long. 76°17'E) is the second largest port along the west coast of India. A narrow gut with a width of about 450 m connects the harbour with the Arabian Sea. This passage has three dredged channels - the Approach Channel lying in the east-west direction, the Mattancherry Channel oriented in the north-south direction with Willington Island and Mattancherry bordering the east and west side and the Ernakulam Channel oriented in north-south direction bordered by Ernakulam and Willington Island **[Fig.8]**. This natural harbour is well known for progressive industrialization, tourism and trade as many cargo and passenger ships frequent the harbour.

The Ernakulam channel is around 5 km in length with a width of around 250-500 m. The Mattanchery channel has a length of 3 km and a width of around 170-250 m. Depth of the two channels vary between 1.5 m and 6.0 m in most parts except the dredged channels, which are 10-13 m deep. The sediments of these channels are a mixture of clay and silt and vary based on the season (Menon *et al.*, 2000)

The salinity gradient of this area is greatly influenced by the seawater intrusion and the emptying of rivers. Saline water intrudes the estuary through the bar mouth area in the approach channel during the daily tidal rhythm. Major rivers such as the Periyar and the Moovattupuzha empty either into the Vembanad Lake or into the backwaters. Another factor influencing the salinity of this area is the yearly rainfall. Maximum rainfall is recorded in this region during the southwest monsoon, which bursts along the southwest coast during late May or early June. Some precipitation occurs during the northeast monsoon and also during the period October – December. The rainfall, during the two monsoons and the consequent drainage, influence the salinity of the backwaters from June to December, and in July and August the surface water of Cochin backwaters may almost be fresh. This fluctuating salinity conditions bring about variations in the availability of food, variation in the substrate characteristics and also other changes in the physical characteristics of the water body. The salinity gradient in Cochin backwater supports diverse species of flora and fauna according to their tolerance for saline environment (Menon *et al.,* 2000). Bryozoans, however, prefer estuarine or marine environments to freshwater.

According to the influence of the southwest monsoon and other associated meteorological conditions, the year may be conveniently split into three well-defined periods with characteristic hydrographic conditions. The pre-monsoon (1 February–31 May) is comparatively a dry period with almost no rainfall and is characterized by distinctly high salinity and temperature for the surface water. The monsoon period (1June–30 September) is characterized by very heavy rainfall and a consequent lowering of salinity of the surface water, which may become almost fresh. The temperature also may show a decrease; this is due to the influence of southwest monsoon. The post-monsoon (1October–31 January) is characterized by the upward trend in surface salinity with fluctuations. Temperature also fluctuates during this season due to the influence of northeast monsoon and irregular rainfall.

Extensive research work on the biological aspects of the Cochin backwaters have been carried out and the studies on the hydrography of Cochin backwaters (Menon, 1967, Lakshamanan *et al.,* 1982) have shown that apart from the influence of monsoons during June to December and the evaporation during pre monsoon period from February to May, various phenomena such as upwelling, silting, coastal piling etc occurring in the Arabian Sea and the estuary result in characteristic variations in hydrography. Much more serious environmental threats which Cochin backwaters encounter are the intertidal land reclamation, pollution, expansion for harbour development, dredging activities and urbanization (Gopalan *et al.,* 1983; Menon *et.al.,* 2000).

Other than natural changes in hydrography, Cochin estuary experiences continuous oil input associated with shipping, fishing vessel operation, transportation, recreation, urban run-off, accidental spillage during tanker operations etc. Menon and Menon (1998) opined that natural causes like effective flushing in monsoon controls the concentration and distribution of petroleum hydrocarbons (PHC) in the surface and subsurface waters of the estuary.

4.2 Stations Investigated

The Five Stations investigated during this study were selected to represent five significantly different ecological habitats in the Cochin Harbour (**Fig. 8**) with an aim to study the seasonal settlement and abundance of the bryozoans, which form an integral part of the fouling community in the estuary.

Station 1: **Ernakulam Channel-Site I-Indian Oil Jetty** [9°57'81"N and 76°16'93"E]

This station is situated in the Ernakulam Channel, adjacent to the Marine Science Campus of Cochin University of Science and Technology in Ernakulam. This is nearly 4.5 km away from the bar mouth. The pier is used to load oil into barges and occasionally, oil pollution is bound to take place during these operations. Dredging in the channels release a cloud of detritus and silt, this raises the turbidity of the area. Depth of the station is about 2.5 m.

Station 2: **Ernakulam Channel-Site II-Oil Tanker Berth** [9°58'04"N and 76°16'83"E]

This station is located on the eastern side of the Ernakulam Channel, which is nearly 4 km away from bar mouth. This berth is used for transferring crude oil and petroleum to Kochi Refinery and other oil companies. Foreign and inland ships frequent this berth. Siltation is high due to dredging operations in the channel. Depth of the station is 3 m.

Station 3: **Mattancherry Channel** [9°58'04"N and 76°15'57"E]

This station is situated in the Mattancherry Channel on the western side of the Willington Island nearly 3 km away from the barmouth. The water at this site is turbid due to dredging activities and is polluted as the cargo and passenger ships regularly anchor at this wharf. The cement factory ship 'Hathi' was anchored in this site throughout the year

- Station 1: Ernakulam Channel-Site I-Indian Oil Jetty
- Station 2: Ernakulam Channel-Site II- North Oil Tanker Berth
- Station 3: Mattancherry Channel
- Station 4: Approach Channel
- Station 5: Vypeen Channel

Fig.8. Satellite imagery of Cochin backwaters: Station location where test coupons were exposed to study incidence of bryozoan foulers.

other than in the months of August and September. The depth of the station is 5 m.

Station 4: **Approach Channel** [9°58'34"N and 76°14'62"E]

This station is located very close to the barmouth, in the approach channel. The water at this site is clear but constantly in motion due to waves. The salinity was high due to the saline intrusion from the Arabian Sea. The depth of the station is about 2.5 m.

Station 5: **Vypeen Channel** [10°00'80"N and 76°14'23"E]

This site is almost 6 km away from the barmouth and situated in a rather unpolluted, less turbid and low saline, inner part of the estuary. There is a thriving mangrove near this area and the depth of the station is 2 m.

4.3 Material and Methods

The Surface water was collected using a clean plastic bucket of 5 litre capacity and the bottom water sample was collected at an interval of 7 days at station 1 and 30 days at the other four stations, using a Van Don Bottom sampler for the measurement of the following hydrographic parameters.

4.3.1. Salinity

Salinity was estimated immediately after collection using a calibrated Salinometer.

4.3.2. Temperature

Temperature was measured immediately after collection of water sample with a high precision mercury thermometer.

4.3.3. Dissolved oxygen

Dissolved oxygen (DO) was measured by Winkler titration method (Strickland and Parson, 1972). This method is based on the reaction between DO and Mn^{2++}ions in a strong alkaline medium. $Mn^{2+}$is oxidized to Mn^{3+} and is precipitated. It is then acidified to a pH range 1- 2.5 and is again reduced to Mn^{2+} by excess I^{2-} and I_2 is liberated. The liberated I_2 corresponds to DO and is estimated by thiosulphate solution, using starch indicator. From the normality obtained amount of oxygen in the sample is calculated.

Oxygen concentration (mg/l)= y X x X 8 X (1000/ s X (b-c) b)

Where: y= normality of sodium thiosulphate.

x= volume of sodium thiosulphate.

s= volume of sample taken for titration.

b= Volume of BOD bottles.

c= volume of reagents added (Winkler A and B).

4.3.4. pH

pH was estimated using Pocket pH Tester (Eutech).

The meteorological data was obtained from INS Garuda.

4.4 Results

Hydrographical Conditions: Salinity, Temperature, Dissolved Oxygen and the pH at different stations were analysed during the study period (2002-2003). The data are presented in Tables 6 to 10 and Figures 9 to 28.

4.4.1. Salinity

Salinity was recorded weekly at Station 1 and Surface salinity of the water (Table 6) ranged from 11.8 psu to 25.4 psu (practical salinity unit) during the post-monsoon period, the former being the average of the weekly salinity values for the month of October and the latter the average of the weekly values of the month of January 2001. Slight fluctuation was observed during pre-monsoon. A sudden drop to 12.5 psu was noticed during the month of May due to the onset of monsoon. Low salinity values were obtained during Monsoon and the surface layers recorded 3.3 psu in August while it was 20 psu in the month of September.

Bottom salinity was higher than the surface salinity. It is evident from Table 6 and Figure 10 that the bottom salinity at station 1 ranged from 24 psu to 28.6 psu during post-monsoon. The bottom salinity for the month of December was relatively high. During the pre-monsoon, the salinity of this site was in the range of 24 psu to 27.8 psu. In the monsoon season, high fluctuation in salinity was noticed. The salinity of the bottom was generally higher by an approximate value of 10 psu than the surface salinity during the period of investigation. The variation in the salinity of the surface and bottom was less during the months of the pre-monsoon season. The drastic change in salinity of the top and bottom layers is due to fresh water discharge or the southwest and the northeast monsoon.

Surface water salinity fluctuated during the post-monsoon period at Station 2 [Table 7 and Figure 14]. Pre-monsoon period had a mesohaline condition. During monsoon, there was a lowering of salinity with a rise to 20 psu in September. Highly saline conditions prevailed in this station throughout the year. Monthly variations in the surface and bottom salinity at this station were not noticeable.

At Station 3, the post-monsoon season showed wide fluctuation [Table 8 and Figure 18]. During the pre-monsoon period there was a constant rise in the surface salinity value. During monsoon very low salinity was recorded. The surface water was nearly fresh in August. A sudden rise to 32 psu in September was very conspicuous. This drastic variation in salinity at Station 3 and 4 may be due to their proximity to the Barmouth. The bottom salinity of this site fluctuated between 6 psu and 32 psu during the post monsoon. However, stable and high saline conditions prevailed during pre-monsoon. Freshwater conditions prevailed during some months of the monsoon season.

The sampling at Station 4 was from May, 2002 to April, 2003 [Table 9 and Figure 22]. In May 2002, the end of pre-monsoon, the surface salinity was low. During monsoon, the water was nearly fresh in August. During post-monsoon, the surface salinities ranged from 4 psu to 34 psu showing an increase towards the end of the season. Pre monsoon months from February to April 2003 showed constant high salinity. The bottom salinity in May showed a value of 10 psu and became nearly fresh in August. The post-monsoon season showed wide range in bottom salinity from 6 psu in October and 34 psu in January. The pre-monsoon season of 2003 had constantly high bottom salinity values (34, 30 and 35 psu) the difference in surface and bottom salinity of this station was negligible.

Sampling at Station 5 was from April 2002 to March 2003 [Table 10 and Figure 26]. During the latter half of the pre-monsoon period in 2002, the salinity showed wide changes in April and May. Monsoon months recorded very low surface salinity from the beginning till the end. Post monsoon months of October and November showed low surface salinity. The pre monsoon period of 2003 registered high salinity. The salinity of the bottom waters at this site fluctuated markedly. The salinity gradually dropped reaching very low values during monsoon. This trend was recorded in the bottom waters also, showing more or less uniform salinity in the whole water column.

Table 6. The meteorological and hydrographical conditions at Station 1 (Ernakulam channel-site 1-Indian Oil Jetty) during the year 2002

Season	Atmospheric temperature (°C)		Rainfall (mm)	Relative humidity (%)	Temperature (°C)		Salinity (psu)		Dissolved Oxygen (mll^{-1})		pH	
	Max.	Min.			Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Pre Monsoon												
February	32.7	23.3	0.4	72	31.3	30.0	20.3	24.0	4.6	3.1	7.6	7.8
March	33.1	25.1	0.3	75	31.1	30.5	23.3	25.8	4.6	3.8	7.2	7.4
April	33.1	26.3	2.8	78	32.0	30.5	24.3	27.8	3.3	4.3	7.5	7.6
May	32.4	25.6	16.4	82	32.6	31.3	12.5	16.0	3.5	3.0	7.6	7.8
Monsoon												
June	29.9	23.8	17.1	88	30.3	28.8	8.5	17.3	5.6	4.4	7.3	7.4
July	28.6	23.4	10.3	91	29.9	28.4	5.4	28.4	5.1	4.4	7.3	7.6
August	29	23.5	19.9	87	30.2	29.0	3.3	12.7	5.0	5.1	7.6	7.6
September	28.8	23.4	5.0	88	28.8	27.6	20.0	30.5	5.6	4.9	7.5	7.5
Post Monsoon												
October	29.7	23.5	14.8	83	29.7	28.4	11.8	24.0	5.8	5.2	7.4	7.4
November	29.9	22.9	4.5	82	29.3	28.5	9.5	23.3	5.2	5.8	7.4	7.6
December	31.1	21.5	0.0	71	29.0	28.0	24.0	33.0	6.9	6.4	7.2	7.4
January	31.2	21.0	0.5	70	29.9	28.8	25.4	28.6	3.6	3.5	7.5	7.6

Table 7. The hydrographical conditions at Station 2 (Ernakulam channel-site 2-North Tanker Berth) during the year 2002

Season	Temperature (°C)		Salinity (psu)		Dissolved Oxygen (mll^{-1})		pH	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Pre Monsoon								
Feb.	30.5	30	26	29	4.3	3.5	7.5	7.7
March	33	32	20	28	6.3	3.8	7.3	7.1
April	32.5	32	21	30	4.8	3.0	7.3	7.8
May	30.5	30.5	10	23	5.1	4.2	7.3	7.4
Monsoon								
June	32	31	7	26	5.3	4.6	7.6	7.8
July	29	29	10	21	4.5	4.2	7.1	7.4
August	30.5	29	5	30	5.5	3.4	7.3	8.0
Sept.	30	29	20	32	5.0	5.9	7.2	7.4
Post Monsoon								
Oct.	30	28	3	26	5.9	5.3	7.1	8.0
Nov.	30	28	11	26	6.4	6.2	7.3	7.8
Dec.	29	28	30	34	7.2	6.7	7.8	7.9
Jan.	31.5	30	20	21	4.5	3.1	7.6	7.3

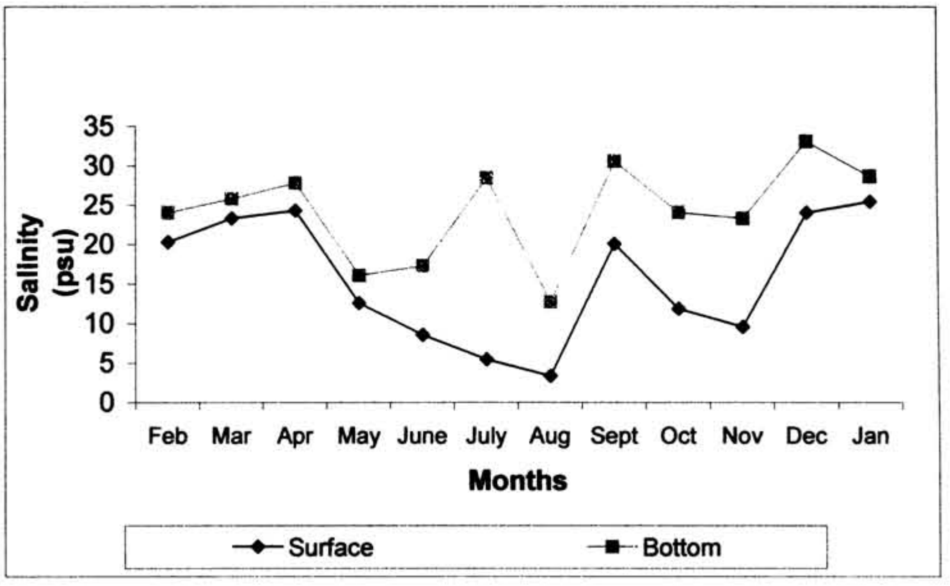


Fig. 9. Surface and bottom salinity at station I (Ernakulam channel site-1) during the year 2001- 2002

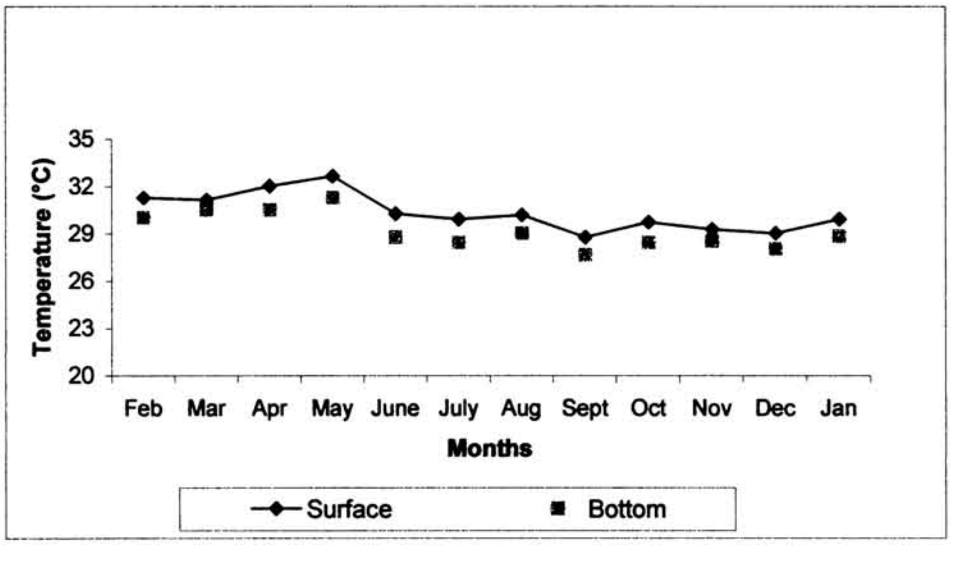


Fig. 10. Surface and bottom temperature at Station I (Ernakulam channel site-1) during the year 2001- 2002

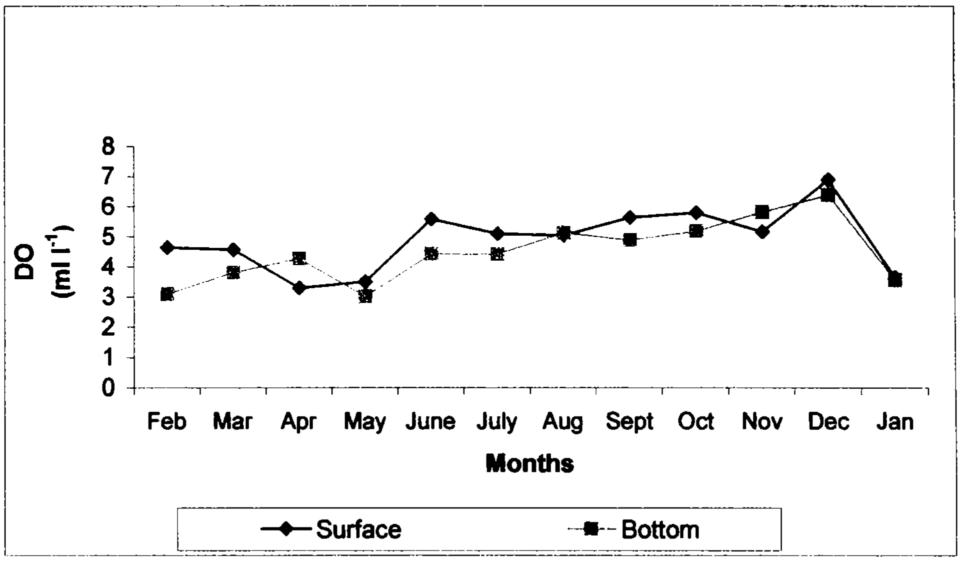


Fig. 11. Surface and bottom dissolved oxygen at station I (Ernakulam channel site-1) during the year 2001-2002

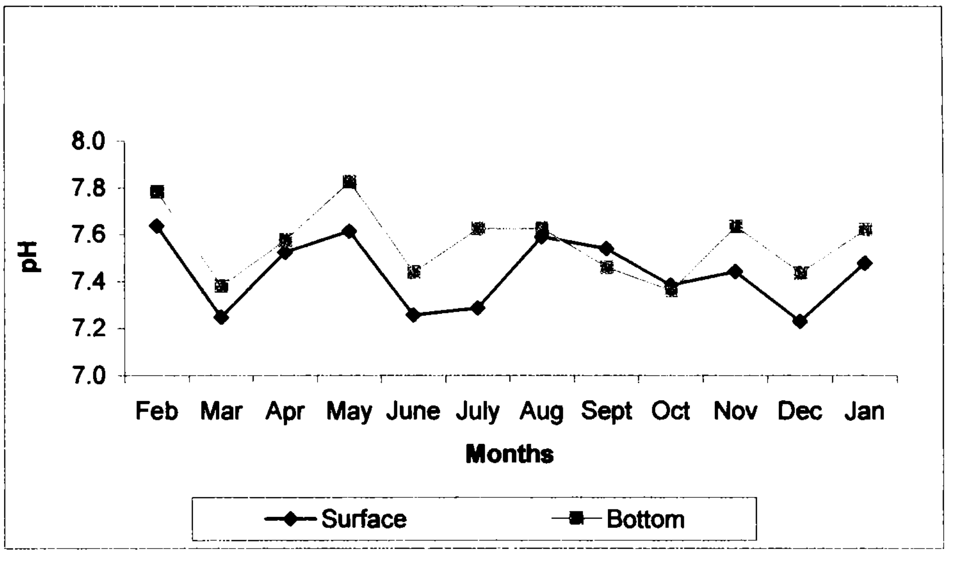


Fig. 12. Surface and bottom pH at station I (Ernakulam channel site- 1) during the year 2001-2002

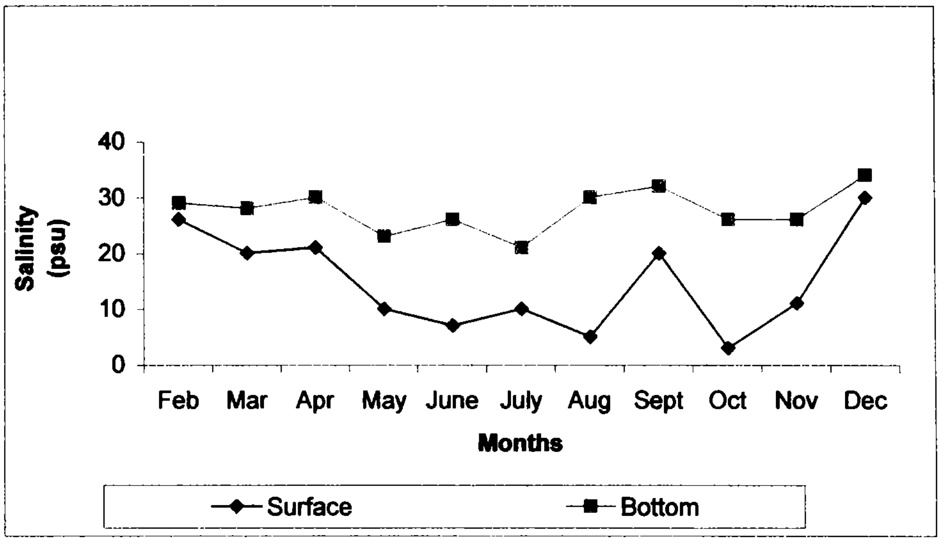


Fig. 13. Surface and bottom salinity at station 2 (Ernakulam channel site-2) during the year 2001- 2002

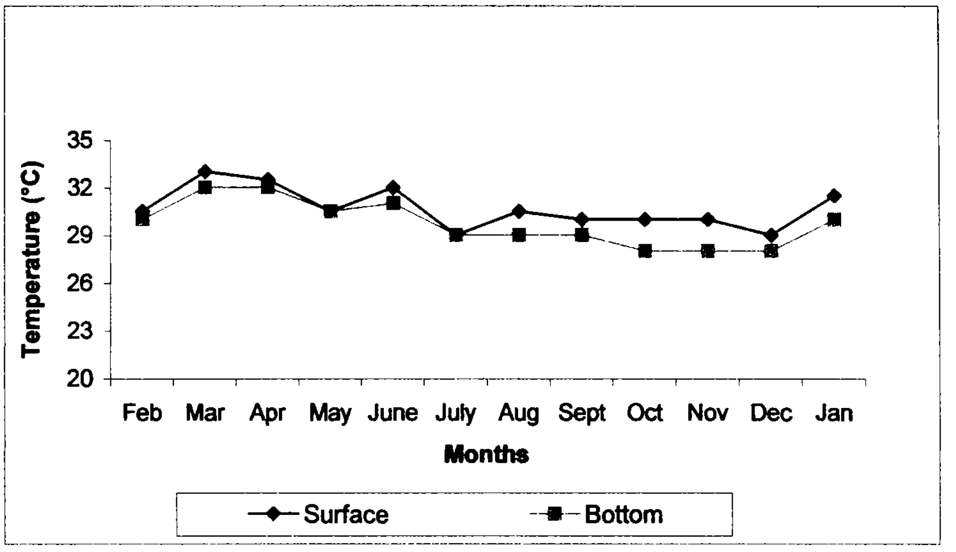


Fig. 14. Surface and bottom temperature at station 2 (Ernakulam channel site-2) during the year 2001- 2002

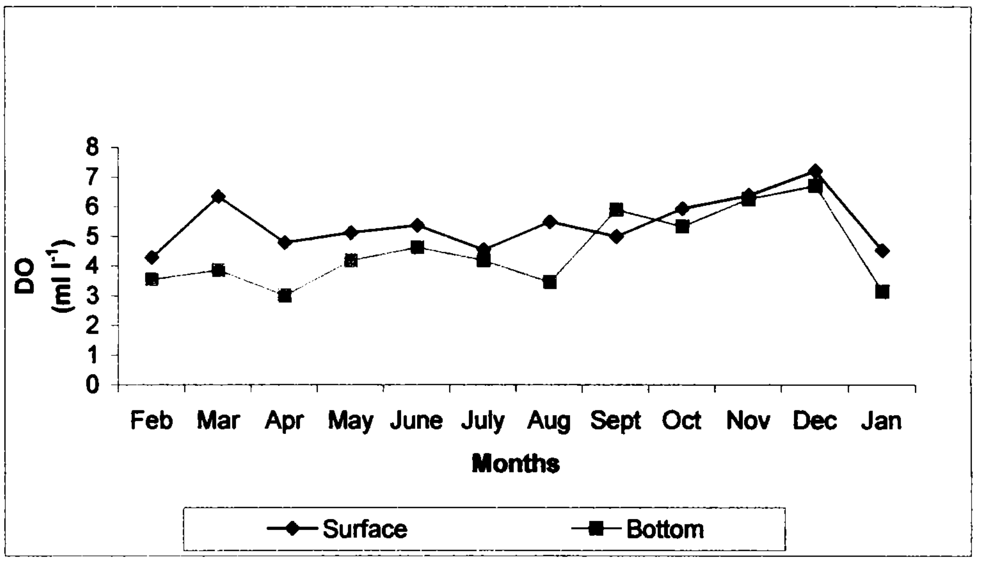


Fig. 15. Surface and bottom dissolved oxygen at station 2 (Ernakulam channel site-2) during the year 2001- 2002

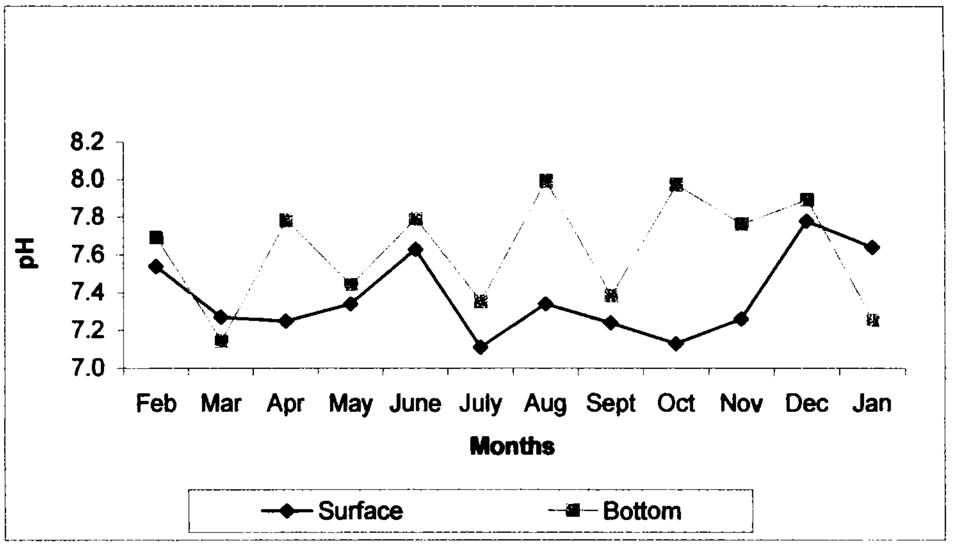


Fig. 16. Surface and bottom pH at station 2 (Ernakulam channel site- 2) during the year 2001- 2002

Table 8. The hydrographical conditions at Station 3 (Mattanchery channel - Wharf) during the year 2002

Season	Temperature (°C)		Salinity (psu)		Dissolved Oxygen (mll^{-1})		pH	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Pre Monsoon								
Feb.	30	30	27	28	3.4	2.6	6.7	7.1
March	29.5	29	29	30	2.6	2.1	7.1	7.7
April	30.5	29	30	30	3.6	1.9	7.5	7.8
May	30	30	10	14	3.1	3.5	7.1	7.7
Monsoon								
June	25	25	3	3	5.3	4.8	7.6	7.7
July	28	27	5	15	4.7	4.6	6.9	7.0
August	31	30	0	0	5.6	5.2	7.0	7.2
Sept.	29	28	32	35	5.0	6.2	7.5	7.5
Post Monsoon								
Oct.	28	28	5	6	4.9	5.9	7.7	7.7
Nov.	29	29	21	29	4.8	6.0	7.9	8.0
Dec.	29	28	33	33	5.6	6.1	7.3	7.2
Jan.	28	27	30	32	5.7	4.6	7.4	7.9

Table 9. The hydrographical conditions at Station 4 (Approach channel - Fort Kochi) during the period April 2002 to March 2003

Season	Temperature (°C)		Salinity (psu)		Dissolved Oxygen (mll^{-1})		pH	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Pre Monsoon								
Feb.	30	29	32	34	5.0	5.2	7.9	7.9
March	31	30	30	30	4.4	4.9	7.1	7.7
April	31	34	35	35	3.9	4.2	7.6	7.7
May	30.5	30	9	10	4.5	4.0	7.0	7.0
Monsoon								
June	28	28	3	3	5.1	4.7	7.1	7.1
July	30.5	30	7	7	5.9	5.7	7.3	7.6
August	30	30	0	0	5.3	4.3	7.5	7.7
Sept.	29	29	31	35	4.5	4.0	7.2	7.7
Post Monsoon								
Oct.	28	27	4	6	4.5	4.9	6.4	6.8
Nov.	30	29	22	23	4.6	5.1	7.2	7.4
Dec.	28	27	30	30	5.5	5.4	7.1	7.5
Jan.	29	28	34	34	5.5	5.8	7.8	8.0

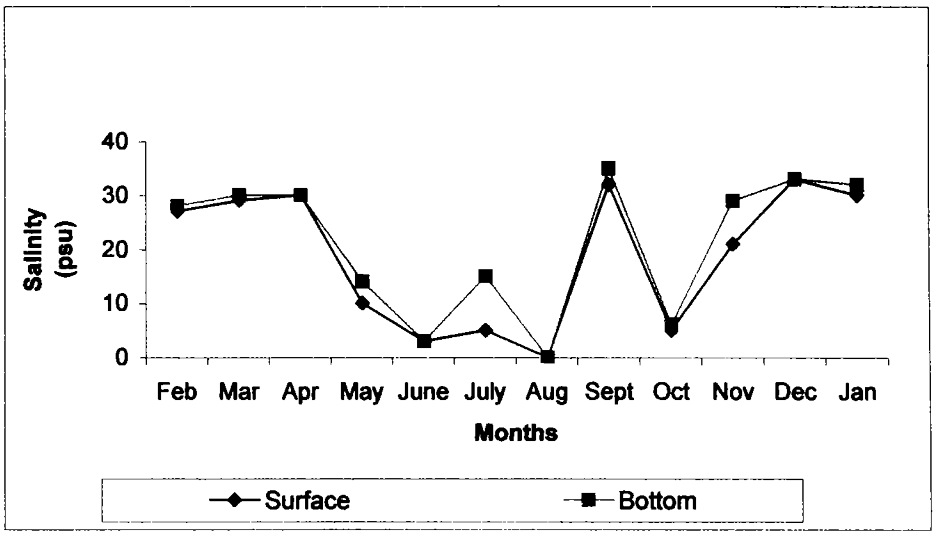


Fig. 17. Surface and bottom salinity at stations 3 (Mattanchery channel) during the year 2001- 2002

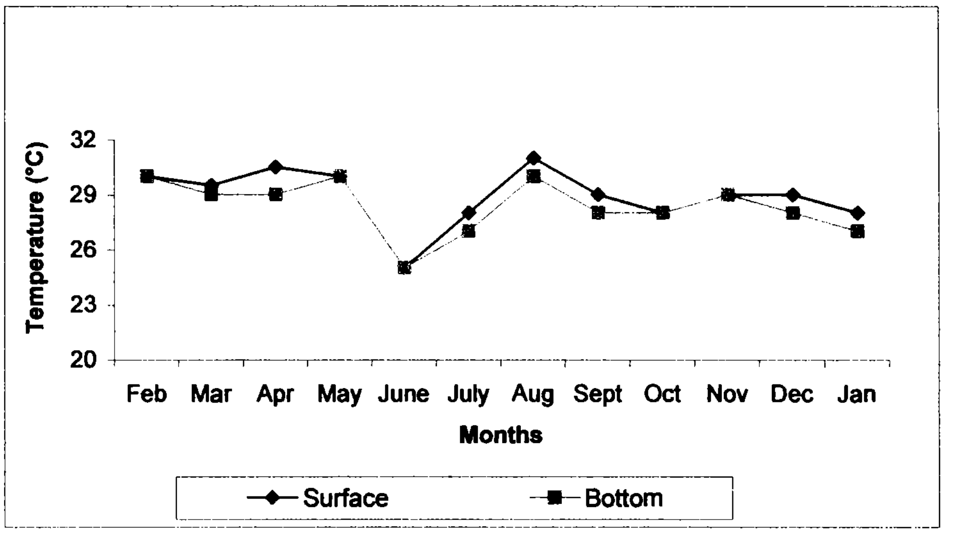


Fig. 18. Surface and bottom temperature at stations 3 (Mattanchery channel) during the year 2001- 2002

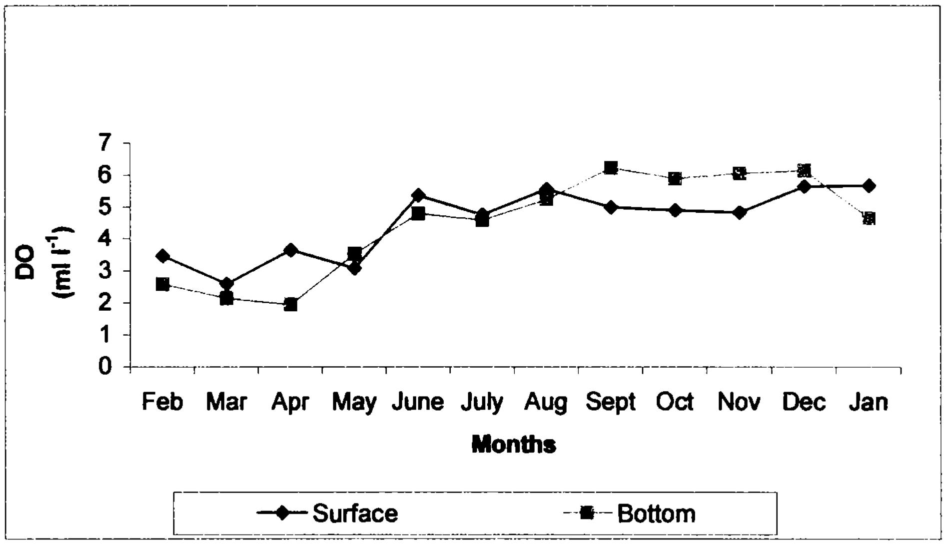


Fig. 19. Surface and bottom dissolved oxygen at station 3 (Mattanchery channel) during the year 2001- 2002

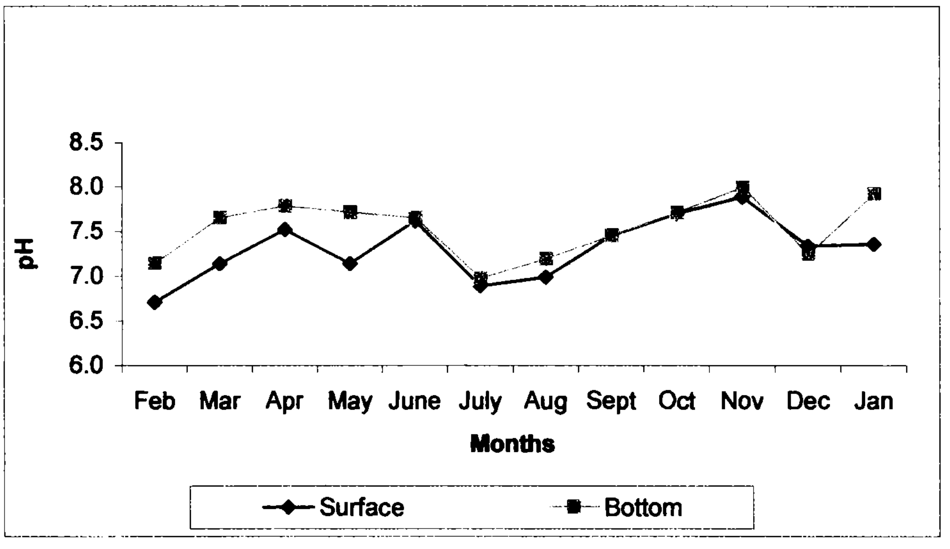


Fig. 20. Surface and bottom pH at station 3 (Mattanchery channel) during the year 2001-2002

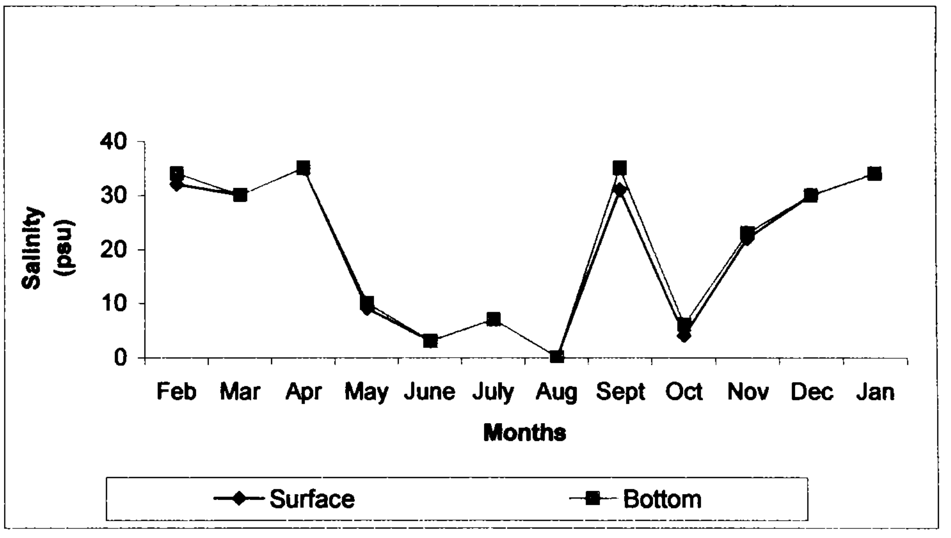


Fig. 21. Surface and bottom salinity at station 4 (Approach channel) during the year 2002 - 2003

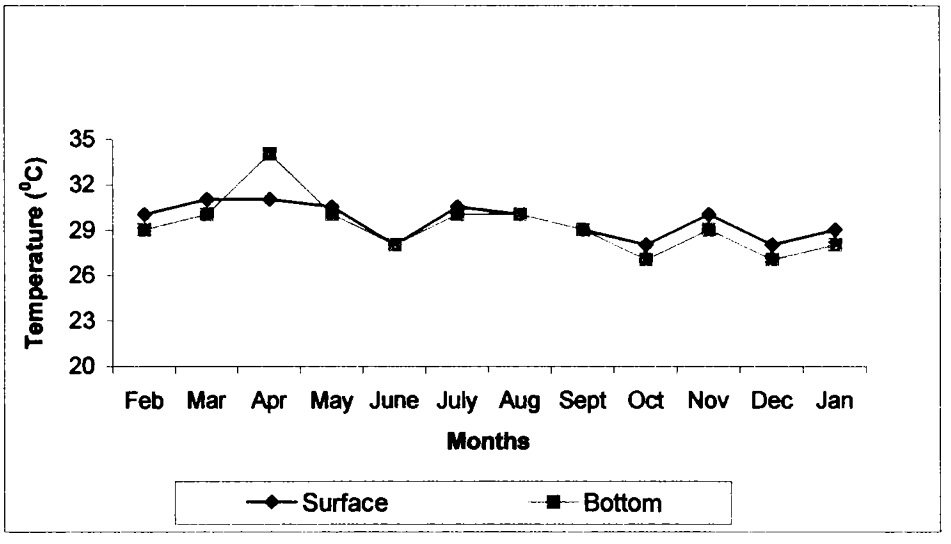


Fig. 22. Surface and bottom temperature at station 4 (Approach channel) during the year 2002- 2003

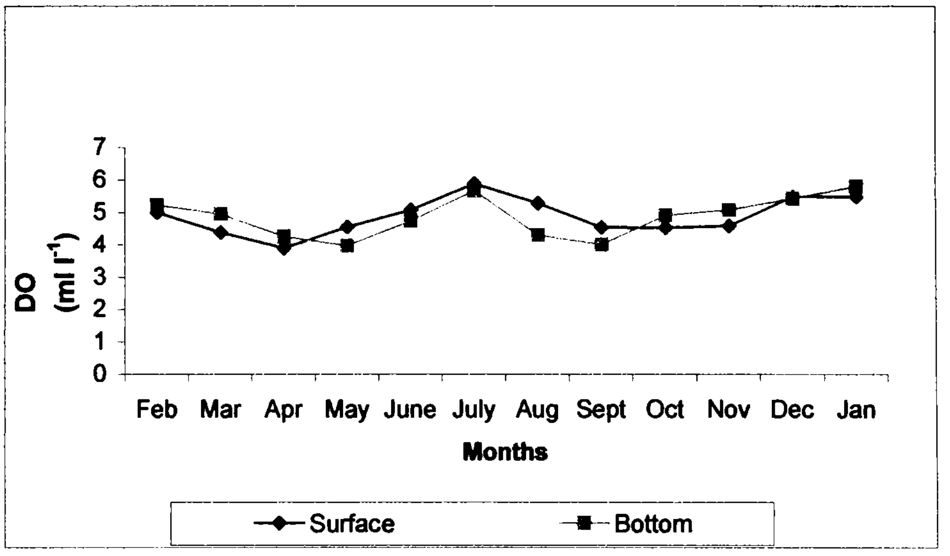


Fig. 23. Surface and bottom dissolved oxygen at station 4 (Approach channel) during the year 2002- 2003

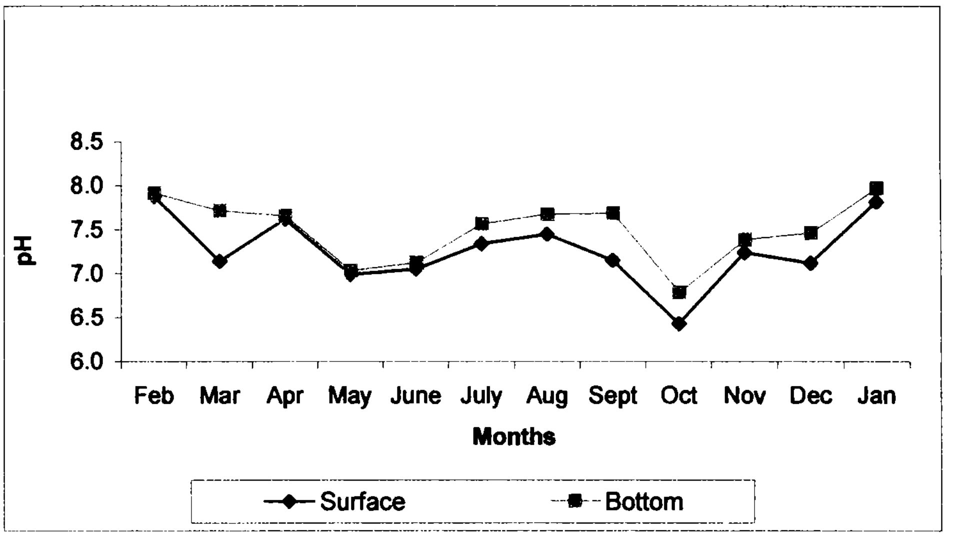


Fig. 24. Surface and bottom pH at station 4 (Approach channel) during the year 2002-2003

Table 10. The hydrographical conditions at Station 5 (Vypeen channel-Ochanthuruth) during the period March 2002 to February 2003

Season	Temperature (°C)		Salinity (psu)		Dissolved Oxygen (mll^{-1})		pH	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Pre Monsoon								
Feb.	31	30	25	27	3.3	4.2	7.7	7.6
March	31	30	28	28	3.3	4.3	7.4	7.9
April	32.5	31	20	24	3.6	3.7	7.3	7.6
May	29	29	4	4	4.0	4.4	6.8	7.0
Monsoon								
June	29	28	1	1	5.1	4.7	7.2	7.4
July	31.5	30	1	1	6.7	5.4	7.6	7.8
August	29.5	28	0	0	5.6	5.1	6.7	7.1
Sept.	28	28	12	14	5.8	6.6	7.4	7.5
Post Monsoon								
Oct.	28	28	3	1	5.7	6.4	6.9	7.0
Nov.	31	30	9	9	5.2	6.0	7.0	7.2
Dec.	29	28	20	20	5.4	5.9	7.4	7.8
Jan.	30	29	28	28	5.3	5.0	7.8	7.8

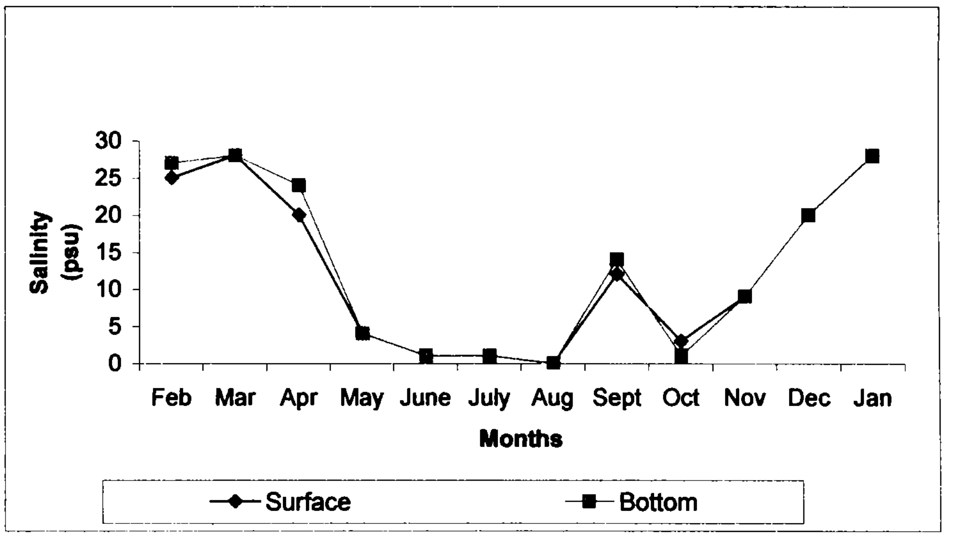


Fig. 25. Surface and bottom salinity at Station 5 (Vypeen channel) during the year 2002-2003

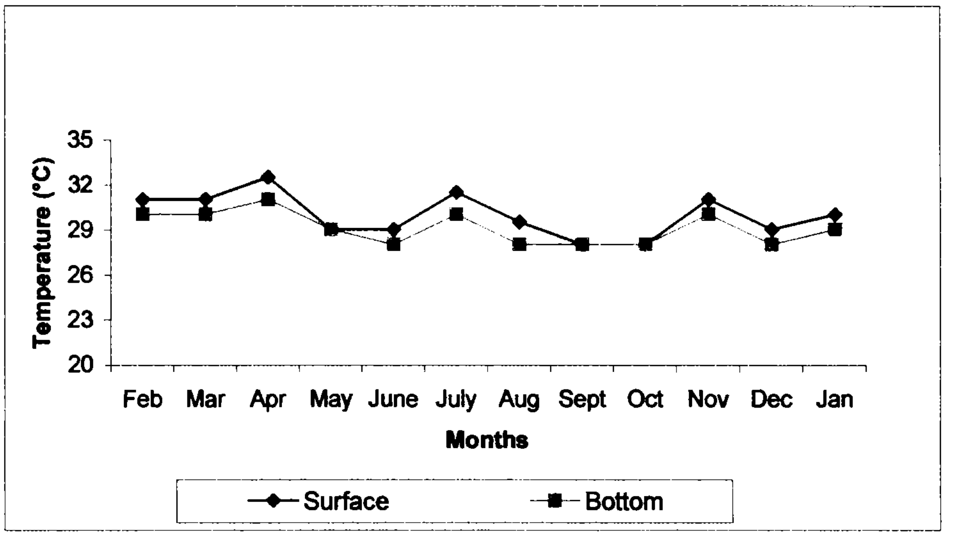


Fig. 26. Surface and bottom Temperature at Station 5 (Vypeen channel) during the year 2002- 2003

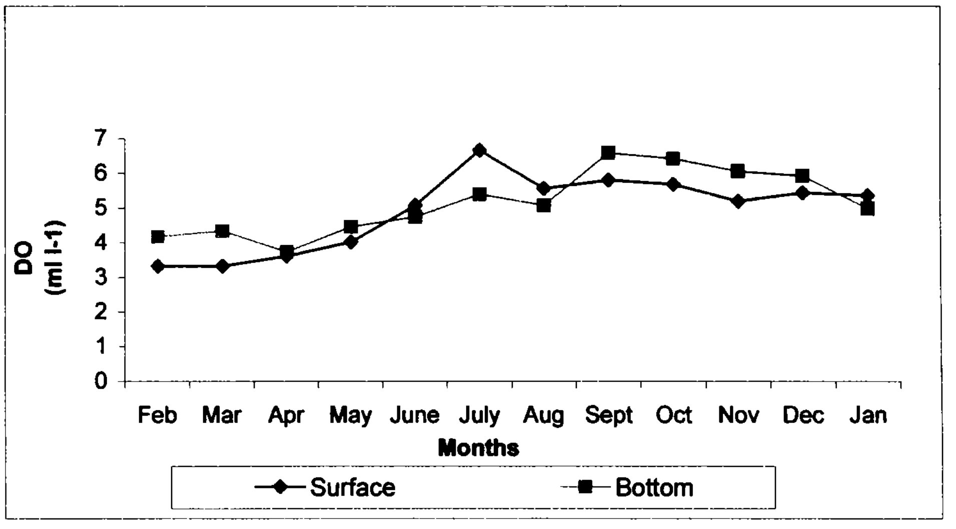


Fig. 27. Surface and bottom dissolved oxygen at station 5 (Vypeen channel) during the year 2002- 2003

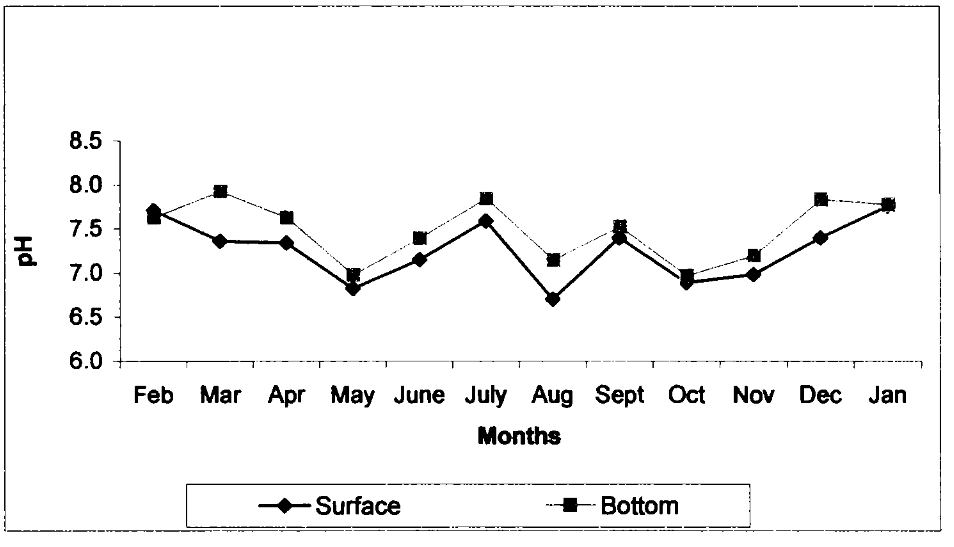


Fig. 28. Surface and bottom pH at Station 5 (Vypeen channel) during the year 2002- 2003

4.4.2 Temperature

Water temperature data are presented in Tables 6 -10. It is evident from the tables that the surface temperature at Station 1 (Ernakulam Channel- site 1) was uniformly high in almost all the months of the year except during April and May. Considering the bottom temperature, certain amount of uniformity was maintained throughout the year except in September, when it lowered to a value of 27.6°C. No drastic difference between the surface and bottom temperature was noticed at this site [See Table 6 and Figure 9].

At Station 2, the surface temperature recorded was high in the month of March. There was uniformly high surface temperature during the other months of the year. The bottom temperature also was uniform, in the range of 28°C to 32°C [See Table 7 and Figure 13].

The surface temperature as well as the bottom temperature at Station 3 was in a uniform range. At the onset of monsoon, both the surface and bottom temperatures dropped [See Table 8 and Figure 17].

At Station 4, the surface and bottom temperatures where in the higher range of 28°C to 32.5°C [See Table 9 and Figure 21].

Temperature recorded at Station 5 showed certain uniformity in both the surface and bottom [See Table 10 and Figure 25].

4.4.3 Dissolved Oxygen

Dissolved oxygen (DO) values of the surface waters and bottom waters were calculated and presented in Tables 6 - 10. At Station 1, the surface dissolved oxygen values were comparatively higher during the post monsoon season. During pre-monsoon there was a gradual lowering of dissolved oxygen. Dissolved oxygen of the bottom water showed the lowest values and highest values in December [Table 5 and Figure 10].

Dissolved oxygen values for surface water at Station 2 showed wide fluctuations with an increase and decrease in the values in alternative months. There was a gradual rise in dissolved oxygen from September to December. The dissolved oxygen of the bottom water showed lowest values of 3.0 ml l^{-1} in April [Table 7 and Figure 15].

At Station 3, dissolved oxygen values were low during pre-monsoon season. During monsoon and post-monsoon, the values ranged from 4.7 ml l^{-1} in July to 5.63 ml l^{-1} in

December. The bottom dissolved oxygen value was low in the pre monsoon season and the lowest value of 1.92 ml l^{-1} was recorded in March [Table 8 and Figure 19].

The dissolved oxygen of surface layers at Station 4 ranged from 3.88 ml l^{-1} to 5.88 ml l^{-1}. The bottom layers showed values ranging from 3.38 ml l^{-1} in April 2002 to 5.79 ml l^{-1}in January 2003 [Table 9 and Figure 23].

Dissolved oxygen of surface layers in Station 5 ranged from 3.31 ml l^{-1} to 6.65 ml l^{-1} in July, while the bottom layers showed a range of 3.67 ml l^{-1} in March to 6.57 ml l^{-1} in September [Table 10 and Figure 27].

4.4.4 pH

The pH values of the surface layers and bottom layers recorded are presented in Tables 6 -10. Comparing the values obtained for surface layers in all the 5 stations, the pH values recorded varied between 6.4 to 7.8. The pH of bottom waters at the various locations remained within 6.8 to 7.9 [Table 6-10 and Figure 9-28].

4.5 Discussion

Cochin harbour, adjacent to the barmouth is an exceptionally informative study area for ecologists as environmental studies around the world are focused on ports, estuaries and inshore marine waters because of the increasing evidences that such areas have irreplaceable biological communities. Many researchers have attended well to the biological, chemical and physical features of the resident waters of the estuary, which is partially flushed during the tidal currents and is greatly influenced by the surrounding land water drainage as well as the freshwater influx. Hence studies focusing on the fauna of this inshore region need to be accompanied by the study of the physico-chemical characteristics of the area capable of providing inorganic input for supporting of phytoplankton, holoplankton and meroplankton. The larvae of bryozoa are meroplanktonic which become sessile as adults and often form a prominent member of the communities on substrata in estuaries, ports and harbours.

The physical configurations of estuaries are mainly affected by salinity gradients based on continual or almost continual freshwater flow from rivers and streams, interaction with a salinity wedge or tidal exchange (Soule and Soule, 1979). However, fluctuations in salinity are not the only state of environment to which sessile and attached estuarine organisms must adjust. The temperature of estuaries is initially determined by the temperature of the rivers and the sea and the proportions these forms of the mixture at different stages of the tide (Rodriquez, 1975). Dissolved oxygen, pH, inorganic and organic salts play an important role though not as much as salinity. The biological oxygen demand (BOD) and chemical oxygen demand (COD) of inputs to an estuary would quickly exhaust the dissolved oxygen in the water column if physical flushing and mixing did not occur (Soule and Soule, 1979)

The sedimentation features at the Cochin port vary according to the three seasons. During the monsoon period, heavy rainfall results in high river discharge, which eventually reaches the estuary and waterways of Cochin harbour. Stratification often develops and results in conditions with less dense river water at the surface and high dense seawater at the bottom layers. Such typical hydrographic features and circulation pattern complicate the sedimentation characteristics of the estuarine channels. In post-monsoon, river discharge gradually diminishes and tidal influence gains momentum as the estuarine conditions change to a partially mixed type, weakening the stratification. This is mainly a transitional period. In pre-monsoon, the river discharge is minimum and seawater influence is maximum upstream; the estuary is well-mixed and homogeneity exists in the water column. The maximum turbidity during high tide within the estuary is very noticeable. During pre and post-monsoon, sedimentation in the inner channels (Mattancherry and Ernakulam) is 1m per annum, which is higher than that during monsoon due to tidal influence. The circulation pattern helps to bring more silt and clay into the estuary and especially during the tide slack period, sedimentation is the highest. But during monsoon, the physical processes alter, leading to sedimentation in the approach channel too (Gopinathan and Qasim, 1971; Menon *et al.,* 2000).

The changes in the hydrology controlled by the seasons play an important role in regulating the fauna of the estuary. The change in the hydrological conditions brought about by the influence of SW monsoon was noticed by many earlier workers (Menon and Nair, 1971; Joseph, 1974; Menon *et al.,* 2000; Qasim, 2004). The monsoon period is characterized by very heavy rainfall. A rapid fall in the salinity of the water occurs during the latter half of June as a result of heavy rains, drainage and inflow of large quantities of freshwater from the west-flowing rivers of northern Kerala into the Vembanad Lake or the Cochin Backwaters. The onset of the monsoon season also causes a sudden drop in temperature.

The study conducted by Menon and Nair (1971) and Lakshmanan *et al.* (1982) at various stations in the estuary revealed that the northern parts of the estuary were subjected to higher salinity wedging and oscillatory movement with vertical temperature exchange than the southern parts, where mass movement of water with considerable mixing was observed. During the post-monsoon season (October – January), comparatively higher temperatures were observed in the southern than in the northern parts. In pre-monsoon (February – May), there was no salinity stratification whereas with the onset of monsoon (June), a rapid build up of stratification occurred. High saline conditions in the estuary during the premonsoon give access to the larvae of truly marine forms to the estuarine areas.

The increase in salinity is a serious limiting factor for the continued existence of sedentary brackish water forms (Menon and Nair, 1971). The sedentary fauna of these areas are definitely prone to these fluctuating situations in the surroundings they live. Wide changes in the environment cause the typical brackish water sedentary animals into a stage of inactivity as well. The monsoon period extending from June to September showed a drastic change in the salinity and eventually that the species available during this season ought to be euryhaline in nature capable of surviving these drastic changes in the environment.

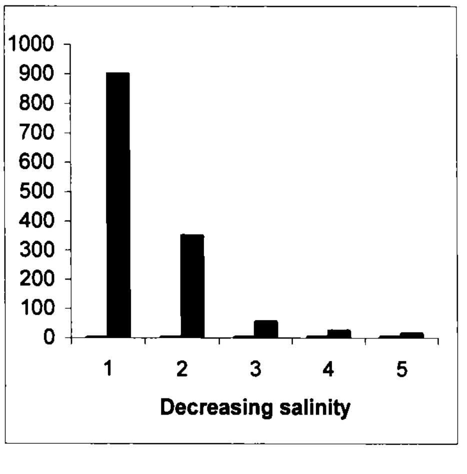


Fig. 29 Impoverishment of ectoproct species in the Baltic Sea [after data from Remane and Schlieper (1971), Ryland (1970) and Winston (1977a)] Area 1, Salinity: 20-30; Area 2, Salinity: 10-20; Area 3, Salinity: 6-10; Area 4, Salinity: 3-6; Area 5, Salinity: <3.

These wide ranges of fluctuations in the hydrography definitely influence the fauna of the estuaries. The bryozoan fauna available in the study area was negligible to that available in the open ocean due to the unstable nature of these inshore areas. According to Winston (1977a) who reviewed the literature on estuarine ectoprocts and tabulated data of the species found in diminished salinity in the tropical, warm-temperate and boreal-antiboreal provinces concluded that only 7% of cyclostome genera occurred in brackish water, where as 55% of ctenostome genera, 12% of the cheilostome anascan genera and 9% of the ascophoran genera were found in brackish waters (see

Fig. 29). The author also added that salinity in the case of bryozoans appeared to be the major environmental factor involved in the pattern of distribution.

Temperature is another important environmental factor that affects the life and activity of marine animals. The degree of temperature tolerance of a given species may change during the ontogeny (Kinne, 1970). The effect of altering environmental factors at the time of metamorphosis of *Bugula* larvae was studied by Lynch (1947; 1949a, b) and it was proved that raising the temperature to 30°C accelerates attachment and metamorphosis, but temperature of 32 to 35°C are fatal. Lynch (*loc.cit.*) concluded that heat, light, salinity and relative proportions of ions in the seawater could profoundly affect the natatory period of *Bugula* larvae and the subsequent growth of zooids (Hyman, 1959). Bryozoans were tested for their responses to environmental conditions by laboratory experiments by Menon (1972e) and revealed that temperature affects rate of regeneration. Menon (*loc.cit.*) remarked that increased temperature accelerates growth rate and final colony size attained after prolonged exposure declines at higher temperatures and the size of the zooecia attained is inversely proportional to the temperature (Menon, 1972e; Kinne, 1977). A new record of *Chartella arabica* was noticed in the high saline and hot pre-monsoon signifying the importance of temperature and salinity to this species. The changes in meristic characters in the species *Steginoporella magnilabris* and *Steginoporella buskii* existing in the Antarctic and Indian waters respectively (Soja and Menon, 2005) have proved the hypothesis. The foliaceous, bilaminar nature of the species is a character and its relations to temperature are yet another aspect to be examined for further conclusions. This signifies the importance of high temperature and salinity for the growth of certain species.

Raising the alkanity of sea water upto pH 9.6 had little effect on the length of natatory period but acidifying the sea water was deleterious, preventing normal metamorphosis even at pH 6. At pH 5.4 to 5.0, most larvae swam briefly but died in attempted metamorphosis or without attaching. At pH 4.6 ciliary actions was stopped with in 3 minutes and the larvae sank to the bottom (Hyman, 1959). Mawatari (1951b) recorded pH 7.0 to 8.5 as optimum for larvae of *B.neritina*. The pH of the backwaters varied less. The pH that existed in the estuary during the present investigation was found to be in the normal range of tolerance by bryozoans.

Annandale (1907, 1911, 1912) and Robertson (1921) described several *Membranipora* species from Indian brackishwaters, with delicate walls, elaborate development of spines and a loose connection to the substrate and Robertson (*loc.cit.*) considered these morphological features to be the effects of the low saline environment. Borg (1931) distinguished between the mainly marine species *Membranipora membranacea* and the more truly brackishwater species *Electra crustulenta.* Borg (*loc.cit.*) further observed reduced size and low calcification of zooids of *Electra* in more brackishwaters in the Baltic region. Menon and Nair (1974b) found that *Victorella pavida* and *Electra crustulenta* show a wide range of salinity tolerance according to the period in which they were collected. Accordingly *V.pavida* and *E. crustulenta* collected in September exhibited salinity tolerance ranging from freshwater to 10 psu whereas colonies occurring in December showed a range of 16 psu to 22.4 psu on the basis of 100% survival for 24 hrs.

This observation is in agreement with the present findings that *Victorella pavida* showed a high tolerance range in the monsoon and the former half of the post monsoon and was totally absent in the pre-monsoon when the salinity of the estuary was comparatively very high. *Electra crustulenta* as well as *Electra crustulenta* var. *novo* were the two species obtained from Station 2. They were present in the monsoon season with varying morphology like absence of granulated cryptocyst and reduced calcification. These morphological changes ought to be due to changes in salinity.

Station 3, located in the Mattanchery wharf, supported 14 species, where as only 3 species were recorded from station 5 at Ochanthuruth, which had predominantly freshwater condition. This adds to the significance of salinity for bryozoan existence and proves that Bryozoa are hardy to pollution than salinity. Salinity of the environment is an important factor that controls the possibility of larval movement of sedentary animals and entry of larvae of marine species restricted by the low saline waters.

5. Fouling bryozoans

Growth of marine organisms on artificial substrata immersed at sea is designated as marine biofouling. Fouling results in frictional resistance affecting the speed of ships, and thereby increasing fuel consumption and duration of the voyage. Even a slime layer of 1mm thickness can cause around 80% increase in friction and a 15% loss in ship speed compared with values obtained for a clear hull (Lewthwaithe *et al.,* 1985; Gordon and Mawatari, 1992). The seawater intake conduit pipes used for cooling the machinery in industrial plants such as power stations, atomic reactors etc., when fouled would result in substantial reduction in the lumen of pipes and create stress on the pumping systems. Biofouling of acoustic sensors used in ships, submarines and other defense related equipments can affect the functioning and communication efficiency of sophisticated electronic equipments. Identification of background noise received by acoustic instruments used for naval operation is an important byproduct of biofouling.

Bryozoans are important group of invertebrates in the fouling community. Although around 50 species of Bryozoa have been recorded on ships hulls, they are less significant foulers in terms of weight and certainly their thin encrusting mode offers least resistance to water flow on ships underway (Ryland, 1970). Notwithstanding this, bryozoans can cause damage through indirect effects, frequently as organisms critical to the ecological development of fouling communities. They are found to be hazardous once they establish their colony on antifouling paint coated surfaces. Its extensive crusts provide a safe substratum for the attachment of barnacles, serpulid worms and bivalves, which together have a remarkable effect on the frictional resistance. *Watersipora* sp. is specially noticed as a hull colonizer, and is the most common copper-resistant macrofouler known (Ryland, 1970). Another factor is that the sulphate reducing bacteria occurring under encrusting bryozoans can accelerate metal corrosion (Srivastava and Karande, 1986). Tufted colonies like *Bugula* and *Zoobotryon* species are found to create a great nuisance by clogging intake pipes of cooling systems, and they cover ships' hull providing great impedance to passage through water.

Fouling of ship is of zoogeographical interest, where a species is spread beyond its original area of distribution. There is vast difference between the organisms capable of surviving on wood, metal or plastic hulls of boats and ships that move through the waters, encountering varied temperature, salinities and other parameters, and those organisms that settle on fixed pilings, anchored boat or a stationery substratum (Soule and Soule, 1977). Some examples cited by Ryland (1970) are *Watersipora* sp. that was introduced to Australian ports, from there, to Auckland ports, New Zealand. *Bugula neritina,* essentially a tropical species, arrived in Britain and flourished in certain south coast ports, while *B. flabellata,* a typical temperate species has been carried to Australia. Ballast water is also a major vector for marine species introduction; though bryozoans were not listed among them earlier, Carlton (1985) has shown that species with cyphonautes larvae could certainly be transported in ballast waters.

Bryozoan colonies begin life when a larva that develops from a fertilized egg attaches to a substratum, may be rock, piling, seaweed, boat hull etc. and metamorphoses to the first zooid of the colony – the ancestrula. This ancestrula buds to give more zooids either upwards in bushy and tufted colonies or radially in encrusting ones. So larva in particular is a critical stage in fouling. Typically, larvae swim in circles of decreasing circumference over the surface of the substratum appearing to 'test' it with its long bundles of cilia (Woollacott, 1984). It temporarily attaches and detaches, thus continuing to test new suitable sites. The ability to disengage from the substrate and continue exploring indicates its high capacity for discrimination in the selection of a suitable substratum.

The nature of substratum is yet another factor of prime importance. Works have shown that wettability, an indication of the degree of surface hydrophilicity, is of paramount importance in influencing larval settlement (Woollacott, 1984). Bryozoan larvae tend to show habitat preferences based on reactions to light, water movement, substrate texture and colour and the physical or chemical properties of the surface (Ryland, 1970; Menon, 1967b; 1972d). Indeed, in the case of the most abundant, sub-cosmopolitan, marine fouling bryozoans the mature colonies may thrive in wider ranges of temperature, salinity, turbidity and pollution that prevail in ports and harbours than open coastal species (Gordon and Mawatari, 1992) and they are rarely found outside such settings.

A positive aspect of biofouling is the biomedical application of various species of bryozoans. Many of these hazardous foulers are now used in clinical trials for extraction of bioactive compounds as a remedy for many ailments. Bryostatin extracted from *Bugula neritina* is now used as an anti-tumor, anti-cancer agent. Further, 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.

Fouling bryozoans are of great economic, zoogeographical and biomedical importance. The present study of fouling species of bryozoans gives an overview on the seasonal incidence of fouling bryozoans in four stations located in the three major shipping channels- the approach channel, the Mattanchery channel and the Ernakulam channel and a fifth rather unpolluted station in Cochin backwater; the Vypeen channel in the southwest coast of India.

5.2 Material and Methods

The three prominent seasons in the study area are Pre-monsoon (01 February to 31 May), Monsoon (01 June to 30 September) and Post-monsoon (01 October to 31 January). Bryozoan settlement during all the three seasons of the year 2002 at five stations (Refer Sec. 4.2) and also during February, May and June of the year 2003 at Mattanchery channel was studied with the aid of test panels.

The test panels consisted of clear glass plates of 15cm x 10cm with one side smooth and the other rough. Use of panels with two types of surfaces enabled to note the influence of texture of the substratum on the settlement of bryozoans. Two method of panel exposure was done based on the depth of the stations.

- The panels were secured endwise in a wooden rack, which in turn was suspended by a plastic rope, 50cm above the mudline. The racks were held in position with the help of concrete block, which functioned as an anchor. This method was carried out at station 1, 2, 4 and 5 where the depth was less than 3 m.

- Five pairs of glass panels were suspended on ropes from the intertidal region to the mud line at an interval of 50 cm. To avoid the effect of silting, the bottom panels were kept 50 cm above the mud-line. A concrete block was used as an anchor to keep the panels and rope in a vertical position. This pattern of exposure was the same as that previously experimented by Menon (1972d) to study the vertical distribution of bryozoans. This method was done only at Station 3 in the Mattanchery Channel where the depth is ca 5m.

A series of short term and long term panels were immersed in backwaters. Short-term panels were those exposed for a short-term duration (a week/ fortnight/ a month) at station 1 and 3. Long-term panels composed of the plates that were immersed together as a set of 16 or 12 panels and one panel each was withdrawn at the end of 7 or 30 days respectively. Details of the short-term and long-term panel exposure are as follows:

The short-term series (A-series)

Short-term panels were put out and changed at the end of 7 days at **Station 1 – Ernakulam Channel-Site 1** and duration of 15* and 30 days at **Station 3 – Mattanchery Channel.** [* - Two set panels of 15 days duration were immersed in May 2003].

The long-term series (B-series)

Sixteen panels were exposed together at the beginning of a season and removed one by one at intervals of 7 days at **Station 1 –Ernakulam Channel-Site 1** for 112 days. Twelve panels were exposed together at the beginning of the experiment and one each was removed at intervals of 30 days at stations, **Station 2 –Ernakulam Channel-Site 2, Station 4- Approach channel and Station 5 - Vypeen Channel.** These panels gave information on the bryozoans, which settled and flourished during different months of the year. It also showed how the settlement was modified by animals that have already settled on the panels and the fate of bryozoan foulers for a period of one year growing on spatially restricted substrate.

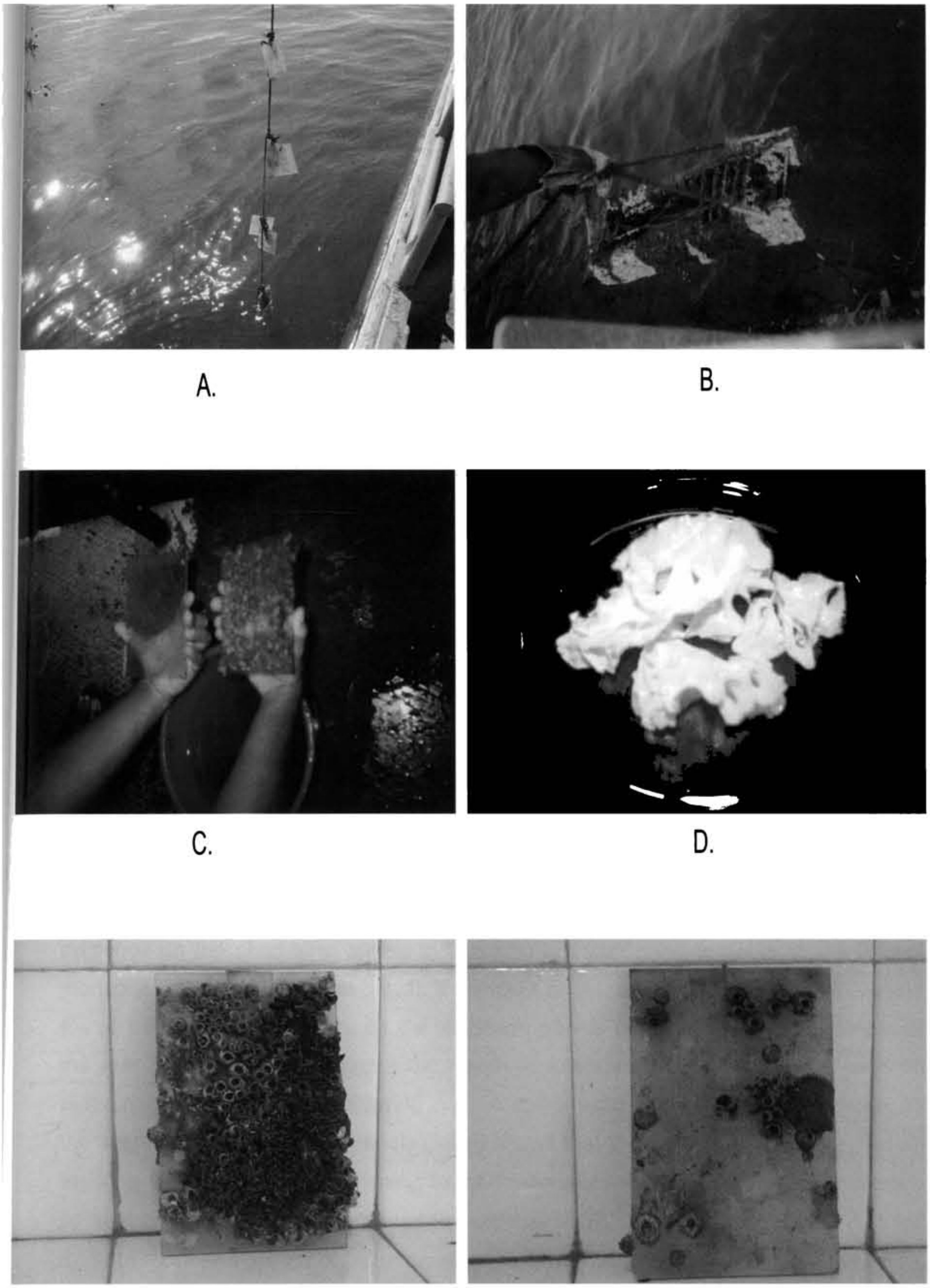


Plate. 33 A. Panels immersed vertically in pairs. B. Wooden rack with panels arranged in it. C. A short and long term panel immediately after collection. D. *Chartella arabica* white and foliaceous nature of the colony E. A long term panel F. A panel with foulers detachted.

5.3 Results: Settlement pattern of fouling bryozoans at different stations in the Cochin backwaters.

5.3.1 Ernakulam Channel- Site 1 (Station 1)

The results obtained on the seasonal settlement of bryozoans with the aid of glass test coupons placed in a wooden rack and exposed at Station 1 (Ernakulam Channel-Site 1) from January 2002 to December 2002 are tabulated and presented in Table 11 and 12. Both the short-term (A-series) and long-term (B-series) exposures were carried out at this station. This mode of panel exposure helped to ascertain the period when fresh settlement of the different species took place. The size of the colonies on the panels gave an idea of the probable time of settlement and the rate of growth. A continuous sampling was done for four months and then the next set of 16 panels was immersed.

Four species viz, *Victorella pavida, Bowerbankia gracilis, Electra crustulenta* and *Alderina arabianensis* settled on the short-term panels. The long-term panels examined every week showed heavy settlement of some species during certain seasons. The species present on these panels were *Victorella pavida, Bowerbankia gracilis, Electra crustulenta, Electra bengalensis, Alderina arabianensis* and *Bugula cucullata*. The species, that established colonies on the panels, are dealt separately below:

Victorella pavida: Settled on both the short term and long term panels mostly during the monsoon season, gradually declined in the post-monsoon season and vanished from the panels in the pre-monsoon season of the year. This species showed its presence on the short-term panels in July (A_5) and continued to settle till the end of monsoon with periods of lush growth as evident on A_{11} and A_{12} of August and A_{13} and A_{14} of September. Settlement on the long-term panels occurred during five months of the year from July to November 2002. However, abundance of *V. pavida* was confined to the B_5 to B_8 plates exposed during July. A comparison of the nature of settlement on the short term and long term panels clearly shows that there was greater settlement on the long term panels probably owing to the favourable influence of other forms already present on them or the availability of the substratum (B series) for longer time duration for settlement and growth of the established colony. The absence of this species on the panels during the high saline period (December-May) indicates that the conditions prevailing are not suitable for larval life, settlement and growth of this species in this locality.

Table 11. Bryozoans settled on Smooth (S) and Rough (R) surface of glass panels at a level 50 cm above the bottom at station 1 – (Ernakulam channel: Site 1) during 2001-2002. **A-Series [Short term panels – 150cm^2]; duration of exposure 7 days**

Season	Species	A1		A2		A3		A4		A5		A6		A7		A8		A9		A10		A11		A12		A13		A14		A15		A16	
		S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
Monsoon 01 June – 30 Sept.	V^p	-	-	-	-	-	-	-	-	r	r	c	c	r	c	r	-	c	r	c	r	c	vc	vc	c	vc	vc	vc	vc	r	c	r	c
	B^g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E^c	-	-	c	-	c	c	c	c	-	c	-	r	-	c	c	r	r	c	c	c	c	c	r	c	c	r	r	c	r	c	r	c
	E^b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	-	-	r	-	r	r	r	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
	C^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Post-monsoon 01 Oct. – 31Jan.	V^p	c	-	r	c	r	r	-	-	-	-	-	-	r	r	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	-	r	r	-	-	r
	E^c	r	r	r	-	r	-	r	-	r	-	r	r	-	-	r	r	-	r	-	r	-	-	-	-	-	-	-	-	-	-	-	-
	E^b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	r	r	-	r
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pre-monsoon 01 Feb. - 31 May	V^p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^g	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	r	r	-	r	r	-	r	c	c	r	r	r	r	r	-	-
	E^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E^b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	r	r	r	r	r	-	r	-	-	-	r	-	r	c	r	c	-	-	-	-	r	-	-	r	-	r	-	-	-	-	r	-
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(V^p – *Victorella pavida*, B^g - *Bowerbankia gracilis*, E^c – *Electra crustulenta*, E^b – *Electra bengalensis*, A^a – *Alderina arabianensis*, B^C – *Bugula cucullata*, C^a – *Chartella arabica*) [r- rare(<5); c – common (6 to 10); vc – abundant (11 to 20); - - absent (0)]

Table 12. Bryozoans settled on Smooth (S) and Rough (R) surface of glass panels at a level 50 cm above the bottom at station 1– (Ernakulam channel: Site 1) during 2001-2002. **B-Series [Long term panels - 150cm²]; 16 plates exposed and removed one by one at the end of 7 days.**

Season (Period)	Species	B1		B2		B 3		B 4		B 5		B 6		B 7		B 8		B 9		B 10		B 11		B 12		B 13		B 14		B 15		B 16	
		S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
Monsoon 01 June – 30 Sept.	V^p	-	-	-	-	-	-	-	-	vc	vc	vc	c	vc	vc	c	vc	r	c	c	vc	vc	c	c	c	vc	r	r	c	c	c	r	c
	B^g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E^c	c	c	r	c	r	c	c	r	c	c	c	r	c	r	r	c	r	-	-	r	-	r	r	-	r	r	c	r	c	c	r	c
	E^b	-	-	-	-	-	r	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	vc	c	c	c	c	c	vc	vc	r	c	r	r	r	r	r	r	r	r	r	r	-	-	-	-	-	-	-	-	-	-	-	-
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	r	c	c	r	r	c	-	-	-	-
	C^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Post-monsoon 01 Oct. – 31Jan	V^p	r	r	r	r	-	-	r	-	-	r	r	-	r	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	c	r	r	c	c	c
	E^c	vc	vc	vc	c	vc	vc	c	vc	vc	vc	c	vc	vc	c	c	vc	vc	c	c	c	c	c	c	vc	c	c	r	c	r	c	c	r
	E^b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c	c	c	c	c	c	c	r
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pre - monsoon 01 Feb. - 31 May	V^p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^g	r	r	r	-	r	r	-	r	r	-	r	r	r	r	r	r	c	c	r	c	c	r	c	r	r	r	r	-	r	-	-	r
	E^c	r	c	r	r	c	r	r	c	c	r	c	c	r	c	r	r	c	c	r	c	c	c	r	c	c	r	c	r	c	c	c	c
	E^b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	vc	vc	c	vc	vc	c	vc	vc	c	c	vc	vc	vc	c	vc	vc	c	c	r	c	c	c	r	c	r	c	c	r	r	r	c	c
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(V^p – *Victorella pavida*, B^g - *Bowerbankia gracilis*, E^c – *Electra crustulenta*, E^b – *Electra bengalensis*, A^a – *Alderina arabianensis*, B^c – *Bugula cucullata*, C^a – *Chartella arabica*) [r- rare(<5); c – common (6 to 10); vc – abundant (11 to 20); - - absent (0)]

Table 13. Bryozoans settled on smooth (s) and rough (R) surface of glass panels at 5 levels 50 cm, 100 cm, 150 cm, 200 cm and 250 cm at station 3 (Mattanchery channel) during the year 2002.

A-Series [Short Term Panels – 150cm^2]; duration of exposure 30 days.

Season		Pre Monsoon (1 Feb. to 31 May)								Monsoon (1 June to 30 Sept.)								Post Monsoon (1 Oct. – 31 Jan.)							
Levels above mud line (cm)	Species	A1		A 2		A 3		A 4		A 5		A 6		A 7		A 8		A 9		A 10		A 11		A12	
		S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
250	V^p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^g	-	-	-	-	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	N^p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
200	V^p	-	-	-	-	-	-	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^g	-	-	c	c	c	c	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	N^p	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A^a	c	c	c	c	r	c	r	r	c	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^n	vc	vc	vc	vc	c	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^c	-	-	-	r	r	r	r	r	r	r	-	r	-	-	-	-	-	-	-	-	-	-	-	-
150	V^p	-	-	-	-	-	-	-	-	c	c	c	r	r	c	r	-	-	-	-	-	-	-	-	-
	B^g	-	-	r	r	c	r	r	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	N^p	-	-	-	-	-	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E^c	-	-	-	-	-	-	-	-	-	-	r	r	r	r	-	r	r	r	r	c	r	c	-	r
	A^a	c	c	c	c	c	r	c	c	c	r	r	r	r	-	-	-	r	-	r	r	r	r	r	-
	B^n	vc	c	vc	vc	c	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^c	-	-	-	r	r	r	r	r	r	r	-	r	-	-	-	-	-	-	-	-	-	-	-	-
100	V^p	-	-	-	-	-	-	-	-	r	r	r	c	r	c	-	-	-	-	-	-	-	-	-	-
	B^g	-	-	-	-	c	r	c	c	c	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	N^p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E^c	-	-	-	-	-	-	-	-	-	-	r	-	-	r	-	-	r	r	r	r	r	r	r	-
	A^a	c	c	c	c	r	r	c	r	c	c	r	c	r	-	-	-	-	r	r	-	-	-	-	r
	B^n	-	-	c	c	c	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	c
	B^c	-	-	c	r	c	r	-	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	V^p	-	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B^g	-	-	-	-	-	r	r	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	N^p	-	-	-	-	-	-	c	c	-	-	c	c	-	-	-	-	-	-	-	-	-	-	-	-
	E^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	-	-	-	-	-	-	r	r
	A^a	c	c	r	c	r	r	r	-	r	r	c	r	-	-	-	-	r	r	-	-	-	-	-	-
	B^n	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c	c
	B^c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(V^p – *Victorella pavida*, B^g - *Bowerbankia gracilis*, N^p – *Nolella papuensis*, E^c – *Electra crustulenta*, A^a – *Alderina arabianensis*, B^n – *Bugula neritina*, B^c – *Bugula cucullata)*

[r- rare (<5); c – common (6 to 10); vc – abundant (11 to 20); -:absent]

Table 14. Bryozoans settled on Smooth (S) and Rough (R) surface of glass panels at a level 50 cm above the bottom at **Station 2 (Ernakulam channel: Site2)** during 2001-2002.

B-Series [Long term panels-150 cm^2]; 12 sets exposed together and removed one by one at the end of 30 days.

Season	Pre Monsoon (1 Feb. to 31 May)								Monsoon (1 June to 30 Sept.)								Post Monsoon (1 Oct. – 31 Jan.)							
Species	B1		B2		B3		B4		B5		B6		B7		B8		B9		B10		B11		B12	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
V^p	-	-	-	-	-	-	-	-	-	-	r	r	r	r	-	-	-	-	-	-	-	-	-	-
B^g	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E^c	c	r	r	vc	c	r	r	c	c	c	c	c	c	r	c	c	c	vc	vc	vc	vc	c	c	c
E^b	-	-	-	r	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A^a	vc	vc	vc	vc	vc	vc	vc	c	c	c	c	vc	c	c	c	c	c	r	r	c	r	c	c	c
B^n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C^a *	-	-	-	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(V^p – *Victorella pavida*, B^g - Bowerbankia *gracilis*, E^c – *Electra crustulenta*, E^b – *Electra bengalensis*, A^a – *Alderina arabianensis*, B^n – *Bugula neritina*, C^a *– *Chartella arabica*; recorded once in Feb – March 2002)

[r : rare(<5); c : common(6 to 10); vc : very common(11 to 20), - : absent(0); p : present on wooden rack]

Table 15. Settlement of Bryozoans on Smooth (S) and Rough (R) surface of glass panels immersed at 5 levels - 50 cm, 100 cm, 150 cm, 200 cm and 250 cm above the mud line at **Station 3 (Mattanchery channel)** during February, May and June in the year 2003.

A-Series (Short term panels-150cm^2):

Levels	February(30days*)		May(15 days*)				June(30 days*)	
			AM1		AM2			
	Smooth	Rough	Smooth	Rough	Smooth	Rough	Smooth	Rough
250	-	-	-	-	-	-	-	-
200	Ae^a, B^g	-	N^p	-	-	Al^e	N^p, T^k	T^k,
150	A^a, B^g	B^g, A^a	N^p, B^g	B^g	T^k, Al^e	-	T^k,	T^k
100	A^a	N^p	B^g, N^p	B^g,	F^r, N^p	B^g	F^r, T^k	-
50	B^g, N^p, E^{cvb}	B^g, E^{cvb}	E^{cvb}, B^g	B^g	B^g	F^r	N^p	-

(B^g – *Bowerbankia gracilis*, N^p – *Nolella papuensis*, F^r – *Farella repens*, T^k – *Triticella korenii*, Al^e – *Alcyonidium erectum*, Ae^a- *Aetea anguina*, A^a – *Alderina arabianensis*, E^{cvb} – *Electra crustulenta* var *borgii*)

[A_{M1}-1 May to 15 May, A_{M2}-16 May to 31 May]

*-Duration of panel immersion

Table 16. Settlement on Smooth (S) and Rough (R) surface of glass panels immersed at a level of 50 cm above the bottom at **Station 4 (Approach channel)** from 2002 April to 2003 April.

B-Series (Long term panels-150 cm^2); 12 panels exposed together and one by one removed at the end of every 30 days.

Season	Pre Monsoon (1 Feb. to 31 May)								Monsoon (1 June to 30 Sept.)								Post Monsoon (1 Oct. – 31 Jan.)							
Species	B1		B2		B3		B4		B5		B 6		B7		B8		B9		B10		B11		B12	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
B^g	-	-	-	-	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E^c	r	r	r	r	r	r	r	-	c	c	c	c	c	r	r	r	c	r	r	c	c	c	c	-
A^a	r	c	-	r	r	r	c	c	c	-	r	c	r	c	c	r	-	-	r	r	-	-	-	r

(B^g - *Bowerbankia gracilis*, A^a – *Alderina arabianensis*, E^c – *Electra crustulenta)*
[r : rare(<5); c : common (6 to 10); vc : abundant (11 to 20); - : absent (0)]

Table 17. Settlement on Smooth (S) and Rough (R) surface of glass panels immersed at a level of 50 cm above the bottom at **Station 5 (Vypeen channel)** from 2002 March to 2003 March.

B-Series (Long term panels-150cm^2); 12 panels exposed together and one by one removed at the end of every 30 days.

Season	Pre Monsoon (1 Feb. to 31 May)								Monsoon (1 June to 30 Sept.)								Post Monsoon (1 Oct. – 31 Jan.)							
Species	B1		B2		B3		B 4		B 5		B 6		B7		B 8		B 9		B 10		B11		B12	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
H^{sp}	-	-	-	-	-	-	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Lost	„
B^g	-	-	r	r	r	r	-	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	„	„
E^c	r	r	r	r	-	-	r	-	r	c	c	c	r	r	r	r	c	r	-	-	r	-	„	„
A^a	c	r	r	r			r	r	c	r	r	c	r	r	-	r	r	r	-	-	-	-	„	„

(V^p – *Victorella pavida*, B^g - *Bowerbankia gracilis*, E^c – *Electra crustulenta*, A^a – *Alderina arabianensis*)
[r- rare(<5); c – common (6 to 10); vc – abundant (11 to 20); - absent (0)]

Bowerbankia gracilis: Attached sparsely on the short term and long term panels during January and the settlement continued during the pre-monsoon season. Settlement on the short-term panels started in January, ceased in February and emerged by the end of March and continued till the end of May. The long term panels showed continuous settlement of this species from January to May with a slight increase in April. A comparison of the nature of settlement on the short-term and long-term panels clearly shows that there was a greater settlement on the long-term panels probably owing to the favourable influence of the prevalent salinity and the availability of substratum for longer duration for settlement at this site of the backwaters.

Electra crustulenta: Settlement of *E. crustulenta* on the short-term panels was sparse when compared to their abundance on the long-term panels. The data on the freshly settled colonies on the short-term panels clearly reveal that they were found during six months of the year i.e., the entire monsoon period and the former months of post-monsoon period. Settlement of this species ceased in December and did not occur in the pre-monsoon period on the short-term panels while on the long-term panels this species was found on almost every panel throughout the year, which could be the collective effect for each season. Their occurrence on panels B_1 of October to B_9 of December showed evidently higher settlement, which may be an indication of the settlement of this species during the favourable post-monsoon season. Though a high salinity is not conducive for the settlement of this species it is clear from the long-term panels that once they settle they can survive the high saline period.

Electra bengalensis: Sparse settlement of this species was noticed only on the long-term panels in the month of June.

Alderina arabianensis: Settlement of this species occurred on both short-term and long-term panels. They showed sporadic settlement on the short-term panels during June, January and the entire pre-monsoon period. Heavier settlement occurred on the long-term panels and they were found to occupy a bigger area and form one of the members of the aged fouling communities.

Bugula cucullata: This species settled on the long-term panels in few numbers during August and September of the monsoon season. Menon and Nair (1971) recorded few colonies during the highly saline period of February – March on the long-term panels and remarked on the irregular nature of settlement of this species, which was indication of the occasional influx of larvae of this form into the estuary by tidal currents. The presence of this species in August indicates the high tolerance of the larvae to fluctuating salinity.

5.3.2 Ernakulam Channel-Site 2 (Station 2)

Settlement pattern of bryozoans on the long term panels (B Series) in the Ernakulam Channel at Station 2 during the period January 2002 to December 2002 revealed the presence of six species [See Table 14]. They were *Victorella pavida, Bowerbankia gracilis, E. crustulenta, E.bengalensis, Alderina arabianensis* and *Chartella arabica* of these *Chartella arabica* is new to science.

***Victorella pavida*:** This species attached to the panels in July and August during the monsoon season. They showed no preference to smooth or rough surface.

***Bowerbankia gracilis*:** Sparsely found only during the high saline, pre monsoon period and showed no preference to the texture of the substratum.

***Electra bengalensis*:** Settlement occurred during the pre-monsoon and only two colonies were found on the panels. One having not more than 12 zooids settled in March and another of not more than 100 zooids settled in May.

***Electra crustulenta*:** This species was represented on the panels throughout the experiment period with peak settlement during the post-monsoon. November 2002 showed heavy settlement which was evident by its abundance on both the smooth and rough surface of the panels, after which there was a gradual decline in the number settled.

***Alderina arabianensis*:** This species was found on the panels throughout the year. Pronounced settlement occurred during the pre-monsoon season. Its presence on almost all the panels throughout the year is an indication of predominant settlement on panels when exposed initially during the pre-monsoon. Their progressive growth was hindered during the unfavourable seasons of the year.

***Chartella arabica* sp. *novo*:** This species is new to science and this genus has hitherto not been recorded from this locale. Two big colonies were obtained in March and found attached by its base to the wooden rack. The size of the whole colony was as big as a shoe-flower, glistening white in colour and brittle in texture.

5.3.3 Mattanchery Channel (Station 3)

Settlement of bryozoans on the short term panels immersed in the Mattanchery Channel during the period January 2002 – December 2002 and February, May and June 2003 are tabulated and presented in Table 13 and 15. Twelve species settled were *Alcyonidium erectum, Victorella pavida, Bowerbankia gracilis, Nolella papuensis, Farella repens, Triticella korenii, Aetea anguina, Electra crustulenta, Electra crustulenta* var *borgii, Alderina arabianensis, Bugula neritina* and *Bugula cucullata,* of which, six are ctenostomes and six are cheilostomatous anascans.

Alcyonidium erectum: Attached once on the smooth surface of the short term panels exposed in May 2003 [Table 15].

Victorella pavida: Settled on the panels during the monsoon season and ceased to settle by August. This species preferred a low saline condition and were present throughout the water column.

Bowerbankia gracilis: Settled on the short term panels from March onwards (A-Series). The settlement was prominent on the panels of the intertidal level.

Nolella papuensis: This species was found on the short term panels immersed in February, May and June 2003 [Table 13 and 15]. The remarkably longer zooid of these stolonate species showed no preference for smooth or rough surface of the panels.

Farella repens and Triticella korenii: These species were rarely present on the panels showing irregular settlement in May and June 2003 [Table 15] on short term panels (A series).

Aetea anguina: Settled on the intertidal level panels in the month of February 2003 [Table. 15].

Electra crustulenta: This species settled on the short-term panels (A Series) in July and continued to settle until January. The colonies showed no preference for the smooth or rough surface and settled only on panels immersed and kept 150 cm above the mudline. *E. crustulenta* did not settle during pre monsoon period at this station.

***Electra crustulenta* var *borgii*:** This species was present on the bottom panels very sparsely in February and May 2003 [Table 15].

***Alderina arabianensis*:** This species was present on the panels throughout the year except September. The reason for the absence can be the drastic change in salinity. There was a sudden increase in salinity in September and the animals did not settle during this month.

***Bugula neritina*:** This species was recorded only at this station. Settlement of this species occurred in February, March and sparsely in April. This settlement pattern shows that *Bugula neritina* prefers high salinity conditions similar to that recorded by Menon (1967). The salinity during these months ranged from 27 to 30 psu.

***Bugula cucullata*:** This species was found to be as common as *Bugula neritina* and was prominently seen during the pre-monsoon season. No preference for smooth or rough surface of the panels was noticeable.

5.3.4 Approach Channel (Station 4)

Settlement pattern of bryozoans on the long term panels immersed at this station for a period of one year are tabulated and presented in Table 16. Four species settled on the panels; *Bowerbankia gracilis, Hislopia* sp., *Alderina arabianensis,* and *Electra crustulenta*. There was considerable reduction in the number of colonies. The colonies that settled could have been sloughed off the panels as evidenced from damaged colonies.

***Bowerbankia gracilis*:** This species was found on the panels in less number during the pre-monsoon season.

***Hislopia* sp.:** This is a new record of this genus from the Cochin backwaters. This species settled in May of pre-monsoon season.

***Electra crustulenta*:** This species occurred on the panels very regularly, though in varying intensity, throughout the year.

***Alderina arabianensis*:** This species settled on the panels during 9 months. It did not settle during April, November and December.

5.3.5. Vypeen Channel (Station 5)

This station was in a low saline unpolluted area situated very close to a mangrove forest. The panels exposed at this site developed a brownish hue due to the organic debris settled. Three species settled on the panels at this station as tabulated in Table 17. They were: *Bowerbankia gracilis, Electra crustulenta* and *Alderina arabianensis.*

Bowerbankia gracilis: Settled on the glass panels sparsely in May at this site.

Electra crustulenta: This species settled on the glass panels throughout the year, in varying intensities.

Alderina arabianensis: This species was found on all the panels throughout the year, except in October.

5.4 Discussion

Barnes and Clarke (1995) stated that in boreal regions the fouling community would vary greatly according to the season of immersion, whereas in tropical regions it may be largely nonseasonal unless the environment is influenced by what may be called meteorological factors, such as freshwater runoff arising from monsoon conditions. In this context, fouling studies in tropical estuaries is interesting since Cochin estuary is governed by seasonal fluctuations in the environment. The spatial settlement of these invertebrate species on the test panels seems not to be a random process but their distribution and settlement is greatly influenced by the behavioral responses of these animals to a range of environmental stimuli and a remarkable influence of the seasons. This seasonal sequence of settlement accounts for the differences noticed here in the species composition of bryozoan fauna during the three periods of the year. Experiments on salinity tolerance of two marine forms have shown that the populations growing during high saline periods cannot tolerate salinities below 26% for more than 24 hours (Menon and Nair, 1974b).

Although fouling occurs throughout the year, seasonality of settlement and variation in abundance exhibited by different species, however, are more marked in some species and focuses to a number of tentative conclusions. Based on this settlement behaviour, the fouling bryozoan species in Cochin backwaters could be grouped into three categories:

(1) Species that settled on test panels throughout the year and exhibited increased frequency of settlement during certain favourable periods of the year – *Alderina arabianensis* and *Electra crustulenta.*

(2) Species that settled only during some definite periods of the year – *Victorella pavida, Bugula neritina, E.bengalensis.*

(3) Species with sporadic settlement – *Farella repens, Hislopia, Triticella korenii, Electra crustulenta* var *borgii, Aetea anguina* and *Bugula cucullata.*

Within minutes of immersing a clean surface in water, it absorbs a molecular conditioning film consisting of dissolved organic material and bacteria. Unicellular algae and cyanobacteria colonize this surface. This phenomenon was evidently seen on the panels immersed for a period of 7 days when the biological layer had formed with some colonial coelenterates like hydroids, ciliates and unicellular algae. This is unrelenting from the time of immersion and Menon (1972d) has reported that panels immersed for 3 days duration show primary film formation. This layer is essential for many of the larval forms to settle. The principle studies of larval attachment have been performed with sp. *Bugula.* Woollacott and Zimmer (1977) have studied the metamorphosis of Cellularoid larvae and revealed the unexpected complex morphogenetic movements involved in attachment of *B. neritina.*

Data on the bryozoans obtained from careful observation of nearly 350 panels exposed at five stations in the study area during a period of 15 months are presented in this chapter. The present study revealed that a total of 15 species of fouling bryozoans occur in Cochin Backwater,s of which *Chartella arabica* is new to science. Nine species have been previously recorded as foulers from test surfaces and bottom of ships. They are *Victorella pavida* (Osburn, 1944; Carrada and Sacchi, 1964; Menon and Nair, 1967b, 1971; Menon, 1972d), *Nolella papuensis* (Menon and Nair, 1971; Menon, 1972b), *Bowerbankia gracilis* (Menon, 1972d; Rao and Balaji, 1988), *Electra crustulenta* (Menon and Nair, 1967b, 1971, 1975), *Electra bengalensis* (Menon and Nair, 1967b, 1975; Rao and Balaji, 1988), *Electra crustulenta var borgii* (Menon and Nair, 1975), *Alderina arabienensis* (Menon and Nair, 1975; Anil and Wagh, 1988), *Bugula neritina* (Kawahara, 1960, Menon and Nair, 1972b), *Bugula cucullata* (Menon and Nair, 1972b). Three species *Alcyonidum erectum*, *Triticella korenii* and *Aetea anguina* were obtained from the carapace, leg and telson of *Peneaus indicus,* appendages of spider crab and epizoic on Bryozoa, respectively from the same locality. In the present study, three of the species *Chartella arabica* sp. *novo, Hislopia* sp. and *Farella repens* are new records to the assemblage of fouling bryozoans from this area.

It is clearly evident that the horizontal distribution of these sedentary organisms was not uniform even though the area investigated was small. The station 3 (Mattanchery Channel) which is nearer to the open sea, recorded the maximum number of species. Of the fifteen species only *Bowerbankia gracilis, Electra crustulenta,* and *Alderina arabianensis* were represented at all the other stations and forms like *Nolella papuensis, Farella repens, Triticella korenii, Aetea anguina* and *E. crustulenta* var. *borgii* were restricted to the Mattanchery channel. If the number of species settled could be taken as a criterion to assess the suitability of the environment for successful settlement and growth of this interesting group of fouling organisms, Mattanchery Channel seems to offer the most congenial conditions in this area. The significance of the Mattanchery Channel as one of the important shipping Channel with a greater depth appends the increased bryozoan diversity at this station. Soule and Soule (1977) commented that fouling studies done with plates or racks suspended in areas where ships do not or cannot anchor are really studies of the local fauna, carried out by offering an additional artificial substrate choice and probably fouling occurs when ships are anchored or berthed in harbors. This adds to the significance of panel studies at jetty, berth and port as done in the present study.

Settlement on a horizontal gradient shows that the intensity of occurrence is indirectly proportional to the distance of the locality from the open sea (Menon, 1972d). This may be explained by the populations of marine fouling bryozoans being replenished every year during the hot pre-monsoon period by transport of larvae of marine species into this locality. The ephemeral planktonic existence does not help the larvae to colonize successfully the interior regions. Those that succeed must be able to exist in a very dormant state during the monsoon period.

Osburn (1944) made a survey of the Bryozoa of Chesapeake Bay which has served as a classic reference on the penetration of marine ectoprocts into freshwater. Osburn (*loc. cit.*) described the change in the composition of the ectoproct fauna from the sea into the estuary, with ctenostomes and membraniporine cheilostomes proportionately better represented, and cyclostomes and ascophoran cheilostomes poorly represented in the Bay than in the sea. He also stressed that while the number of species were reduced, the number of individuals of these few species could be quite large at any given locality. Osburn (*loc.cit.*) and Menon (1972d) opined that the successful colonization of the estuary by the brackish water forms during the monsoon and post-monsoon periods and the settlement of marine forms during the hot pre-monsoon period is a characteristic feature of the estuarine fouling bryozoans. Similar results were obtained in the present study as ctenostomes showed a better representation than the cheilostomes; anascans thrived better than the ascophorans while cyclostomes representatives were not found in the estuary.

Menon (1967) stated "not even a single species continued to settle throughout the year". Contrary to this observation, in the present study, two species *A. arabianensis* and *E. crustulenta* were present on the panels throughout the year. This shows that endemic population of species exists in the estuary. *Victorella pavida*, was grouped by Menon and Nair (1967b, 1971) as "a typical brackish water forms" not encountered in purely marine condition, while *B. neritina* and *E. bengalensis* appeared on the panels during the high saline pre monsoon period only. In the present study *E. bengalensis* settled very rarely on the panels and only four colonies were noticed, whereas heavy settlement was noticed on short term and long term panels in pre-monsoon during the biofouling studies conducted by Menon (1972d). The inability of larvae to survive and settle on panels is symptomatic of the charges undergone in the Cochin backwater system during the past four decades due to the increase in anthropogenic activities. The rest of the bryozoan foulers were present intermittently on the panels with any specificity for marine or brackish conditions. *Chartella arabica* sp. *novo* was noticed only in March, the peak marine and hottest season of the year.

Barnes and Clarke (1995) and Genovese and Witman (1999) attributed substrate limitation, as a physical factor limiting the distribution of epifaunal invertebrates. The size of the panels of 10 x 15 cm may be insufficient for all the species to attach on it. However, cheilostomes are capable to overgrow other fouling organisms and cause suffocation by avoiding environmental contacts resulting in the death of the organisms. Gregarious settlement of larvae can lead to a situation of overgrowth. Many studies of spatial competition among epifaunal invertebrates have been conducted in fouling communities where overgrowth competition is common (Sebens, 1986). The colonies which are not sloughed off or not smothered by the heavy settlement of barnacles (Nair, 1965) may come back to activity by regeneration and succeed in producing larvae. The bryozoans were found to over grow the barnacles as an indication of limitation of space and an ability to regenerate.

Settlement and succession of macrofoulers including bryozoans have been studied by many scientists (Schoener, 1982; Oshurkov, 1994). Formation of primary film and attachment of macrofoulers culminating in a climax community was very clearly documented by Scheer (1945). Scheer (1945) found that fast growing hydroids, serpulids, bryozoans and ascidians controlled the climax community. This concept was subsequently supported and developed in many consequent studies including a newly established port in the southern India (Menon *et al.,* 1977; Braiko, 1985; Khalaman, 1989). The fast growing macrofoulers remain in the fouling community for periods up to 2 weeks to 2 years. The present study also shows that panels exposed for about a year harboured animals belonging to the category of hydroids, polychaetes, barnacles, bryozoans. A majority of the studies on succession, fouling community has been studied near the coast and in shallow waters that is in unstable environment. Therefore, the there are limitations in identifying general processes of macrofouling succession. Under the condition of frequent disturbances of the physical medium, the stable climax state may not be achieved at all in a number of cases, this even gives us reason to doubt the very existence of climax community establishment in macrofouling (Railkin, 2004). Under unstable conditions the succession process may be often interrupted.

It is well known that coastal biofouling is characterized by greater biomass and higher species diversity (Zevina, 1994). Since coastal marine areas represent unstable habitats, the communities do not reach the climax stage. Therefore, settlement studies employing smaller surface are likely to show the prevalence of fast growing species belonging to hydroids, cirripedes, polychaetes and bryozoans. This could be one of the reasons for the incidence of more number of species of bryozoans in the Mattancherry channel where large number of cargo ships berth.

The settlement of sedentary organisms on artificial substrates is a relatively recently developed phenomenon. The appearance of anthropogenic surfaces in the sea and the exponential growth of their overall area has become an essentially new factor in the evolution of the settlement of organisms on anthropogenic surfaces. In the coastal areas these surfaces are represented primarily by technical objects, the largest total area being that of submerged parts of vessels. At the present stage, artificial surfaces have become an important factor in the concentration and micro evolution of marine organisms. It may be assumed that their role will be even more significant in the future, since human activity in the ocean especially coast and the continental shelf area is bound to increase. The concentration of organisms especially those well adapted to settle and grow on artificial materials, seriously hampers the use of technical objects in the marine environment and requires constant antifouling measures.

6. Bryozoan diversity in the Cochin estuary

The estuaries of India cover an area of 2.14 x 10^6 ha, and are influenced by the semi-diurnal tides. Almost all the estuaries are used for the exploitation of marine and estuarine living resources, with the intensity of use ranging from moderate to heavy. Around metropolitan cities [Kolkata (Calcutta), Chennai (Madras), Kochi (Cochin), Mumbai (Bombay) etc.], the intensity of utilization is heaviest and may at times even exceed the carrying capacity of the estuaries (Khan and Murugesan, 2005). The sustainable capacity of these coastal ecosystems is being subjected to stresses and degradation from inappropriate development activities within the coastal zone itself as well as in the ocean (open seas) and in the upland areas.

Coastal zones of the world, constituting 15% of the earth's land surface, are major centers of human population as these are the areas of rapid development, due to the fact that the coastal waters serve as primary route for transport, tourism and communication among the different countries of the world. The changing development caused by population growth, increasing quality of life and the national economic restructuring, having forced nations to intensify and diversify the utilization of coastal and marine resources.

Despite the high potential development that can be offered by coastal estuarine and marine ecosystems and resources as described above, the threats to the sustainable capacity of marine ecosystems, to provide resources and environmental services have, in many cases, reached a critical level. Human activities which threaten estuarine biodiversity can be broadly grouped into five categories:

- overexploitation of living resources
- physical alteration of coastal and marine habitats
- coastal and marine pollution
- introduction of alien species
- global climatic change

Industrial clusters and oil terminals also release effluents into the estuaries. Shrimp farms in all the maritime states discharge the used water containing organic matter and chemicals into the estuaries (Hutomo and Moosa, 2005). The most serious and direct threats to coastal and marine biodiversity are the conversion of coastal habitats (e.g. mangroves and estuaries) into man-made land uses, such as industrial estates and settlement and harvesting of coastal and marine resources. Indirect threats to marine biodiversity would be in the form of pollution and sedimentation. However, these threats in essence are symptoms of more fundamental forces, which are causing the degradation of estuarine biodiversity.

Accelerated loss of coastal marine biodiversity components over the last few decades has been of great concern. Environmental changes, overexploitation and habitat loss are among the major cause of species loss that, according to certain estimates, is of the order of a species per day (Venkataraman and Wafar, 2005). It is not known what fraction of this loss is from estuarine environment, a situation owing to a lack of systematic coverage of all faunal and floral classes with the prominence placed often on economically important groups. With every species lost, we lose not only a biological specimen but also the ecological, economic or livelihood security the species could offer the mankind.

Equally important as knowledge of what lives in the estuary, is a prediction of what would live there in the future. This is especially true in regions where rapid loss of habitats and decline in water quality could be drastically altering the species diversity.

Estuarine regions with developing islands, cities around them analogous to Cochin estuary, are particularly vulnerable to this situation.

The wide distribution of many gymnolaemate bryozoans may be attributed to dispersal on drifting seaweed, floating pieces of wood and ship bottoms. Transport via ships is ever increasing in our waters and so the possibility of introduction of species is also increasing. Cochin harbour is frequented by cargo and passenger ships from around the world and hence these are sites for exchange of distinctly geographic species among regions of the world. Allen (1953) remarks that gymnolaemates never seen before in Australian coasts may suddenly become abundant, having been brought in on ships, evidently enduring passage through tropical waters.

The important aspect of environmental monitoring is to detect changes or trends over time, with respect to biomass, biodiversity or ecological processes. These may be either negative trends due to human activities or natural disasters or positive trends due to effective management interventions, e.g., protection and restoration. These informations are lacking and are of great importance to ensure that adequate conservative measures are taken to protect the unique facets of the world biodiversity.

Cochin estuary is a unique water body with its capacity to nurture flora and fauna of its own (Menon *et al.,* 2000). This is why studies pertaining to fauna of the estuary are significant in giving information on the changes that would have happened or the changes that would happen in near future. A thorough knowledge of the composition and occurrence of sessile marine invertebrates, extend to which species are indigenous to Cochin backwaters requires assessment. Long term and periodical monitoring of spatial variability of bryozoans, the extent of their utility in assessing habitat deterioration, especially in situations of intense human intervention as in Cochin estuary (harbour and industrial activities and sewage) can predict the impact of development activities on diversity of estuarine bryozoans. Information on the opportunistic species and moderately tolerant species from intensively used estuaries can evaluate variations in bryozoan diversity and their use in assessing health of estuaries.

6.2 Material and methods

Incidence of various bryozoans on glass panels was examined during the period January 2002 to December 2002 and in February, May and June, 2003 at Mattanchery wharf. For this a series of non-toxic glass panels were immersed in backwaters, for both long term and short term. The panels were immersed as mentioned in Sec: 5.2.

The data on the bryozoan settlement in the estuary during the present investigation was compared with the results of a similar experiment carried out during 1964, 1965 and 1966, to assess the rate and magnitude of bryozoan settlement on inert substrata (Menon, 1972d; Menon and Nair, 1971).

6.3 Results

Among the 15 species of bryozoans collected and studied during the present investigation one species was found new to science, one genera and two species were first records for this locale. The table listing the species in the present study (2002-2003) and those present on panels and other substrata in the Cochin estuary during the year 1964-1966 are on hand for comparison in Table 18.

Seven species belonged to the order Ctenostomes while eight were of the suborder Anasca which are the less calcified group of the order Cheilostomata. No ascophoran or cyclostome bryozoans were available on the test panels. The ctenostomes that attached to panels during the three seasons of the year were *Alcyonidium erectum, Victorella pavida, Nolella papuensis, Bowerbankia gracilis, Hislopia* sp., *Farella repens* and *Triticella korenii.* They were found to attach during their most favourable season within their preferred salinity and temperatures ranges while the cheilostomatous anascan species present were *Aetea anguina, Electra bengalensis, Electra crustulenta, Electra crustulenta* var. *borgii, Alderina arabianensis, Chartella arabica* sp. *novo,* *Bugula neritina* and *Bugula cucullata.*

In the studies conducted by Menon (1967) in 1965-66 he reported a total of 16 species from the Cochin estuary in a similar pattern of experiments. Among them four species were ctenostomes, eight species were of the cheilostomatous anascans while four were of the well calcified group of Ascophora. Menon and Nair (1971) reported three new species from this study area; they where *Electra crustulenta* var. *borgii, Alderina arabianensis* and *Schizoporella cochinensis.* Of these, *Electra crustulenta* and *Alderina arabianensis* were readily available on the panels in the present study while the species *E. crustulenta* var. *borgii* and *E. bengalensis* were scarcely available in the pre-monsoon months of the year. The alarming decline of the heavy calcareous forms from the estuary is a signal of the changes that have taken place during the past four decades.

Table 18. Bryozoans present on the glass panels immersed for biofouling studies in the Cochin backwaters during the year **1964-1966** and the year **2002-2003.**

Year / Bryozoans	1964 – 1966	2002 – 2003
Ctenostomes	***1. Victorella pavida*** 2. *Nolella papuensis* 3. *Bowerbankia gracilis* 4. *Aeverrillia setigera*	1. *Alcyonidium erectum* 2. *Victorella pavida* 3. *Nolella papuensis* 4. *Bowerbankia gracilis* 5. *Hislopia sp.* 6. *Farella repens* 7. *Triticella korenii*
Cheilostomes (Anascans)	1. *Electra bengalensis* 2. *Electra crustulenta* 3. ***Electra crustulenta* var. *borgii*** 4. *Electra crustulenta* var. *artica* 5. ***Alderina arabianensis*** 6. *Membranipora savaratii* 7. *Bugula neritina* 8. *Bugula cucullata*	1. *Aetea anguina* 2. *Electra bengalensis* 3. *Electra crustulenta* 4. *Electra crustulenta* var. *borgii* 5. *Alderina arabianensis* 6. ***Chartella arabica*** 7. *Bugula neritina* 8. *Bugula cucullata*
(Ascophorans)	1. ***Schizoporella cochinensis*** 2. *Schizomavella linearis* var. *inarmata* 3. *Watersipora subovoidea* 4. *Savignyella lafonti*	Nil
Cyclostomes	Nil	Nil

Table 19. Horizontal distributional gradient of fouling bryozoans in Cochin backwaters.

Sl. No.	Species	Station1 **Indian Oil Jetty** 4.5 km away from the Barmouth	Station2 **North Tanker Berth** 4 km away from the Barmouth	Station3 **Mattanchery Wharf** 3 km away from the Barmouth	Station4 **Fort Kochi** 1 km away from the Barmouth	Station5 **Ochanth-uruth** 6 km away from the Barmouth
1	*Alcyonidium erectum*			*		
2	*Victorella pavida*	*	*	*		
3	*Nolella papuensis*			*		
4	*Bowerbankia gracilis*	*	*	*	*	*
5	*Hislopia sp.*				**	
6	*Farella repens*			**		
7	*Triticella korenii*			*		
8	*Aetea anguina*			*		
9	*Electra bengalensis*	*	*			
10	*Electra crustulenta*	*	*	*	*	*
11	*Electra crustulenta* var.*borgii*			*		
12	*Alderina arabianensis*	*	*	*	*	*
13	***Chartella arabica* sp. novo**		***			
14	*Bugula neritina*			*		
15	*Bugula cucullata*	*		*		

[* -present; **- First record; ***- New species recorded; new species in bold letters]

The present study has shown that the quantum of bryozoan foulers who are typically marine have drastically come down. The typically marine bryozoans are very sensitive to changes in the physico-chemical characteristics of the seawater. This evidently shows that the quality of the resident water of the estuary has declined.

6.4 Discussion

The current rate of species extinction has been estimated to be of the order of 100-10,000 per year, compared to one or so per year prior to the 'evolution people' (Venkataraman and Wafar, 2005). In tropical estuaries of Mexico, studies were made at Mazatlan harbour in 1957 and in 1973 and a comparison between the relative underdeveloped Mazatlan harbour with the urbanized Los Angeles – Long Beach Harbour (Soule and Soule, 1979) by measuring the temperature, salinity, dissolved oxygen and pH at 1m intervals through the water column distribution of invertebrates and sediment grain size revealed that some of the species have disappeared. A variety of wastes originated from both land-and marine-based activities eventually enter into the estuarine and marine environment. Sources of land-based pollutants include: coastal and upstream agriculture which discharge pesticide, fertilizer and sediment runoff; and urban and industrial development leading to discharge of untreated wastes and effluents. Sources of marine-based pollutants include: oil and gas related activities resulting in discharges of drilling wastes, chronic spills and potential major oil spills (tanker accidents, blow outs); and marine traffic accidents resulting in release of waste and toxic materials. The aforementioned environmental threats will either directly or indirectly reduce or degrade marine biodiversity at genetic, species or ecosystem levels.

As a result of larval drift, the transport of foulers by ships, and their rafting upon various objects afloat on the sea surface, a number of invertebrates and macroalgae are carried to geographical zones, regions and biotopes new to them and in some cases could become naturalized there. This results in the extension of ranges of these species, in their biological progress, and in some cases, they replace native species. The problem of invasion by species and disturbance of marine (and freshwater) ecosystems is one of the ecological problems of the twentieth century (Carlton, 1985)

The total absence of the highly calcareous ascophores and cyclostomes can be attributed to many factors of which one important character is the salinity changes encountered by these sessile animals in the estuary. The irregularity in the salinity of the estuary is a factor which the ascophorans cannot tolerate and the estuary is prone to the sudden drop in salinity during the monsoon season. Of the many salts that influence salinity, calcium is one of the important component which is a key component for the formation of the chitinous outer covering of these advanced bryozoans. The characteristic change in calcium accompanied with changes in salinity in the environment of these immobile organisms can have direct regulatory effect on the formation of the calcareous armory of the ascophorans and the cyclostomes may be one of the many reasons for the total absence of these forms.

Another limiting factor is carbon dioxide. CO_2, like O_2 may be present in water in highly variable amounts. Although present in low concentration in the air, CO_2 is extremely soluble in water and seldom is a limiting factor in aquatic environment. Furthermore, unlike O_2, CO_2 enters into chemical combination with water to form H_2CO_3 which in turn reacts with available limestone to form carbonates and bicarbonates. Other sources of CO_2 in water are respiration, decay, soil and underground sources. Carbonates and bicarbonates not only provide a source of nutrients but also act as buffers, helping to keep the Hydrogen ion concentration of aquatic environments near to the neutral point. Moderate increase in CO_2 in water seems to speed up the developmental process of many organisms. CO_2 is an essential factor in the formation of the calcium carbonate exoskeletal armory of this animal. The enhanced size of the zooids in the Antarctic species could be an effect of the constantly high salinity and moderate CO_2 concentration. The above findings can be regarded as a confirmation of the suggestion that bryozoans synthesize their fine calcium based exoskeleton from the immediate water they live in.

The first stages of colony dispersion are the reproductive strategies such as brooding, transport and selection of substrate; these are followed by adult strategies such as mode of attachment; colony form, resistance to predation, and tolerance to environmental stress. There are species with larvae capable of surviving as plankton for long periods of time and those that settle within a few hours after release. Ova with little yolk, develop into feeding (planktotrophic) larvae, capable of remaining in the plankton for days and sometimes weeks (Soule and Soule, 1977). The presence of the new species *Chartella arabica* at Station 2, North Tanker berth, needs special mention as this was a site frequented by oil tankers from geographical regions. This species was found during the high saline and hottest season of the pre-monsoon when the temperature and salinity was high. This can be regarded as the most favourable conditions for the release of the larvae to attach on to the substratum and accelerated vegetative growth of the colony.

The presence of *Chartella arabica* in the estuary is a clear indication of transport of marine bryozoans from outside the Arabian Sea. The species recorded as *Chartella arabica* could be a species abundantly surviving in the wild but not recorded so far. The Mattancherry channel near the main wharf recorded the maximum number of bryozoans. This clearly indicates that this region gets regular supply of marine bryozoan which could be from local endemic population or supplied via the hulls of ships that frequent Cochin harbour.

The most important information obtained on bryozoan distribution in the Cochin estuary from the present investigation is the nearly total absence of *Electra bengalensis* in the fouling community. Menon (1972d) and Menon and Nair (1971) found luxurious distribution of this species in all the stations situated in and around Cochin harbour. *E. bengalensis* was described as *E. anomala* by Osburn (1950) on the ground that this species is typically marine and is found in abundance in marine localities. Menon (1967) has collected this species from various stations along the east and west coasts of India. This gymnolaemate probably represent a sensitive group of animals which might prove to be important indicator of the health of the coastal waters.

In the case of ascophorans, absence of the genus *Schizoporella cochinensis* is also significant Menon (1972d) and Menon and Nair (1971) recorded one species of this genus in enormous numbers on glass panels and on other artificial substrata. Curiously enough, this species has been totally displaced from the Cochin estuary as it was not found on any of the panels immersed at various localities in the Cochin estuary. In this connection it becomes obvious that species diversity index alone may not give a correct picture of ecological disturbance due to pollution but comparison of specific species in space, time and abundance would be important to arrive at a better conclusion on the pollutional effects of benthic assemblages when the candidate species selected forms a group which has both highly tolerant and less tolerant species.

Taking into consideration, Bryozoa as a group to assess water quality criteria, the taxonomic category should be properly identified and any consideration of number of species alone may not give clear-cut evidences. In the present study many species recorded are fresh entrants into the estuary whereas established species (at least two) have been removed from the locality. This requires further clarification by more intensive sampling of areas along the Indian coast where conspicuous pollution has happened. Probably the Mumbai Harbour, Panambur, Kochi, Tuticorin, Chennai, Vishakapatanam, Paradeep and Calcutta should form important localities to analyse variations in sedentary communities with reference to space and time commencing early 50's. This is possible as we have enough documentation on the sedentary fauna of these harbours.

Mc Dougall (1943) noted selection of the slowest of water currents of varying speed by many bryozoans. The effect of water current is more obvious in very shallow water where characteristic assemblages of sponges, ascidians, serpulid worms and bryozoans occur in areas benefiting from particularly high mass transport of water such habitats may be large channels intake conditions or land locked bay with the sea. (Ryland, 1970). The result obtained at station 4 Fort Kochi, clearly shows that constantly moving waters are less prone to bryozoan fouling. This was a site very close to the barmouth and high wave break was a constant phenomenon here. Not only the attachment of animals was lowered but the panels and rack did break at this site. This justifies the thought that the moving surfaces have less risk of sedentary attachers and ship-fouling process happens when stationary and anchored at the ports.

7. Summary

The thesis deals with taxonomy as well as geographical distributional aspects of bryozoans of the Indian EEZ and a locality in the Antarctic in part one and bionomics and fouling, an economically relevant aspect of the bryozoan in part two. Bryozoan morphology is rather complicated and hence has deterred marine scientist for making any attempt to study in detail especially from the Indian continent. This is amply testified by the lack of serious work on the taxonomy and biology of this group. These animals have not been embarked by any marine biologists since a series of publications appeared in the early seventies. Considering the importance of a study on the biodiversity of microbenthos, which is normally composed of representatives from the EEZ of India, samples available was utilized to produce a very useful input.

Analysis of bryozoan fauna during the Holocene (11,000 years) to understand links between Australia, New Zealand, south America and Antarctica have shown that clear-cut links do exist between the bryozoan fauna of these regions although the richness varied between regions (Moyano, 1996). Marine invertebrates and vertebrates show zoogeographical links between very isolated lands and bryozoans due to their highly calcareous exoskeleton offer an excellent material for the study of zoogeographical links. Hence an attempt to study the zoogeographical linkage and evolutionary success of this group in the various geographical regions of the world is imperative.

Marine biofouling is found to be hazardous. Study of the organisms responsible for this process is essential to formulate methods to check foulers. Bryozoans are important group of invertebrates in the fouling community. 50 species of bryozoa have been recorded on ships hull, though they are less significant foulers in terms of weight, their thin encrusting mode provide a safe substratum for the attachment of barnacles, serpulid worms and bivalves, which together have a remarkable effect on the frictional resistance. The essential part of the fouling process involving attachment of larvae happens when a ship is anchored at a port or a harbour. For this reason, an investigation on the bryozoan species in the harbour, which are the key contributors to fouling, was essentially to formulate any anticipatory methods.

An acquisition of fundamental knowledge of these sedentary and highly sensitive organisms that cause fouling is necessary to relate it to the changes in the environment that have happened and would occur in the near future. In the present work, an extensive study on the bryozoan foulers that occur at five selected site of the Cochin estuary had to be examined and since the hydrographic parameters such as salinity, temperature, pH and dissolved oxygen in the estuary, vary greatly from that in the open ocean, a frequent monitoring of these parameters was essential.

The thesis is presented in 7 chapters:

Chapter I. Introduction

This chapter gives a general account on Bryozoa, an overview of the literature available on the various studies carried out on Bryozoa and significance of this animal on evolution, ecology and economy. The objectives of the present study are also given.

Chapter II. Taxonomic account

Classification of the bryozoans identified from the Indian EEZ and the Antarctic waters are presented in this chapter. The species list of bryozoa from these two regions as well as a complete description including morphometrics, salient features, occurrence, remarks, previous records from the respective region, and the geographical distribution of the identified species with scanning electron micrographs attached as plates at the rear end of the section is the elements in this chapter.

The present taxonomic work on the bryozoans of Indian EEZ accounts the details of 102 species including 39 species of Anasca belonging to 23 genera of 17 families, 54 species of Ascophora belonging to 34 genera of 22 families, 4 species of cyclostomes under 4 genera and 3 families and 5 species of ctenostomes belonging to 5 genera of 4 families.

Of the 24 species of bryozoans from the Antarctic waters 12 species of Anasca belonging to 10 genera of 5 families, 10 species of Ascophora belonging to 10 genera of 7 families and 2 cyclostomes of 2 genera and 2 families have been identified and described.

A total of 51 Anascans, 64 Ascophorans, 6 Cyclostomes and 5 Ctenostomes are systematically placed. Of these, 54 species are first records from the Indian EEZ and 11 species from the Antarctic are premier records from the Antarctic waters. There are 3 records new to science; they are ***Chartella arabica*** from the Cochin estuary, ***Cleidochasma sampada*** from the EEZ of India and ***Iodictyum anomala*** from the Antarctic waters.

Chapter III. Biodiversity and geographical linkage of bryozoans

Bryozoan abundance and diversity show great variations geographically and seasonally according to environmental conditions in which they live. Hence diversity of bryozoans from two entirely different marine environments and their geographical distribution was studied with the help of the secondary data in this chapter. The study showed that major numbers of species recorded from the Indian EEZ in the present study were confined to areas of the Indo-Australian Archipelago, the Pacific and Australian waters.

The list of species and numerical abundance of each species from one station in the Arabian Sea, the Bay of Bengal and the Antarctic were selected for multivariate analysis of PRIMER (Plymouth Routines in Multivariate Ecological Analysis [Version 5]) to evaluate similarity in these bottom communities. The similarity in percentages showed that the species number and abundance within two localities comparable latitudinally in the Arabian Sea and the Bay of Bengal ranged between 40-60 %. On the other hand, these two assemblages qualitatively depicted no similarity with the Antarctic fauna (<5%).

Chapter IV. Environment of fouling bryozoans

Observations on variations in the hydrographic parameters at the five stations selected for biofouling studies is presented in this chapter. Surface and bottom water samples collected monthly from five stations in the Cochin estuary for a period of one year were analysed for changes in salinity, temperature, pH and dissolved oxygen. Drastic fluctuations in salinity were noticed during the monsoon season and post-monsoon while high saline conditions prevailed during the pre-monsoon. Temperature showed less variation but was high in the pre-monsoon season. Dissolved oxygen and pH showed slight variations. These parameters were mostly affecting the incidence of certain species. For e.g. *Victorella pavida* which was confined only to the low saline monsoon season while *Chartella arabica* sp. *novo* was present in the high saline and hot premonsoon season.

Chapter V. Fouling bryozoans

This chapter provides information on the different species of bryozoans that attached on the panels immersed for one year at stations 1, 2 in the Ernakulam channel, 4 in the approach channel and 5 in the Vypeen channel and a period of 2 years at station 3 in the Mattanchery channel. The spatial settlement of these invertebrate species on the test panels seemed not to be a random process but their distribution and settlement was greatly influenced remarkably by seasons and the behavioral responses of these animals to a range of environmental stimuli. This seasonal sequence of settlement accounts for the differences noticed here in the species composition of bryozoan fauna during the year. Of the fifteen species only *Bowerbankia gracilis, E. crustulenta* and *A. arabianensis* were represented at all the stations and forms like *Nolella papuensis, Farella repens, Triticella korenii, Aetea anguina* and *E. crustulenta* var. *borgii* were restricted to the Mattanchery channel.

Chapter VI. Bryozoan diversity in the Cochin estuary

This chapter provides information about the composition and occurrence of bryozoans and the extent to which species are indigenous to Cochin backwaters. Long term and periodical monitoring of spatial variability of bryozoans, the extent of their utility in assessing habitat deterioration, especially in situations of intense human intervention (harbour, industrial activities and sewage)as in Cochin estuary, are employed to predict the impact of development activities on diversity of estuarine animals. Information on the opportunistic species and moderately tolerant species in this intensively exploited estuary can evaluate variations in bryozoan diversity and their use in assessing health of estuaries. This section including changes in diversity of bryozoans is exemplified by a comparison with the data available on these animals based on the work, which was carried out four decades ago.

Chapter VII. Summary

This chapter includes an overall summing up of the main findings in the present study.

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