STUDIES ON THE TAXONOMY OF INTERSTITIAL FAUNA OF SOME PROMINENT BEACHES OF KERALA

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON THE TAXONOMY OF INTERSTITIAL FAUNA OF SOME PROMINENT BEACHES OF KERALA"** is an authentic record of the research work carried out by Ms. Priyalakshmi.G, under my scientific supervision and guidance in the Department of Marine Biology, Microbiology and Biochemistry, School of Ocean Science, Cochin University of Science and Technology, in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Marine Biology of Cochin University of Science and Technology and that no part of the thesis has been presented before for the award of any other degree, diploma or associateship in any University.

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DECLARATION

I hereby declare that the thesis entitled **"Studies on the Taxonomy of Interstitial Fauna of Some Prominent Beaches of Kerala"** is a genuine record of the research work done by me under the scientific guidance and supervision of **Prof. Dr. N. Ravindranatha Menon**, Hon. Director and Emeritus Professor, Centre for Integrated Management of Coastal Zones, School of Ocean Science and Technology, Cochin University of Science and Technology, Kochi and that this has not previously formed the basis for the award of any degree, diploma or associateship in any University.

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PREFACE

As important as it is in its own right and for its material benefits to humankind, the diversity of marine life has provided the raw material for ideas that apply far beyond marine biology. Among the numerous examples that illustrate this point are ideas about the ecology of uncommon species, ecosystems with very rigorous environmental conditions and the evolution of predation and antipredation mechanisms.

Of the various marine ecosystems, the sandy beaches have attracted the attention of numerous marine biologists. By and large, the macro invertebrates especially the decapods, bivalves and the gastropods drew the attention of naturalists to this serene environment. More than two centuries ago, the British writer Samuel Johnson observed about the joy of watching the wave washed sandy beaches. However, only in 1935, Nicholls introduced the terminology 'interstitial fauna' to categorize an array of amazing microscopic animals that thrive in the interstitial water of sand. Organisms spending major part of their life in the interstitial space between all types of sediment particles are properly referred to as interstitial and they offer no disturbance to the substrata in which they thrive.

The diversity of the organisms that inhabit the interstices of beach sands in the intertidal realm is so astounding that 22 of the known 33 metazoan phyla have their representatives living in this ecosystem. The changes, both physical and chemical that occur in the water washing the interstices, are controlled by various factors among which the waves, tides, rain and sea ice are the important ones apart from those anthropogenic factors which interfere with the life and activity of the interstitial animals living in the beaches. The dynamics of the ecosystem is so variegated that they have influenced the morphology, activity and all-important organismic characteristics of the numerous species that colonized this fascinating microcosm. The flushing of seawater that takes place in the interstices should be having an over riding role in controlling the trophodynamics of this unique marine ecosystem.

The present study was undertaken to understand the variety and complexity of the interstitial fauna occupying five prominent beaches of Kerala having different ecological and anthropogenic influences. The study, apart from the taxonomy of the dominant groups also includes some related ecological and trophic aspects of selected groups.

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Abbreviations used in the thesis

%	percentage
µ	microns
°C	degree celsius
µm	micrometers
a.b.d.	anal body diameter
C	Carbon
c. d.	corresponding diameter
cf	comparable to
cm	centimeter
Cnid	cnidaria
comb nov	New transfer of a species to another genus
CS	coarse sand
DO	dissolved oxygen
E	East
FS	fine sand
Gastr	gastrotrichs
H	Hydrogen
h. d.	head diameter
Hrpc	harpacticoids
i.e.	that is
Isop	isopods
Kinor	kinorhynch
l	Litre
lat.	Latitude
loc. cit.	In the place located
long.	Longitude
mg	milligram
mm	millimeters
MS	medium sand
N	Nitrogen
N	North
Nem	nematode
nov. sp.	New species
Oligo	oligochate
op	In the opinion of
Org.C	organic carbon
P. size	Particle size

Poly	polychaete
Sal.	salinity
SD	standard deviation
sp.	Species
st. 1 & st. 2	Cherai beach
st. 3 & st. 4	Fort Kochi beach
st. 5 & st. 6	Arthungal beach
st. 7 & st. 8	Sakthikulangara beach
st. 9 & st. 10	Veli beach
st.	station
syn	Synonym
Temp.	temperature
TG	Trophic group
Turb	turbellarians

Co	caudal organ
CP	caudal papilla
DP	dorsal papilla
E	egg
eg	epidermal gland
Fo	frontal organ
Lt	total length from the anterior tip of pre-buccal extension to posterior tip of caudum or pedicles including adhesive tubes.
U	percentage unit of total length used for the location (U-) from anterior to posterior.
pb	pre-buccal apparatus
PhIJ	junction between pharynx and intestine
Pp	pharyngeal pore
T	testis
TbA	anterior adhesive tube
TbL	lateral adhesive tube
TbVL	ventro-lateral adhesive tube
TbDL	dorso-lateral adhesive tube
TbP	posterior adhesive tube
Vp	ventral papilla

S11	Pre-monsoon. Cherai
S12	Pre-monsoon. Cherai
S13	Pre-monsoon. Fort Kochi
S14	Pre-monsoon. Fort Kochi
S15	Pre-monsoon. Arthungal
S16	Pre-monsoon. Arthungal
S17	Pre-monsoon. Sakthikulangara
S18	Pre-monsoon. Sakthikulangara
S19	Pre-monsoon. Veli
S110	Pre-monsoon. Veli
S21	Monsoon. Cherai
S22	Monsoon. Cherai
S23	Monsoon. Fort Kochi
S24	Monsoon. Fort Kochi
S25	Monsoon. Arthungal
S26	Monsoon. Arthungal
S27	Monsoon. Sakthikulangara
S28	Monsoon. Sakthikulangara
S29	Monsoon. Veli
S210	Monsoon. Veli
S31	Post-monsoon. Cherai
S32	Post-monsoon. Cherai
S33	Post-monsoon. Fort Kochi
S34	Post-monsoon. Fort Kochi
S35	Post-monsoon. Arthungal
S36	Post-monsoon. Arthungal
S37	Post-monsoon. Sakthikulangara
S38	Post-monsoon. Sakthikulangara
S39	Post-monsoon. Veli
S310	Post-monsoon. Veli

Chapter - 1

Introduction

> *"Above all there was Whitsand Bay.....There was a rough path leading to an exquisite beach of white sand, over which curled and dashed waves from the Atlantic, bringing in razor shells, tellinas of delicate pink, cockles and mactras. It was the most delicious place that I ever knew, and to this hour a windy night will make me dream of the roll and dash of its waves and the delight of the sands."*
>
> ***Charlotte Mary Yonge***

1.1 General Introduction

The oceans in their vast expanse cover seven-tenths of the Earth's surface. The mean depth of the ocean has been estimated at about 4000 meters, which is considerably greater than the mean height of land (about 850 meters) above sea level. Living things inhabit all this tremendous expanse and depth. Since life exists through out this immense volume, the oceans constitute the single largest repository of organisms in the planet.

The littoral zone, an integral part of the oceanic system is subject to tidal ebb and flow. The seashore has long been a subject of fascination and study. This region is better known as the 'Intertidal zone', where land meets the water. Although the littoral zone constitutes a small area, this intertidal zone is perhaps the best studied. This is an extremely narrow fringe area, and represents the transitional area from marine to terrestrial conditions. Despite being restricted in size, the intertidal zone has the greatest variation in environmental factors of any marine area. Stemming from this variation a tremendous diversity of life, which may be as great as or greater than that found in the more extensive subtidal habitats exist in this realm. The richness, the diversity of environmental factors and the ease of access to this area attract a disproportionate amount of scientific attention. Technically, the intertidal zones include beaches and estuaries. Beaches are unique areas and the organisms that live there face many challenges. Great variation in topography and substrate is often noticed. Based on substratum, beaches could be classified as shingle, muddy, rocky or sandy. Depending on the strength of the wave action the shore receives, the beaches may be identified as exposed and sheltered (protected) ones. Protected sandy shores could be found where wave action is weaker and the substratum is more stable. The exposed beaches receive great wave action.

The sandy beaches harbour diverse and abundant assemblage of marine organisms. All the macro organisms inhabiting this area are burrowing animals. Besides macrofauna, the sandy beaches are profusely inhabited by microscopic organisms belonging to the lower and higher invertebrate taxa. The ecological realm where these animals exist is known as the interstitial environment, which in principle includes the pore spaces in between sand grains containing copious supply of nutrient rich oxygenated seawater.

The general term 'interstitial' for the microfauna in the interstitial water of sand was introduced by Nicholls (1935); Remane (1940) used the word 'mesopsammon' and the term 'meiobenthos' was coined by Mare (1942). In 1952, Remane introduced the term 'Lebensform-typus' where certain morphological features in very different taxa recur as a result of selective pressures for living in this habitat. The vermiform body of interstitial organisms, which allow them to move between the sand, is one of the various body formations encountered in interstitial animals.

Interstitial fauna or sand microfauna occur not only in the sea, but also in other similar sediments in lakes, rivers, springs and brackish water. The study of meiofauna started long before the term meiofauna (or meiobenthos) was coined and the earliest studies focused on the discovery and description of new forms. Despite the discovery of many of the higher meiobenthic taxa by the mid nineteenth century, new meiofaunal groups continued to be described (Sorberacea (Tunicata) – Monniot *et al.*, 1975; Loricifera-Kristensen, 1983). An astonishing diversity of taxa could be found within the meiofauna. In fact, twenty-two of the 33 metazoan phyla have representatives of meiobenthic taxa. The Gastrotricha, Kinorhyncha, Gnathostomulida, Loricifera, Mystacocarida, Nematoda, Polychaeta, Copepoda, Ostracoda, Turbellaria, Halacaroidea, Hydrozoa, Nemertina, Entoprocta, Gastropoda, Aplacophora, Brachiopoda, Holothuroidea, Tunicata, Priapulida, Sipuncula and many representatives of Rotifera are permanent meiofauna, whereas some organisms like the larvae of macrofauna are a part of meiobenthos, only during their juvenile stages (temporary meiofauna).

Zoological investigations and taxonomic descriptions of interstitial animals were being published by the mid 19th century. One of the first of these was the discovery of the Kinorhyncha by Dujardin in 1851. In 1901, Kowalevsky studied Microhedylidae (Gastropoda) in the Eastern Mediterranean and in 1904, Giard described the first archiannelid (*Protodrilus*) and the gastrotrich (*Chaetonotus*). But it was Remane, the "father of meiofaunal research" who, on the basis of complete samplings, first recognized the rich populations in intertidal beaches, subtidal sands, mud and algal habitats as definable ecological assemblages. Remane (1927a) described *Halammohydra,* the unique interstitial hydrozoan depicted on the emblem of the "International Association of Meiobenthologists". The significance of Remane's work is reflected in his contention that the meiobenthic fauna of sand is not merely a loose aggregation of isolated forms, but a biocoenoses different, not only in species abundance and composition, but also in morphological and functional features.

The interstitial animals are physiologically adapted to endure both the seasonal variation and the rapid changes that occur in connection with ebb and flow. The littoral interstitial fauna is therefore eurythermal and euryhaline There is a wide spectrum of morphological adaptations to meet the biological demands of the dynamic environment. These include vermiformity, different kinds of reinforcement of the body wall such as cuticular scales or spines (turbellarians), adhesive organs, static sense organs, modified buccal apparatus and organismic adaptations for the maintenance of populations.

The composition and development of the fauna of various sand biotopes depend greatly on the environment. The environmental variables which the adult animals encounter in the intertidal zone, and which they endeavour to counter by morphological, physiological and behavioural means, are manifold and complex. One environmental factor of prime importance is that of space, which is dependant on the grain size distribution in sediment. Space determines the overall volume of organisms in a given interstitial environment. The granulometric characteristics of the sand affect the composition of the microbiocoenoses and their distribution within a beach area. A correlation between body size of interstitial animals and grain size has been found. In fine sands, (finer than 200μm, the critical grade of Wieser, 1959; or finer than 125μm, McIntyre and Murison, 1973), the truly interstitial fauna is replaced by a numerically poorer burrowing fauna. It is only natural that the interstices in fine sand are too small for the larger interstitial organisms that normally inhabit coarse sand. Grain size may in this way act as a distribution barrier in the interstitial fauna (Wieser, 1956;1959). In tidal zones, the grain size will have biological significance because it affects the ability of the sand to retain water during the ebb period. The capillary water in a beach may vary considerably during the ebb and thereby restrict the living space of the interstitial organisms to a thin film of water around the particles of sand (Pennak, 1951). The drainage of interstitial water is rapid in coarse sand and ciliary gliding locomotion typical of interstitial forms like Turbellaria, Gastrotricha and Archiannelida is almost impossible (Jansson, 1967). 125µm-500µm-particle diameter inter-tidal sand harbours abundant meiofauna. However, the complexity of the habitat is not adequately represented by the mere determination of the median diameter of the particles. Jansson (loc. cit.) feels that the pore space available is a more relevant factor.

Sorting relates to pore spaces more closely. Poorly sorted sediments have small pore spaces; where as larger pore spaces occur in well-sorted sediments in the equivalent size range of particles. Space alone cannot limit meiofaunal abundance since the fauna never occupy the total volume of pores. Sorting also indicates the severity of the hydrodynamic regime affecting the sediment. Well-sorted sediments are found where wave, tide and current action occur and conversely, poorly sorted sediments are found where weak action of the above factors occur. The surface texture of sand grains, whether smooth or rough, may be of importance to the interstitial fauna. The roundness of grains will affect the size of the interstices. Physical disturbance is a key factor that influences the structure and composition of marine benthic communities (Hall, 1994). Effects will depend on the nature of disturbance, its frequency and intensity, which are spasmodic and largely unpredictable (Schratzberger *et al.*, 1998).

Majority of the environmental gradients exhibit distinct verticality. The inhabitability by an organismic assemblage and its composition depend on the porosity of the sediment, which directly controls the quantity of interstitial water, and the space available to live. The oxygenated layer also decides the vertical movement of interstitial animals. Harpacticoid copepods are typically the most sensitive meiobenthic taxon to decreased oxygen levels.

A significant factor in the nutritional biology of the interstitial fauna is the availability of organic matter in the sand. Their food mainly consists of organic detritus, bacteria, diatoms and protozoans. Major groups of animals like nematodes, gastrotrichs, archiannelids and turbellarians are reported as detritus feeders (Swedmark, 1964). The organic debris is either adsorbed to the sand grains or remains as colloidal suspension after bacterial decomposition. The adsorbed organic matter may serve as food for the scavenging microfauna while colloidal suspensions may be made use of by the suspension feeders. The organic debris while undergoing bacterial decomposition affects the pH and oxygen concentration of the medium, which in turn may alter the characteristics of the population (Krishnaswamy, 1957).

Benthic bacteria have long been thought to be a major food source for meiofauna (Boucher and Chamroux, 1976). A positive correlation was observed between bacterial and meiofaunal densities in a study conducted by Moreno *et al.* (2006), suggesting that bacteria constitute a primary food source for meiofauna and in particular for Copepoda (Marcotte, 1986) and nematodes (McIntyre *et al.*, 1970; Tietjen, 1980; Montagna *et al.*, 1983). The reduced meiofaunal abundance in regions of low concentrations of organic matter and bacterial density pinpoint their role as the primary food sources (Montagna *et al.*, 1983; Montagna, 1984; Rudnick *et al.*, 1985). The trophic net of the fauna is rather important since the main food consists of bacterial epiphytes and detrital organic particles. Soluble organic materials are made available via attached bacteria from water percolating through the beach sand and also micro-organic particles formed by the polymerization of surface-active molecules. In this case, the foam that is formed on the surf beaten beach must be a regular source of food derived from the surface layer of the seawater.

The biology and general ecology of the interstitial animals are controlled by the physico-chemical characteristics of the interstitial water, which is the main source of their life supporting activities. Of the several factors of the medium that influence the occurrence and distribution of interstitial fauna, salinity is by far the most important. The salinity of the interstitial waters of a beach is dependant on the amount of fresh water flowing from the land, changes in the salinity of the adjoining seawater, tidal exposure, evaporation, grade of sand and local conditions of contour and drainage of the beach. It has been shown that rain and flow of fresh water during a receding tide reduce the salinity while evaporation of the capillary water has the opposite effect (Swedmark, 1964). Since the physical parameters to which a species is exposed have significant impact in its physiology, one may expect significant variations in the population density of particular species during monsoon and pre-monsoon, due to significant differences in salinity and other ambient parameters in the Indian beaches. Lowered water salinity influences both species composition and density of nematodes in biotopes such as estuary, coastal lagoons and salty marshes (Gerlach, 1953; Bouwman, 1983).

Temperature has a direct influence on the meiofaunal abundance in that most taxa are seasonal and increase in numbers in summer. According to Pennak (1951), temperature is a limiting factor in the interstitial habitats only on cold shores. Cloudiness influence the temperature and in turn in the evaporation from the sand surface. The ability of the fauna to withstand drastic temperature fluctuations must be a major controlling factor influencing distribution.

Measurement of hydrogen ion concentration (pH) is of relevance mainly in fresh water environments and especially polluted or dystrophic waters, where pH can become limiting for many organisms. In the well-buffered marine habitats (pH around 8), only extreme conditions will exert a demonstrable influence on the marine benthos.

The presence of oxygen in the interstitial water is indispensable to the respiration of the organisms (Renaud-Debyser, 1963). Beaches with a greater slope and consequently better drainage, contain more oxygen (Jansson, 1966b). A high content of particulate organic matter reduces the oxygen concentration. The interstitial oxygen concentration decreases steadily from the surface downwards in areas not agitated by waves (Jansson, 1967). Many workers have established the significance of wave action in determining the concentration and distribution of oxygen. The sea has always been pointed out as the most important source of oxygen in the beach. Jansson (1966a) has shown that each wave abruptly increases oxygen availability at points touched by the seawater. The interstitial water is not stagnant and is renewed at each high tide by the seawater of the zone of wave formation (Renaud-Debyser, 1963).

The study of marine invertebrate fauna inhabiting interstitial spaces in sandy beaches the world over, have made innumerable contributions to systematic zoology in the twentieth century. The works carried out on the taxonomy and distribution of various interstitial groups of animals have shown that the biodiversity of these groups can vary, depending on the physical characteristics of the beach, geographical location of the sampling sites and above all, the tidal amplitude of the stations.

The interstitial environment is very well suited to ecological studies. Extensive studies on taxonomy and ecology of interstitial fauna have been carried out in Europe during the last century. However, information about this interesting habitat from the tropics, especially from the Indian coast is scanty. The available literature of the Indian coast include the works of Aiyar and Alikunhi (1944), Gnanamuthu (1954), Rao and Ganapati (1967; 1968), Rao (1969; 1970; 1980; 1981), Rao and Clausen (1970), Westheide and Rao (1977) and Jouin and Rao (1987) which brought to light the mysterious fauna of the east coast of India. Studies by Ganapati and Raman (1973), Ganapati and Sharma (1973), Parulekar *et al.* (1976), Parulekar (1981), Varsheny *et al.* (1984), Ansari *et al.* (1990), Sunitha Rao and Rama Sharma (1990) and Ingole and Parulekar (1998) are mainly quantitative confined to the east coast of Indian peninsula. The studies of sandy beaches on the western coast of India are rather scanty. No account has hitherto been published on the taxonomy, biology and ecology of the interstitial beach fauna of the west coast of India, except for the meritorious work by Govindankutty and Nair (1966; 1967), Govindankutty (1967) and Rajan (1972). The present research work is an attempt to study the interstitial beach fauna of southwest coast of Kerala, envisaging that it might unravel new facets of interstitial ecology brought about by the anthropogenic activities over the years.

1.2 Miniaturisation of interstitial fauna – a perspective

The expression "macrofaunal taxa of predominantly meiofaunal size" was used by Hessler (1974) for those species in deep sea, which belong to taxa, normally comprised of representatives retained on a 1mm mesh screen. In the context of interstitial species, a strict size definition has not been applied since interstitial fauna or mesopsammon refers to the organisms living in the interstitial spaces between all types of sediment particles. Apart from the exclusive meiobenthic taxa like the Gastrotricha, Kinorhyncha, Loricifera and Tardigrada, representatives of many other invertebrate taxa from lower grade of organization such as Cnidaria to higher-grade macrofauna like Polychaeta, Mollusca or Echinodermata inhabit this habitat. Miniaturisation of body becomes particularly evident in interstitial animals belonging to mostly macrobenthic groups that prevail in other habitats. Diminution of body parts is believed to have intrinsic lower limits for various animal groups, 0.5 to 1mm in many taxa (Swedmark, 1964). It often entails reduction in cell number, since the average cell size is fairly constant. Dwarfism often leads to a simplification of body organization or loss of organs (number of gonads, loss of eyes). Adaptation to interstitial habitats is often achieved by reduction in width, while the slender body can remain surprisingly long as in the case of several nematodes and polychaetes (*Polygordius* sp.).

Most of the interstitial polychaete species are part of suprageneric taxa with a majority of macrofaunal species. These polychaetes do not represent a single taxonomic group. They evolved in several independent lines from larger species, which may have lived on top of the sediments. Among them are many highly derived, secondarily reduced or distinctly paedomorphic (= progenetic) species. So also are the interstitial forms of gastropods, brachiopods and echinoderms, where the small body size is unusual for these groups. Of general biological interest are the adaptations that these taxa have made to the ecological demands of the environment. They have a reduced or modified anatomy, which may cause problems for the phylogenist and systematist when relationships between these aberrant forms and the more typical members of their taxa are studied.

Despite the heterogeneity of the numerous animal groups represented in the meiobenthos, despite their different organization, complexity in structure, taxonomic rank and probably also phylogenetic age, they all have been subject to integrating adaptations (Remane, 1952) by the constraints and dynamics of the habitat. These adaptations often formed "analogous specializations" with surprisingly uniform convergent traits in groups of different systematic position and habitat. Their presence indicates the ecological links connecting all (mesopsammic) meiofauna.

Discussions on evolutionary links between animal groups often center around the meiobenthos. Phylogenetic considerations mostly refer to morphological features of the small-sized animals often in combination with an unusual, disjunct zoogeographic pattern. As the basic pre-requisite for every phylogenetic argument, the nature of each structure considered has to be carefully examined, whether based on true homology or on a deceptive convergence, whether plesiomorphic or apomorphic (secondarily derived) and simplified (Giere, 1993). The interstitial fauna offers good examples for the complex structural mosaic of features differing in their evolutionary significance, in cases where the whole taxon is restricted to the interstitial of sediments and has entirely evolved in this ecological refuge (plesiotope). The situation is different in those cases where a few specialized members are reduced in size and live interstitially while their "normal" relatives are of macrofaunal size and belong to large and diverse animal groups. Combined with their minute size and often reduced vagility, some trends are evolved which results in a simplified "primitive" body organization. These represent cases of an apomorphic and phylogenetically rather recent development, *Halammohydra* among cnidarians, *Monobryozoan* among bryozoans, *Microhedyle* among molluscs.

For consideration of phylogenetic relationships within meiobenthic groups, the role of larval structures is very important. Persistent retention of larval structures (progenesis) is a characteristic phenomenon of considerable relevance for the phylogeny of meiobenthic taxa. According to Westheide (1987), loss of planktonic stages and adaptation to a permanent settlement in the voids of the sediment has led to the evolution of interstitial meiobenthos.

Whether of primary origin or secondarily acquired, restriction to a sedimentary life put interstitial fauna in the focus of evolutionary considerations. One has to consider the scenario, which probably led to colonization of subsurface habitats. It is widely accepted that the epibenthal represent one of the earliest and preferred habitats for animal life due to its rich food supply. On the other hand, the rigid condition typical for this zone forced the fauna to continuously adapt and respond to the biotopical stress with evolutionary versatility. Those species not able to cope with the demands of this competitive and radiative center became displaced. Many forms of less radiative and adaptive capacity are thought to have evaded vertically away from the surface into the endobenthal and, if small enough into the interstitial habitat with its lower number of competitors and more balanced physiography. In these refuge areas of enhanced stability, many meiobenthic forms could maintain their features and ecology. In subsurface horizons, the protective habitat character not only enabled survival of old forms, but also allowed for reduced reproductive rates, limited distributional means via propagative stages, highly specialized adaptations and escaped predation.

Miniaturization of body size, in turn, favours geographical isolation because of a reduced potential of dispersal and speciation. These characteristics are often linked to a set of features frequently occurring in meiobenthos of extreme habitats:

- low food consumption.
- simplification of organs.
- conservation of energy by developing highly efficient reproductive structures.
- abbreviated generation and life time often combined with neotenic trends.

1.3 Significance of the present study

With recent concern about enhanced rate of species extinction caused by human activity, the need for a reliable estimate on the global number of species has become urgent. Compared to the macrobenthic fauna, little is known about the diversity of the meiofauna in marine sediments (Higgins and Thiel, 1988; Giere, 1993). According to Snelgrove *et al.* (1997), the meiofauna of the marine sedimentary habitats comprise about 7000 species, while the projected number of species is estimated to be 10^8. Although, the number of known macrofaunal species is much higher (87000) than that of meiofauna, the projected number is 1 order of magnitude lower (loc. cit.). In order to make a sound estimate of marine benthic diversity and to provide an unbiased comparison with terrestrial diversity, we need to improve our knowledge on the meio and micro fauna of marine sediments (Armonies and Reise, 2000). Only the future will tell how many species there are and which environments are more diverse.

Meiofauna plays a key role in the food web and productivity of benthos (Hulings, 1971; Hulings and Gray, 1971; McIntyre, 1971). They constitute a substantial component of marine heterotrophic assemblages (Giere, 1993), influencing the transfer of material and energy through the ecosystem (Li *et al.*, 1997). Interstitial organisms are important consumers of microphytobenthos (Blanchard, 1991; Montagna, 1995; Pace and Carman, 1996; Moens *et al.*, 2002; Pinckney *et al.*, 2003) and serve as a food source for other members of the meiobenthos (Elmgren, 1976), benthic macrofauna (Ronn *et al.*, 1988; Walters *et al.*, 1996; Gregg and Fleeger, 1998; Tita *et al.*, 2000) as well as juvenile fish species (Marinelli and Couil, 1987; Giere, 1993; Mc Call and Fleeger, 1995). Sikora *et al.* (1977) has emphasized that energetically it is more economical to ingest one meiofaunal organism than numerous dispersed microorganisms of the same energetic value. It is possible that the interstitial fauna compete with the macrofauna nutritionally since it is assumed that the food resources are limited. However, the knowledge on the variations on the food availability of tropical interstitial system is poor. In mud, the meiobenthos are richer and more concentrated in the superficial layers (epibenthic life style) resulting in high exposure to predation. On the contrary, meiofauna is often considered to represent a dead end in the food web in sandy sediments since the endobenthic life style considerably reduce predation pressure from macrobenthos. Trophically, the psammon constitutes an almost closed ecological system assuming that the consumption of psammophilic fauna by macrobenthos is rather insignificant. The nutritional ethology of the fauna according to Swedmark (1964) includes predation, epigrowth feeding, detritus feeding and suspension feeding. However, the vital role played by meiofauna in mineralisation and nutrient regeneration cannot be overlooked.

Meiofauna are known to be sensitive indicators of environmental disturbances and have great potential as pollution indicators. It was suggested independently by Wieser *et al.* (1974), and Hummon, (1975) that motile meiofauna may be treated as 'finely tuned' integrated sensors of the environment and that their distribution and interactions can tell us about properties of the environment that cannot be measured as readily in any other way. Due to the small size, meiofauna quickly responds to changes in biotic and abiotic environmental factors and its distribution may significantly affect food web structure and survival strategy of higher trophic levels. Among meiofaunal taxa, the nematodes in particular represent the most ubiquitous and abundant taxon (Nicholas, 2001) recently employed as ecological indicators of the benthic environments (Platt and Warwick, 1980; Heip *et al.*, 1985; Schratzberger *et al.*, 2000; Gheskiere, 2005). Polychaetes are also considered as an important tool to evaluate environmental impacts, since they can be potential bioindicators (Somerfield *et al.*, 1995). The high population density of meiobenthic animals enables one to receive statistically significant information. The great taxonomic diversity helps to arrive at conclusions about the variations of its componential structure in ecosystems exposed to pollution (Gal'stova, 2004).

Heip *et al.* (1988) presented some of the potential advantages of meiofauna over macrofauna in pollution monitoring. The shorter generation time of meiofauna result in a faster potential response to pollution incidents. Changes in the community structure of interstitial fauna take place over a time span of months rather than years. Meiofauna is abundant and diverse in habitats which are subjected to considerable natural and chemical stress and where only a handful of macrofaunal species remain. They have no planktonic larval stage and for generations, they are consistently exposed to the effects of local pollutants accumulated in sediments. Meiofaunal response to heavy metal pollution and radioactive contamination is much faster than macrofauna. They are less sensitive to mechanical disturbances and destabilisation of the ground (Gal'stova, 2004). Interstitial organisms being motile, actively seek out food particles, thus maintaining diversity by narrowly specialized feeding behaviour and partitioning of food resources (Warwick, 1989; Giere, 1993).

The coastline of Kerala that extent up to 690 km is intercepted by fishing harbours, ports, tourist resorts, bridges, mangrove beds, river mouths, boat yards, sandy beaches etc. Coastal zones are vulnerable to pollution due to enhanced anthropogenic activities like fishing, recreation, transport and aquaculture. Beaches have turned out to be dumping sites of domestic wastes, industrial effluents, hydrocarbons and solid waste materials (Kaladharan *et al.*, 2004). The present research work is an attempt to study and compare the interstitial faunal composition of selected sandy beaches of Kerala coast and the subsequent changes brought about in the community structure and morphology of organisms.

Boucher and Lambshead (1995) gave paramount significance to the issue of taxonomic consistency in the comparison of biological diversity. Similarly, Lambshead *et al.* (2002) stressed on the need for the generation of base line data within the context of marine habitat and opined that the taxonomy of meiobenthic studies needed standardization. The present study is significant from the taxonomic point of view as well.

Meiofaunal assemblages are ideal for experiments, wherein environmental conditions and experimental variables could be controlled optimally (Warwick, 1993) and have been widely used to determine the effects of perturbations in aquatic ecosystems (Coull and Chandler, 1992). Their short life cycle and maintainability in relatively small volumes of sediment make them apt organisms to study changes in community structure in short term experiments.

1.4 Objectives of the present study

The present work involves an enquiry into the taxonomy of aberrant groups of interstitial organisms of selected beaches of Kerala and their related ecology. The main objectives of the present study are:

a. To understand the predominant interstitial taxa on the coast of Kerala.

b. Analyse whether variations exist in the faunal composition in different beaches.

c. Study the systematics of various taxa.

d. Identify species new to science.

e. Study the community structure of nematodes in general.

f. To study the species diversity of the interstitial fauna and within selected groups.

* * *

Chapter - 2

Review of Literature

2.1 General review of interstitial faunal studies

The study of meiofauna is a late component of benthic research, despite the fact that meiobenthic animals have been known since the early days of microscopy. The marine meiobenthos represent a separate, biologically and ecologically defined group of animals, a concept long accepted in the case of interstitial fauna of coarse sands. Elements of the marine and fresh water benthos, which we now call meiofauna have been known and studied since the 18th century, but only in the twentieth century, have we looked carefully at the myriad of the component taxa more analytically and responded with a series of investigations into the nature of this assemblage of microscopic invertebrates. One of the first of this was the discovery of 'Kinorhyncha' by Dujardin in 1851. The earliest meiofaunal studies focused on the discovery and description of new forms.

Research on organisms of meiofaunal size has been conducted in a vast array of habitats and for a large number of taxa. Much progress in research on the biology of meiofauna has been attributed to the development of suitable sampling devices, increased systematic sophistication and a substantial rise in research efforts. Meiofauna research has thus seen a progression from basic taxonomy and descriptive ecology to process oriented experimental ecology and phylogenetics. The background descriptive phase was, of course, necessary and led to the performance of experimental studies. Descriptive studies are often requisite to generate data that encourage experimental hypothesis testing. As technology continues to advance, the goal of meiofaunal research should be to explain the functional components of the biology of meiofauna.

The period between the two world wars saw much research interest in shore ecology. There was also considerable debate about the use of shore communities for monitoring pollution in coastal waters and measuring human impacts on shores. The use of shores for developing and testing ecological theory has proceeded apace during the last quarter of the twentieth century (Reise, 1985). Their potential as an ecological laboratory seems limitless. Since the present research work is an attempt to study the bio-diversity of beach meiofauna including the systematics of aberrant groups of interstitial organisms, a comprehensive review of meiofaunal studies in general is given here rather than reviewing the studies of individual meiofaunal groups.

The study of microfauna inhabiting the interstitial biotope dates back to 1901, when Kowalevsky (1901a) studied a number of interstitial opisthobranchs in the Eastern Mediterranean. Kowalevsky (loc.cit.) has also published a valuable study on the opisthobranch, *Pseudovermis* and was probably the first biologist to describe a method for extracting microfauna from sand. Giard (1904) studied microfauna, principally the gastrotrichs and the archiannelids of a sandy beach at Ambleteuse in Normandy. Later, Cobb (1917) called attention to the high densities of free-living nematodes. The marine interstitial fauna has been extensively studied under the leadership of Remane since 1924. Remane stressed an essentially new notion that "these biocoenoses differ not only by species abundance and composition but also in morphological and functional features". Remane wrote extensively on the distribution of Gastrotricha (1927b), the Rotifera (1929), the Archiannelida (1932), the Kinorhyncha (1936) and other taxa from various shorelines in Northern Germany and the island of Helgoland. The first systematic work on the psammolittoral was in 1927, when

Sassuchin and colleagues published a paper on psammon. Bruce (1928a, 1928b) working at Plymouth stressed the importance of physical and chemical factors of the microenvironment in marine beaches.

During 1930s – 1950s the Swedish Marine biologist Swedmark began studies on the systematics and ecology of the marine interstitial fauna, particularly Gastrotricha. Moore (1931), Nicholls (1935) and Mare (1942) could be considered as pioneers in benthic studies in Britain. Pennak gave the first descriptive account of the ecology of freshwater meiobenthos (1939) and in 1940 published a comprehensive monograph, "Ecology of the Microscopic Metazoa inhabiting the sandy beaches of some Wisconsin lakes". While working on the meiofauna of Massachusetts's marine sandy beaches, Pennak and Zinn (1943) discovered and described a unique subclass of Crustacea, the Mystacocarida. After World War II, the experimental approach gathered momentum, but did not attract much attention.

There was an accelerated interest in Meiofaunal Systematics and Descriptive Ecology during 1950s through the 1960s. During this early part of mid twentieth century, quantitative information on the growth rates, fecundity, nutrition, physiological ecology and energetics of several meiofaunal species added significantly to the understanding of the functional role of meiobenthos in aquatic ecosystems. In the field of taxonomy, emphasis on finding, identifying and classifying new taxa was prevalent during this period. Various investigators all over the world described many new taxa, but, more importantly, they began to consider the role of various meiofaunal organisms. In this context, the meiofaunal research done by Delamare Deboutteville (1960) along the African shores and Renaud-Debyser and Salvat (1963) along the French Atlantic coast is worth mentioning. A review on the interstitial fauna of marine sand by Swedmark (1964) is considered a classic work among the meiofaunal literature even today. It was during this period that attempts were made to ascertain the factors controlling meiofaunal distribution and abundance.

The 1960s saw renewed interest in ecology sparked by the work of Connell (1961). They are essentially ecologists who used the shore to experimentally test ecological ideas and theories. This interest was because shores are amenable to studies of energetics, eco-physiology, animal behaviour and behavioural ecology. Late 1960s into the 1970s was an era during which occurred a surge of ecological interest in the meiofauna.

Despite the increasing interest in the ecology of interstitial meiofauna (Renaud-Debyser, 1963; Renaud-Debyser and Salvat, 1963; Jansson, 1968; Schmidt, 1968, 1969; Gray and Reiger, 1971) nothing was known about the seasonal changes that occur in interstitial populations. Schmidt (*loc.cit.*) provided the only information for a total meiofauna population based on regular sampling over a year's cycle. In 1969, McIntyre published the first overall review of meiofaunal ecology. His data suggest a decrease in meiofaunal abundance from coarse intertidal sediments, where diversity of taxa is maximal, toward finer sand sediments. Nevertheless, maximal meiofaunal density is reached in very fine sediments although diversity of taxonomic groups is probably the lowest. The general distribution of the fauna and physical environment of the beach was described by Harris (1972), which contained a detailed account of the study area and the sampling methods. Following these, seasonal changes in population density and vertical distribution of meiofauna of an intertidal sand beach at Whitsand Bay, Cornwall, were described. The meiobenthic field experimentation works of Coull, on soft bottom meiofauna drew attention of marine benthologists to meiofauna. A classic work worth mentioning is one done by Gerlach and Riemann (1973/74) which is a comprehensive one that gives references to almost all original and subsequent descriptions of aquatic adenophorean nematodes. Significant studies of this period include the importance of meiofauna and its dispersal (Gerlach, 1971; 1977), a brief review of sampling methods (Wells, 1971; Uhlig *et al.*, 1973), factors controlling distribution and migration of meiofaunal community (Boaden and Platt, 1971; Hulings and Gray, 1976); studies in the shallow water meiobenthos (Coull, 1975) and deep sea (Coull *et al.*, 1977), on the ecology of micro (Fenchel, 1978) and meiobenthos (Gray, 1978; Elmgren, 1978). In this decade, primary emphasis was given to ecophysiology and behaviour of meiofauna. Attempts to ascertain the functional and life history parameters of meiofauna were conducted primarily in the laboratory. From this physiological approach, there developed a great interest in the energetic role of meiofauna in the benthic systems. Gerlach (1971) suggested that for an equivalent biomass, the meiofauna are responsible for about 5 times the total benthic metabolism of the macrofauna. The prerequisite according to Gerlach (loc.cit.), for understanding the production of meiofauna are estimates of life history parameters like reproductive potential, fecundity, and number of broods, longevity and rate of development. Extrinsic factors such as temperature, salinity and nutrition are also known to affect life history parameters. Most of our knowledge related to reproductive capabilities of meiofauna, comes primarily from species cultured in the laboratory (Tietjen and Lee, 1972, 1977b; Fenchel, 1974; Hicks and Coull, 1983). Many studies were conducted during this decade to understand the role of meiofauna as food for higher trophic levels McIntyre and Murison (1973) and Heip and Smol (1975) suggested that meiobenthic prey species were consumed primarily by meiobenthic predators and thus were not available to higher tropic levels. McIntyre (1964) and Marshall (1970) were of the opinion that there was competition for food between macrofauna and meiofauna and that the meiofauna served primarily as rapid metazoan nutrient regenerators. However, many papers have been published since the early 1970 documenting the presence of meiofaunal prey in the stomach contents of marine fish and invertebrate predators and thus established the significance of meiofauna as food for higher trophic level.

1970s into the 1980s, the focus was on population dynamics. Comprehensive studies have been conducted on the interstitial zonation, vertical stratification, population dynamics and ecology of intertidal communities on beaches in the eastern Cape, South Africa (McLachlan, 1977, 1980; McLachlan *et al.*, 1977, McLachlan *et al.*, 1981). A number of investigations were devoted to studying macrofaunal-meiofaunal interactions including predator - prey interactions, the role of meiofauna as food for higher trophic levels, the effect of macrobiotic structure on meiofaunal distribution and the recolonisation of meiofauna into disturbed areas. Where both habitat and gut content abundance values are available for prey (Bodiou and Villiers, 1979; Sibert, 1979; Schmidt-Moser and Westphal, 1981; Alheit and Scheibel, 1982; Coull and Wells, 1983; de Morais and Bodiou, 1984; Hicks, 1984; Sogard, 1984), benthic copepods were reported to be overwhelmingly selected over other available prey even though, copepods are rarely the most abundant taxon in the habitat (Coull and Wells, 1983; Gee, 1989; Coull, 1990).

Both the meiofauna and macrofauna are ecologically distinct components of zoobenthos (Warwick, 1984), which has been identified as a suitable ecological group for monitoring the effect of environmental disturbance (Heip *et al.*, 1988). Meiofauna in general, reacts more promptly and drastically to pollution than macrofauna (McIntyre, 1977; Van Damme *et al.*, 1984). Tietjen (1977) suggested that meiofauna might respond faster to environmental perturbations than macrofauna due to their relatively fast generation times, general absence of pelagic larva, potential competitive advantage over macrofauna and other considerations. Heip *et al.* (loc. cit.) presented some of the potential advantages of meiofauna over macrofauna in pollution monitoring. Meiofauna can be less sensitive than macrofauna, to sediment disturbance (Austen *et al.*, 1989), increased sediment re-suspension and physical damage to external structures. Many investigations on pollution effects on meiofauna were based on a divergent reaction of the main taxa, the nematodes and the harpacticoids.

Raffaelli and Mason (1981) first proposed the use of nematode to copepod ratio as a tool for biomonitoring. The validity of this technique subsequently became the subject of discussion among meiobenthologists, with some (Coull *et al.*, 1981) arguing that it was an over generalization and others (Warwick, 1981) suggesting modifications to improve its utility. Lambshead (1984) cast doubt on the usefulness of the ratio by pointing out the difficulties in separating the effects of pollution on the ratio from the effects of other environmental variables. Mc Gwynne *et al.* (1988) in their studies on the impact of'sandy beaches wrack breakdown on interstitial meiofauna, found that modified nematode/copepod ratios do not reflect any disturbance in the relationship between the two communities. They concluded that differential responses within communities of nematodes and copepods, showing adaptations by individual groups, are probably better indicators of stress at the community level than the simple ratio between their abundances. In an interesting approach using the rationale and methods of cladistic systematics and applying them for the ecological analysis, Lambshead and Paterson (1986) compared sample stations for their pollution stress. Other authentic works of this decade include dispersal and distribution of benthic meiofauna (Hagermann and Reiger, 1981; Arlt *et al.*, 1982; Alongi, 1985; Palmer, 1988; Murrel and Fleeger, 1989), compendium of meiofauna study (Higgins and Thiel, 1988), role of meiofauna in the marine ecosystem evolutionary considerations (Warwick, 1989; Gee, 1989). The last decade of the twentieth century witnessed a series of investigations on the role of meiofauna as a potent pollution indicator, perturbation effects on meiofaunal communities etc. Sandulli *et al.* (1990), after their studies on the effect of pollution on the meiofaunal community structure in Naples Bay concluded that the harpacticoid copepod assemblage might be considered as a very sensitive and useful tool in pollution monitoring.

Discovery of new meiofaunal taxa continued its momentum, disclosing the vast array of species that remain unexplored. A range of publications assessing the effects of chemical disturbance by different kinds of pollutants on meiofauna include review of Coull and Chandler (1992), and Austen *et al.* (1994), using a variety of approaches in the field, laboratory and meso- and microcosms. Clarke and Warwick (1998) stressed the advantage of taxonomic distinctness index over traditional species richness indices as a measure of biodiversity, through its lack of dependence on sampling effort. Other relevant studies in 90s include distribution and meiobenthic community structure in relation to pollution (Austen and Wibdom, 1991; Warwick and Clarke, 1991); meiobenthos in deep sea and other biotopes (Tietjen, 1992; Huys, *et al.*, 1992; Aller and Aller, 1992; Vanreusel *et al.*, 1995; Li *et al.*, 1997; Colangelo *et al.*, 1998); use of modern techniques in meiofaunal studies for the estimation of biomass (Thomsen, 1991); predation effect on macrobenthos and meiobenthos in microcosms (Service *et al.*, 1992); detritus-bacteria-meiofauna interaction (Danovaro, 1996; Buffan-Duban and Carman, 2001 and Shimanaga *et al.*, 2000) and effect of physical disturbance on nematode communities in sand and mud (Schratzberger and Warwick, 1998). Several experimental studies were conducted on nematodes due to the fact that nematodes generally constitute the maximum number in any meiofaunal assemblage and are more resilient to physical disturbance.

The new millennium witness more and more studies on the exploration and systematics of meiofaunal taxa from different geographical areas on one side and studies on the meiofaunal community structure, impact of pollution on them, further studies on the potential usage of meiofauna as pollution indicators and phylogenetics on the other side.

A major switch over seen in particular, is the varied manipulation of the meiofaunal data using different statistical approaches. Certain studies include the relationship between meiofaunal distributions and oxygen / organic matter availability (Neira *et al.*, 2001); potential use of nematode-copepod ratio in metal pollution monitoring (Lee *et al.*, 2001); influence of artificial reefs on the surrounding infauna (Danovaro *et al.*, 2002); differential dispersal rates in an intertidal meiofauna assemblage (Commito and Tita, 2002); Attempts to acquire the base line data on meiobenthos is also on the surge (Zhang *et al.*, 2001; McArthur *et al.*, 2001; De Troch *et al.*, 2001). Meiofauna is thought to respond rapidly to environmental changes such as grain size, redox potential and food availability (Danovaro, 1996). The results of the study by Danovaro *et al.* (loc.cit.) on the influence of artificial reefs on the surrounding infauna indicate clear influences of reefs on the adjacent sediments. The necessity for including the role of dispersal of meiofaunal taxa in any consideration of the ecology of soft bottom systems at local and regional spatial scales was stressed by Commito and Tita (2002) in their studies. The studies on the role of seamounts in the dispersal of interstitial fauna were conducted by Gad and Schminke (2004). Currently, extensive studies are being done to understand the influence of anthropogenic activities, the impact of geomorphological changes in meiofaunal populations and how they reflect the extent of pollution in any area. Studies by Suderman and Thistle (2003) indicated that a spill of orimulsion would have approximately the same impact as a spill of fuel oil on the meiofauna.

Modern statistical approaches may be considered as the limelight of this decade. Traditional diversity indices such as Shannon entrophy or the Simpson index summarize the information about the relative abundance of species within a community or sample without regard to differences between species. The need to quantify the taxonomic values for conservation purposes was suggested for the first time by Vane-Wright et *al.* (1991) and proposed a measure of taxonomic distinctiveness of individual species based on phylogenetic relationships among species. Vane-Wright *et al.* (loc. cit.) further developed an index of community taxonomic distinctiveness of the species in a sample. Clarke and Warwick (2001) take "taxonomic distinctiveness" to refer to the distinctiveness of a particular species in relation to the rest of the community. Warwick and Clarke (1995) introduced the concept of taxonomic distinctness, as a measure of the average degree to which individuals in an assemblage are related to each other. Clarke and Warwick (1998, 2001) have shown that taxonomic distinctness measures overcome most of the problems of traditional measures of diversity. The usefulness of taxonomic distinctness for marine biodiversity assessment has been reported in several studies in the recent years (Piepenburg *et al.*, 1997; Warwick and Light, 2002) suggesting that taxonomic distinctness of degraded locations is significantly reduced when compared with those of relatively pristine locations for different groups of organisms like the benthic nematodes. Bridging the gap between traditional biodiversity measures and taxonomic diversity measures, Carlo Ricotta (2004) introduced a parametric diversity index that combines species relative abundances with their taxonomic distinctiveness. However, studies on a Mediterranean river basin by Abellan *et al.* (2006) indicate that taxonomic distinctness indices may not always perform as well as other matrix in the assessment of environmental quality. Moreover, taxonomic distinctness measure should be interpreted with caution, as their performance and ability to detect anthropogenic disturbance may depend on the phylogenetic structure of sampled taxa within a region and their evolutionary and ecological history.

Jorgensen (1992) suggested that a holistic or a whole system approach is required to draw conclusions on ecosystem properties. With regard to coastal marine ecosystems, Fabiano *et al.* (2004) proposed applying exergy, specific exergy (thermodynamic oriented indicators) and ascendancy (network oriented indicator) to assess ecosystem health based on sediment microbenthic measures. A holistic approach based on sediment micro and meiobenthic measures was taken to assess the health of coastal marine ecosystems (Vassallo *et al.*, 2006) by applying a thermodynamic and network analysis and concluded that a combination of these indicators may provide a powerful tool for the health assessment of coastal marine ecosystems.

Tourism has long been considered a 'clean industry' with almost nil negative effects on the environment. On the contrary, studies conducted by Gheskiere *et al.* (2005) in two different coastal systems demonstrated that tourism related activities affect the sandy beach meio-nematofauna in particular, especially in the upper sandy beach zone and contribute to higher community stress, lower taxonomic range and species diversity of the nematode assemblages. The increasing usage of sandy beaches as recreational resources has forced the regional authorities of many tourist countries to remove all litter of fabricated origin and natural wrack from the beach for which, a variety of heavy equipments have been developed and is being used. Gheskiere *et al.* (2006) in their studies, focusing mainly on free living nematodes demonstrated that density, species-specific densities and assemblage structure are significantly influenced by mechanical beach cleaning, while number of species and taxonomic richness suffer no direct impacts after one cleaning.

The importance of molecular studies for the phylogenetic placement of interstitial organisms is evidenced by the phylogenetic placement of *Pisione remota* using the molecular evidence (Struck *et al.*, 2005). Other studies conducted recently include geographical diversity studies (Gobin and Warwick, 2006) across shore variability and trophodynamic features of meiofauna (Moreno *et al.*, 2006); The role of food supply in influencing the benthic community structure of a beach (Anabella Covazzi *et al.*, 2006);

Communities of Hydrobionts Developing at the Water-Rock Interface in Lake Baikal (Parfenova *et al.*, 2008); Meiofauna sediment relations in leeward slope turf algae of Heron Island reef (David Logan *et al.*, 2008); Benthic meiofauna assemblage structure of headwater streams: density and distribution of taxa relative to substrate size (Andrea *et al.*,2008) and species composition and distribution of various meiofaunal assemblages in different geographical locations.

Even as the research works advanced at the molecular level, the importance of the studies on the taxonomy and systematics of benthic communities in different geographical habitats maintained its pace and several works on this line continued to be carried out (Perez *et al.*, 2006; Schratzberger *et al.*, 2007; Azovsky and Mazei, 2007). Monitoring and assessment tools for the management of the marine ecosystem are generally most effective when they are based on a clear understanding of the mechanisms that lead to the presence or absence of species groups in the environment. Organisms are generally influenced by complex and interacting sets of physical and biological processes, leading to variation in their distribution at different spatial scales.

2.2 Meiofaunal Research in India

The marine interstitial fauna, inhabiting the intertidal zone on Indian coasts, began receiving considerable attention only in the latter half of the twentieth century. No previous attempt was made to study in detail the interstitial fauna as such, in the sandy beaches of Indian coasts. Sandy shores provide an environment of high physical stress to marine fauna, as a result of which relatively few species inhabit this zone. Different authors studying the intertidal macro and meiofauna, have reported impoverished macrofauna but abundant and diverse meiofauna. There are a few reports on isolated groups of sand dwelling microfauna from Madras coast such as archiannelids by Aiyar and Alikunhi (1944), two species of isopods by

Gnanamuthu (1954) and on copepods by Krishnaswamy (1957). A pioneering effort was made by Ganapati and Rao (1962) on the meiofaunal animals that inhabited the interstitial environment and their ecology on the sandy beaches of Waltair coast. Thereafter, works on several aspects of interstitial animals and environment were commenced by several meiobenthologists.

Interstitial faunal studies and their ecology of the south-west coast of India were attempted by Govindankutty and Nair (1966, 1967); Desai and Kutty (1967a, 1967b); Rajan (1972); Damodaran (1973); Parulekar *et al.* (1976); Ansari *et al.* (1980); Azis and Nair, (1983); Reddy and Hariharan (1985, 1986); Harkantra and Parulekar (1989); Ingole *et al.* (1992); Ansari and Parulekar (1993). Several workers (Damodaran, 1973; Ansari, 1978) have studied the vertical distribution of meiofauna in sediments from the shallow waters of Indian coast.

Pollution related meiobenthic works were attempted by Ganapati and Raman (1973); Ganapati and Sarma (1973); Rodrigues *et al.* (1982); Sarma and Ganapati (1975); Alongi *et al.* (1983); Varshney *et al.* (1984); Rao (1987a); Ingole *et al.* (2000); and Ansari *et al.* (2002). Results of a study on the contamination of nine beaches by solid waste materials and tar balls along the Kerala coast reported by Kaladharan *et al.* (2004), indicated a higher contamination rate in urban area due to anthropogenic activities. A study conducted on the distribution of organic carbon on the sediments of Cochin mangroves reported by Sunil Kumar (1996), point to a constant and eternal supply of mangrove detritus, irrespective of seasons, which give substantial flux of organic residues to the sediments by the decomposition process. A study on the vertical distribution and community structure of nematodes on the continental shelf of west coast of India was done by Sajan and Damodaran (2005; 2007). Differential distribution of marine nematodes in areas with different mangrove cover from Cochin, Southwest coast of India has been documented by Chinnadurai and Fernando (2007).

More studies have been conducted on the east coast of India compared to the west coast. A preliminary systematic survey of the interstitial fauna inhabiting the beach sands of Waltair coast was conducted and presented by Rao and Ganapati (1968a). The varying degree of adaptability, which largely determines their preference to colonize and thrive in a particular level of the beach, is exemplified in this study.

Many quantitative and qualitative studies on meiofauna have been conducted along the coastal areas and back waters of the east coast of India (Mc Intyre, 1968; Rao, 1969; Ganapati and Sarma 1973; Sarma and Ganapati, 1975; Ansari and Parulekar 1981; Sarma *et al.*, 1981; Rao and Murthy, 1988; Anita Patnaik and Lakshmana Rao, 1990; Vijayakumar *et al.*, 1991; Chatterjee *et al.*, 1995). A few studies on sub-littoral meiobenthos have also been done on either coasts of India (Ansari *et al.*, 1980; Rodrigues *et al.*, 1982).

Beyond the Indian subcontinent, studies on the interstitial meiofauna of the intertidal and subtidal sediments led to the discovery of more known and unknown species of marine interstitial organisms from Andaman and Nicobar Islands (Rao, 1975; 1980; 1987) and Lakshadweep (Rao, 1983; 1991). From Lakshadweep archipelago, a comparative account of intertidal macro and meiobenthos of six different beaches on quantitative basis have been given (Ansari *et al.*, 1990). The study of the impact of tsunami on the meiofauna of Marina Beach, Chennai, suggest that polycheates and turbellarians can withstand the impact of disturbance better than other groups like nematodes, harpacticoids and oligochaetes (Altaff *et al.*, 2005).

Most of the interstitial studies reach on a consensus that the maximum concentration of the fauna is found near the mid water level in the deeper levels of the medium, where perhaps the community finds the optimum biotic and climatic conditions. Distribution and abundance of meiofaunal population is particle size dependant. Ganapati and Rao (1962), described a relationship between density and size wherein small forms exist in large numbers, but large forms tend to be rare. Remarkable changes in the occurrence and distribution of meiofauna are brought about by marked fluctuations in salinity. Govindankutty and Nair (1966) and Ganapati and Rao (1962), recorded severe reduction in meiofaunal abundance during reduced salinity accompanying monsoon. In addition, meiofauna apparently seek deeper levels in the sediment in the presence of lowered salinity (Govindankutty and Nair, 1966; Jansson, 1968). In intertidal areas of large sediment size, the oxygen content is often low but is seldom zero (Ganapati and Rao, 1962). It could be seen that most of the research work in India during the past twenty years pertain to quantitative and ecological studies and least focus is given on the systematics of various meiofaunal taxa. Intensive survey of unexplored and underexplored areas are likely to reveal the existence of more known and unknown species of different taxa of interstitial animals.

2.3 A brief review on the systematics of some major interstitial taxa encountered in the present study – Indian Scenario

Zoogeographically India belongs to the Oriental realm, but the Ethiopian, Palaearctic species and some belonging to other realms are also found here, partly due to bioinvasion from other areas. The geographical area of India is about 329 million hectares and its coastline stretches to nearly, 7000 km. The richness of animal resources of India is largely due to its geographical position and the fact that it possesses all possible kinds of ecosystems. Unfortunately India is loosing at an alarming rate its vast genetic heritage, the animal wealth of the country, even before these are properly studied and understood. The main brunt of the inevitable expansion, aggression and exploitation by one species, the *Homo sapiens*, is borne by the natural ecosystems and their biota.

The richness of the fauna of the country and the need for their exploration was recognized a long time ago. It has become absolutely essential to obtain information on the identity, distribution, interactions and population levels of animal species so that the future developmental programmes should not be at the cost of our faunal wealth. Major constituents of the marine meiofauna are Nematoda, Gastrotricha, Kinorhyncha, interstitial Polychaeta, Harpacticoida and some other groups such as Isopoda, Halacarida and Cnidaria. The studies so far have shown a high degree of endemicity. The studies on various marine groups have brought out the existence of a very rich biological diversity in Andaman and Nicobar group of islands.

Nematoda

Nematodes are one of the most highly diversified and perhaps the largest group of invertebrates. In terms of number of species, although outnumbered on land by arthropods, in the sea, they are the most diversified metazoan taxa. According to Platt and Warwick (1983), nematodes occur in a wide range of habitats, which is unsurpassed by any other metazoan group. In fact, they occur in every conceivable habitat that can support life, sometimes even in uninhabitable habitats like hot spring, ice, deserts etc. Cobb (1914), a legendry nematologist has stated, "........ if all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable.........we would find its mountains, hills, valleys, rivers, lakes and oceans represented by a film of nematodes."

The nematology in India developed with rapid pace after 1965. The work on plant and soil nematodes in India started rather late, though considerable work has been done on different aspects of animal nematodes. The marine nematodes received little attention in India. Rao and Ganapati (1968) have reported 108 species from Indian coasts, all as new records. Rao (1969) again reported the occurrence of about forty nematodes from the beach sands of Orissa coast. Only very few taxonomic studies have been attempted by meiobenthologists in Kerala, among whom mention could be made of Govindankutty (1967) and Rajan (1972). The influence of physical factors and biological interaction in the sediments on the vertical distribution of marine nematodes from the shelf sediments of west coast of India has been reported by Sajan and Damodaran (2005). Our present knowledge of marine nematodes from India is almost insignificant, though the number of marine nematode species is about 1/5th of the total known nematode fauna of the world. Unfortunately, only about 200 species of marine nematodes are known from India. Studies on nematode morphology, systematics, diversity and ecology have been constrained by one aspect of documentation i.e., the static, slow, inaccessible and subjective method of representing a three dimensional nematode body in the form of line drawings which requires lengthy in print publications (Abebe *et al.*, 2004).

Gastrotricha

Gastrotricha constitutes one of the most interesting and challenging groups of meiobenthic marine invertebrates. Marine gastrotrichs are mostly interstitial animals living in spaces between particles of sandy sediments, their greatest density and diversity being limited to intertidal and subtidal parts of the sea. Most of our basic knowledge and conception of the rich variety of gastrotrichs is due to the pioneering contribution made by Prof. Adolf Remane of the Kiel University from North, Baltic and Mediterranean seas. While studying the sand living copepods on Madras coast, Krishnaswamy (1957), reported for the first time the occurrence of marine gastrotrichs on the Indian coast. Later Ganapati and Rao (1962), in a pioneering effort reported the occurrence of gastrotrichs from the interstitial meiofauna in the intertidal sands of Waltair coast. Detailed investigations of the gastrotrichs from Waltair beach sands resulted in the discovery of 13 known species (Rao and Ganapati, 1968). Subsequent studies of the fauna in this region have resulted in the description of a new species, new genus and new family (Rao and Clausen, 1970). Exploration of the intertidal sediments at several localities in the east coast of India has brought to light more known and unknown species of gastrotrichs (Rao, 1969; 1970; 1980; 1981a). In the southwest coast of India, Govindankutty and Nair (1967) reported the occurrence of seven species from intertidal sands, of which one was described as new to science. Govindankutty and Nair (1972) have also studied the colonizing behaviour of gastrotrichs in different grades of marine beach sands. Beyond the Indian subcontinent, studies on the interstitial fauna of the intertidal and subtidal sediments have led to the discovery of more known and unknown species of marine gastrotrichs from Andaman and Nicobar Islands (Rao, 1975; 1980; 1987; 1993) and Lakshadweep (Rao, 1991). A complete picture of the gastrotrichs recorded from India and the neighbouring islands have been reviewed and illustrated by Naidu and Rao (2004). Intensive survey of unexplored and under explored areas is quite likely to reveal the existence of more known and unknown species of gastrotrichs. Faunistic surveys conducted in several areas on the Indian coasts, during the last quarter of the 20th Century, however indicated a remarkable and progressive decline of this fauna both in their density and diversity largely due to the increasing effects of human activities, resulting in the degradation of natural environment by pollution.

Kinorhyncha

Kinorhyncha forms one of the most interesting groups of marine meiobenthos. They are quite susceptible to ecological stress in the environment due to the effect of organic pollution, which largely affects their population density and diversity. Nothing was known of this group in the Indian fauna until Krishnaswamy (1957) reported their occurrence from Madras coast while studying the sand living harpacticoid copepods. Later, Ganapati and Rao (1962) recorded kinorhynchs from the interstitial fauna of Waltair coast and subsequently reported three species from the area (Ganapati and Rao, 1966; 1968). As part of his studies of the Indian ocean kinorhyncha , Higgins (1968; 1969a; 1969b) described four new species from meiobenthos at different localities in the seas around India. Four more species were subsequently reported from Andaman Islands (Higgins and Rao, 1979) of which, one species was described as new to science. They also recorded the genus *Pycnophyes* for the first time from the Indian Ocean. Occurrence of kinorhynchs from India and the surrounding islands have been reviewed by Rao (1991) in the 'Animal Resources of India' published by the Director, Zoological Survey of India. However, many areas on the Indian coast still remain unexplored for the presence of this group.

Annelida

The phylogeny of Annelida is a matter of great debate and their classification has been re-assessed recently. The name 'Archiannelida' was erected in the last quarter of the 19th century, which comprised a heterogeneous group of small segmented marine worms, usually without parapodia, by which they were readily differentiated from their closest relatives, the polychaetes. The archiannelids were earlier considered as a class of primitive annelids, but according to the recent opinion of some zoologists, they are polychaetes secondarily adapted for interstitial mode of existence by the loss of lateral parapodia and hence to be considered as an order of polychaetes .

Although, some textbook authors obviously do not believe they can do without the term, Westheide (1985) is of the opinion that the category 'Archiannelida' should be eliminated from modern zoological systems and should no longer be used when referring to families such as Polygordidae, Protodrilidae, Protodriloidae, Saccocirridae etc which are well adapted for interstitial life.

Besides forming food for larger animals in the littoral ecosystem, archiannelids proved quite sensitive to ecological stress resulting from organic pollution in the habitat thereby serving as indicators of pollution.

They also form suitable material for experimental studies on ecology. Though the interest in the study of archiannelids inhabiting the intertidal marine sediments and littoral algae dates back to the middle of the 19th Century, nothing was known of this group from Indian coasts until the pioneering contribution on archiannelids was made by Aiyar and Alikunhi (1944) from intertidal sands on the Coromandal coast. These authors described with much anatomical details two species of *Polygordius*, two species of *Protodrilus* and four species of *Saccocirrus* as new to science. Subsequently, while studying the interstitial fauna from the beach sands of Waltair coast, Rao and Ganapati (1968), reported the occurrence of 12 species of archiannelids. A good number of archiannelids were also reported from intertidal sediments on the Orissa coast (Rao, 1969). Outside the Indian mainland several known and unknown species of these worms were commonly reported from the littoral sediments on the coasts of Andaman and Nicobar Islands (Rao, 1975; 1980; 1987) in the Bay of Bengal and Lakshadweep (Rao, 1991) in the Arabian Sea. Jouin and Rao (1987) made detailed morphological investigations employing SEM on archiannelids and resulted in the description of new sub-species of *Polygordius*. The occurrence of different interstitial polychaete families along the Indian coast has been reviewed by Rao (1991). Protodriloidae, the only interstitial polychaete family unknown within Indian region was reported recently by Priyalakshmi and Menon (2007) from the coast of Kerala. All these taxonomic works throw considerable light on the wide geographical distribution of these worms in the seas around India. Yet, many areas of Indian coast, particularly on the west, remain unexplored. Hence, detailed exploration of the littoral habitats is likely to reveal the existence of more species in this region.

Harpacticoida

The copepods form an important constituent of the crustacean fauna. Copepods of the calanoid group have the highest number of species forming an essential part of nourishment for several common food fishes. The harpacticoids are marine interstitial copepods that live near the shores among algae, sand or mud at different depths of the sea. The pioneering work in India on marine interstitial copepoda was that of Krishnaswamy (1951; 1957) who made a systematic study of the group inhabiting the beach sands of Madras coast. Other important taxonomic studies on harpacticoids of Indian coasts as well as Andaman and Nicobar Islands are by Rao and Ganapati (1969) and Rao (1969).

Other Groups

Taxa such as Cnidaria, Isopoda and Halacaroidea, which are represented by only very few species in the present collection are included here. Other taxa like Turbellaria, Oligochaeta etc are not reviewed since their systematics has not been touched upon. Cnidaria constitute an interesting group adapted typically for an interstitial mode of life. Of the four-cnidarian classes, representatives of class hydrozoa have been recorded from India. Though several interstitial species of the solitary hydrozoans were known to inhabit the European coasts, the occurrence of a hydrozoan, *Halammohydra octopodides* in Indian waters was reported for the first time from the Waltair coast by Rao and Ganapati (1966). Thereafter, their presence was reported from other Indian coasts also (Rao and Ganapati, 1968; Rao, 1969). Later on, three new species were described from India, which include *Halammohydra chauhani* (Rao, 1975); *H. andamanensis* (Rao, 1978) and *H. sagarensis* (Rao and Misra, 1980).

Isopods were first recorded from India long back by Gnanamuthu, (1954). Further records on isopods from Indian coasts include the works of Coineau and Rao (1972); Messana *et al.* (1978); Rao and Ganapati (1968); Rao (1969); Sarma and Ganapati (1975). Halacarids are exclusively benthic forms that live in almost all sorts of substrata except for silty and oxygen free sediments. In muddy sands, most halacarids are found in the upper

0-3 cm, whereas in sandy beaches, they penetrate to a depth of 100cm (Bartsch and Schmidt, 1978). Eventhough research on halacarids is active in India, work on interstitial psammophilous forms remain scanty, except for a few reports on the species occurrence from some parts of India.

One might think that the systematics of meiofaunal organisms is completely known by now. However, the task of the meiofaunal systematist remains demanding. As more and more areas are explored, we can be sure that additional descriptions of new families, genera and species will follow. By harnessing advances in electronics and genetics, the latest technique of DNA Barcoding might help people quickly and cheaply recognize the known species and retrieve information about them; speedy discovery of millions of species yet to be named; and provide vital tools for appreciating and managing the Earth's immense and changing diversity.

* * *

Chapter - 3

Material and Methods

3.1 Study Area

Humans have changed coastal processes by various anthropogenic activities. The major pressure on our coast comes from the increasing pace of human activity. Many of the pressures have grown gradually. The effects of these activities can extend well beyond the physical boundaries to affect habitats in adjacent intertidal and sub-tidal areas. The coast protection measures undertaken by the Government by erecting breakwaters, building sea walls, dumping rocks etc can significantly alter water movement along the coasts. Sand mining, beach replenishment and land reclamation occur in many areas along the coast of Kerala. This can alter and destroy habitats, alter seabed levels and substrates and generate large quantities of suspended solids, which would be constantly transported and deposited along the sandy beaches of Kerala.

Taking these aspects into consideration, five sandy beaches along the coast of Kerala were identified by site survey to undertake a study of the psammophilous fauna. The five beaches are Cherai, Fort Kochi, Arthungal, Sakthikulangara and Veli located on the west coast of Kerala. Cherai and Arthungal beaches are relatively unaltered and less disturbed. Fort Kochi and Veli beaches are affected by industrialization and the coast of Sakthikulangara, characterized by natural radioactive pollution of thorium and large quantities of human waste disposal.

Cherai beach (lat.10°09′ N; long.76°02′ E), (Site-1), a 15 km long stretch is considered as the clean golden beach of Kerala and is rightly called "The Princess of the Queen of the Arabian Sea". It is an extensive beach, located 30 km north of Kochi with gentle slope and moderate wave action. The wave energy increases from Cherai southwards with considerably higher wave energy at Thiruvananthapuram. Sampling stations 1 and 2 are located at this site, at a distance of 100 meters apart. Direct observations of the beach characteristics (morphology) at the time of sampling indicate a reduction in beach area at this site due to extensive beach erosion.

Fort Kochi beach (lat.9°18′N; long.76°05′ E), (Site-2), is also an exposed beach, about 0.25 km south of the Cochin bar mouth. The area experiences moderate wave action during the non-monsoon months. The gradually sloping Fort Kochi beach has medium to fine sand and without fresh water influence except during monsoon. Sea wall construction has reduced the expanse of the beach considerably. Stations 3 and 4 are located at Fort Kochi.

Stations 5 and 6 are at Arthungal (lat.9°10′N; long.76°23′E) in Alleppey district (Site-3). It is about 35km further south of Fort Kochi. This beach is characterized by gentle slope and moderate wave action. No damage was reported from this area due to tsunami of 2004.

The beaches follow a cyclic activity in response to the cyclic climatic changes unless they are disturbed by external interferences. Beaches of Kerala are used by more people than any other habitat in the coastal zone of Kerala. Beaches are also the first line of defence against storm and erosion. Beaches are not stable; they are instead dynamic landforms, constantly subject to erosion and accretion. The differences in beach form and position reflect the local balance or imbalance between the deposition and erosion. However, in the coast of Kerala, erosion (natural and human induced) dominates over deposition. The Bar, Foreshore and Backshore are areas which considerably control the morphology and the aesthetics of a sandy beach.

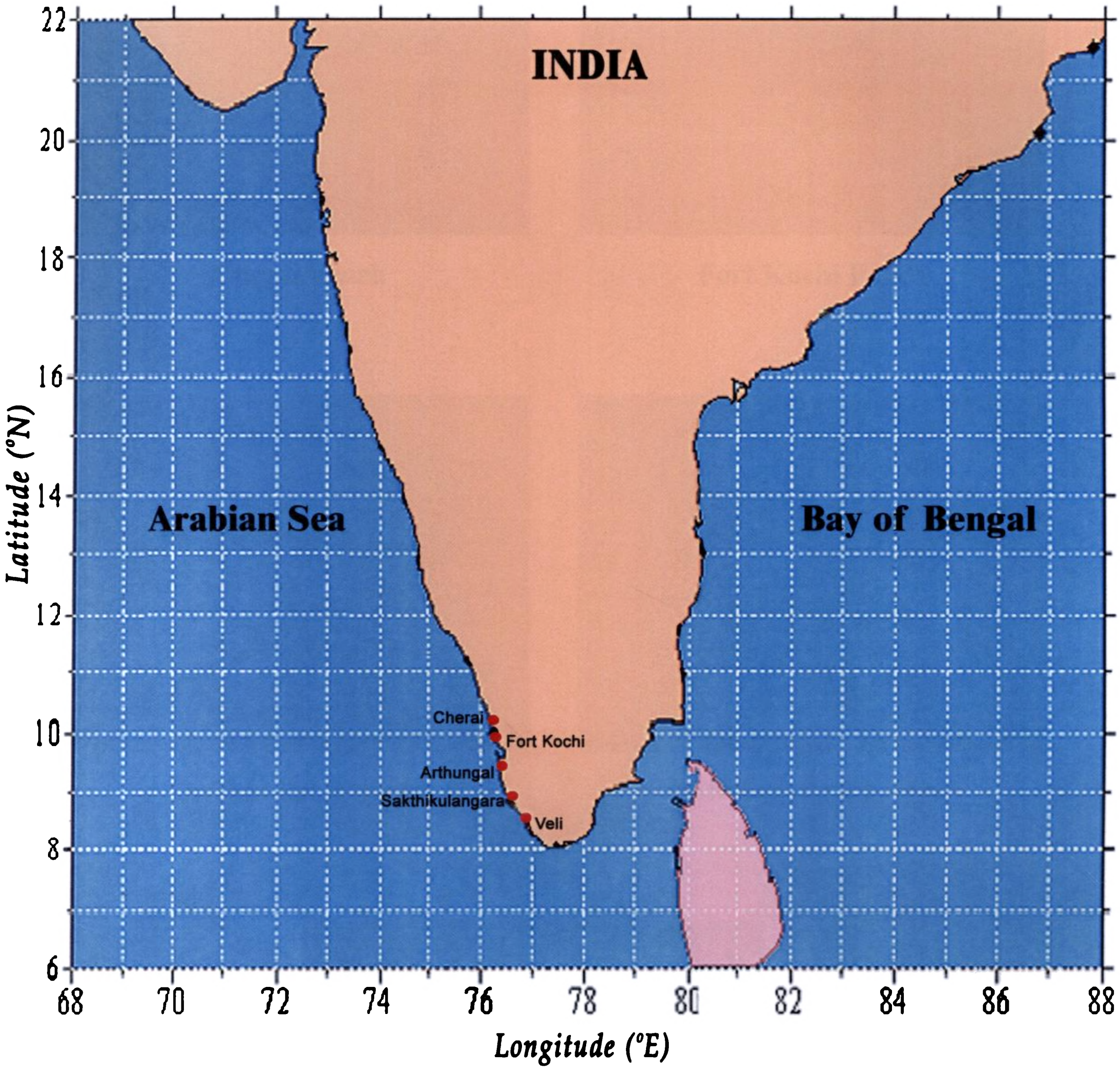
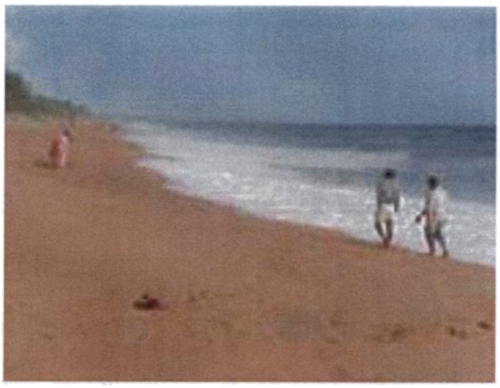


Fig. 3.1. Study area showing the sampling locations

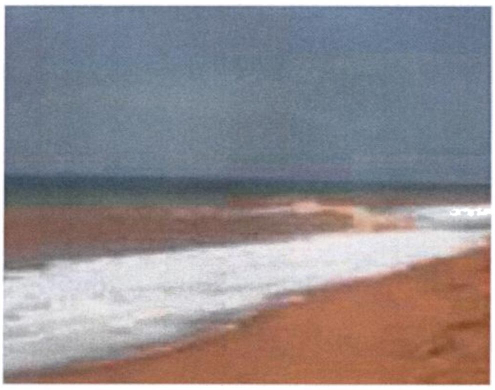
Cherai Beach

Fort Kochi Beach

Arthunkal Breach



Sakthikulangara Beach



Veli Beach

Fig. 3.2. Selected beaches of Kerala

Three types of profiles generally observed at the stations are (a) a narrow beach, steep foreshore characteristic of rough season, during the monsoon; (b) a wide beach, steep foreshore and a well developed berm, characteristic of a fully developed beach during the summer and (c) a gentle sloping beach face and multiple berms, indicative of a developing beach, during the post monsoon. The beaches selected for the present study were found to be in dynamic equilibrium.

The 4th site Sakthikulangara (lat.8°45′N; long.76°38′ E) is about 7 km north of Kollam. Stations 7 and 8 are located on this coast. Stonewalls constructed on a major part of this area was badly hit by the tsunami of 2004 (Kurien *et al.*, 2006). The sampling site was characterized by large gravels and shells mixed with fine black monazite sand. The beach slope is gentle and experiences moderate wave action.

The sampling site at Veli (lat. 8°29′ N; long.76°59′ E), located 5km north of Thiruvananthapuram, has all the typical characteristics of a high-energy beach. The wave intensity - beach configuration - sediment size pictures suggest that this beach has all the ingredients to remain in a stable condition. It has a high wave intensity (6m) during the monsoon months of June/July due to proximity of the coast to the wave generating zones in the Arabian Sea. The water increased only up to the monsoonal berm during the tsunami and no damage was reported. Stations 9 and 10 are located on this coast.

3.2 Sampling Method

Ecologists have recognized topographical heterogeneity as a major factor regulating species distribution and abundance within a community (Raffaelli and Hughes, 1978; Bourget *et al.*, 1994). Community characteristics such as diversity and richness are also modified by topographical heterogeneity (Menge *et al.*, 1985). Three seasons could be recognized in a year based on the influence of southwest monsoon and the associated meteorological conditions.

The pre-monsoon (February-May) a comparatively dry period, the monsoon season (June-September) characterized by heavy rainfall and consequent lowering of salinity and post-monsoon (October-January) showing a gradual increase of salinity and temperature.

Seasonal collections and observations were done during the low tide, when the whole intertidal belt was accessible for sampling. Sampling was done by thrusting a galvanized iron core (8cm inner diameter) into the sand up to the level of interstitial water. The undisturbed sediment sample (in triplicate) was immediately transferred into a bottle and 7% $MgCl_2$ prepared in filtered seawater was added to anaesthetize the interstitial organisms. After 15 minutes, the sample was fixed and preserved in buffered formalin diluted to 4% by filtered seawater. The fixed samples were stained with .1% Rose Bengal (Pfannkuche and Thiel, 1988) for efficient faunal extraction.

3.3 Sedimentology

For C, H, N analysis and textural analysis of sediments, approximately 150 gm of sediment were taken from each station (in triplicate). Desalination of the sediment was carried out by repetitive rinsing and decanting with distilled water prior to drying at 40-50°C. The percentage of organic carbon was estimated with the help of CHN analyzer (Elementar Vario III) and later on organic carbon in mg/gm was converted to organic matter using a conversion factor of 1.724 as described by Wiseman and Bennet (1960). Energy content was obtained from the organic matter using an equivalent of 21.6 Joules/mg dry weight (Barnes, 1959). The analysis of Organic Carbon, Hydrogen and Nitrogen (CHN) present in the sediment was conducted at Sophisticated Instruments and Techniques Cell (STIC), CUSAT.

Grain size composition is influenced by numerous environmental factors like exposure, currents and in turn determines many physiographic parameters closely related to substrate as porosity, permeability, oxygen supply and salinity gradients. Since meiobenthic animals can exploit the environment of sandy substrate, the proportion and distribution of finer sediment particles will influence the degree of accessibility (Giere *et al.*, 1988).

Dry sieving method of Buchanan (1984) was followed for the textural analysis of the sediment sample, since the beach sand contained less than 5% silt-clay fraction. The equipment for the analysis consisted of a stacked set of Wentworth grade sieves with .5 phi (φ) intervals within the range of 62-2000μ. A pre-weighed oven dried sample (80g) of salt free sand was introduced into the 2000μ sieve at the top of the stack and the stack transferred to the mechanical shaker and agitated for 15 minutes. After shaking, the material in each sieve was weighed and noted, together with any material <62μm that had passed into the closing pan at the bottom of the sieve stack. The sediment weight fraction (calculated in percentage of the total sample) was transferred into cumulative frequency series and then plotted as cumulative frequency curve. From the resulting roughly sigmoid curve, the particle diameter, i.e., the φ value corresponding to the 50% point of the cumulative scale was estimated and further interpretations were made.

From the cumulative frequency curve, Graphic Mean, Standard Deviation, Inclusive graphic skewness and Kurtosis were calculated (Folk, 1974).

$$\text{Graphic Mean} = \frac{\varphi 16+\varphi 84+\varphi 50}{3}$$

$$\text{Inclusive Graphic Standard Deviation} = \frac{\varphi 84-\varphi 16}{4}+\frac{\varphi 95-\varphi 5}{6.6}$$

$$\text{Graphic Skewness} = \frac{\varphi 16-\varphi 84-2\varphi 50}{2(\varphi 84-\varphi 16)} \quad \frac{+\varphi 5+\varphi 95-2\varphi 50}{2(\varphi 95-\varphi 5)}$$

$$\text{Graphic Kurtosis} = \frac{\varphi 95+\varphi 5}{2.44(\varphi 75+\varphi 25)}$$

The nature of sediment was identified from the verbal classification measure given by Folk (loc. cit.).

< 0.35	very well sorted
0.35- 0.50	well sorted
0.50- 0.71	moderately well sorted
0.71- 1.0	moderately sorted
1.00- 2.00	poorly sorted
2.00- 4.00	very poorly sorted
> 4.00	extremely poorly sorted.

3.4 Hydrography

Interstitial water samples were collected and analysed for temperature, salinity, pH and dissolved oxygen. **Temperature** was measured with a high precision mercury thermometer; **salinity** was noted immediately after collection using a calibrated Salinometer; **pH** was found with Pocket pH Tester (Eutech), **dissolved oxygen** was analysed by Winkler's method (Strickland and Parsons, 1972).

Winkler's 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 sodium thiosulphate solution, using starch indicator. From the normality, amount of oxygen in the sample was calculated.

Oxygen concentration (mg/l) = $y \times x \times 8 \times (1000/ s \times (b-c)\ b)$

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).

3. 5 Extraction of the interstitial fauna

Meiofauna was separated by suspension- decantation method (Wieser, 1960) with a few modifications (Neira and Rackemann, 1996). The efficiency of decantation method has been documented by Murrel and Fleeger (1989). The sample was transferred into a large conical flask containing filtered seawater. It was stirred well and kept for 5 seconds for the denser sand particles to settle down. The supernatant was then carefully poured into a 62µm bolting silk. This process was repeated 6-8 times for the maximum extraction of the fauna. Aliquot of the sediment in the flask was examined under a stereomicroscope to ensure that no organisms were left behind. The organisms retained in the sieve were transferred to a small petridish containing minimum quantity of filtered seawater. The organisms were sorted and counted group wise into major taxa. Permanent slides of certain selected groups like nematodes, gastrotrichs, polychaetes, kinorhynchs, isopods and cnidarians were made.

3.6 Preparation of microscopic slides

Seinhorst's method (1959) was followed to prepare the permanent mounts of nematodes. The preserved nematode specimens were kept in distilled water for the removal of salts. The nematodes were concentrated in a small volume after 2 hours. Then 6-8 ml of Seinhorst's solution I (20 parts 95% ethanol, 1 part glycerin and 79 parts water) was added to the nematode suspension. The petridish was kept in oven at 35- 40°C for a period of at least 12 hours. This removed most of the water. The excess Seinhorst's solution I was drained off from the dish under a dissection microscope to avoid loss of specimens. Seinhorst's solution II (95 parts 95% ethanol and 5 parts glycerin) was then added and returned to oven and kept at 40°C. Several hours later, the excess solution if present was drawn off and fresh Seinhorst's solution II was added. Then the dishes were put back in the oven. This was repeated several times until all the alcohol evaporated and nematodes were in pure glycerin. The dehydration process was continued for two weeks. A small drop of anhydrous glycerin was put at the center of the cover glass of an aluminium slide. Several nematodes were arranged in the center of the slide. 2mm glass wool was placed at three corners of the glycerin drop. A 22mm cover glass was kept. The edges of the cover glass were sealed with a sealant. After the sealant had dried, a second coat of sealant was applied and allowed to dry. The labelled slides were used for further examination using various types of microscopes.

The organisms belonging to the remaining taxa were processed through a series of different grades of ethyl alcohol after the removal of salt and finally impregnated in anhydrous glycerin. Microscopic slides were prepared as explained above. Detailed examination of the specimens was carried out using a high power microscope equipped with a 100X oil immersion lens. Necessary measurements were taken using calibrated ocular micrometer. Camera Lucida sketches of interstitial organisms were prepared for species identification. Scale of camera lucida drawing is given in the description.

Absolute and relative measurements are given in the description of nematodes. These measurements given in the present study are based on De Man's formula, a formula expressing certain relative measurements, as adopted by Jensen (1978; 79). The abbreviations used in De Man's formula are indicated below:

L = Total Body Length

$$a = \frac{\text{Body Length}}{\text{Maximum Body Width}}$$

$$b = \frac{\text{Body Length}}{\text{Oesophagus Length}}$$

$$c = \frac{\text{Body Length}}{\text{Length of Tail}}$$

Position of vulva (O+) in percentage,

$$V = \frac{\text{Body Length from anterior end to vulva}}{\text{Total Body Length}}$$

The location of various structures of the nematode body is expressed in the following way after Jensen, (1979).

$$\frac{\text{Body Length in } \mu\text{m from anterior end to measured organs}}{\text{Corresponding body diameter (D) in } \mu\text{m}}$$

$$\frac{\text{Level of cephalic}}{\text{D}}\ \frac{\text{Nerve Ring}}{\text{D}}\ \frac{\text{End of Oesophagus}}{\text{D}}\ \frac{\text{Middle (♂) Vulva (O+)}}{\text{D}}\ \frac{\text{Anus}}{\text{D}} \text{---Total Body Length}$$

The oesophagus was measured from the anterior end of the body and the head diameter at the level of the first circle of cephalic setae. The morphology of the head structures of both the sexes and copulatory organs of males were carefully examined, as they were essential to study taxonomy of the specimens (Wieser and Hopper, 1967).

3.7 Nematode trophic groups

Based on the buccal features, the nematodes were categorized into four feeding groups such as selective deposit feeders (1A), non-selective deposit feeders (1B), epigrowth feeders (2A) and predators (2B) as proposed by Wieser (1953). Further studies on the community structure of nematodes were done based on this.

3.8 Nematode biomass

Biomass was estimated with the biovolumes method using the equation $V=530 * L * W^2$ (Warwick and Price, 1979), where V is the volume (nl), L the total length (mm) and W the maximum width (mm) of a given nematode. The nematode's wet weight (μg w.w) was obtained by using a specific gravity of 1.13 and converted into dry weight (μg d.w) assuming a dry/wet ratio of 0.25 (Jensen, 1983).

3.9 Statistical analysis

The software programmes viz., **SPSS** (Version 11.0) and **PRIMER v6** (Plymouth Routines in Multivariate Ecological Research, Version 6) were used for univariate and multivariate analysis of data.

Statistical analysis for 3 way ANOVA, correlation was done, based on SPSS 11 software package for Windows. ANOVA was done to establish the level of significance of data and to detect differences among the parameters between stations and between seasons. When necessary, square root, log transformed data were used in order to remove heteroscedasticity and to correct residuals. Pearson product-moment correlations were performed to test for relationships between meiofaunal distributions and environmental variables. Correlations were considered significant at $p < 0.01$. Duncan Test (Post HOC Test) was conducted to highlight the significance of variation. Standard deviation graphs are drawn to compare the variability between stations.

BEST Analysis: The BEST routine available in PRIMER v6 (Clarke & Gorley, 2006) combines the BIO ENV and BV STEP procedures of PRIMER v5. This routine uses all the available environmental variables to find out the combination that 'best explains' the patterns in the biological data. Starting with the variable showing the maximum matching coefficient, variables are successively added, the combinations tested at each stage. The variable contributing least is eliminated. Several iterations of the procedure are carried out from a random selection of variables to ensure that the 'best' match is found.

Community Structure: PRIMER v6 for windows was used for the analysis of community structure.

(a) ***Diversity indices:***

1. **Shannon – Wiener index (H')**

In the present study, the data were analysed for diversity index (H') using the following Shannon – Wiener's formula (1949):

$$H' = -\sum^{S}_{i=1} Pi \log 2\, Pi \ldots\ldots$$

which can be rewritten as

$$H' = \frac{3.3219\,(N \log N - \sum ni - \log ni}{N}$$

where, H' = species diversity in bits of information per individual

ni = proportion of the samples belonging to the i^{th} species (number of individuals of the i^{th} species)

N = total number of individuals in the collection and

$\sum$ = sum.

2. **Species richness (S)**

Calculated using two formulae given by Simpson and Margalef.

3. **Margalef Richness index (d)**

d = (S-1)/log N

4. **Pielou's evenness index (J')**

The equitability (J') was computed using the following formula of Pielou (1966):

$$J' = \frac{H'}{\log_2 S} \text{ or } \frac{H'}{\text{In}S}$$

where, J' = evenness,

H' = species diversity in bits of information per individual and

S = total number of species

5. **Taxonomic diversity index / Taxonomic distinctness index**

Recently, Warwick and Clarke (1995) proposed two new biodiversity indices, capturing the structure not only of the distribution of abundances amongst species but also the taxonomic relatedness of the species in each sample. The first index is taxonomic diversity (Δ) and the second one is taxonomic distinctness (Δ^*). The taxonomic distinctness can be divided based on presence/absence data into two types namely (i) average taxonomic distinctness (Δ^{+}) and (ii) variation in taxonomic distinctness (Λ^{+}). The Δ and Δ^{*} were calculated using the following two equations:

$$\Delta = \frac{\Sigma\Sigma i < j\,\mathrm{Wij\ Xi\ Xj} + \Sigma \mathrm{i}\,0.\mathrm{Xi}\,(\mathrm{Xi}-1)/2}{\Sigma\Sigma i < \mathrm{jXi\ Xj} + \Sigma \mathrm{i}\,0.\mathrm{Xi}\,(\mathrm{Xi}-1)/2}$$

$$\Delta^{*} = \frac{\Sigma\Sigma i < j\,\mathrm{Wij\ Xi\ Xj} + \Sigma \mathrm{i}\,0.\mathrm{Xi}\,(\mathrm{Xi}-1)/2}{\Sigma\Sigma i < \mathrm{jXi\ Xj} + \Sigma \mathrm{i}\,0.\mathrm{Xi}\,(\mathrm{Xi}-1)/2}$$

Average taxonomic distinctness index (Δ^{+})

Average taxonomic distinctness (delta^{+}) was calculated using the following formula:

$$\Delta^{+} = [\Sigma\,\Sigma\ i<j\omega ij\,]/\,[s\,(s-1)/\,2]$$

where S is the number of species present, the double summation is over the set {i= 1, S; j= 1, ….S, such that i< j} and ω_{ij} is the 'distinctness weight' between species i and j.

Variation in taxonomic distinctness index (Λ^{+})

Variation in taxonomic distinctness (Λ^{+}) was calculated using the following formula:

$$\Lambda^{+} = [\Sigma\Sigma_{i\neq j}\,(\omega\omega_{ij} - \omega)^{2}]\,/\,[s\,(s-1)]$$

$$= [\{\Sigma\Sigma_{i\neq j}\,\omega_{ij}^{2}\}/\,\{s\,(s-1)\}] - \omega^{2}$$

95% confidence funnel and 2 – dimensional plot

Average taxonomic distinctness index (delta^{+}) and variation in taxonomic distinctness (lambda^{+}) were studied graphically by the following three ways:

i Funnel and

ii Ellipse

(b) *Similarity indices:*

1. Cluster analysis

Cluster analysis was done to find out the similarities between groups. The most commonly used clustering technique is the hierarchical agglomerative method. The results of this are represented by a tree diagram or dendrogram with the x- axis representing the full set of samples and the y-axis defining the similarity level at which the samples or groups are fused. Bray – Curtis coefficient (Bray and Curtis 1957) was used to produce the dendrogram. The coefficient was calculated by the following formula:

$$S_{jk} = 100 \left\{ 1 - \frac{\sum_{i=1}^{p} \left| y_{ij} - y_{ik} \right|}{\sum_{i=1}^{p} (y_{ij} + y_{ik})} \right\}$$

$$= 100 \; \frac{\sum_{i=1}^{p} 2 \min(y_{ij}, y_{ik})}{\sum_{i=1}^{p} (y_{ij} + y_{ik})}$$

where, y_{ij} represents the entry in the i th row and j th column of the data matrix i.e.

the abundance or biomass for the i th species in the j th sample;

y_{ik} is the count for the i th species in the k th sample;

| … | represents the absolute value of the difference;

'min' stands for, the minimum of the two counts and

Σ represents the overall rows in the matrix.

2. **SIMPROF Test:** The significance of the cluster groups created was tested by similarity profile (SIMPROF) test.

3. MDS (non - metric Multi Dimensional Scaling)

This method was proposed by Shepard (1962) and Kruskal (1964) and was used to find out the similarities (or dissimilarities) between each pair of entities to produce a 'map', which would ideally show the interrelationships of all.

The relative abundances and biomass are plotted as a curve, which retains more information about the distribution than a single index. True to this, the data collected were considered for dominance plot and geometric abundance class plot.

4. Geoplot (x2 geometric abundance class plot)

Geometric abundance class plot was performed following the procedure outlined by Gray and Pearson (1982). The y- axis represents the percentage of species and geometric abundance class on the x- axis.

5. Dominance plot

The species were ranked in terms of abundance. The ranked abundances calculated as percentages of the total abundances of all species were plotted against the relevant species rank.

* * *

Chapter - 4

Taxonomy

4.1 Introduction

The living world consists of about fiftyeen million recognized species of organisms. The knowledge about all these organisms will be confusing, meaningless and useless, if they are not properly identified and arranged systematically. Systematics is a broad area, which encompasses three disciplines – identification, taxonomy and phylogenetics. Eighteenth century is a landmark in the history of taxonomy. This was an era of Carolus Linnaeus, who created the modern systematics and is aptly called the "Father of modern classification". Many of the zoological groups belonging to the meiobenthos are commented upon as 'small and isolated groups', which in fact represent anatomically fascinating and phlygenetically important taxa. The study of interstitial taxa has resulted in, among other things, considerable number of discoveries, which have remarkable contributions to systematic zoology in the twentieth century.

Zoological investigations and taxonomic descriptions of minute benthic animals were being published by the mid 19th century. Animals belonging to various phyla, from Protozoa to Echinodermata occur in marine interstices. Practically, all groups of invertebrates are represented in the interstitial fauna. Invertebrate groups with very small bodies (copepods, tardigrades) or which by their normal type of organization are pre-adapted for life in an interstitial environment are usually represented by many species in interstitial biotopes. Other groups of invertebrates like Coelenterata; Bryozoa etc. are instead represented by small number of morphologically aberrant forms (*Halammohydra*, *Monobryozoan*). It is in the interstitial fauna the smallest representatives of most of the invertebrate phyla are found. Interstitial meiofaunal sandy species reside within the space between the sand grains. Protozoa and metazoa in this environment have about the same dimensions.

Taxonomic study of selected groups such as Nematoda, Polychaeta, Gastrotricha, Kinorhyncha, Isopoda and Cnidaria was conducted and the specimens were identified at the species level.

4.2 Results

Sixty-seven species of interstitial organisms at the species level belonging to various phyla, families, order and genera and two organisms at the generic level were identified by the taxonomic studies conducted on selected groups of interstitial taxa. The present taxonomic work accounts the details of forty one species of nematodes, fourteen polychaete species, eight gastrotrichs, two species of isopods, a cnidarian, a kinorhynch and two halacarids. Among the nematodes, forty species belong to the class Adenophorea and one Secernentean. The adenophoreans are spread out in 3 orders such as Enoplida, Monhysterida and Chromadorida belonging to 14 families and 29 genera. 14 polychaete species belong to 6 families and 7 genera; 8 gastrotrich species belonging to two orders such as Macrodasyida and Chaetonotida include 4 families and 7 genera and isopods belong to 2 genera of 2 families. Seven species have been described as new to science, which include 3 nematodes, 2 polychaete species and 2 gastrotrichs. Family Protodriloidae among polychaetes and the genus *Halichaetonotus* of Gastrotrotricha are premier records from India.

4.3 Taxonomic List of Interstitial Organisms

I.	**Phylum**	NEMATODA
	Class	ADENOPHOREA
	Subclass	ENOPLIA
	Order	ENOPLIDA

Suborder **ENOPLINA**

Family **Ironidae** De Man, 1876

Genus ***Trissonchulus*** Cobb, 1920

1. N1 *Trissonchulus acutus* Gerlach, 1953
2. N2 *Trissonchulus janetae* Inglis, 1961

Family **Oxystominidae** Chitwood, 1935 (Filipjev, 1918)

Genus ***Halalaimus*** De Man, 1888

3. N3 *Halalaimus capitulatus* Boucher, 1977

Family **Thoracostomopsidae**

Genus ***Epacanthion*** Wieser, 1953

4. N4 *Epacanthion buetschlii* Southern, 1914
5. N5 *Epacanthion georgei* Inglis, 1971
6. N6 *Epacanthion gorgonocephalum* Warwick, 1970
7. N7 *Epacanthion pellucidum* (Ssaveljev, 1912)

Genus ***Enoplolaimus*** De Man, 1893

8. N8 *Enoplolaimus connexus* Wieser, 1953
9. N9 *Enoplolaimus propinquus* De Man, 1922

Genus ***Mesacanthion*** Filipjev, 1927

10. N10 *Mesacanthion pali* Wieser, 1959

Genus ***Enoploides*** Ssaveljev, 1912

11. N11 *Enoploides brunettii* Gerlach, 1953

Genus ***Oxyonchus*** Filipjev, 1927

12. N12 *Oxyonchus culcitatus* Wieser, 1959

Genus ***Trileptium*** Cobb, 1933

13. N13 *Trileptium anomala* nov.sp.

Family **Phanodermatidae** Filipjev, 1927

Genus ***Phanoderma*** Bastian, 1865

14. N14 *Phanoderma campbelli* Allgen, 1928

Family **Oncholaimidae** Filipjev, 1916

Genus ***Metoncholaimus*** Filipjev, 1918

15. N15	*Metoncholaimus haplotretos* Mawson, 1958	
	Genus	***Oncholaimus*** Dujardin, 1845
16. N16	*Oncholaimus flagellatus* Gerlach, 1967	
17. N17	*Oncholaimus brachycercus* De Man, 1889	
	Genus	***Viscosia*** De Man, 1890
18. N18	*Viscosia antarctica* Allgen, 1959	
	Suborder	**TRIPYLOIDINA**
	Family	**Tripyloididae** Filipjev, 1918
	Genus	***Bathylaimus*** Cobb, 1894
19. N19	*Bathylaimus capacosus* Hopper, 1962	
	Family	**Trefusiidae** Gerlach, 1966
	Genus	***Rhabdocoma*** Cobb, 1920
20. N20	*Rhabdocoma obtusicaudata* (Chitwood, 1936)	
	Order	**MONOHYSTERIDA** Filipjev, 1929
	Family	**Xyalidae** Chitwood, 1951
	Genus	***Daptonema*** Cobb, 1920
21. N21	*Daptonema psammoides* Warwick, 1970	
22. N22	*Daptonema setifer* Gerlach, 1952	
23. N23	*Daptonema vicinum* Riemann, 1966	
	Genus	***Theristus*** Bastian, 1865
24. N24	*Theristus acer* Bastian, 1865	
25. N25	*Theristus sp.*	
	Genus	***Paramonohystera*** Steiner, 1916
26. N26	*Paramonohystera albigensis* (Riemann, 1966)	
	Genus	***Rhynchonema*** Cobb, 1920
27. N27	*Rhynchonema hirsutum* Hopper, 1961	
	Genus	***Prorhynchonema*** Gourbault, 1982
28. N28	*Prorhynchonema warwicki* Gourbault, 1982	
	Subclass	**CHROMADORIA**
	Order	**CHROMADORIDA**

Suborder **CHROMADORINA**

Family **Ceramonematidae** Cobb, 1933

Genus ***Ceramonema*** Cobb, 1920

29. N29 *Ceramonema africana* Furstenberg and Vincx, 1993

30. N30 *Ceramonema sp.*

Family **Cyatholaimidae** Filipjev, 1918

Genus ***Marylynnia*** Hopper, 1972

31. N31 *Marylynnia keralensis* nov.sp.

Genus ***Pomponema*** Cobb, 1917

32. N32 *Pomponema multipapillatum* Filipjev, 1922

Genus ***Paracyatholaimus*** Micoletzky, 1922

33. N33 *Paracyatholaimus chilensis* Gerlach, 1953

Family **Selachinematidae** Cobb, 1915

Genus ***Gammanema*** Cobb, 1920

34. N34 *Gammanema punctuata* nov.sp.

Family **Chromadoridae** Filipjev, 1917

Genus ***Prochromadorella*** Micoletzky, 1924

35. N35 *Prochromadorella quinquepapillata* (Stekhoven, 1935)

Genus ***Neochromadora*** Micoletzky, 1924

36. N36 *Neochromadora tecta* Gerlach, 1951

Family **Desmodoridae** Filipjev, 1922

Genus ***Metachromadora*** Filipjev, 1918

37. N37 *Metachromadora (Bradylaimus) suecica* Allgen, 1929

Genus ***Onyx*** Cobb, 1891

38. N38 *Onyx ferox* (Ditlevsen, 1921)

39. N39 *Onyx perfectus* Cobb, 1891

Family **Epsilonematidae** Steiner, 1927

Genus ***Metepsilonema*** Steiner, 1927

40. N40 *Metepsilonema magdae* Decraemer and Gourbault, 1989

Class **SECERNENTEA**

Order **RHABDITIDA**

Family **Rhabditidae**

Genus ***Rhabditis*** Dujardin, 1845

41. N41 *Rhabditis ehrenbaumi* Bresslau and Stekhoven, 1940

II. **Phylum** **ANNELIDA**

Class **POLYCHAETA**

Family **Pisionidae** Levinsen, 1887

Genus ***Pisione*** Grube, 1857

42. P1 *Pisione gopalai* Alikunhi, 1941

43. P2 *Pisione bifida* nov. sp.

44. P3 *Pisione remota* (Southern, 1914)

Genus ***Pisionidens*** Aiyar and Alikunhi, 1940

45. P4 *Pisionidens indica* (Aiyar and Alikunhi, 1940)

Family **Saccocirridae** Czerniavsky, 1881

Genus ***Saccocirrus*** Bobretzky, 1872

46. P5 *Saccocirrus minor* Aiyar and Alikunhi, 1944

Family **Hesionidae**

Genus ***Hesionides*** Friedrich, 1937

47. P6 *Hesionides arenaria* Friedrich, 1937
48. P7 *Hesionides peculiaris* Westheide and Rao, 1977
49. P8 *Hesionides remani* nov.sp.

Family **Protodriloidae** Purschke and Jouin, 1988

Genus ***Protodriloides*** Jouin, 1966

50. P9 *Protodriloides chaetifer* (Remane, 1926)

Family **Protodrilidae** Czerniavsky, 1881

Genus ***Protodrilus*** Hatschek, 1880

51. P10 *Protodrilus pierantonii* Aiyar and Alikunhi, 1944

52. P11 *Protodrilus indicus* Aiyar and Alikunhi, 1944

53. P12 *Protodrilus sp.*

Family **Polygordidae** Czerniavsky, 1881

Genus ***Polygordius*** Schneider, 1868

54. P13 *Polygordius madrasensis* Aiyar and Alikunhi, 1944

55. P14 *Polygordius uroviridis* Aiyar and Alikunhi, 1944

III. **Phylum** **GASTROTRICHA** Metschnikoff, 1864

Order **MACRODASYIDA** Remane, 1926 (Rao, 1970)

Family **Thaumastodermatidae** Remane, 1926

Subfamily ***Thaumastodermatinae*** Ruppert, 1978

Genus ***Pseudostomella*** Swedmark, 1956

56. G1 *Pseudostomella cheraensis* Priyalakshmi, Menon and Todaro, 2007

Genus ***Tetranchyroderma*** Remane, 1926

57. G2 *Tetranchyroderma swedmarki* Rao and Ganapati, 1968

Family **Turbanellidae** Remane, 1925

Genus ***Turbanella*** Schultze, 1853

58. G3 *Turbanella lutheri* Remane, 1952

Genus ***Paraturbanella*** Remane, 1927

59. G4 *Paraturbanella sp.*

Order **CHAETONOTIDA** Remane, 1925 (Rao, 1970)

Suborder **PAUCITUBULATINA** d'Hondt, 1971

Family **Chaetonotidae** Gosse, 1864

Genus ***Chaetonotus*** Ehrenberg, 1830

Subgenus ***Marinochaetus*** Kisielewski, 1997

60. G5 *Chaetonotus (M.) apolemmus* Hummon, Balsamo & Todaro, 1992

Genus ***Halichaetonotus*** (Remane, 1936) Schrom, 1972

61. G6 *Halichaetonotus spinosus* Mock, 1979

62. G7 *Halichaetonotus sp.*

Family **Xenotrichulidae** Remane, 1927

Subfamily **Xenotrichulinae** Ruppert, 1979

Genus ***Xenotrichula*** Remane, 1927

63. G8	*Xenotrichula chaetosa* nov. sp.	
IV.	**Phylum**	**ARTHROPODA**
	Class	**MALACOSTRACA**
	Subclass	**PERACARIDA**
	Order	**ISOPODA**
	Family	**Microparasellidae** Karaman, 1933
	Genus	***Angeliera*** Chappius and Delamare Deboutteville, 1954
64.	*Angeliera phreaticola* Chappius and Delamare Deboutteville, 1952	
	Family	**Microcerberidae** Karaman, 1933
	Genus	***Coxicerberus*** (Karaman, 1933)
65.	*Coxicerberus predatoris* (Gnanamuthu, 1954)	
V.	**Phylum**	**CNIDARIA**
	Order	**ACTINULIDA** Swedmark and Teissier, 1959
	Family	**Halammohydridae** Remane, 1927
	Genus	***Halammohydra*** Remane, 1927
66.	*Halammohydra octopodides* Remane, 1927	
VI.	**Phylum**	**KINORHYNCHA**
	Order	**CYCLORHAGIDA**
	Suborder	**CRYPTORHAGAE** Higgins, 1968
	Family	**Cateriidae** Gerlach, 1956
	Genus	***Cateria*** Gerlach, 1956
67.	*Cateria styx* Gerlach, 1956	
VI.	**Class**	**ARACHNIDA**
	Order	**ACARI**
	Family	**Halacaridae**
	Genus	***Anomalohalacarus*** Newell, 1949
	Genus	***Scaptognathides Monniot, 1972***

4.4 NEMATODA

The phylum Nematoda consists of cylindrical, sometimes fusiform or rarely saccate multicellular organisms, which are usually microscopic. They can colonise virtually every moist habitat that can sustain metazoan life. Platt and Warwick (1983; 1988) demonstrate that the main reason, which defers meiobenthologists from dealing with nematodes, is their exorbitant species richness and often-minute size. About 4000 to 5000 species of free-living nematodes have been described so far and it has been estimated that about 20,000 are as yet unknown. Identification of marine Nematoda is based on numerous anatomical features, some of the more important being the cuticle, amphid, cephalic and somatic setae, oesophagus, tail and the male copulatory apparatus. The phylum Nematoda consists of two classes, the Secernentea and Adenophorea. The main diagnostic characters are the presence of caudal glands, bristles and conspicuous amphids in the majority of Adenophorea, being either absent or inconspicuous (amphids) in the Secernentea. Only three species from Secernentea belonging to the genus *Rhabditis* have been found as free-living organisms in the marine environment. Forty Adenophorean and one Secernentean nematode species have been identified and studied in the present investigation.

4.5 Glossary

a)	amphid	: Paired lateral sense organs situated on or just posterior to the head.
b)	annulation	: Conspicuous transverse cuticle striation.
c)	apophysis	: A separate process of the gubernaculum.
d)	bulb	: Muscular swelling of the oesophagus.
e)	cardia	: Muscular structure at the posterior end of the oesophagus connecting to the anterior part of the intestine.

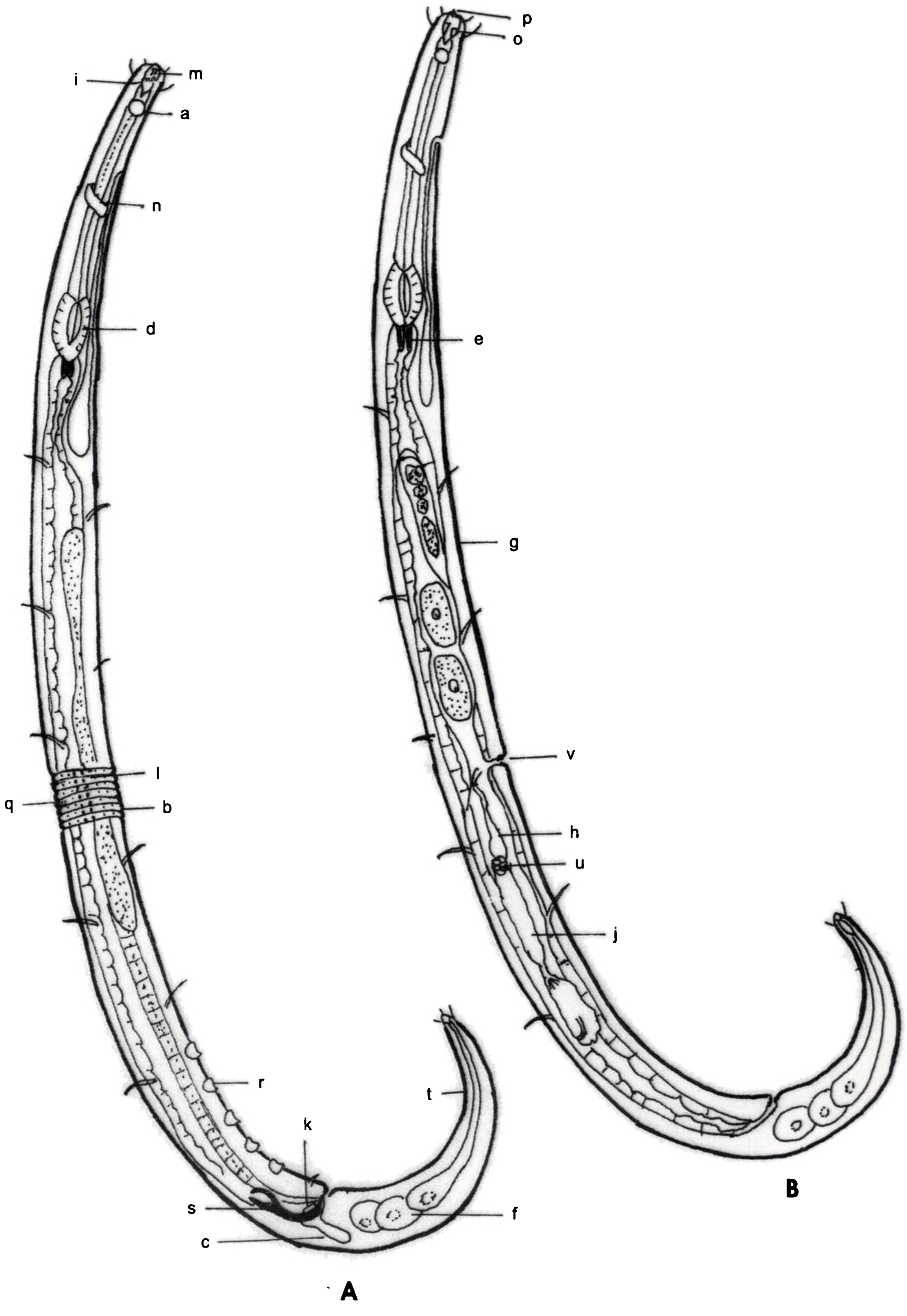


Fig. 4.1. Schematic diagram of marine nematodes

A : Male B : Female

f)	caudal glands	: Unicellular glands, lying within or extending anterior to tail but discharg through a spinneret at the tail tip.
g)	cuticle	: Outer covering of the body which also lines the buccal cavity, oesophagus lumen, vagina and rectum.
h)	demanian system	: Complex seminal receptacle found in females of the family Oncholaimidae.
i)	denticle	: Small tooth or projection, often found in groups or bands.
j)	ductus uterinus	: The connection between the demanian system and the uterus.
k)	gubernaculum	: A cuticularised guiding piece lying dorsal to the spicules in the cloaca.
l)	lateral differentiation	: Ornamentation of the cuticle confined to the lateral region.
m)	mandible	: Cuticularised movable structure in the buccal cavity used for gripping or biting.
n)	nerve ring	: Discrete ring of nerve tissue around the oesophagus.
o)	onchium	: A tooth in the buccal cavity.
p)	papilla	: Small nipple like projection of the cuticle.
q)	punctuation	: Dotted cuticle, formed from tiny raised knobs, rods or rounded depressions in the cuticle.
r)	supplements	: In males, additional copulatory organs, usually situated ventrally or sub ventrally anterior to the cloaca and appears to have a secretory function.

s) spicule : Copulatory organs, usually paired, in the cloaca of males.

t) tail : The portion of the body posterior to the cloaca or anus.

u) uvette : Swollen structure at the junction of the main duct of the demanian system and the ductus uterinus.

v) vulva : Opening of the female reproductive system.

4.6 Description of Species

Phylum	**NEMATODA**
Class	**ADENOPHOREA**
Subclass	**ENOPLIA**
Order	**ENOPLIDA**
Suborder	**ENOPLINA**
Family	**IRONIDAE** De Man, 1876

The members of the family are distinguished by the presence of single or double dorsal teeth, sometimes fused at varying degrees towards the base. The single or double nature of the dorsal tooth in Ironidae can be seen best in *en face* preparations, but can often be seen more clearly in the replacement teeth of juveniles. The presence of cephalic setae or papillae; short tail with or without swollen tip or long and tapering tails are other features of the family.

Genus *TRISSONCHULUS* Cobb, 1920

Type species *Trissonchulus oceanus* Cobb, 1920: 297. Revision: Chitwood, 1960: 350-351 (*Dolicholaimus*); Inglis, 1961: 300; Yeates, 1967: 308; Vitiello, 1970: 208.

Trissonchulus species have four teeth in the buccal cavity, with the dorsal pair fused together to varying degrees, often appearing completely separate in the replacement teeth of the juveniles. The species of this genus have ten cephalic papillae, relatively short tails, with no cylindrical portion distally.

1. N1 ***Trissonchulus acutus*** (Gerlach, 1953) comb nov

(Plate. 1: Fig. 1a, b, c & d; Plate. 14: Fig. 67a, b, c & d)

Dolicholaimus acutus Gerlach, 1953: 10

Occurrence: A male and a few female specimens were collected from Veli and Cherai beaches during post monsoon season from the intertidal region at a depth of 17.5 cm.

Description

Male: L = 1.370 mm; a = 21.7; b = 5.5; c = 17.6; Scale: 30μ

-	125	250	M	1292	1370μm
28	55	60	63	40	

Female: L = 1.360 mm; a = 23.5; b = 5.4; c = 15.5; Scale: 30μ

-	100	250	740	1272	1360μm
26	55	57.5	58	30	

Smooth body. Dome shaped head is set off by a constriction. Cephalic papillae replace the setae. Solid teeth present in the buccal cavity. Amphid, 10μm in diameter is seen faintly in the male. Oesophagus about 0.18 times the body length. Anterior region of the oesophagus slightly enlarged, followed by a curled region and then cylindrical. Nerve ring at 50% of the oesophagus length in male and at about 40% in female. Tail 2.0 or more a.b.d. with a sharp pointed tip. Caudal glands post-anal in position. Spicule measuring 40μm (1.0 a.b.d.) as chord is very wide and blunt proximally with central lamellar structures. Gubernaculum 11μm long, with a small posteriorly directed apophysis. Supplements are absent. Ovaries paired and opposed.

Remarks: The present species was separated from *Trissonchulus benepappillosus,* Schultz due to the presence of a sharply pointed conical tail.

The form under consideration comes very close to *Trissonchulus acutus*, Gerlach in the presence of a pointed tail, nature of head and buccal structures. However, The shape of the spicule with gubernaculum and a posteriorly directed apophysis resemble that of *Trissonchulus benepappillosus*, Schultz figured by Hopper (1961). The shape of the tail and the relative values of De Man's ratio are quite different from it and confirm the present placement. The local forms are therefore assigned to *Trissonchulus acutus*, Gerlach. This species has been reported as *Dolicholaimus acutus*, Gerlach from Fort Kochi and Azhikode beaches (Govindankutty, 1967).

Distribution: Chile (Gerlach, 1953); Arabian Sea (present record).

2. N2 ***Trissonchulus janetae*** Inglis, 1961

(Plate. 1: Fig. 2a & b; Plate. 14: Fig. 68a & b)

Trissonchulus janetae Inglis 1961: 294

Occurrence: A juvenile specimen was collected from Fort Kochi in summer season from a depth of 19 cm during low tide.

Description

Juvenile: L = 1.94mm; a = 36.6; b = 6.9; c = 28.1; Scale: 30µ

$$\frac{-}{20}\quad\frac{138}{50}\quad\frac{280}{53}\quad\frac{-}{53}\quad\frac{1971}{43}\quad 1940\mu\text{m}$$

Smooth elongate body with a dome shaped head, set off by a constriction. Setae are replaced by cephalic papillae. Amphid marked by a faint impression in the specimen. Two solid curved teeth are present, in which one appears to have a double-edged tip. The nerve ring at about 50% of the oesophagus length. The oesophagus is modified as a pharynx anteriorly, lined by distinct cuticular pharyngeal rods. The rod measures 30µm - 40µm in length. The pharyngeal region is slightly swollen. Sharply pointed and distally curved secondary teeth (3µ - 4µ long) are present at the level of amphid. The tail is very short and round. The dorsal opening of the spinneret indistinct in the present specimen.

Remarks: The only juvenile specimen available compares well with *Trissonchulus janetae* described by Inglis (1961) from South Africa in the possession of curved buccal teeth, replacement teeth, distinct pharyngeal rod, relative measurements of De Man's ratio such as 'a' and 'c' and the short round tail. The only difference is the slightly higher value of 'b', which according to Inglis is of minor importance. The present juvenile specimen is therefore assigned to *Trissonchulus janetae* Inglis, 1961.

Distribution: South Africa (Inglis, 1961); Arabian Sea (present record).

Family OXYSTOMINIDAE Chitwood, 1935 (Filipjev 1918)

Buccal cavity may be absent or very small and conical. Amphid represented by a longitudinal slit, horseshoe shaped or pocket-like; precloacal supplements: winged, spiny or papillate. Setae include cephalic and sub – cephalic ones.

Genus *HALALAIMUS* De Man, 1888

Type genus *Halalaimus* De Man 1888, established by De Coninck, 1965: 652

The characteristic feature of *Halalaimus* is the long slit like amphid and the strongly attenuated anterior end. The cuticle of some species seems to be faintly striated (probably all species have striated cuticle but some are beyond the resolving power of the light microscope).

3. N3 ***Halalaimus capitulatus*** Boucher, 1977

(Plate. 1: Fig. 3a, b, c & d; Plate. 14: Fig. 69a, b, c & d)

Halalaimus capitulatus Boucher, 1977: 733

Occurrence: A few male and female individuals were collected from Cherai and Sakthikulangara during different seasons of the year from the low tide region.

Description

Male: L = 1. 8mm; a = 103; b =?; c = 10; Scale: 30µ

-	?	?	M	1620	1800µm
4	?	?	17.5	15	

Female: L = 1. 76mm; a = 127.5; b = 5.9; c = 8.8; Scale: 30µ

-	?	300	850	1562	1760µm
4	?	12.5	14	10	

Smooth cuticle. Cuticle margin is lightly sclerotised. Body attenuated at both ends. Cephalic setae are long and arranged in two circles. Six anterior cephalic setae 3.7- 4.3h.d. long; and four posterior setae about 5h.d. in length. Setae other than these are absent. No buccal cavity. Amphid, 31-34µm long, located at .9 times distance from the anterior end of the body. Tail is long and tapering with a slightly swollen tip. Spicule 20µm long. Gubernaculum not very distinct. In females, a clear vulva is present on a papilla, located at 48.29% from the anterior end of the body.

Remarks: Boucher in 1977 described the species based on the measurements of several males and females. A distinctive feature noticed in his description is a wide variation in the length and value of 'a' of De Man's ratio. The difference in the value of 'a' between sexes and among the same sex is noticed in the present specimens also. Eventhough the value of 'a', as given by Warwick and Platt is much higher against the specimens at my disposal, it comes close to the values of Boucher. In the arrangement and length of the cephalic setae, shape and length of the spicule, the local forms agree well with the original description. The spicule shows some resemblance with *Halalaimus cirrhatus* as well, but disagrees with it in many respects. Hence, without any hesitation, the local specimens are assigned to *Halalaimus capitulatus*.

Distribution: Loch Ewe, Scotland (Boucher, 1977); Arabian Sea (present record).

Family THORACOSTOMOPSIDAE

The family includes several related genera like *Enoploides, Epacanthion, Mesacanthion, Paramesacanthion, Enoplolaimus* etc. characterized by the presence of mandibles that differ in their size and structure. The mandibles may be either solid and bifurcate or formed of lateral rods united by a curved bar. The cephalic setae may originate from the base of the cephalic capsule, middle of the capsule or from the extreme anterior end in different genera. Nematodes belonging to this family are more abundant in sandy sediments.

Genus *EPACANTHION* Wieser, 1953

Type species *Enoplus buetschlii* Southern 1914, designated by Wieser 1953: 79. Syn *Hyalacanthion* Wieser, 1959: 18 (type species *Hyalacanthion multipapillatum* Wieser 1959) op Inglis 1966: 89

Epacanthion constitute a very heterogeneous group of species distinguished apart by the relative dimensions of the mandibles, arrangement of setae on the head and the structure of male copulatory apparatus. The mandibles are intermediate in structure between those of *Enoploides* and *Enoplolaimus/ Mesacanthion/ Paramesacanthion;* more solid in appearance than those of the latter group of species, but with a central clear sheet of cuticle unlike *Enoploides.*

4. N4 ***Epacanthion buetschlii*** (Southern, 1914)

(Plate. 1: Fig. 4a & b; Plate. 14: Fig. 70a & b)

Enoplus buetschlii Southern, 1914: 50

Epacanthion buetschlii (Southern, 1914) Wieser, 1953: 79; Gerlach, 1957:421 (as cf *buetschlii*); Grimaldi-De Zio, 1967: 126.

Occurrence: The present material was collected from Veli beach in summer season and from Cherai and Arthungal beaches from a depth of 19 cm during low tide.

Fig.1a

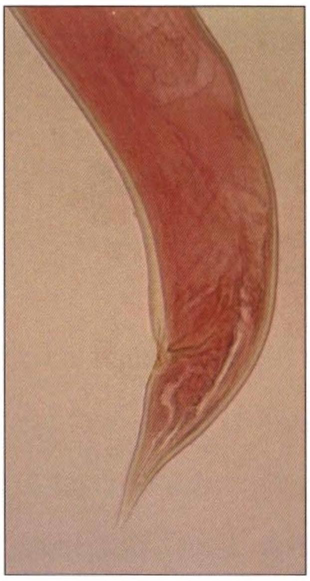


Fig.1b

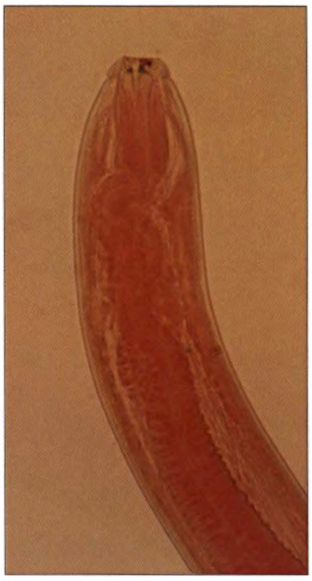


Fig.1c

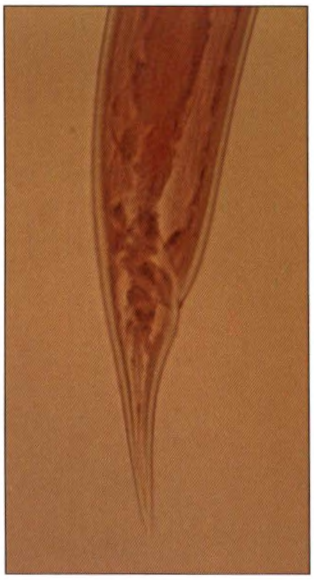


Fig.1d

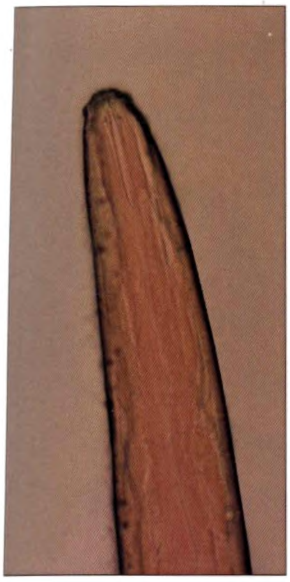


Fig.2a

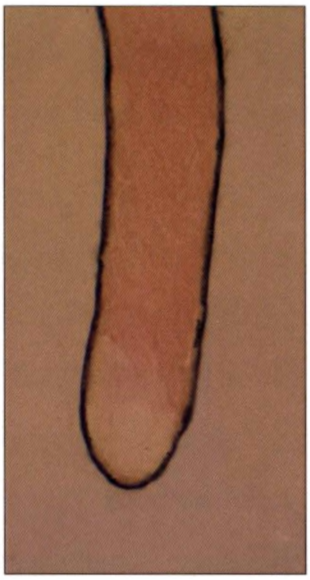


Fig.2b

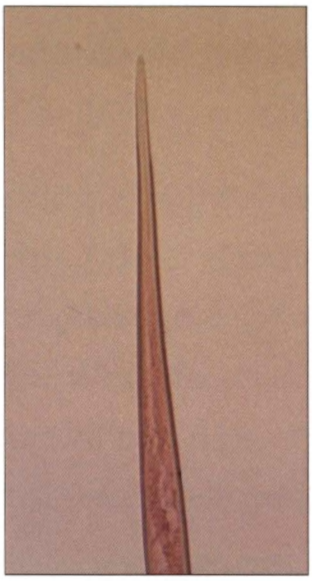


Fig.3a

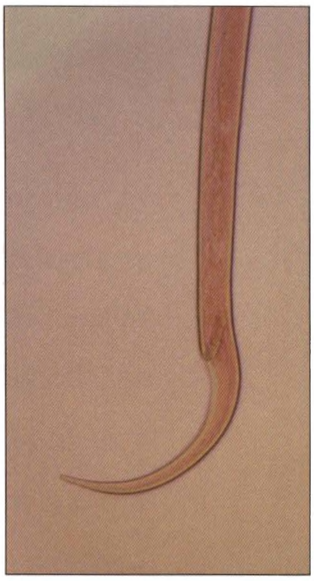


Fig.3b

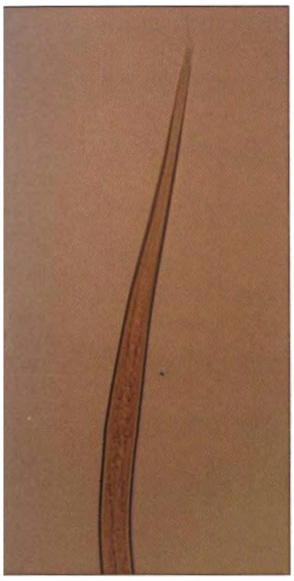


Fig.3c

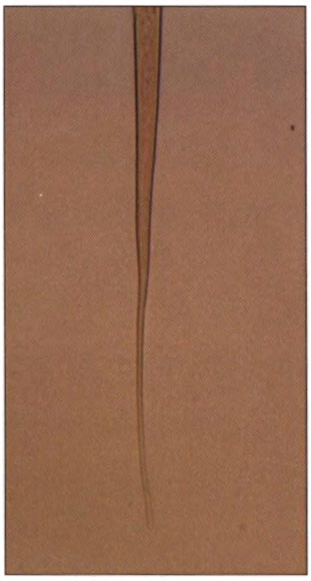


Fig.3d

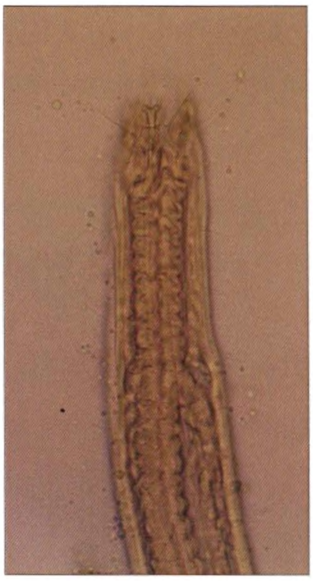


Fig.4a

Fig.4b

Description

Female: L = 2.01mm; a = 32.4; b = 3.7; c = 12.6; v = 57.2%; Scale:20µ;30µ

-	105	545	1150	1850	2010µm
36	55	65	70	40	

Stout body tapers slightly towards the tail. Labial setae measure 14-15µm. Six long (48µm) and four short (15-16µm) cephalic setae lie in a circle, at the level of onchium. A layer of sub-cephalic setae seen behind the cephalic setae. Mandibles short, stout and broad. A cup shaped amphid, 5µm in diameter located at the level of cephalic setae. Cervical setae 16-17µm long. Oesophagus bulges anteriorly. Eventhough body setae are very short and scanty, certain somatic setae are visible posterior to the vulva. Caudal setae, 18-19µm long arranged in four rows. Short terminal setae at the tip of conico-cylindrical tail.

Remarks: The material in hand agree closely with the description of *Enoplus buetschlii* described by Southern (1914). Certain differences noticed pertain to the presence of longer cephalic setae and a variation in the shape and length of tail. The length of tail in the present material is 160µm, although Southern (loc.cit.) mentioned the length as 200µm in a 4.0mm specimen in his description of the species. A male specimen was not available for examination pending which the specimen is assigned tentatively as *Epacanthion buetschlii.*

Distribution: Irish Coast of Atlantic (Southern, 1914); Brazil (Wieser, 1953); Mediterranean (Grimaldi- De Zio, 1967); Arabian Sea (present record).

5. N5 ***Epacanthion georgei*** Inglis, 1971

(Plate. 2: Fig. 5a & b; Plate. 14: Fig. 71a, b, c & d)

Epacanthion georgei Inglis, 1971: 72

Occurrence: Several male and female specimens were collected during pre-monsoon and monsoon seasons of the year from Arthungal beach at a depth of 14 -17cm from the intertidal area.

Description

Male: L = 1.68mm; a = 39.06; b = 4.8; c = 12.0; Scale: 30µ

-	120	350	M	1540	1680µm
23	30	43	43	38	

Female: L = 2.04mm; a = 41.6; b = 5.1; c = 14.06; v = 55.4%; Scale: 30µ

-	120	400	1130	1895	2040µm
30	40	47	49	40	

Cuticle smooth. The head bears three narrow high lips. Cephalic setae of variable lengths present in different circular rows. Inner cephalic setae measure 9 – 10µm. Six outer long setae and four shorter ones measure 27 and 20µm respectively. The mandibles, 7 - 8µm long, consist of two curved rods connected by a narrow cuticular sheet. The onchia lies at the base of the mandibles. The cup shaped amphid is 6 - 7µm wide. Immediately behind the cephalic setae, are placed several cervical setae ranging in length between 8 - 13µm. The number of setae gradually decline towards the posterior of the body. The anterior end of oesophagus slightly swollen. A pair of terminal setae present. Spicule more or less L shaped and measure 25µm as chord. The gubernaculum was not distinct. Pre – cloacal supplements absent. Caudal glands post anal in position. Ovaries are paired.

Remarks: From a study of the available literature, the specimens under consideration resemble with the description and figures of *Epacanthion georgei* given by Inglis. The short spicules, absence of pre-cloacal supplements, values of De Man's ratio and the position of vulva in female agree well with the original description. However, the gubernaculums mentioned as a reduced one in the original specimen was not distinct in the material now examined. The specimens examined also show similarities with *Epacanthion multipapillatum*, although total absence of supplements distinctly separates them from *E. multipapillatum. Epacanthion oliffi* (also described by Inglis) is another species to which the present material shows similarities.

However, the different shape of the spicule with serrated posterior margin does not justify including the specimens at hand to this species. The present specimens are therefore assigned to *Epacanthion georgei* Inglis, 1971 to which the material agrees in all-important specific morphology.

Distribution: Australia (Inglis, 1971); Arabian Sea (present record).

6. N6 ***Epacanthion gorgonocephalum*** Warwick, 1970

(Plate. 14: Fig. 72a & b)

Epacanthion gorgonocephalum Warwick, 1970: 145; 1971: 447, 449

Occurrence: Several female specimens were collected from Cherai, Fort Kochi, Arthungal and Veli beaches in different seasons of the year.

Description

Female: L = 2.140mm; a = 38.9; b = 3.45; c = 16.5; v = 60.28%; Scale: 30µ

-	195	620	1290	2010	2140µm
40	48	50	55	40	

Body cuticle smooth. Lips are high, marked with semilunar striations. Margin of the lips are scalloped. Labial setae are 15µm long. Six longer and four shorter cephalic setae, measuring 52.5µm and 22.5µm respectively, originate at the level where the bases of onchia are located. Sub – cephalic setae absent. Cervical (7.5µm long) and somatic (4 to 7.5µm in length) setae are short and sparse. A few 5µm long caudal setae are present. Terminal setae absent. Mandibles 12.5µm long appear as two longitudinal rods joined by a thin sheet of cuticle. Equal sized (5µm long) onchia are located at the base of the mandibles. Buccal cavity is surrounded by oesophagal tissue. Oesophagus, 0.28 times the body length is cylindrical with a slightly swollen anterior end. Tail (3.25a.b.d.) is conico-cylindrical. Vulva at 60.28% of body length. Ovaries are opposed and reflexed.

Remarks: Morphometric analysis of the specimens in hand indicate the value of 'a' to range from 32.8 to 38.9. The structural details of the specimens in hand are in total agreement with *Epacanthion gorgonocephalum* described by Warwick in 1970 from the English Channel. While confident in assigning the generic and specific status of the present forms, variability in body length, in the length of setae and a reduction in their number is noticed. Warwick has noticed marked reductions in the number of cervical setae in females in his specimens. The overall size of the tropical specimens were small and it is assumed that this is due to the geographical difference and is of relatively insignificant importance. The present specimens are therefore assigned to *Epacanthion gorgonocephalum.*

Distribution: English Channel (Warwick, 1970); Exe estuary; Isles of Scilly (Warwick, 1971); Arabian Sea (present record).

7. N7 ***Epacanthion pellucidum*** (Ssaveljev, 1912)

(Plate. 2: Fig. 6a & b; Plate. 14: Fig. 73a & b)

Enoploides pellucidus (Ssaveljev, 1912) Wieser, 1959a: 18 (to *Hylacanthion*) Syn *Enoploides pellucidus* Ssaveljev, 1912: 115; Wieser, 1953: 89 (as *Enoploides pellucidus*)

Occurrence: Several female specimens were collected from Cherai, Sakthikulangara and Veli beaches in different seasons of the year.

Description

Female: L = 1.73mm; a = 56.3 – 62.9;b = 3.4; c = 11.9;v = 47.7%;Scale:30

-	110	510	825	1585	1730µm
20	24	26	27.5	24	

Body comparatively slender. Lips are high. Six labial setae 10 -11µm long. Cephalic setae, 21 µm long are located at the base of the mandibles, in line with onchia. Three 13µm long mandibles present in the buccal cavity. Very few cervical setae 7-8µm long are present. Somatic setae 12.5µm long are few and scattered. Two terminal setae present. Tail 6.04 a.b.d. long. Vulva located a little anterior to the middle of the body.

Remarks: Ssaveljev (1912) described the species as *Enoploides pelllucidus*, based on a single specimen. Further, no figure was given, along with the original description. Wieser (1959) described the species as *Epacanthion pellucidum* based on juveniles and a male specimen and incorporated *Enoploides pellucidus* of Ssaveljev under the genus *Epacanthion.* Variation in the De Man's value in the adults and among the juveniles is evident in their descriptions. Such variation in the value of 'a' is seen in the local specimens also. Although the specimens examined here agree well with that of Wieser (1953), certain differences are noticed with that of Ssaveljev's values. However, the presence of smooth cuticle in the present form in contradiction to striated one in Wieser's specimen is not reckoned seriously as Wieser himself was not clear whether his specimen and the single female specimen seen by Ssaveljev are one and the same species. Probably lack of sufficient material at the disposal of Ssaveljev did not help him to notice the ecotypical variations quite common among interstitial nematodes.

Distribution: White Sea (Ssaveljev, 1912); Chile (Wieser, 1953); Arabian Sea (present record).

Genus *ENOPLOLAIMUS* De Man, 1893

Type species *Enoplolaimus vulgaris* De Man, 1893: 118. Revision Wieser, 1953: 72; Hopper, 1962: 42

Enoplolaimus is characteristically found in sandy sediments in shallow waters. They are voracious predators, specimens often found ingesting other nematodes. Recurved points projecting into the buccal cavity from the tips of the mandibles prevent the prey from escaping. All species have mandibles which appear as two lateral rods united by an anterior curved bar, the cephalic setae arise from near the base of the cephalic capsule and the spicules are never elongated.

8. N8 ***Enoplolaimus connexus*** Wieser, 1953

(Plate. 2: Fig. 7a & b; Plate. 14: Fig. 74a & b)

Enoplolaimus Connexus Wieser, 1953: 74; Gerlach, 1957: 421

Occurrence: A few female specimens were collected from Arthungal during summer and monsoon months and from Cherai in post-monsoon season.

Description

Female: L = 2.03mm; a = 45.1; b = 4.3; c = 14; v = 60.3%; Scale: 30µ

-	138	470	1225	1885	2030µm
29	40	43	45	37	

Body cuticle is smooth and devoid of inner striations. Lips 9µm long, characterized by the absence of striations. Cephalic capsule measures 15µm in length. Mandibles with curved ends project into the buccal cavity. Mandibular rods are 12-13µm wide anteriorly between the outer margins. Dorsal tooth prominent. Labial setae are 11µm long. A circle of six longer (30µm) and four shorter (20µm) cephalic setae are located at the base of the buccal cavity. Oesophagus, that follows the buccal capsule is slightly swollen anteriorly and borders the posterior margin of the buccal cavity. Nerve ring at 29.4% of the oesophagus length. Immediately behind the cephalic capsule, four sets of 8µm long setae are visible, spaced at a distance of approximztely 44µm. This is followed by a few, 3µm long setae, behind the region of nerve ring. Somatic setae, measuring 10µm are few and scattered. A single 10µm long sub terminal caudal seta is noticeable among the very few and minute caudal setae. The tail, 3.9a. b. d. ends in a pair of 4 -5µm long terminal setae. The spinneret opens at the tip of the tail. Caudal glands are prominent.

Remarks: Wieser (1953) described the species based on the description of male, female and juvenile organisms. The present identification is based on female specimens only. The value of De man's ratio of the material in hand goes well with that of the original description. The structure of the mandible, onchium, and the nature of tail are typically similar to that observed by Wieser. The only noticeable difference is the length of the cephalic setae. The present material also shows resemblance with several other closely related species like *E. denticulatus, E. enatus, E. lenunculus, E. paralittoralis* and *E.punctatus* in many features. Eventhough it shows close similarity with *E. denticulatus*, the latter is much larger than the local forms. The morphology of the mandible, onchia and spinneret opening brings the local forms closely allied to *E. parallitoralis, E. punctatus* and *E.lenunculus*. But all these species have characters, which distinguish their placement. Among the characters of the female specimens examined, similarities are very close to that of *Enoplolaimus connexus*. Probably a detailed examination of the type specimens would help in understanding the specific differences of the forms assigned under the genus *Enoplolaimus* which contains numerous species from the tropical, sub-tropical and temperate sea shore.

Distribution: Chile (Wieser, 1953); Brazil (Gerlach, 1957); Arabian Sea (present record).

9. N9 ***Enoplolaimus propinquus*** De Man, 1922
(Plate. 2: Fig. 8a, b, c & d; Plate. 14: Fig. 75a, b, c & d)

Enoplolaimus propinquus De Man, 1922: 132; Allgen, 1929: 7; 1935: 25; 1940: 492; 1946: 6; 1947: 7; 1949: 118; 1950: 63; 1959: 54; Stekhoven, 1935: 5, 9, 14; Gerlach, 1952: 344; 1954: 51; Delamare *et al.* 1955: 373; Riemann, 1966: 184; Warwick, 1971: 446, 449.

Occurrence: Two male and two female specimens were collected from the intertidal belt of Veli beach during post- monsoon season.

Description

Male: L = 1.11mm; a = 42.7; b = 3.2; c = 7.9; Scale: 30µ

-	120	345	M	971	2030µm
18	25	25	26	23	

Female: L = 1.35mm; a = 35.5; b = 4.5; c = 7.9; v = 51.8%; Scale: 30µ

-	100	300	700	23	1350µm
19	30	33	38	1180	

Smooth body surface. Head slightly tapered with three very low flaps like lips devoid of internal striations. Slender body almost of uniform width tapering towards the tail. Mandibles appear as lateral rods united by an anterior curved bar. Almost equal sized onchia located at the base of the mandibles. Six labial setae10µm in length are present. Six long and four short cephalic setae arising from near the base of the cephalic capsule measure 73µ and 28µ respectively. A few median setae 10µm long are present behind the cephalic setae. A few somatic setae 7. 5µm long seen scattered on the body. In one of the specimens, two pre-cloacal spines (setae) and a post cloacal spine measuring 6µm and 7. 5µm respectively are visible. Tail long and conico-cylindrical, 6 - 6. 5 a. b. d. with slightly swollen tip. Spicule measures 33µm as chord, bent sharply in the middle. Gubernaculum with a backwardly directed 20µm long apophysis. In one of the specimens, the spicule protrudes conspicuously. A cuticularised short pre-cloacal supplement measuring 7. 5µm, is located at a distance of 50 - 65µm (2.2-2. 7a. b. d.) anterior to the cloaca.

Females slightly longer and stouter than male. Ovaries are paired. Prominent vulva located in the mid posterior region of the body.

Remarks: *Enoplolaimus* and *Mesacanthion* are two closely related genera, the species of which are distinguished on the basis of the location of cephalic setae. A few specimens at hand come close to *Enoplolaimus* *propinquus* De Man in the measurements of cephalic setae, shape and length of tail, form and size of spicule and the location of pre-cloacal supplement. The conspicuous difference noticed are the placement of vulva and a backwardly directed dorsal gubernacular apophysis which is not distinct in the type description and figure given by De Man. In fact, only very few species like *Enoplolaimus acanthospiculum,* Allgen and *Enoplolaimus robustus*, Gerlach have been reported as having such an apophysis. But the short cephalic bristles, conical tail, long apophysis and the spiny tip of the posterior end of spicule of *E. acanthospiculum* makes them distinct from the local forms; where as the long spicule and the shape and length of tail of *E.robustus* does not agree with the specimens at hand. Eventhough the gubernacular apophysis of *Mesacanthion pali,* Gerlach is very similar to that of the present form, the unusually long supplement, short tail and the elongated mandibles and onchia of the *Mesacanthion* species clearly demarcates them. The material in hand is very close to *Enoplolaimus propinquus* De Man, 1922 in their morphology and hence the assignment.

Distribution: North Sea (De Man, 1922; Gerlach, 1953; Riemann, 1966); Oresund (Allgen, 1929, 1935); Norway (Allgen, 1940; 1946; 1949; 1950); Mediterranean (Gerlach, 1962); Bay of Biscay (Delamare *et al.*, 1955); Fuegian Archipelago; Falkland Islands (Allgen, 1959); English Channel (Warwick, 1971); Arabian Sea (present record).

Genus *MESACANTHION* Filipjev, 1927

Type species *Enoplolaimus lucifer* Filipjev 1927; established as subgenus of *Enoplolaimus* De Man 1893 by Filipjev, 1927: 143, raised to genus by De Coninck and Stekhoven, 1933: 38. Revision Wieser, 1953: 75

The genus is characterized by mandibles which appear as two lateral rods united by an anterior curved bar and the recurved points from the tips of the mandibles, preventing the prey from escaping. The cephalic setae arise from the middle or anterior of the cephalic capsule. Several species have elongated spicules.

10. N10 ***Mesacanthion pali*** Wieser, 1959

(Plate. 2: Fig. 9a & b; Plate. 14: Fig. 76a & b)

Mesacanthion pali Wieser, 1959a: 1- 179

Occurrence: A few female specimens were collected from Arthungal beach during the month of July from the intertidal belt.

Description

Female: L = 1.76mm; a = 46.3; b = 3.4; c = 18.5; v = 44.3%; Scale: 30µ

-	140	520	780	1665
28	33	34	38	31

Body cuticle is smooth with light posterior internal striations. Head characteristically dome shaped. Lips are high (10µm long) with scalloped margin, but devoid of internal striations. Mandibles, characteristic of the genus are 10µm long. Three large onchia (8µm), almost equal in length are present at the base of the mandibles. There are six labial setae, 10µm in length (0.35h.d.). Six long (0.9h.d.) and four (9µm long) short cephalic setae originate from the middle of the buccal cavity. Very few somatic setae are visible. Two or three setae near the anal region measure 25µm. Caudal setae 13µm in length are present. Terminal setae are absent. Oesophagus is cylindrical, 0.29 times body length, with a proximal swollen end. Two caudal glands are located post anally.

Ovaries are paired and symmetrical. Vulva is placed anterior to the middle of the body.

Remarks: The present specimens are assignable to the genus *Mesacanthion* by virtue of the presence of mandibles constituted of two

PLATE – 2

EXPLANATION OF FIGURES

Fig. 5 ***Epacanthion georgei***
a: Anterior end of female
b: Posterior end of female

Fig. 6 ***Epacanthion pellucidum***
a: Anterior end of female
b: Posterior end of female

Fig. 7 ***Enoplolaimus connexus***
a: Anterior end of female
b: Posterior end of female

Fig. 8 ***Enoplolaimus propinquus***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig. 9 ***Mesacanthion pali***
a: Anterior end of female
b: Posterior end of female

Fig.5a

Fig.5b

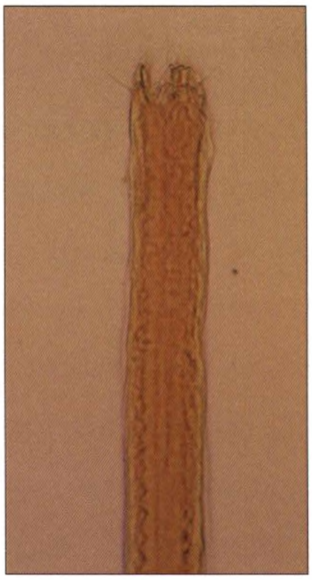


Fig.6a

Fig.6b

Fig.7a

Fig.7b

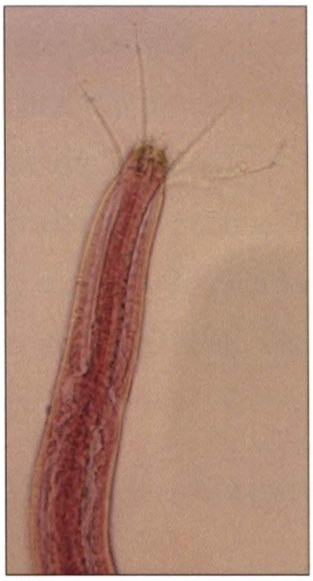


Fig.8a

Fig.8b

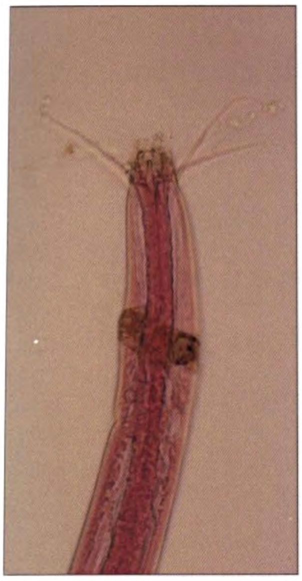


Fig.8c

Fig.8d

Fig.9a

Fig.9b

lateral rods united by an anterior curved bar and the origin of cephalic setae from the middle of the cephalic capsule. These female specimens seem to be distinctly different from all the species of *Mesacanthion* hitherto described. The specimens resemble *Mesacanthion pali* described by Wieser in 1959 from Puget Sound, with regard to fine cuticular striations, De Man's ratios and prominent onchia. The original description was purely based on female specimens. However, differences in the relative lengths of different setae and mandibular size are considered significant. Lack of female description and the paucity of a male organism in the present collection make it difficult to arrive at a definite conclusion regarding its specific identity. Nevertheless, the anterior location of vulva, shape of tail and the elongate setae near the anal region are characters, which make the material in hand totally different from those species described under this genera. It is felt that examination of a male specimen is highly essential to decide whether the specimens examined belong to a new species. Until then, the form before me may be tentatively tagged with *Mesacanthion pali*, Wieser.

Distribution: Washington, USA (Wieser, 1959); Arabian Sea (present record).

Genus *ENOPLOIDES* Ssaveljev, 1912

Type species *Enoploides typicus* Ssaveljev, 1912: 113. Syn *Labyrinthostoma* Cobb, 1898: 421 (nomennudum established without nomination of a species) op Filipjev, 1921: 566. Revision Wieser, 1953: 86; Wieser and Hopper, 1967: 251.

Enoploides species are characterized by solid bifurcate mandibles. Species are rather small with cephalic setae and tail of variable lengths. Species are best separated on the detailed morphology of the male copulatory apparatus.

11. N11 ***Enoploides brunettii*** Gerlach, 1953

(Plate. 3: Fig. 10a, b, c & d; Plate. 14: Fig. 77a & b; Plate. 15: Fig. 77c & d)

Enoploides brunetti Gerlach, 1953b: 527; 1954c: 317, 331, 333; 1954d: 110; 1954e: 223; 1955a: 279; Delamare, 1954b: 420; Grimaldi, 1965: 62; Galhano, 1970: 109; Warwick, 1971: 446, 449.

Occurrence: Several male and female specimens were collected from Arthungal beach in post-monsoon season at a depth of 18-19 cm from low tide area.

Description

Male: L = 2.120mm, a = 42.4; b = 3.9; c = 13.3; Scale: 30µ; 75µ

-	127.5	550	M	1960	1220µm
45	50	50	50	37.5	

Female: L = 2.510mm; a = 32.2; b = 4.1; c = 15.7; Scale: 30µ

-	155	610	1500	2360	2510µm
45	75	75	78	50	

Male: Body length ranges from 2.1 – 2.4 mm and maximum body diameter 50 – 70µm. Cuticle smooth, lips are high and scalloped on the outer margin. Semi-lunar striations are present. Labial setae, 0.28 h.d. Cephalic setae at the level of anterior margin of cephalic capsule. Six long cephalic setae (1.6 h.d.) and four shorter setae (0.50 h.d.) are present. Six very short sub-cephalic setae, 3.8µm long, seen at the level of bases of onchial plates. Somatic setae 13µm in length seen scattered on the body. Three solid mandibles, bifurcated at the tip are 12.5µm long. Radial mass seen at the base of the mandibles. Small equal sized onchia present. Triangular radial process present at the level of cephalic setae. Oesophagus, 0.25 times body length wavy laterally. Anterior end of oesophagus swollen. Four to five 10µm long caudal setae are present. A pair of terminal setae visible. Tail is conico-cylindrical (4.2 a. b. d.). Spicules elongate, 240µm long (6.4 a.b.d.) and transversely striated. Gubernaculum present, terminating in a blunt tooth and a lateral tooth on either sides. A distinct sclerotised pre-cloacal supplement is located 83µm anterior to the cloacal opening. A projection is seen posterior to the cloaca.

Female: The female specimens while resembling male in most of the structural features depicted certain variations. Slight attenuation is observed on the cephalic end. Conico-cylindrical tail is 3.2a. b. d. Terminal setae absent in the specimen examined. Single prominent caudal gland that opens at the tail tip is visible. Towards the anal region, very fine and light striations present. Ovaries paired and juxtapposed. Vulva located at 57% of the body length.

Remarks: The present specimens agree well with the type specimens described, in the nature and disposition of various setae, mandibular structure, crescentic radial masses and scalloped outer lip margin. Certain differences noticed from the description are the absence of striations in the anterior swollen oesophageal region and the presence of very faint striated body in females. Wieser (1953), in his key has mentioned the length of cephalic setae as less than 1.0 h.d. However, Warwick (1971) has reported the presence of longer cephalic setae and tail in specimens from exposed beaches. Eventhough the gubernaculum shows some variation from the original description, the complexity in the gubernacular structure observed in the present specimens has been described by Gerlach (1953) who discovered this species. Notwithstanding the difference noticed in the gubernaculum, the specimens examined here are assigned to *Enoploides brunettii*.

Distribution: Mediterranean (Gerlach, 1953; 1954; 1955; Delamare, 1954; Grimaldi, 1965); Bay of Biscay (Delamare *et al.*, 1955); Portugal (Galhano, 1970); English Channel (Warwick, 1971); Arabian Sea (present record).

PLATE – 14

EXPLANATION OF FIGURES

Fig. 67 ***Trissonchulus acutus***

a & b Anterior and posterior end of male

c & d Anterior and posterior end of female

Fig. 68 ***Trissonchulus janetae*** (juvenile)

a: Anterior end ; b: Posterior end

Fig. 69 ***Halalaimus capitulatus***

a& b: Anterior and posterior end of male

c& d: Anterior and posterior end of female

Fig. 70 ***Epacanthion buetschlii***

a: Anterior end of female; b: Posterior end of female

Fig. 71 ***Epacanthion georgei***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig.72 ***Epacanthion gorgonocephalum***

a: Anterior end of female ; b: Posterior end of female

Fig. 73 ***Epacanthion pellucidum***

a: Anterior end of female ; b: Posterior end of female

Fig. 74 ***Enoplolaimus connexus***

a: Anterior end of female ; b: Posterior end of female

Fig. 75 ***Enoplolaimus propinquus***

a & b: Anterior and posterior end of male

c: & d: Anterior and posterior end of female

Fig. 76 ***Mesacanthion pali***

a: Anterior end of female ; b: Posterior end of female

Fig.77 ***Enoploides brunettii***

a & b: Anterior and posterior end of male

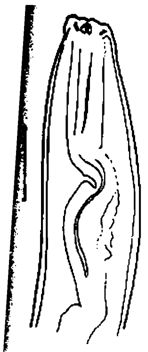


Fig. 67a

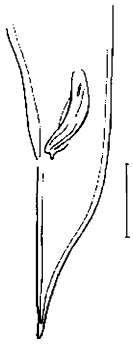


Fig. 67b

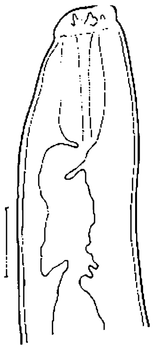
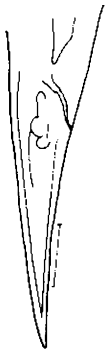


Fig. 67c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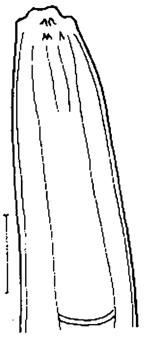
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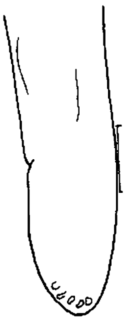
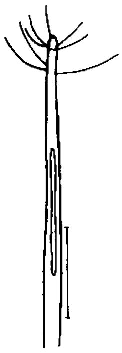


Fig. 68b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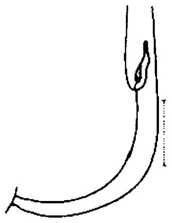


Fig. 69b

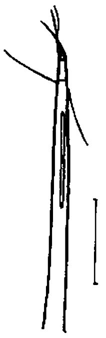


Fig. 69c


Fig. 69d

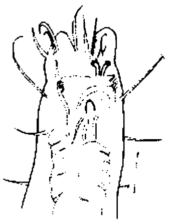


Fig. 70a

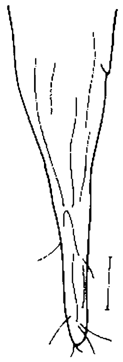
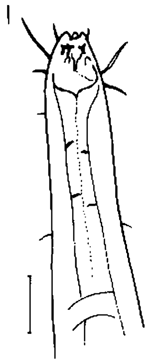


Fig. 70b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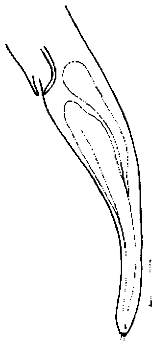


Fig. 71b

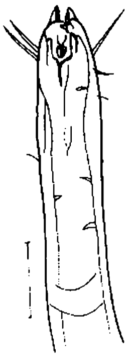


Fig. 71c

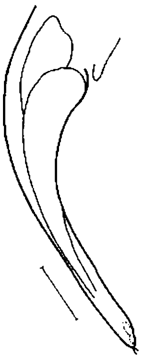
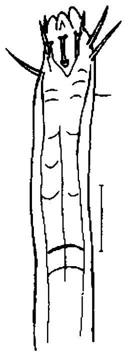


Fig. 71d


Fig. 72a


Fig. 72b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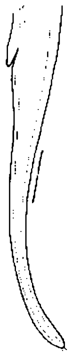


Fig. 73b

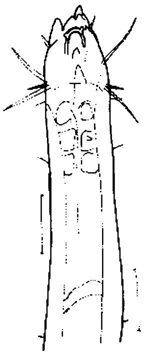


Fig. 74a

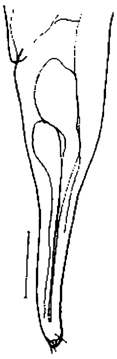


Fig. 74b

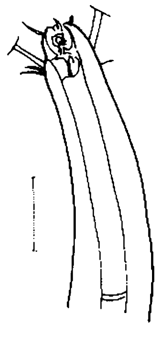


Fig. 75a


Fig. 75b

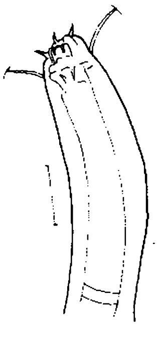


Fig. 75c

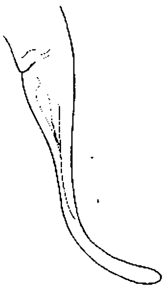


Fig. 75d


Fig. 76a

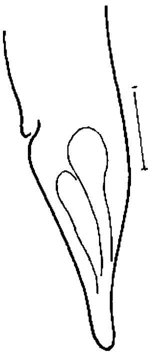


Fig. 76b

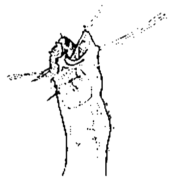


Fig. 77a

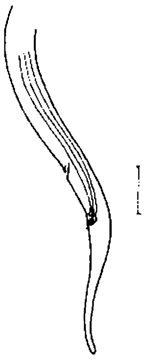


Fig. 77b

Genus *OXYONCHUS* Filipjev, 1927

Type species *Enoplolaimus hamatus* Steiner 1916; established as sub genus of *Enoplolaimus* De Man 1893 by Filipjev 1927: 144; raised to genus by De Coninck and Stekhoven, 1933: 38. Revision Wieser, 1953: 64 - 66.

This genus is characterized by two large subventral teeth extending to the anterior bar of mandibles; reduced dorsal tooth and gubernaculum with apophysis.

12. N12 ***Oxyonchus culcitatus*** Wieser, 1959

(Plate. 3: Fig. 11a, b, c & d; Plate. 15: Fig. 78a, b, c & d)

Oxyonchus culcitatus Wieser, 1959a: 11

Occurrence: Several male and a few female specimens were collected from Cherai beach during all seasons of the year and from Arthungal beach in pre and post-monsoon seasons.

Description

Male: L = 1. 92mm; a = 37. 6; b = 3. 8; c = 12. 2; Scale: 30μ

-	106	500	M	1762	1920μm
29	49	50	51	48	

Female: L = 1. 88 mm; a = 37. 6; b = 4. 0; c = 12. 7; Scale: 30μ

-	100	470	?	1732	1880μm
33	40	45	48	39	

Body cuticle is very smooth and distinct, but fine internal striations visible under high magnification. The head bears a pair of characteristic 'cirri' between the labial and cephalic setae. Lips provided with velum. Labial setae are 16-19μm long. Six cephalic setae measures 54 -59μm. shorter setae also present. The sub - cephalic setae measure around 13μm. Somatic setae (11-14μm) seen scattered on the body. Two 13μm long subventral onchia present in the buccal cavity. Denticles arranged in two rows between the arc and the horizontal bar.

Spicules measure 45- 50µm as chord. The gubernacular apophysis, dorsocaudal in position is 16µm long. A single faint 5µm long pre-cloacal supplement located at 80µm anterior to the cloaca. Caudal setae short and sparse. Terminal setae absent. Tail conico-cylindrical, 3. 3 – 3. 8 a. b. d. in males and 4. 5a. b. d. in females. Vulva was not distinguishable.

Remarks: The present material compares well with the specimens described by Wieser (1959) from Puget Sound. The presence of cirri, denticles, relative lengths of different setae, length of spicule and the location of the pre-cloacal supplement agree with Weiser's description of *Oxyonchus culcitatus.* The low value for 'a' in the type specimen is conspicuous. With reference to the value of 'a', the present material resembles *oxyonchus ditlveseni* (Inglis, 1964). The current material has a relatively low 'a' value (37.6), although Wieser reported an 'a' value of 50.5 for his specimens. However, considering other cardinal features, it is felt that the material in hand should be assigned to *Oxyonchus culcitatus.*

Distribution: Washington, USA (Wieser, 1959); Arabian Sea (present record).

Genus *TRILEPTIUM* Cobb, 1933

Trileptium Cobb, 1933: 82 pro *Trilepta* Cobb, 1920: 312, which is said to be a homonym.

Type species *Trileptium guttatum* (Cobb, 1920). Revision Wieser, 1959a: 21.

Cephalic setae are arranged at the base of the cephalic capsule, but the lips are much lower and the mandibles and onchia are smaller and occupy a more anterior position. The development of mandibles and onchia are variable; in some species neither are visible and in others, the onchia are strongly developed but the mandibles are weak. Some species are characterized by the differential development of three onchia, with the dorsal one either larger or smaller than the other two. The form of spicules

and gubernaculums and the presence or absence of a pre-cloacal **supplement** is important characters to distinguish between the species.

13. N13 ***Trileptium anomala*** nov. sp.

(Plate. 3: Fig. 12a & b; Plate. 15: Fig. 79a & b)

Occurrence: Several female specimens were collected from Cherai beach during post monsoon season between mid and low water level.

Type locality: In medium sand 17 cm below surface, intertidal zone, Cherai beach (lat. 10°09'N long. 76°02'E) Kerala, India. Clean medium sand. Moderately well sorted.

Type material: Holotype: PM 3a. Sl. 4

Paratype: PM 3a. Sl. 1.

Description

Female (Holotype): L = 4.44mm; a = 68; b = 5.55; c = 43; Scale: 30µ

-	145	800	3440	4337	4440µm
31	58	60	65	55	

Female (Paratype): L = 4.36mm, a = 67; b = 5.8; c = 40.4

-	163	750	?	4252	4360µm
25	60	60	65	51	

Body attenuated anteriorly. Cuticle is smooth with very fine internal striations. The cephalic capsule is sclerotised and the buccal cavity appears to be narrow. Mandible and onchia are not distinct. A faint circular amphid (5µm wide) seen at the anterior region of buccal capsule. Lips are low and labial papillae appear as short and stout setae, 3 - 5µm in length. Six cephalic setae arranged at the base of the cephalic capsule range between 45µm and 50µm. They spring from distinct fenestrae. Behind cephalic capsule are present 2-3 rows of few smaller setae measuring 10µm - 15µm. A few 10µm long setae are seen at the posterior region of the oesophagus.

A pair of somatic setae (10μm long) visible at the posterior region of the oesophagus. The distal half of the oesophagus is crenulated. Irregular pigmented areas scattered on the body. Tail short (1. 9 –2.1 a. b. d.). and conical. A minute terminal seta located in the holotype specimen. Caudal gland, post anal in position. Vulva located at 77% from the anterior end of the body in the holotype; it could not be located in the paratype.

Remarks: Nine species of *Trileptium* have hitherto been described, among which species like *T. subterranean* Gerlach (1952), *T. ayum* Inglis (1964) and *T. stylum* Gerlach (1956) resemble the specimens at my disposal in several respects. This genus is widespread in the UScoast, El Salvador, South Africa, Brazil, Chile, Mediterranean, Madagascar and Scotland. Species description becomes complete only when members of both sexes are examined and written with all the necessary specific characters justifying a correct placement. Further certain specific characters of the local forms make them stand apart from any of the species described so far. These features are the presence of short, stout conical tail giving reasonably high value for 'c' of De Man's ratio, a feature not seen in any of the species hitherto described, absence of shorter cephalic setae, the fenestrae at the point from which the cephalic setae spring and indistinct mandible and onchia. These characters are strikingly different from already described forms. Therefore this species is designated as a new species and can be diagnosed as described below:

Long and stout individuals with anterior end attenuated. Smooth cuticle has very fine internal striations. Sclerotised cephalic capsule. Low lips with short and stout labial papillae. Six long cephalic setae originate from the base of the cephalic capsule. Somatic setae of variable lengths abundant in the oesophageal region. The distal half of oesophagus crenulated. Short and conical tail. Caudal glands located post-anally. Vulva placed mid posteriorly.

Family PHANODERMATIDAE Filipjev, 1927

The family is characterized by the presence of a trilobed cephalic capsule or the cephalic capsule may be absent. Cervical capsule may be present or absent. Pre-cloacal supplements present in *Phanoderma, Phanodermella* and *Micoletzkja*, whereas *Crenopharynx* and *Phanodermopsis* lack supplements. Ocelli present or absent. Sub-cephalic setae present in most of the genera.

Genus *PHANODERMA* Bastian, 1865

Type species *Phanoderma cocksi* Bastian, 1865. Syn *Heterocephalus* Marion, 1870: 18. Syn *Cophonchus* Cobb, 1920: 328. Syn *Phanodermina* Allgen, 1939: 404. Subg *Alyncoides* Wieser, 1953. Subg *Phanoderma* Bastian, 1865. Revision Wieser, 1953: 48 – 51.

Phanoderma is distinguished by the strong trilobed cephalic capsule, often with striated posterior margin, short spicules and the presence of a precloacal supplement. Wieser (1953) subdivided *Phanoderma* species into two subgenera based on the presence or absence of ocelli. However the pigment in the ocelli can fade on preservation. Mainly the shape of the tail, spicule size and structure of the cephalic capsule differentiate species.

14. N14 ***Phanoderma (Phanoderma) campbelli*** Allgen, 1928

(Plate. 3: Fig. 13a & b; Plate. 4: Fig. 13c & d; Plate. 15: Fig. 80a, b, c & d)

Phanoderma tenuicolle Allgen, 1947 op Wieser 1953:51

Phanoderma (Phanoderma) Campbelli Allgen, 1928: 300; 1930: 250; 1933: 15; 1940: 490; 1947a: 92; 1951: 336; 1957: 11; 1959: 30; Wieser, 1953: 51; Mawson, 1956: 37; 1958a: 301; 1958b: 327.

Occurrence: Several male and female specimens were collected from the Cherai, Fort Kochi, Arthungal, and Sakthikulangara beaches during the summer and the post-monsoon seasons of the year.

Description

Male: L = 1.90mm; a = 36.5; b = 4.5; c = 27.1; Scale: 30μ

-	188	425	M	1830	1900μm
10.5	45	49	52	43	

Female: L = 1.32mm; a = 27.5; b = 3.6; c = 20.3; Scale: 30μ

-	165	365	?	1255	1320μm
10	44	48	48	35	

Male: Body cuticle smooth with anterior end attenuated. The head is small. Buccal cavity is supported by cuticular rods. Ten cephalic setae arranged in a circle. The six longer ones measure 40 - 45μm and the remaining four setae are 19-20μm in length. Somatic setae 6μ- 28μ long are arranged in six to seven whorls upto the posterior end of the oesophagus. Behind the oesophageal region, the setae are much shorter and reduced in number. Remnants of ocelli present in the male specimen examined. In certain specimens, a light circular amphid visible. Oesophagus characteristic with a crenulated appearance on the distal half. Tail conical with the dorsal surface convex and slightly concave on the ventral side. Caudal glands extent from the post-anal to the pre-anal region. Spicules measure 46μm as chord (1.06a.b.d.). A greatly reduced gubernaculum, 5-6μm long is present. Distinctly cuticularised, 11μm long tubular supplement is located at 57μm anterior to the cloaca.

Female: Lengths of various setae differ from the male specimens. Of the ten cephalic setae, the longer ones measure 30- 37 μm and the remaining ones are 20- 25 μm long. The somatic setae around the oesophagus are shorter than males. Eventhough a distinct vulva could not be located in the female specimen under description, a study of several females showed the position of vulva at 62% from the anterior end of the body.

Remarks: *Phanoderma campbelli* has been described and reported from different geographical locations by several workers like Allgen (1927, 1947),


Fig.10a


Fig.10b


Fig.10c


Fig.10d


Fig.11a


Fig.11b


Fig.11c


Fig.11d


Fig.12a


Fig.12b


Fig.13a

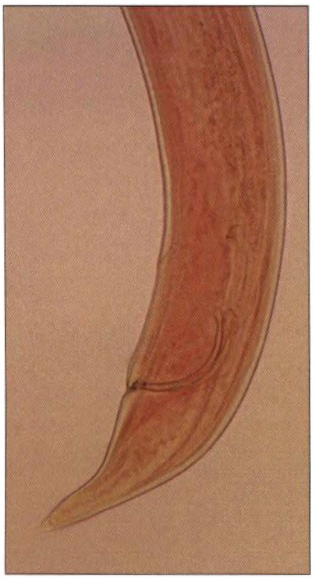


Fig.13b

Wieser (1951, 1953), Mawson (1956, 1958) and Palacin (1985). The specimens under consideration come close with the original description in the length and shape of spicule, type of tail, shape, disposition and presence of a single pre-cloacal supplement, in the arrangement of cephalic and somatic setae and the position of vulva in females. A comparison of the values of α, β and χ of the De Man's ratio as given by the earlier workers show a wide range of variation among themselves and this variation is noticed in the present specimens also. Mawson (1956) mentioned the possibility of lower α and χ values for shorter specimens. A marked difference noticed in the local forms in comparison with type description is the presence of extremely long cephalic setae in the former. The elongate setae reminds of *Phanoderma unica* described by Inglis (1964). The present material also shows resemblence with *P. parafilipjevi, P. segmenta and P. wieseri.* The extremely long and segmented spicule of *P. segmenta*; comparatively longer pre-anal organ and elongate spicule of *P.wieseri* and the spicule shape and pre- cloacal supplement of *Phanoderma parafilipjevi* makes the respective species distinct from the specimens at hand. Regardless of variation in the length of cephalic setae and the absence of minute sub-terminal setae, I refer the local forms to *Phanoderma (Phanoderma) campelli* with which they agree well. The present record extends the distribution of this species to Indian waters.

Distribution: Campbell Island (Allgen, 1932); Norway (Allgen, 1933; 1940); California, USA (Allgen, 1947; 1951); Chile (Wieser, 1953); Antarctica (Mawson, 1956; Allgen, 1959); Fuegian Archipelago (Mawson, 1958); Kerguelen Islands (Mawson, 1958).

Family ONCHOLAIMIDAE Filipjev, 1916

Type genus *Oncholaimus* Dujardin 1845, established as sub-family Oncholaimini by Filipjev, 1916: 105, raised to family by Baylis and Daubney, 1926:109, to suborder ONCHOLAIMINA by De Coninck, 1965: 658. Revision Kreis, 1934:1-271; Chitwood, 1960: 354.

Stomatorhabdions are heavily cuticular. Stoma somewhat capsuliform, only the posterior part surrounded by oesophagus.

Genus *METONCHOLAIMUS* Filipjev, 1918

Type species *Oncholaimus demani* Zur Strassen 1894, designated by Filipjev, 1918: 139. Revision Chitwood, 1960: 366.

Metoncholaimus is characterized by large left ventrolateral tooth, single ovary, elongated and slender spicule. A few species, however, do have short spicules, where a gubernaculum is present. Females have a demanian system.

15. N15 ***Metoncholaimus haplotretos*** Mawson, 1958

(Plate. 4: Fig. 14a & b; Plate. 15: Fig. 81a & b)

Metoncholaimus haplotretos Mawson, 1958: 305; Wieser and Hopper, 1967: 256 (sp inq)

Occurrence: A single female was present in the collection done in monsoon from Arthungal beach at a depth of 14 cms.

Description

Female: L = 2. 37mm; a = 40. 9; b = 5. 0; c = 34. 5; v = 83.7%; Scale: 30µ

-	200	470	1985	2301	2370µm
40	50	50	58	40	

Smooth body cuticle. Well developed buccal capsule measuring 49µm x 33µm with three teeth, the left subventral being the largest which is sharp and pointed measuring 24. 5µm from the anterior margin. Unequal cephalic setae measure 10µm and 6µm respectively. A few cervical setae, 7µm in length. Somatic setae,(7µm - 11µm) are found scattered. Caudal setae (3µm long) and two-minute terminal setae visible under oil immersion. A well developed demanian system present. Uvette located 125µm behind the vulva and 185µm anterior to anus. Osmosium could not be located. Only one external pore could be seen for the demanian system. Vulva located at 83.7% of the body length. Tail 1.7 a.b.d.

Remarks: Mawson (1958) described the species based on a single female present in the collection from Antarctica. The local specimen agrees well with the original description except for the slightly longer cephalic setae than Mawson's specimen. Moreover, the single pore of the demanian system confirms beyond doubt that the local specimen belongs to *Metoncholaimus haplotretos*. Restricted records along with the absence of information on the availability of this species in the Southern ocean islands like the Prince Edward Island archipelago and the Marion Island depict a distinct discontinuous distribution of this species.

Distribution: Antarctica (Mawson, 1958); Arabian Sea (present record).

Genus *ONCHOLAIMUS* Dujardin, 1845

Type species *Oncholaimus attenuatus* Dujardin, 1845; subsequent designation by Stiles and Hassal, 1905: 124. Syn *Oncholaimium* Cobb, 1930: 227 (type species *Oncholaimium appendiculatum* Cobb, 1930) op Rachor, 1969: 137. Revision Wieser, 1953: 109, 117; Chitwood, 1960: 362

The combination of large left ventrolateral tooth, single ovary and short spicule without gubernaculum serves to distinguish *Oncholaimus* from other oncholaimid genera. The accessory papillae and circumcloacal setae associated with copulation in the male helps in distinguishing the species within the genus.

16. N16 ***Oncholaimus flagellatus* Gerlach**, 1967

(Plate. 4: Fig. 15a & b; Plate. 15: Fig. 82a & b)

Oncholaimus flagellatus Gerlach, 1967: 28; Rachor, 1969: 132; 1970: 450, 452.

Occurrence: A single male specimen was present in the sample collected from Sakthikulangara during the monsoon season from the intertidal region.

Description

Male: L = 2. 27mm; a = 44. 5; b = 5.7; c = 49. 3; Scale: 20µ; 30µ

-	163	400	M	2224	2270µm
32	45	50	51	25	

Elongate body with smooth cuticle. The head truncated. Spacious buccal cavity, 30µm long and 15µm wide. Ventro lateral tooth is large and distinct. Amphid 7µm wide (0. 23c. d.) is located at 14µm from the anterior. Cephalic setae situated far anterior measure 7 - 12µm in length. Labial papillae are minute. Setae in line with the posterior margin of the buccal cavity are 10µm long. Cervical setae, 7µm long are seen scattered, surrounding the region of the oesophagus. Somatic setae that project out of the body absent. Excretory pore located at 64µm from the anterior end of the body. Cylindrical oesophagus with a slightly swollen posterior end. Bulb absent. Tail (1. 8 a. b. d.) is conical with a blunt posterior end. Caudal glands are pre-anal in position. Characteristic muscle bands present in the last quarter of the body.

Spicule, 60µm long (2.4 a. b. d) is diagonally straight. Gubernaculum absent. Cloaca surrounded by 6-7 pairs of circumcloacal setae of variable lengths (5µ - 15µ).

Remarks: The present specimen agrees well with *Oncholaimus flagellatus* described by Gerlach (1967) from the Red- Sea. However the slight curvature of the tail figured in the type specimen was not observed in the present form. This minor variation may not be of specific importance and hence assigned to *Oncholaimus flagellatus* Gerlach (1967).

Distribution: Red sea (Gerlach, 1967); Arabian Sea (present record).

17. N17***Oncholaimus brachycercus*** De Man, 1889

(Plate. 4: Fig. 16a & b; Plate. 15: Fig. 83a & b)

Oncholaimus brachycercus, De Man, 1889a: 211; Allgen, 1932: 113; Gerlach, 1952: 344; 1958: 73; Wieser, 1959: 25; Rao and Ganapati, 1968: 96; Rao, 1969: 94; Tietjen, 1969: 262; Warwick, 1971: 444.

Occurrence: A few female specimens were collected from Veli and Fort-Kochi in summer months and from Arthungal beach during monsoon season.

Description

Female: L = 0. 920mm; a = 18. 4; b = 3. 2; c = 24. 2; Scale: 30 µ

-	128	288	?	882	2270µm
33	46	48	50	29	

Medium sized stout body with a smooth cuticle. Large buccal cavity, 33µm deep and 25µm wide. Lips are small and round with minute labial papillae. Left ventrolateral tooth is the largest, measuring 15µm. Small dorsal tooth is 9µm long. Amphid pocket like, 8µm wide (0.23c. d.). Cephalic setae arranged in 6+4 pattern. The longer ones measure 15µm and the shorter 10µm in length. Body setae was absent. Oesophagus cylindrical with a distinct small triangular cardia at its posterior margin. Tail is extremely short with a distinct ventral curve. Minute setae (4µm in length) present on the tail. Caudal glands are pre-anal in position.

Remarks: *Oncholaimus brachycercus* De Man (1889) is a cosmopolitan species and has been reported from the east coasts of India (Rao and Ganapati, 1968; Rao, 1969). Apart from the features of buccal cavity, the specimens at my disposal come close to *Oncholaimus brachycercus* described by De Man (1889) from the English Channel and North Sea in the presence of a short tail (<2.5a.b.d.) and disposition of minute caudal setae. But the small size of the specimen in hand render them a low value for ‘a’ in contrast to the high value of De Man’s ratio given in the original description. The non-prominent vulvar region and the small size of the specimens question the maturity of the specimen. For the determination of the species, especially of this genus, a study of the characters of both the male and female are essential. Pending examination of male specimen, the specimens in hand are currently assigned to *Oncholaimus brachycercus*, De Man (1889).

Distribution: English Channel (De Man, 1889); North Sea (De Man, 1889); Campbell Island (Allgen, 1932); Mediterranean (Gerlach, 1952); Kiel Bay (Gerlach, 1958); Washington, USA (Wieser, 1959); New England, USA (Tietjen, 1969); Bay of Bengal (Rao and Ganapati, 1968; Rao, 1969).

Genus *VISCOSIA* De Man, 1890

Genus *Viscosia* De Man, 1890: 184 as sub genus of *Oncholaimus* Dujardin 1845, raised to genus by Filipjev, 1918: 122. Revision Wieser, 1953: 121; Wieser and Hopper, 1967: 258.

The genus *viscosia* is characterized by a combination of three sub-equal teeth in the buccal cavity, short spicule, absence of gubernaculum, males without copulatory bursa and female with paired ovaries. It is a large and difficult genus, the species being separated on the length of the cephalic setae or papillae, the size of the amphids, the form of dorsal and left sub-ventral teeth in the buccal cavity, the length of tail and the copulatory apparatus.

18. N18 ***Viscosia antarctica*** Allgen, 1959

(Plate. 4: Fig. 17a, b, c& d; Plate. 15: Fig. 84a, b, c & d)

Viscosia antarctica Allgen, 1959: 72.

Occurrence: Several male and female specimens were collected from Cherai, Fort Kochi, Sakthikulangara and Veli beaches during different seasons of the year.

Description

Male: L = 1.710mm; a = 35. 6; b = 6. 3; c = 28.0; Scale: 30µ

-	128	288	?	882	2270µm
33	46	48	50	29	

Female: L = 2. 448mm; a = 37. 6; b = 8. 5; c = 28. 5; v = 72.7%; Scale: 20µ

-	158	288	1745	2362	2448µm
27	46	55	65	38	

Male: Body cuticle is smooth; buccal cavity is much longer than broad. Lips are round. The three sharp unequal teeth measuring 9 - 10µm, 7. 5µm and 7µm Amphid 9µ - 10µ wide, is pocket like and located at 23µm from the anterior end. Cephalic setae arranged in 6+4 pattern. Longer setae measures 9 - 10µm in length and shorter ones 7µ - 8µ (0.35h. d.). Posterior margin of buccal cavity is surrounded by oesophageal tissue. Posterior end of oesophagus swollen. Somatic setae are 9µ - 11µ long and extent to the mid-oesophageal region. Excretory pore is located at 75µ from the anterior of the body. 6–7 pairs of circum-cloacal setae present. Tail is characteristic. The anterior third is conical and the remaining part is uniformly thin and filamentar. Paired spicules are 52 -53µm long, straight with sharp pointed distal ends. No gubernaculums. Supplement absent.

Female: Margin of the body cuticle smooth and distinct. Non – extended lips border the anterior end. Buccal cavity longer than wide. Pocket like amphid, 7µm wide located at 0.6h. d. from the anterior. Three highly sclerotised teeth larger in size than those in males. Arrangement of cephalic setae as in males. Somatic and caudal setae absent. Caudal gland extent from the post-anal region of the body.

Remarks: Allgen described the species in 1959 from the collection of Swedish Antarctic Expedition (1901-03). This species recorded mostly as males are characterized by the spicule structure and the specific shape of tail, uncommon to the genus. The present collection consisting of both males and females allow one to draw the specific features with fair degree of confidence. These specimens appear very similar to *Viscosia antarctica,* Allgen in the essential features like the shape of tail with a proximal conical part followed by a long extremely narrowed region, straight spicule with sharp pointed end and armature of buccal cavity. However, certain differences observed from the type description are the presence of round lips and the extremely small size of the specimens. The larger size of Allgen's specimens

PLATE – 4

EXPLANATION OF FIGURES

Fig. 13 ***Phanoderma campbelli***
a: Anterior end of female
b: Posterior end of female

Fig. 14 ***Metoncholaimus haplotretos***
a: Anterior end of female
b: Posterior end of female

Fig. 15 ***Oncholaimus flagellatus***
a: Anterior end of male
b: Posterior end of male

Fig. 16 ***Oncholaimus brachycercus***
a: Anterior end of female
b: Posterior end of female

Fig. 17 ***Viscosia antarctica***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig.13c

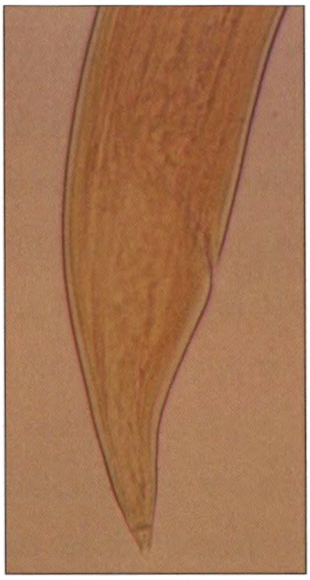


Fig.13d

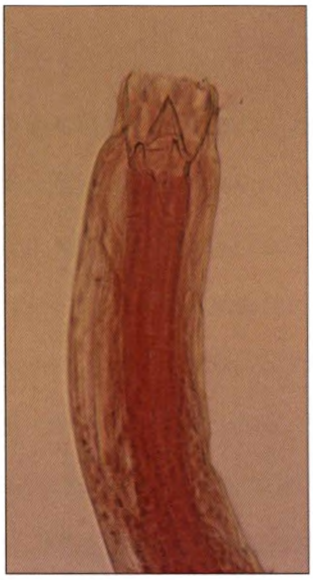


Fig.14a

Fig.14b

Fig15a

Fig.15b

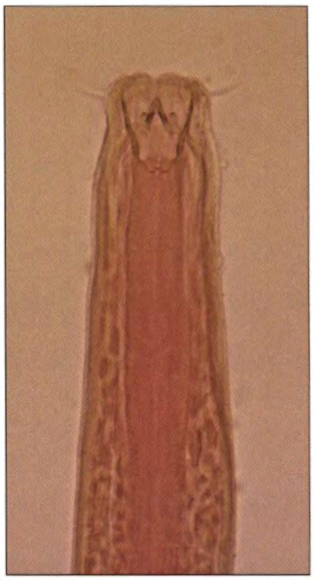


Fig.16a

Fig.16b

Fig.17a

Fig.17b

Fig.17c

Fig.17d

might probably be due to their occurrence in the higher latitudes and hence the variation in the values of De Man's ratio. The inadequate description of Allgen's species in respect of the disposition and size of different setae and amphid and the lack of description of females make a complete comparison difficult. The local forms also show resemblence with *Viscosia similes* Allgen, recorded from the same collection, in the form of buccal tooth, shape of tail and paired spicules. However, the swollen end of the spicule is a distinct feature not noticed in the present form. The present record extent the distribution of the species to the Indian waters.

Distribution: Falkland Islands; South Georgia (Allgen, 1959); Arabian Sea (present record).

Family TRIPYLOIDIDAE Filipjev, 1918

This family includes three genera – *Bathylaimus, Tripyloides* and *Gaerleanema*, with buccal cavity in sections. Amphid may be circular or rounded spiral. Labial setae of genus *Gaerleanema* with bulbous swelling.

Genus *BATHYLAIMUS* Cobb, 1894

Type species *Bathylaimus australis* Cobb, 1894: 409; syn *Cothonolaimus* Ditlevsen, 1919: 299; *Parabathylaimus* De Coninck and Stekhoven, 1933: 120 op Gerlach, 1951: 206. *Bathylaimoides* Allgen, 1947: 22 op Wieser, 1956: 30. Revision Wieser, 1956: 31.

Bathylaimus is distinguished from *Tripyloides* by the deeply incised lips and relatively large buccal cavity. The structure of the spicules and gubernaculum are rather uniform throughout the genus. The number of teeth on the distal end of the gubernaculum is best determined in ventral view. Characters used to separate the species are the length and form of the cephalic setae, the size and position of the amphids and the shape of the tail. Many older descriptions show the cephalic setae unjointed, but this feature has probably been overlooked and it is likely that all species have jointed setae. The buccal cavity varies considerably in appearance depending on the angle from which it is viewed. This is particularly true of the teeth-like structures in the posterior section.

19. N19 ***Bathylaimus capacosus*** Hopper, 1962

(Plate. 5: Fig. 18a, b, c & d; Plate. 15: Fig. 85a & b)

Bathylaimus capacosus Hopper, 1962: 48; Riemann, 1966: 55; Hopper, 1968: 1105.

Occurrence: A few female specimens including juveniles were collected from Veli and Arthungal beaches during the monsoon and post-monsoon seasons of the year. The description is based on a mature female specimen from Arthungal beach.

Description

Female: L = 1.295mm; a = 25.9; b = 3.6; c = 14.4; Scale: 30μ

-	111	355	785	1205	1295μm
25	45	47.5	50	35	

Body more or less cylindrical with smooth cuticle. Very fine internal striations present. Head with three deeply incised lips, bearing 20μm long labial setae. Their tips are slightly expanded. Among the cephalic setae, the six longer ones measure 43μm, with a flat terminal tip. The first segment of the elongate cephalic setae is 20 μm long. The posterior buccal cavity not as prominent as in certain other species of the genus. Teeth are absent. A 20μ long sclerotised rod located in the region of buccal cavity. Amphid, with an incomplete posterior margin is 8μm wide, corresponding body diameter 28μm, located at a distance of 30μ from the cephalic extremity. Setae in the cervical region are 8-10μm long and those on the distal half of the esophageal region measure 18μm. Somatic setae very few and scattered. Caudal setae measure around 8μm. No terminal setae. Caudal glands post-anal in position, the tail (2.6 a.b.d.) ends in spinneret gland. Vulva placed at 60.6% of the body length.

Remarks: Hopper (1962) described the species from Rhode Island waters, based on the structure and measurements of several females and males. The value of 'a' of De Man's ratio shows a range between 29.0 and 37.0. Later on, Hopper (1968) himself rediscovered the species specifying the need for the inspection of tube setae of caudal region in males and length of cephalic setae since those characters were overlooked in his original description. Riemann (1966) described *Bathylaimus capacosus* from Elbe estuary, North Sea. The specimen at my disposal compare well with the type description except for certain remarkable differences. The foremost amongst them is the presence of a sclerotised rod like structure in the anterior region of the present specimen. Slight variation in DeMan's value may be ecotypical, since variation in absolute lengths is quite possible in geographically separated areas. Furthermore, the elongated setae in the vulvar region could not be located in the present specimen. The local forms agree well in the disposition and length of labial and cephalic setae, amphid, and setae in the oesophageal region. The specimen also shows some resemblance with *B.bicoronatus* Wieser, (1954) and *B. paralongisetosus* Stekhoven and De Coninck, (1933). The smaller size and short cephalic setae (43µm Vs 60µm) of the specimens in hand make it distinct from *B. bicoronatus*. Hopper (1962) has mentioned that the taxonomic status of *B. bicoronatus* will remain uncertain until additional materials including males are examined from Puget Sound, the type locality. The fine body striations and lightly striated lip brings the local forms close to *B. paralongisetosus*. But the absence of a well-defined posterior buccal cavity separates it from the latter. All these features justify the inclusion of the present specimen under *Bathylaimus capacosus*.

Distribution: Rhode Island, USA (Hopper, 1962); North Sea (Riemann, 1966); Prince Edward Island, Canada (Hopper, 1968); Arabian Sea (present record).

Family TREFUSIIDAE Gerlach, 1966

Type genus *Trefusia,* De Man, 1893, established as subfamily of Oxystominidae by Gerlach, 1966: 35, raised to family (gradnov). For discussion Riemann, 1966: 24; Wieser and Hopper, 1967: 248.

Cephalic setae jointed or unjointed; amphid may be circular or pocket like; cervical papillae present in *Trefusia* and *Rhabdocoma.* Female may be didelphic or monodelphic as in *Rhabdocoma.*

Genus *RHABDOCOMA* Cobb, 1920

Type species *Rhabdocoma americana* Cobb, 1920: 252.

Rhabdocoma is characterized by segmented cephalic setae, circular amphid and presence of cervical papillae. Females have a single ovary posterior to the vulva and males have 12 to 16 pre-cloacal papillae.

20. N20 ***Rhabdocoma obtusicaudata*** (Chitwood, 1936) Ott, 1977 comb nov

(Plate. 5: Fig. 19a & b; Plate. 15: Fig. 86a & b)

Cytolaimium obtusicaudatum Chitwood, 1936: 13; op Gerlach, 1962: 93.

Cytolaimium exile Cobb, 1920: 252; Gerlach, 1962: 93; Wieser and Hopper, 1967: 249; Rao and Ganapati, 1968: 101; Rao, 1969: 95.

Rhabdocoma obtusicaudata (Chitwood, 1936) ott, 1977: 120.

Occurrence: Only one female specimen was present in the sample collected from Fort-Kochi during monsoon season.

Description

Female: L = 1.2mm; a = 70.6; b = 6.2; c = 20.3; Scale: 30μ

-	?	193	?	1141	1200μm
13	?	17	17	17	

Body extremely slender, almost cylindrical throughout its length. Cuticle thin, smooth and devoid of somatic setae except at the cervical region. Head with three lips, bearing minute papillae. Segmented cephalic setae are 16μm long. Stoma conical and unarmed. Amphid with a break at the posterior margin, located at 18μm from the anterior margin of the specimen. At the level of the posterior margin of amphid, four 6μm long sublateral setae present. Oesophagus is cylindrical. Vulva located somewhat in the middle region of the body. Tip of tail rounded.

Remarks: The distinction between *Rhabdocoma* and *Trefusia* are drawn from the presence or absence of buccal cavity and monodelphic or didelphic nature of ovaries. The present identification is based on a female specimen. *Rhadocoma obtusicaudata* was identified as *Cytolaimium exile* Cobb (Ott, 1972) accepting synonimisation by Gerlach (1962), which is based on Chitwood's text. Gerlach viewed *C.obtusicaudatum* Chitwood, 1936 as a synonym of *C.exile* Cobb, 1920. The present material shows close similarity with *R. obtusicaudata* described by Ott (1977) except in the shape and length of the tail. Even though the shape of tail of the local form compare with that of *Trefusia varians* Gerlach, 1955, the female specimen available now is assigned to *Rhabdocoma obtusicaudata*, Chitwood as Gerlach felt that the shape of tail is not a taxonomically important feature in this genus. The paucity of material and lack of male individuals restricts further comments on this species from the Arabian Sea.

Distribution: Florida, USA (Cobb, 1920); North Carolina, USA (Chitwood, 1936); Maldive Islands (Gerlach, 1962); Bay of Bengal (Rao and Ganapati, 1968; Rao, 1969); West Atlantic (Ott, 1977); Arabian Sea (present record).

Family XYALIDAE Chitwood, 1951

Xyalids typically have the following characters: transversely striated cuticle; ten cephalic setae in a single circle, six always equal to or longer than the other four, often with additional cephalic setae; anterior ovary or testis to the left of the intestine, posterior testis if present to the right; buccal cavity conical, usually without teeth.

Genus *DAPTONEMA* Cobb, 1920

Established as genus *Daptonema* Cobb, 1920: 281; reduced to sub genus of *Theristus* Bastian, 1865 by Wieser, 1956: 78. Revision Wieser, 1956a: 84; 1959a: 88. Raised to genus *Daptonema* by Lorenzen, 1977: 197.

Daptonema has 10-14 cephalic setae in six groups, unarmed conical buccal cavity; conico-cylindrical tail with terminal setae; somatic setae not much longer than 1c.d.; spicules short, less than 2a.b.d. Mainly the relative length of setation, size and position of amphid, size and structure of the copulatory apparatus and the shape and length of the tail distinguish species.

21. N21 ***Daptonema psammoides*** (Warwick, 1970) comb nov

(Plate. 5: Fig. 20a, b, c & d; Plate. 15: Fig. 87a, b, c & d)

Trichotheristus psammoides Warwick, 1970.

Theristus (trichotheristus) psammoides Warwick, 1970: 163; 1971: 446.

Occurrence: Several male and female organisms were collected from Cherai, Fort Kochi, Arthungal, and Sakthikulangara beaches during the summer, monsoon and post – monsoon seasons of 2005- 06.

Description

Male: L = 0.720 – 0. 910mm; a = 23. 2 – 25.3; b = 3.8 – 4.1; c = 5.6 – 5.9

$$\frac{-\qquad 95\qquad 238\qquad M\qquad 757}{20\qquad 35\qquad 35\qquad 36\qquad 30}\ 910\mu m$$

Female: L = 0. 920 – 1.07mm; a = 24.9 – 26.8; b = 3.8 – 4.7; c = 6.1 – 6.7; v = 63% - 67.3%; Scale: 30µ

$$\frac{-\qquad 104\qquad 280\qquad 720\qquad 910}{20\qquad 34\qquad 36\qquad 40\qquad 27}\ 1070\mu m$$

Annulated body cuticle. Buccal cavity cup shaped. Cephalic setae in 6+4 pattern. Longer setae, 14µ - 17µ (0.7 - 0. 8h.d.) and shorter ones 10 - 11µm (0.5 - 0.6h.d.) in length. Surroundingthe region of oesophagus, several somatic setae (0.7 – 1.0c.d.) are present.. Amphid conspicuous only in a few specimens. Amphid Circular, 6µm (0. 25c.d.) in diameter. Tail 4.7 – 4. 9a. b. d. Terminal setae 6µm - 10µm in length. Caudal glands post-anal in position. Spicules 26µ - 30µm (1.0 – 1. 2a. b. d.) as chord, circuate, cephalate proximally. Gubernaculum 9 - 10µm with a short dorsal apophysis of 5 to 6µm in length. Vulva posterior to middle region of the body.

Remarks: Though the genus is a complex one, the materials before me are assigned under the genus *Daptonema* by virtue of the conico – cylindrical tail without terminal setae. The length of the cephalic setae and somatic setae, size and shape of tail and the structure and size of the spicule agree remarkably well with *Daptonema psammoides* Warwick (1970). A well-defined amphid as is shown in the type specimen could not be identified in many of the male and female specimens. The position of vulva seems to vary. Notwithstanding the variation noticed the present specimens are tentatively assigned to *Daptonema psammoides,* Warwick.

Distribution: English Channel (Warwick, 1971); Arabian Sea (present record).

22. N22 ***Daptonema setifer*** (Gerlach, 1952)

(Plate. 5: Fig. 21a & b; Plate. 6: Fig. 21c & d; Plate. 16: Fig. 88a, b, c & d)

Theristus setifer Gerlach, 1952: 366.

Mesotheristus setifer (Gerlach 1952) Wieser, 1956a: 91.

Occurrence: Several male and female individuals were collected from Cherai, Fort Kochi, Arthungal and Veli beaches during different seasons of the year.

Description

Male: L = 1.310mm; a = 37.4; b = 4.5; c = 10.9; Scale: 30µ

$$\frac{-\qquad 105\qquad 290\qquad M\qquad 1190}{22\qquad 40\qquad 43\qquad 44\qquad 33}\ 1310\mu m$$

Female: L = 1.430mm; a = 33. 3; b = 4. 3; c = 10.4; V = 53. 5%; Scale: 30µ

$$\frac{-\qquad 104\qquad 330\qquad 765\qquad 1292}{24\qquad 40\qquad 43\qquad 44\qquad 33}\ 1430\mu m$$

Male: Cuticle annulated, the annulations originate behind the cephalic capsule. Cephalic setae 18 to 22µm long, arranged in two whorls. Regularly arranged somatic setae (1. 8 – 2. 7h.d. long) present upto the mid oesophageal region. Amphid not distinct. Caudal setae present. Terminal setae comparatively long (26µm). Tail 4.1a.b.d., distal quarter cylindrical. Spicule L-shaped, 32µm long (1.1a.b.d.) as chord and bifurcate distally. Gubernaculum tubular; apophysis not prominent.

Female: Annulated body. Specimens stouter than males. Cephalic setae 1.0h.d. Cervical and somatic setae are long (1. 6 – 3. 2h.d.). Elongated setae are absent beyond the oesophageal region. 2 to 3 caudal setae (5 -13µm long) present. Terminal setae (6µm long) are shorter in females. Tail, 4.1a.b.d.

Remarks: A scrutiny of the characters of genera *Daptonema* and *Theristus* of the family Xyalidae has shown that these two genera are closely allied ones. Species belonging to *Daptonema* are different from those of *Theristus* only by the morphology of the tail and the presence or absence of terminal setae. However, the material before me comes close to certain species of *Theristus* in respect of spicular structure, although the distinct conico-cylindrical tail with terminal setae justifies the inclusion of the present forms under the genus *Daptonema*. Even though the structure and size of the male specimen fits well with the description of Gerlach's *Daptonema*

PLATE – 5

EXPLANATION OF FIGURES

Fig. 18 ***Bathylaimus capacosus***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig. 19 ***Rhabdocoma obtusicaudata***
a: Anterior end of female
b: Posterior end of female

Fig. 20 ***Daptonema psammoides***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig. 21 ***Daptonema setifer***
a: Anterior end of male
b: Posterior end of male

Fig.18a

Fig.18b

Fig.18c

Fig.18d

Fig.19a

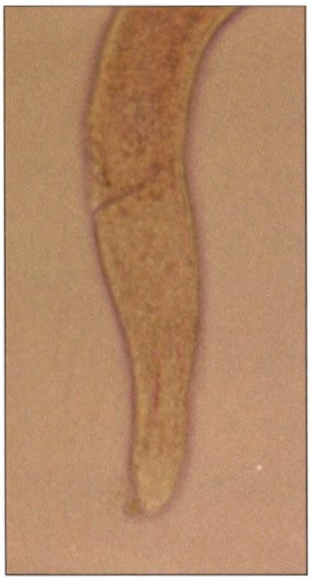


Fig.19b

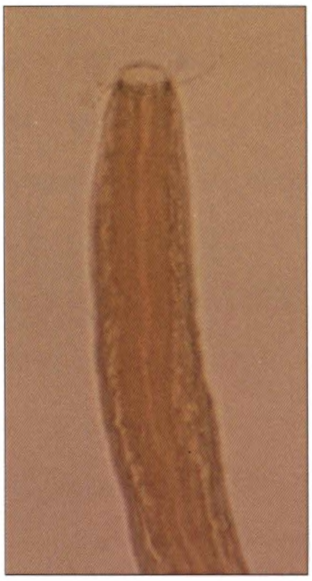


Fig.20a

Fig.20b

Fig.20c

Fig.20d

Fig.21a

Fig.21b

PLATE – 15

EXPLANATION OF FIGURES

Fig. 77 ***Enoploides brunettii***

c & d: Anterior and posterior end of female

Fig. 78 ***Oxyonchus culcitatus***

a & b: Anterior and posterior end of male

c & d Anterior and posterior end of female

Fig. 79 ***Trileptium anomala***

a : Anterior end of female; b: posterior end of female

Fig. 80 ***Phanoderma campbelli***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 81 ***Metoncholaimus haplotretos***

a: Anterior end of female; b: Posterior end of female

Fig. 82 ***Oncholaimus flagellatus***

a: Anterior end of male; b: Posterior end of male

Fig. 83 ***Oncholaimus brachycercus***

a: Anterior end of female; b: Posterior end of female

Fig. 84 ***Viscosia antarctica***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 85 ***Bathylaimus capacosus***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 86 ***Rhabdocoma obtusicaudata***

a: Anterior end of female; b: Posterior end of female

Fig. 87 ***Daptonema psammoides***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 77c

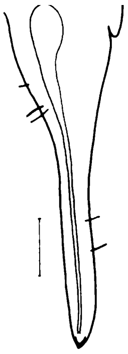


Fig. 77d

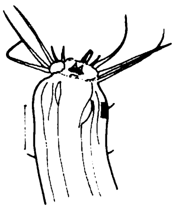


Fig. 78a

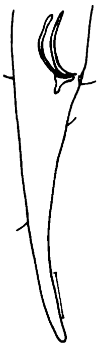


Fig. 78b

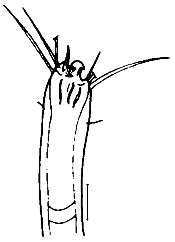


Fig. 78c

Fig. 78d

Fig. 79a

Fig. 79b

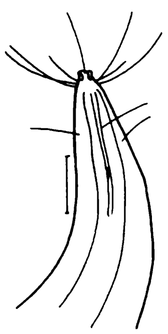


Fig. 80a

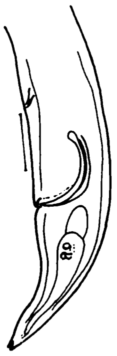


Fig. 80b

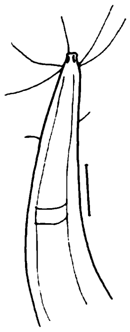


Fig. 80c

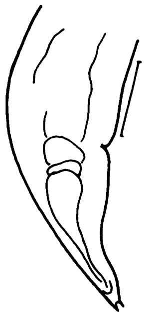


Fig. 80d

Fig. 81a

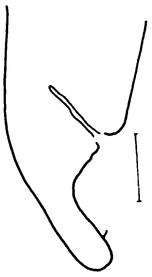


Fig. 81b

Fig. 82a

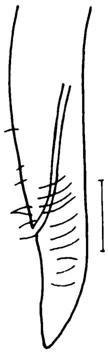


Fig. 82b

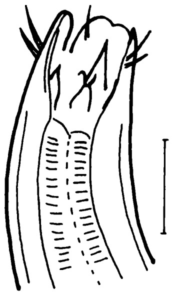


Fig. 83a

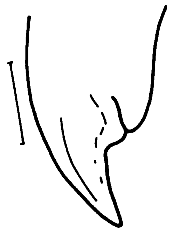


Fig. 83b

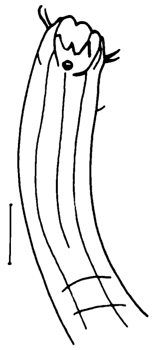


Fig. 84a

Fig. 84b

Fig. 84c

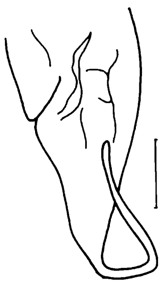


Fig. 84d

Fig. 85a

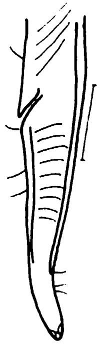


Fig. 85b

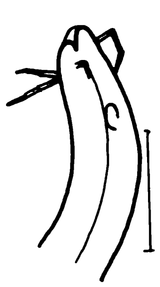


Fig. 86a

Fig. 86b

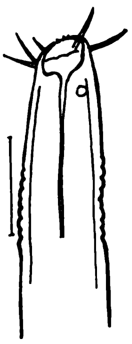


Fig. 87a

Fig. 87b

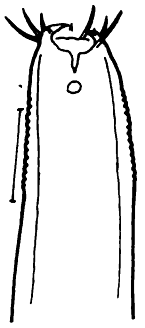


Fig. 87c

Fig. 87d

biggi, it is different from the aforesaid species in the general body size, distribution and length of different setae and shape of tail. The present specimens can be placed close to *Daptonema setifer,* Gerlach (1952) in many respects. The size and distribution of somatic setae, the shape and size of spicule and the shape of tail show resemblance to Gerlach's species. However, the difference in the shape of the buccal cavity and minute apophysis is noticeable. Moreover, the paucity of the original description of a female specimen of the type species makes a comparison impossible. These minor differences are not considered of specific importance and hence the present assignment.

Distribution: Mediterranean (Gerlach, 1952,1953,1954,1955); Portugal (Gerlach, 1954); Bay of Biscay (Delamare *et al.,* 1955); Red Sea (Gerlach, 1967); Exe Estuary, South west England (Warwick, 1970); Arabian Sea (present record).

23. N23 ***Daptonema vicinum*** (Riemann, 1966)

(Plate. 16: Fig. 89a & b)

Theristus (Cylindrotheristus) vicinus Riemann, 1966: 105; Jayasree, 1976.

Occurrence: Very few male specimens were collected from Cherai and Veli beaches during summer and post-monsoon seasons of the year.

Description

Male: L = 1.145mm; a = 28.5; b = 4.3; c = 8.1; Scale: 30µ

$$\frac{-}{20}\quad\frac{104}{33}\quad\frac{268}{34}\quad\frac{M}{40}\quad\frac{1104}{33}\quad 1145\mu m$$

Annulated body cuticle without punctuation. Unequal cephalic setae, 8µ - 12µ long. Somatic setae minute and scattered. Single circle of 33 - 34µm long setae present at the proximal part of the oesophagus. Amphid, 5µm in diameter (0. 25c.d.). Tail, 4. 3a.b.d., is conico-cylindrical. Caudal glands arranged in tandem, are post-anal in position. Spicules measure 27-

28µm (0.8a.b.d.) as chord, L-shaped, cephalate at the proximal end and undulating distally. Gubernaculum has a short apophysis. Pre-cloacal supplements absent.

Remarks: Genus *Daptonema,* earlier considered as a sub genus of the supergenus *Theristus* was accorded generic rank by Riemann in 1966. The specimens agree well with *Daptonema vicinum* Riemann, 1966 on account of structure and form of L - shaped spicule. , proximally cephalic and undulating distally does exhibit some variations in respect of the presence of a circle of elongated setae. Notwithstanding this minor difference, the specimens at hand are assigned to *Daptonema vicinum* Riemann, 1966. The present record extends the distribution of the species to the tropical waters.

Distribution: North Sea (Riemann, 1966); East Scotland (Jayasree, 1976); Arabian Sea (present record).

Genus *THERISTUS* Bastian, 1865

as *Theristus* sub genus *Theristus sensu stricto.* Revision Wieser, 1956a: 80, 83; 1959a: 87.

The genus is characterized by the presence of 10-14 cephalic setae in six groups; unarmed conical buccal cavity; somatic setae not longer than 1.0 c.b.d., conical tail without terminal setae and short spicules, less than 2 a.b.d.

24. N24 ***Theristus acer*** Bastian, 1865

(Plate. 6: Fig. 22a, b, c & d; Plate. 16: Fig. 90a, b, c & d)

Theristus subg *Theristus acer* Bastian, 1865: 156; De Man, 1928: 97; Allgen, 1934: 64; 1935: 27; 1959: 178; Gerlach, 1951c: 383; 1965: 163; Wieser, 1959a: 91; Riemann, 1966: 80; Rao and Ganapati, 1968: 102; Hopper, 1969: 687; Warwick, 1971: 444 – 445; Heip, 1971: 193.

Occurrence: Several male and female specimens were collected from all the beaches along the Kerala coast during the summer and monsoon seasons of the year.

Description

Male: L = 0. 870mm; a = 31. 6; b = 4. 9; c = 7. 1; Scale: 30μ

-	?	176	M	747.5	870μm
15	?	25	27.5	27.5	

Female: L = 0. 800mm; a = 32. 0; b = 4. 7; c = 7. 3; V = 64. 4%; Scale: 30μ

-	45	170	515	690	800μm
15	25	27.5	27.5	27.5	

Male: Small slender body with annulated body cuticle. Buccal cavity wider than long. Amphid, 6μm in diameter is located at 1.1h.d.from the anterior end. Cephalic setae are 0.5 – 0.7h.d. in length. Somatic setae are short (5μ - 7.5μ long), scattered and sparse. Tail is conical, 4. 5 a.b.d. in males. Spicule is 34μm (1. 23 a.b.d.) as chord, L-shaped with proximal half bent ventrally, and the gubernaculum with a distinct plate like apophysis.

Female: Amphid, 6μm in diameter is located at 0. 83 h.d. from the anterior margin. Cephalic setae extent upto 0.83 h.d.The conical tail is 4.0 a.b.d. Ovaries are paired and stretched.

Remarks: The specimens at my disposal resembles remarkably with Warwick's (1971) description of the species from the English Channel. These are easily assignable to *Theristus acer* Bastian (1865) by virtue of the distribution and length of cephalic setae, type of tail, position of vulva and above all, the structure of spicule, which is typical of the type species. The only variation observed in comparison with the original description is the smaller size of the present specimens, which may be due to the tropical situation. Considering this as an ecotypical variation, the present materials are assigned to *Theristus acer* Bastian (1865). This particular species, which enjoys a cosmopolitan distribution, has been reported earlier from

India (Bay of Bengal) by Rao and Ganapati (1968). This species was not collected from the Arthungal beach.

Distribution: English Channel (Bastian, 1865; Wieser, 1951; Warwick, 1971); North Sea (De Coninck and Stekhoven, 1933; Stekhoven, 1935; Schulz, 1938; Bresslau and Stekhoven, 1940; Gerlach, 1951; 1953; 1959; Riemann, 1966; Lorenzen, 1969; Heip, 1971); Norway (Allgen, 1934; 1939; 1949); Mediterranean (Wieser, 1954); Kiel Bay (Schultz and Kinne, 1955; Gerlach, 1958; Ohm, 1964); Falkland Islands (Allgen, 1959); Bay of Bengal (Rao and Ganapati, 1968); Washington, USA (Wieser, 1959); Arabian Sea (present record).

25. N25 ***Theristus sp.***

(Plate. 6: Fig. 23a & b; Plate. 16: Fig. 91a & b)

Occurrence: Several male and female individuals were collected from Cherai beach during the summer and monsoon seasons of the year and two specimens from Fort Kochi beach.

Description

Male: L = 0.840mm; a = 24; b = 4.6; c = 11.2; Scale: 30μ

-	80	180	M	765	840μm
13	25	28	35	26	

Female: L = 0.680mm; a = 21.9; b = 5.07; c = 9.3; Scale: 30μ

-	52	120	?	607	680μm
13	25	28	31	23	

Male: Annulated body is small, without punctuations. Oval amphid, 4μm in diameter is located 13μm from the anterior. Cephalic setae include six longer (0.77c.d) and four slightly shorter ones. Setae around the region of amphid measure 13 to 14μm. Tail is short (2.9a.b.d.) and conical without terminal setae. Spicules are flat and plate like, measuring 23μm in length. Gubernaculum not distinct. Apophysis absent.

Female: Smaller than males. Cephalic setae are 12 to 15µm in diameter. Amphid similar to that of males are placed at 1.1h.d from the anterior. The conical tail is 3.2a.b.d. Vulva could not be located.

Remarks: About 71 species have hitherto been described under the genus *Theristus*. The presence of large number of related individuals necessitate a continuous revision of this and the related genera. The lot of specimens collected during the present study was small to medium sized. A comparison of the present materials with the available literature and figures did not help to reach a conclusion about the specific identity of the organisms. The flat plate like short spicule seemed to be quite different from the related individuals of the genus. The specimens underwent some sort of shrinkage and the tail remained curled. As a more detailed examination of fresh specimens are needed, the specimens at hand are not assigned to any species.

Genus ***PARAMONOHYSTERA*** Steiner, 1916

Paramonohystera Steiner, 1916: 639, established as subgenus of *Monhystera* Bastian, 1865, raised to genus by Filipjev, 1918: 279

Subg *Paramonohystera* Steiner, 1916

Subg *Leptogastrella* Cobb, 1920

Revision Wieser, 1956a: 66; 1959a: 84

The genus is characterized by the presence of 10 – 14 cephalic setae in six groups; unarmed simply conical buccal cavity; conico-cylindrical tail with terminal setae; somatic setae may be longer than 1c.d. Spicules are elongate (>2 a.b.d.) and slender.

26. N26 ***Paramonohystera albigensis*** (Riemann, 1966)

(Plate. 6: Fig. 24a, b, c & d; Plate. 16: Fig. 92a & b)

Promonhystera albigensis Riemann, 1966: 75.

Daptonema albigensis Hopper, 1968: 1110.

Occurrence: Several male specimens were collected from Cherai and Arthungal beaches and a few specimens from Fort-Kochi beach in different seasons of the year.

Description

Male: L = 1. 53mm; a = 43. 09; b = 3. 8; c = 15. 3; Scale: 30µ

$$\frac{-\qquad 100\qquad 400\qquad M\qquad 1430}{30\qquad 32\qquad 32\qquad 35.5\qquad 28}\ 1530\mu m$$

Body cuticle is annulated. Six cephalic setae are longer, (20µm) and four shorter, (15µm). Circular amphid is 5µm (0.21c.d.) in diameter. Regularly arranged somatic setae reaches up to 65µm (2.0 c.d.) in length. Behind the mid oesophageal region, somatic setae are fewer and shorter (6µ - 12µ). A pre-cloacal seta is 16 to 17µm in length. Post – cloacal setae measure up to 40µm. Variability in length (20 - 36µm) is shown by paired terminal setae. Spicules are 76µm to 77µm (2.7a.b.d.) in length, slender with a characteristic dilation distally; the proximal end seems to be hooked. Gubernaculum curved and cuticularised, ventral to spicule. Apophysis absent.

Remarks: A comparative study of the available literature and figures reveal the specimens to be distinct from the different species of *Paramonohystera*, hitherto described, on account of the structure of the spicule. The long and slender spicule (>2 a.b.d.) of the present specimen justifies its inclusion in this particular genus, eventhough structurally it resembles *Metadesmolaimus gaelicus*, Platt. The proximal structure of the spicule compares with the spicule of *Enoploides brunetti.* The general form of the body, elongated somatic setae, long terminal setae and the length and form of spicule brings the local forms close to *Paramonohystera albigensis* (Riemann, 1966). However, long somatic setae were not observed all through the body length and the tail was shorter. Eventhough, lack of female description makes comparison difficult, the present specimen is tentatively assigned to *Paramonohystera albigensis.*

PLATE – 6

EXPLANATION OF FIGURES

Fig. 21 ***Daptonema setifer***
c: Anterior end of female
d: Posterior end of female

Fig. 22 ***Theristus acer***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig. 23 ***Theristus sp.***
a: Anterior end of female
b: Posterior end of female

Fig. 24 ***Paramonhystera albigensis***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig.21c

Fig.21d

Fig.22a

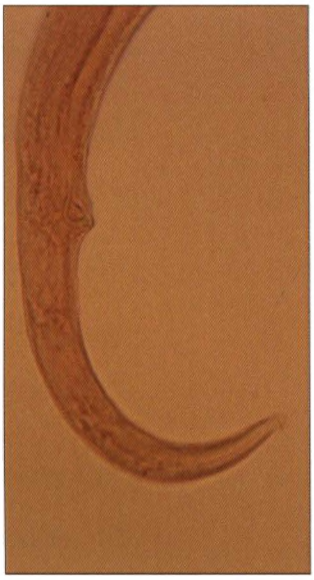


Fig.22b

Fig.22c

Fig.22d

Fig.23a

Fig.23b

Fig.24a

Fig.24b

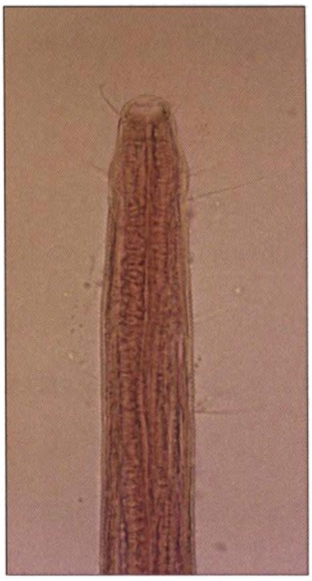


Fig.24c

Fig.24d

Distribution: North Sea (Riemann, 1966); Prince Edward Island, Canada (Hopper, 1968); Arabian Sea (present record).

Genus *RHYNCHONEMA* Cobb, 1920

Type genus *Rhynchonema* Cobb, 1920 established by De Coninck, 1965: 620. Revision Vitiello, 1967: 119.

Cuticle is distinctly annulated; buccal cavity is elongated; anterior third of oesophagus region is attenuated; amphid posterior to attenuated section.

27. N27 ***Rhynchonema hirsutum*** Hopper, 1961

(Plate. 7: Fig. 25a, b, c & d; Plate. 16: Fig. 93a, b, c & d)

Rhynchonema hirsutum Hopper, 1961a: 362.

Rhynchonema cinctum sensu Gerlach, 1955: 300 op Hopper, 1961: 361.

Occurrence: Several male and female specimens were collected from Cherai, Sakthikulangara and Veli beaches during different seasons of the year.

Description

Male: L = .525 mm; a = 21; b = 4.0; c = 7.5; Scale: 30µ

$$\frac{-}{2.5}\quad\frac{?}{?}\quad\frac{130}{23}\quad\frac{M}{25}\quad\frac{455}{24}\quad 525\mu m$$

Female: L = .500 mm; a = 20.4; b = 3.7; c = 7.8; v = 70%; Scale: 20µ

$$\frac{-}{2.5}\quad\frac{?}{?}\quad\frac{134}{24}\quad\frac{M}{24.5}\quad\frac{455}{18}\quad 500\mu m$$

Body strongly annulated through out. Annules spread at 1.5µm. Anterior region upto the level of amphid is highly narrow, forming a beak like neck region bearing 36-45 annules. Six cephalic setae 2-3µm long are visible. Stoma 48 µm long and 2.5 µm wide. In males, 2-3 sets of 6µm long setae are seen on either sides of the stoma. In females, only a few setae are observed. Amphid, 6-7µ in males and 4.5 µ in females are located opposite to stoma, at 45-47 µm from the proximal end. Body diameter at amphid is

9-10 µm. Body posterior to the base of the neck is of uniform diameter (24µm) up to the anal region. Somatic setae regularly arranged posterior to the amphid. They are longer (10µ -20µ) in females and shorter in males. Oesophagus conoid, 7.5µm wide anteriorly and 15µm wide posteriorly. Tail conical, with a terminal spinneret. Minute caudal setae found scattered. Caudal glands post anal.

Spicules 18µ long (as chord). Gubernaculum 6µm with a caudally directed apophysis. Three furrows visible anterior to the anus in the hypodermis and musculature. Their distances from the cloacal opening are 25µ, 43µ and 60µm respectively. Ovary single and outstretched.

Remarks: Of all the species hitherto described under the genus *Rhynchonema,* the form under consideration resembles *Rhynchonema hirsutum* Hopper, 1961 remarkably, in cardinal features like the values of De Man's ratio, position and diameter of amphid, distribution and length of cervical and somatic setae and the nature of spicules. Spicule length as 26µm given by Hopper (loc.cit.) is the absolute length as against 18µm in the local specimens, which is measured as chord. Hopper (loc.cit.) in his differential diagnosis has specified that the only difference between his description of *R. hirsutum* as n.sp., and *R. cinctum* of Gerlach, of 1955 is in the length of the spicules, which is 26µm and 21µm respectively. All these features substantiate the inclusion of the specimens before me as *Rhynchonema hirsutum.* It has to be noticed that the specific importance given to the length of the spicule could create taxonomic ambiguities, should the size of the spicules vary as a function of growth and age of the specimens. Govindankutty (Ph.D thesis, 1967) has reported the presence of this species on the Arabian coast.

Distribution: El Salvador (Gerlach, 1955); Alabama, USA (Hopper, 1961); Arabian Sea (present record).

Genus *PRORHYNCHONEMA* Gourbault, 1982

Prorhynchonema Gourbault, 1982: 75-87.

This genus is characterized by distinctly annulated cuticle, less elongated buccal cavity than *Rhynchonema,* but attenuated head, amphid posterior to attenuated section and the reproductive apparatus with spermatophora.

28. N28 ***Prorhynchonema warwicki*** Gourbault, 1982

(Plate. 7: Fig. 26a & b; Plate. 16: Fig. 94a & b)

Prorhynchonema warwicki Gourbault, 1982: 78.

Occurrence: One specimen was present in the collection from the intertidal area of Sakthikulangara beach in summer season and a set of three specimens were collected from Cherai beach during the post- monsoon month.

Description

Male: L = 0. 583mm; a = 19.1; b = 6. 6; c = 8. 3; Scale: 30μ

$$\frac{-}{6}\quad\frac{60}{28}\quad\frac{88}{28}\quad\frac{M}{30.5}\quad\frac{513}{27}\quad 583\mu m$$

Annulated body cuticle; head is attenuated and measures 36μm upto the region of amphid; circular amphid is 3-3.5μm in diameter. There are about 35-36 annules upto the level of amphid. Cephalic setae are 7μm long. Oesophagus with a short oesophageal bulb. Spicule measures 20μm as chord. Distal end of spicule projects out. Gubernaculum with a short gubernacular apophysis. Pre-cloacal supplement absent. Tail is conical. Caudal setae were not observed.

Remarks: Only one species has hitherto been described under the genus *Prorhynchonema.* The characteristic morphology and length of the attenuated head of the material before me justify the inclusion of this specimen under the aforesaid genus. The specimen compares well with *Prorhynchonema warwicki* described by Gourbault (1982), in the shape of attenuated head, location and size of amphid and the shape of spicule. However, the comparatively short oesophagus with posterior bulb and the absence of triradiate spines at the distal end of the spicule are conspicuous. Despite these differences, the specimen under consideration is placed tentatively, under *Prorhynchonema warwicki* Gourbault (1982), since the paucity of material prevents a more detailed comparison of spicular structure so as to establish this as a new species under the genus.

Distribution: Guadelope, Mexico (Atlantic) (Gourbault, 1982); Arabian Sea (present record).

Family CERAMONEMATIDAE Cobb, 1933

The characteristics of the family are thick, coarsely annulated cuticle in the form of overlapping plates with longitudinal ridges; unstriated cephalic capsule on which amphids are situated; labial sensilla not discernible; usually 6+4 cephalic sensilla, sometimes only four; amphids usually Ω - shaped; minute buccal cavity; conical tail with an unstriated tip; paired and opposed testes and ovaries. Ovaries are reflexed.

Genus *CERAMONEMA* Cobb, 1920

Ceramonema Cobb, 1920: 264.

Ceramonema has 70 –280 often transversely undulating cuticle annules; eight longitudinal cuticle ridges or crests; 6+4 cephalic setae.

29.N29 ***Ceramonema africana*** Furstenberg, 1993

(Plate. 7: Fig. 27a & b; Plate. 16: Fig. 95a & b)

Ceramonema africana Furstenberg and Vincx, 1993: 139.

Occurrence: A male specimen was collected from the low tide area of Veli beach during the post-monsoon season.

Description

Male: L = 1.13mm; a = 45. 2; b = 6.1; c = 10. 8; Scale: 30µ

-	?	185	M	1025	1130µm
14	?	23	25	25	

Conspicuously annulated slender body. Each annule is divided into eight longitudinal cuticular plates; the annules are 5- 6µm wide anteriorly, 9µm wide in the middle region followed by 7µm wide annules in the pre-cloacal region; cuticle is also marked by faint transverse undulations. Cuticle measures 9µm in length. Total number of annules 153, including the 27 annules in the tail. The unstriated terminal cone is 19µm in length. Cephalic capsule is 22µm long and 20µm wide at the widest point. An anterior circle of six setae of 12- 15µm long and posterior circle of four setae of 9µm length. Amphid is an oval loop, 12-13µm long and 6µm wide. Tail is 4. 2 a. b. d. in length. Curved spicules measure 21-22µm as chord with a 16-18µm long and backwardly directed gubernaculum. Testes remain masked by cuticular ornamentation.

Remarks: The present specimens are easily assignable to *Ceramonema africana* Furstenberg by virtue of the shape and size of amphid, relative size of buccal capsule, body ornamentation and structure and size of the spicule. However, a distinctly wide cloacal annule present in the original species could not be seen in the present form. Notwithstanding this variation, the local forms are assigned to *Ceramonema africana* Furstenberg and Vincx, 1993.

Distribution: South Africa (Furstenberg and Vincx, 1993); Arabian Sea (present record).

30. N30 ***Ceramonema sp.***

(Plate. 7: Fig. 28a & b; Plate. 16: Fig. 96a & b)

Occurrence: Seven male specimens were collected from Cherai and one specimen from Veli beach in post monsoon season co-existing with *Ceramonema africana.*

Description

Male: L = 1.18mm; a = 38. 06; b = 5. 9; c = 11. 8; Scale: 30µ

-	?	200	M	1080	1180µm
28	?	30	31	31	

The specimen is comparatively long and cylindrical with 200 distinct cuticular annulations of which 30 annules are present in the tail. Head is 35µm long and 26µm wide. Amphids, seen in pairs are Shepherd's crook shaped, 14µm in length and located in the middle of the head. Setae are 10-11µm long, arranged in two circles. Distinct buccal cavity absent. 10µm long cuticular ridges overlap each other. Undulations are faint. Spicules are slightly curved, measuring 34 -35µm as chord. Their pointed gubernaculum is 15µm in length. Tail remains curved.

Remarks: Eleven species have hitherto been described under the genus *Ceramonema*. The present male specimens differ from all these species in the possession of Shepherd's crook shaped paired amphids which do not extend to the posterior margin of the buccal capsule, distinct transverse bands with very faint undulations; second circle of cephalic setae, located towards the middle of the capsule and 10µm long cuticular ridges characteristically overlapping with each other at either ends. Certain teeth like structures seen on the head region appear to be unique to this species. Non-availability of female specimens makes a more detailed comparison of the species impossible, making the specific identity difficult. The specimen is therefore assigned as *Ceramonema sp.*

Family CYATHOLAIMIDAE Filipjev, 1918

Cyatholaimids typically have an annulated cuticle with transverse rows of punctuations; multispiral amphids; 6+4 cephalic setae in a single circle, the six always longer than the four; buccal cavity anteriorly twelve folded, often appearing as 12 cuticularised rugae, more posteriorly with a distinct dorsal tooth and sometimes small sub-ventral teeth; oesophagus (with the exception of *Paralongicyatholaimus*) lacks a posterior bulb; testes paired and opposed, rarely only one; ovaries paired, opposed, reflexed, vulva at about mid point of body length.

Genus *MARYLYNNIA* Hopper, 1972

Marylynnia Hopper, 1972: 68.

Marylynnia has cuticle with transverse rows of dots; lateral differentiation of larger more widely spaced dots ie; about half as many rows laterally as medially; cuticle pores of two types, simple rounded and longitudinally oval, the latter situated between two dots and referred to as Lateral Modified Punctuations (LMP) and extending on to the conical part of the tail, buccal cavity with prominent dorsal tooth and two pairs of sub ventral teeth; gubernaculum expanded slightly distally with several small teeth,that are paired; pre-cloacal supplements cup-shaped, not cuticularised; tail conico-cylindrical.

31. N31 ***Marylynnia keralensis*** nov. sp.

(Plate. 7: Fig. 29a & b; Plate. 8: Fig. 29c & d; Plate. 16: Fig. 97a, b, c & d)

Occurrence: Several male and female specimens were collected from the intertidal region of Cherai, Arthungal and Sakthikulangara beaches in different seasons of the year during low tide.

Type locality: Male specimen from intertidal zone, Cherai beach (lat. 10°09′ N; long. 76°02′E) Kerala, India, moderately well sorted sand.

Female specimen from the low tide belt of Sakthikulangara beach (lat. 8°45′N; 76°38′E), Kerala, India. Sand poorly sorted.

Type material: Holotype- Male S3b; Female M4bb$_1$. Sl. 1

Paratype- Male PM3bb1. Sl. 1; Female- M4b. Sl. 1

Etymology: Named after Kerala, the maritime state of India.

Description

Male: L = 0.9mm; a = 22. 5; b = 7.7; c = 8.5; Scale: 30µ

-	?	116	M	794	2270µm
26	?	30	40	28	

Female: L = 0. 815mm; a = 16.3; b = 6.9; c = 7.4; v = 54%; Scale: 20µ

-	60	118	440	705	815µm
26	30	38	50	32	

Male: Homogenous cuticle is marked by the presence of transverse rows of punctuations in the form of dots. Dots are spaced at 1.5µm anteriorly and the spacing decreases posteriorly. Lateral differentiation is irregular and faint. A hollow tooth projects into the buccal cavity. Anteriorly directed 2µm long lateral papillae visible. Unequal cephalic setae ranges from 3µm to 5µm in length. Amphid is not clear in the male specimen. Oesophagus is short with a swollen posterior end, but lacks a definite bulb. Two or three 3.5 to 4µm long caudal setae are visible. Tail (3.8a.b.d.) is conico-cylindrical. Two types of cuticle pores are present. Two rows of circular pores present through out the length of the body, and longitudinally oval pores or Lateral Modified Punctuations (LMP) originate a little above the cloaca extending upto the conical part of the tail. Spicules are simple and tubular with a prominent scletorised proximate region and the distal part remains faint. Clearly visible region measures 20-25µm. Five cup shaped pre-cloacal supplements are present, the farthest one placed at 63µm from the cloaca. Adjacent supplements are spaced at 8 to 10µm except for the first two, which are closely located.

Female: Cuticle is homogenous with transverse rows of punctuations. Lateral differentiation irregular, with larger and more widely spaced punctuations. Rugae are present. A hollow tooth project into the buccal cavity. Two sets of cephalic setae measure 6µm and 4µm respectively.

Multispiral amphid,.3 times c.d. with 3-4 turns.Three sets of very fine 4μm long setae visible in the anterior half of the oesophageal region. The posterior region of the oesophagus is swollen, but lacks a distinct bulb. Somatic setae and caudal setae not observed. 2μm long minute setae seen at the tail tip. Tail, which is 3.4 a.b.d. is conico-cylindrical. Caudal glands post anal in position. Two types of cuticle pores present, 1. 5 – 2μm wide circular pores and longitudinally oval pores, the Lateral Modified Punctuations (LMP). The longitudinal diameter of oval pores is 3 to 5μm. Circular pores seen throughout the length of the body. LMP extent to the conical region of the tail. Ovaries double and opposed. Caudal glands present.

Remarks: Cyatholaimidae is a difficult family with closely related genera. The pattern of cuticular ornamentation with circular pores and Lateral Modified Punctuations and the type of pre-cloacal supplements forms the basis for distinguishing different genera. Though the material come close to *Marylynnia complexa*, described by Warwick in 1971 in the values of De Man's ratio and the distribution pattern of cuticle pores, the position of vulva, spicular size and structure and the tail length make the material before me distinct from the species described by Warwick (1971). In the presence of short and simple faint spicule, the present specimens resemble *Paracyatholaimus vancouverensis* described by Sharma and Vincx in 1982 from Canadian Pacific Coast. However, cup shaped supplements of the material before me makes them distinct from the aforesaid genera which is characterized by species with setose supplement. Moreover, the presence of the smaller amphid with 3 turns, restriction of LMP's to the cloacal region, 5 cup-shaped supplements and the ratio of tail length diameter at less than 4.0 are features characteristic to the material in hand. Variability in the values of 'a' for males and females (contributed by marked difference in the maximum diameter of the body) is conspicuous. Wide variation in the value

PLATE - 7

EXPLANATION OF FIGURES

Fig. 25 ***Rhynchonema hirsutum***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig. 26 ***Prorhynchonema warwicki***
a: Anterior end of male
b: Posterior end of male

Fig. 27 ***Ceramonema africana***
a: Anterior end of male
b: Posterior end of male

Fig. 28 ***Ceramonema sp.***
a: Anterior end of male
b: Posterior end of male

Fig. 29 ***Marylynnia keralensis***
a: Anterior end of male
b: Posterior end of male


Fig.25a


Fig.25b

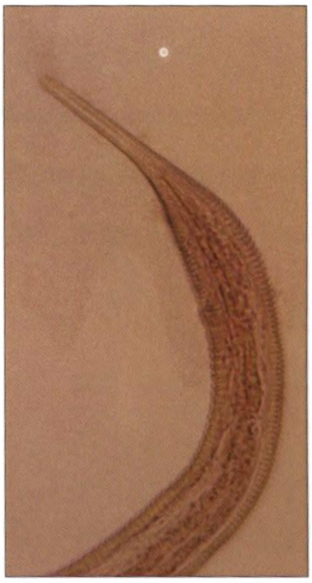


Fig.25c

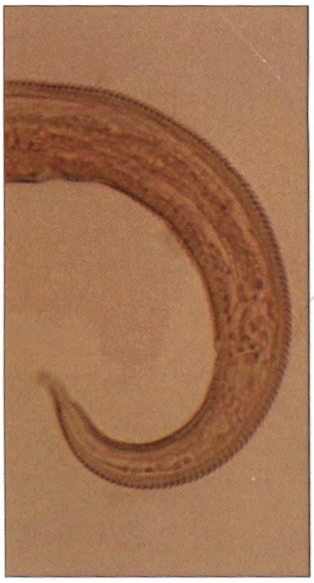


Fig.25d


Fig.26a


Fig.26b


Fig.27a

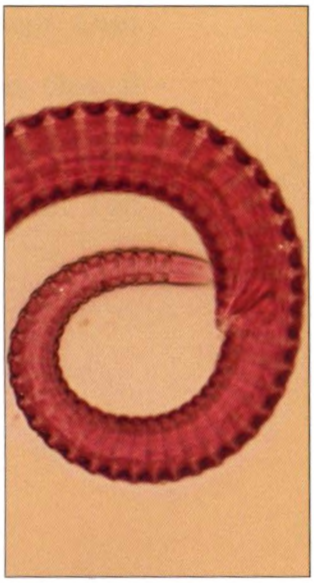


Fig.27b

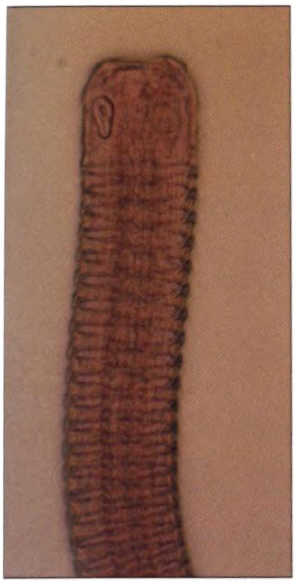


Fig.28a


Fig.28b


Fig.29a


Fig.29b

of 'a' between sexes and within sexes have been observed in species such as *Marylynnia hopperi* described by Sharma and Vincx (1982) from Canada. Location of vulva at about mid point of the body is conspicuous.

It is therefore strongly felt that this material should be described as a new species under the genus *Marylynnia* and could be diagnosed as described below.

Medium sized individuals with body striations. Punctuations in the form of transverse rows of dots; multispiral amphid with 3-4 turns. Hollow dorsal tooth project into the buccal cavity. Oesophagus short and swollen posteriorly without a distinct bulb. Two types of cuticle pore present. Oval shaped Lateral Modified Punctuations (LMP) restricted to the cloacal region. Spicules are simple and tubular with a prominenet sclerotised proximal region. Five cup shaped pre-cloacal supplements present. Tail conico-cylindrical. Morphometry is as follows:

Male: L = 0.9mm; a = 22. 5; b = 7.7; c = 8.5

-	?	116	M	794	900µm
26	?	30	40	28	

Female: L = 0. 815mm; a = 16.3; b = 6.9; c = 7.4; v = 54%

-	60	118	440	705	815µm
26	30	38	50	32	

Genus *POMPONEMA* Cobb, 1917

Type species *Pomponema mirabile* Cobb, 1917:118

Anaxonchium Cobb, 1920: 319 op Lorenzen, 1972: 286

Endolaimus Filipjev, 1922: 133 op Wieser, 1954: 6

Cobbiacanthoncus Allgen, 1953: 562 op Hope and Murphy, 1972: 23

Nummocephalus Filipjev, 1946: 170, 182 op Lorenzen, 1972: 286. Revision Lorenzen, 1972: 286-290

Pomponema has a cuticle with fine punctuations and lateral differentiation of four longitudinal files of enlarged dots commencing some distance behind the head, cuticle in head region particularly thick with the punctuations appearing in lateral view as elongated rods with Y-shaped ends; the lateral and cephalic setae usually jointed at the tip section markedly narrower than the base; 6+4 arrangement for cephalic setae, but the four smaller setae are sometimes absent or so small and adherent to the larger setae that they cannot be detected; buccal cavity strongly armed with a large pointed dorsal tooth, medium sized sub-ventral teeth and additional tentacles; gubernaculum with lateral wings in the middle which enfold the spicules; spicules with a central lamella; pre-cloacal supplements characteristic, consisting of several elements, with short transverse cuticular bars between them; tail conico-cylindrical with a swollen tip.

32. N32 ***Pomponema multipapillatum*** (Filipjev, 1922) Wieser, 1954
(Plate. 8: Fig. 30a & b; Plate. 16: Fig. 98a & b)

Endolaimus multipapillatus Filipjev, 1922: 134

Pomponema multipapillatum (Filipjev, 1922) Wieser, 1954: 6;Warwick, 1971: 96; Lorenzen, 1972: 299

Pomponema sp. of Warwick and Buchanan, 1970:136,138; Lorenzen, 1972: 299

Occurrence: A few male specimens were collected from the intertidal belt of Cherai and Veli beaches during the post monsoon season.

Description

Male: L = 0. 99mm; a = 28. 3; b = 7. 6; c = 6. 6; Scale: 30µ

$$\frac{-}{20}\quad\frac{70}{30}\quad\frac{130}{30}\quad\frac{M}{35}\quad\frac{840}{27}\quad 990$$

Cuticle ornamentation consists of transverse rows of dots; lateral differentiation commences a little behind the amphid, consisting of four longitudinal rows of dots with inner pair larger, 5µm apart and united by a transverse bar. This distance is reduced to 2µm in the middle region of the body and behind the cloaca the width is 3µm. These prominent dots are vertically spaced 1µm from each other. The punctuations on either side of the lateral field are more closely arranged from behind the region of the nerve ring. Six lateral setae are 5 - 6µm long and the cephalic setae measure 12µ - 13µm in length. The bases of setae are broad. A few somatic setae seen scattered. Single pre-cloacal spine, 3- 4µm long and a pair of sub-terminal setae (4 -5µm) are observed. Circular amphid, 15µm wide (0.55c.d.) is positioned at the region of cephalic setae. Number of amphid turns not distinct. Buccal cavity with a large dorsal tooth, 11µm long, two small sub ventral teeth and a row of minute denticles. Oesophagus with a bulge at either ends, covering the posterior region of the buccal cavity anteriorly and muscular at the posterior end. Oesophageal bulb absent. 1to1.5µm wide circular pores distributed all over the body and 5µm wide larger pores spread out in the anterior region of the body. Tail (5.5a.b.d.) is conico-cylindrical with a swollen tip. Caudal glands extent from post anal to a little above the cloaca.

Spicules are paired, 35-38µm (1.3c. d.) as chord. Gubernaculum 27-30µm in length and occur as two pieces with two spines at the distal end. About 19 pre-cloacal supplements are characteristic with about 3-5 short cuticular bars between them, giving a lamellated appearance.

Remarks: The shape of the oesophagus, body ornamentation, buccal features, relative body measurements and the structure of spicules of the present specimens agree remarkably with the description and figures of *Pomponema multipapillatum* Filipjev given by Lorenzen (1972). The only conspicuous difference that could be noticed was the amphid, represented by a distinct marginal ring unlike the spiral amphid

PLATE – 16

EXPLANATION OF FIGURES

Fig. 88 ***Daptonema setifer***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 89 ***Daptonema vicinum***

a: Anterior end of male; b: Posterior end of male

Fig. 90 ***Theristus acer***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 91 ***Theristus sp.***

a: Anterior end of female; b: Posterior end of female

Fig. 92 ***Paramonhystera albigensis***

a: Anterior end of male; b: Posterior end of male

Fig. 93 ***Rhynchonema hirsutum***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 94 ***Prorhynchonema warwicki***

a: Anterior end of male; b: Posterior end of male

Fig. 95 ***Ceramonema africana***

a: Anterior end of male; b: Spicular region

Fig. 96 ***Ceramonema sp.***

a: Anterior end of male; b: Spicule

Fig. 97 ***Marylynnia keralensis***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 98 ***Pomponema multipapillatum***

a & b: Anterior and posterior end of male

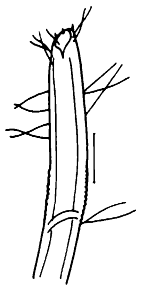


Fig. 88a

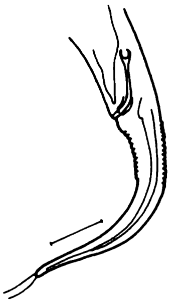


Fig. 88b

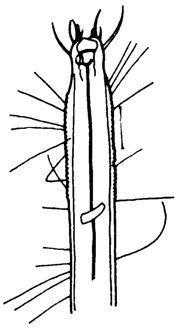


Fig. 88c


Fig. 88d

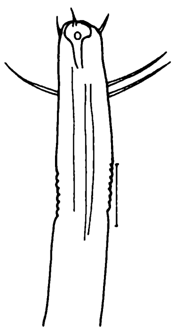


Fig. 89a

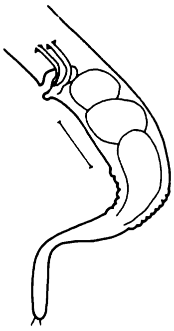
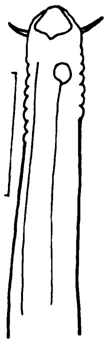
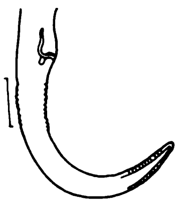
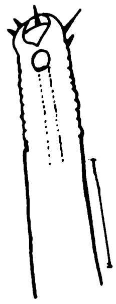
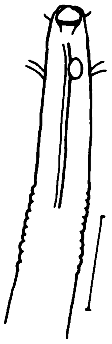


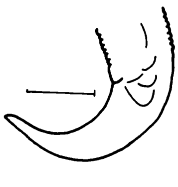
Fig. 89b











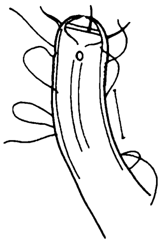


Fig. 92a

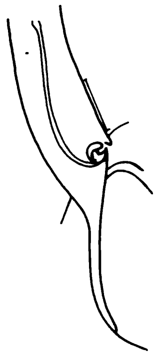


Fig. 92b

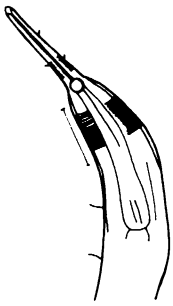


Fig. 93a

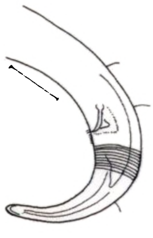


Fig. 93b

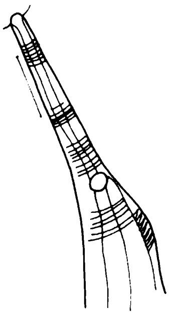


Fig. 93c

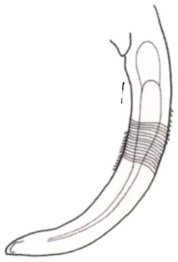


Fig. 93d

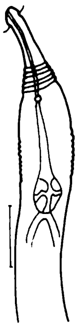


Fig. 94a

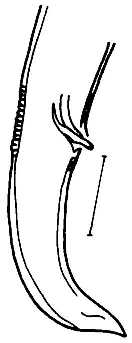


Fig. 94b

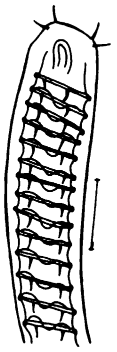


Fig. 95a

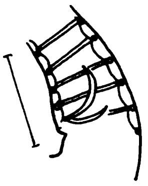


Fig. 95b

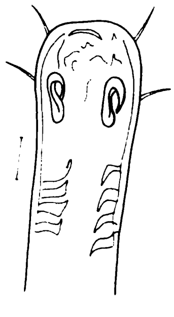


Fig. 96a


Fig. 96b

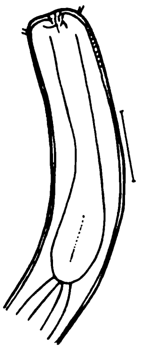


Fig. 97a

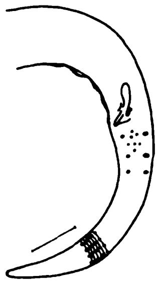


Fig. 97b

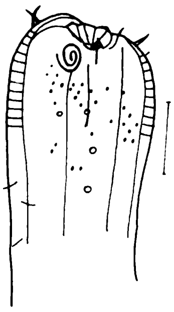


Fig. 97c

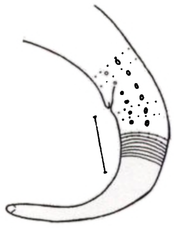


Fig. 97d

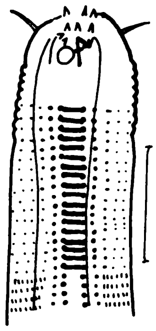


Fig. 98a

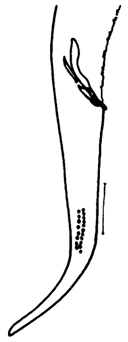


Fig. 98b

with five turns described by Lorenzen in which respect the local specimens show some resemblance to *Pomponema sedecima* Platt (1973). However, this morphological difference does not affect the present placement.

Distribution: Black Sea (Filipjev, 1922); North Sea (Warwick, 1971; Lorenzen, 1972); Arabian Sea (present record).

Genus *PARACYATHOLAIMUS* Micoletzky, 1922

Established as a sub genus of *Cyatholaimus* Bastian, 1865 by Micoletzky, 1922: 374; raised to a genus by Micoletzky, 1924: 140. Revision Wieser, 1954: 26.

In addition to the family characters, this genus has cuticle without lateral differentiation; pre-cloacal supplements setose; gubernaculum small and simple, hardly dilated at the distal end, rounded or notched distally but never with pronounced teeth; tail conical.

33. N33 ***Paracyatholaimus chilensis*** Gerlach, 1953

(Plate. 8: Fig. 31a, b, c & d; Plate. 17: Fig. 99a, b, c & d)

Paracyatholaimus chilensis Gerlach, 1953a: 19; Pastor De Ward, 1985:1-83.

Occurrence: A few male and several female specimens were collected from the intertidal area of Cherai and Sakthikulangara beaches in post-monsoon and monsoon seasons in the year, 2005- 06.

Description

Male: L = 1.115mm; a = 22.3; b = 5.6; c = 19.2; Scale: 30µ

-	?	200	M	1057	1115µm
36	?	40	50	38	

Female: L = 0.1mm; a = 15.8; b = 4.0; c = 12.8; v = 66.5%; Scale: 30µ

-	?	250	665	922	1000µm
55	?	55	63	38	

Annulated body with punctuations in the form of dots; lateral differentiation absent; anterior margin of buccal cavity with small prominent labial setae. Spiral amphid, located at a distance of 18µm from the anterior in male had 3.5 turns. Cephalic setae, 10µ long are arranged in a circle. Somatic (9µm) setae very few and scattered. Three to four 5µm long caudal setae are visible. Anterior end of oesophagus is slightly swollen. The pigmented granules of intestinal cells render the specimen a brownish colouration. Spicule measured 42-43µm as chord. Gubernaculum, 19- 20µm; apophysis absent. The three male specimens studied had 11, 17 and 18 pre-cloacal supplements respectively. Females wider than males. The inner part of vulvar opening highly sclerotised. Bunches of granular cells were observed surrounding the uterus-vagina zone. Tail (2. 0a.b.d.) is conical with a sclerotised terminal region. Paired ovaries. Vulva located mid posteriorly. Caudal glands post – anal in position.

Remarks: *Paracyatholaimus chilensis* described by Gerlach (1953) from the Chilean coast exhibited some variations between his specimens in the values of De Man's ratio. Moreover, the description was very brief. Later, Pastor De Ward (1985) reported its occurrence on the Argentinean coasts, but the specimens were bigger in size than the Chilean forms. A comparison of the figures given by Ward (loc.cit.) with the specimens in hand proves beyond doubt their resemblances with Ward's specimens. The presence of glandular cells near the vulvar region was observed in Argentinean specimens also. Furthermore, the size and shape of the spicule of male specimens in hand fit well with the figures and descriptions given by earlier authors. While confident regarding the generic and specific identity of the present forms as *Paracyatholaimus chilensis*, the presence of variable number of pre-cloacal supplements may be cited as a feature in which the present forms differ from the original descriptions of *P.chilensis*. But, neither Gerlach (1953) nor Ward (1985) made a mention of the pre-cloacal supplements of their specimens. Also, the location of vulva in the local forms at 66.5% as against 52% - 53% of the type species is rather conspicuous. But, many of the important features and the values such as 'a', 'b', and 'c' of De Man's ratio are enough to substantiate the present placement as *Paracyatholaimus chilensis*, Gerlach.

Distribution: Chile (Gerlach, 1953); Argentina (Pastor De Ward, 1985); Arabian Sea (present record).

Family SELACHINEMATIDAE Cobb, 1915

Selachinematids have an annulated cuticle with transverse rows of punctuations; multi spiral amphids; buccal cavity armament in the form of mandibles when present, pre-cloacal supplements, cup-shaped or setose when present but never tubular; testes usually paired; ovaries always paired, opposed, reflexed; vulva usually situated slightly posterior to the mid-point of the body, about 60-65% of the body length.

Genus ***GAMMANEMA*** Cobb, 1920

Gammanema Cobb, 1920: 291.

Gammanema has a buccal cavity, which is divided, into an anterior cup shaped section supported by strongly developed buccal rugae and a narrower posterior tubular section supported by longitudinal cuticular rods. The cuticular lining of the cup shaped part has fine longitudinal striations; cuticle without lateral differentiation; posterior bulb absent.

34. N34 ***Gammanema punctuata*** nov. sp.

(Plate. 8: Fig. 32a, b, c & d; Plate. 17: Fig. 100a, b, c & d)

Occurrence: Several females and a few male individuals were collected from Cherai and Sakthikulangara beaches during the post monsoon months.

Type locality: Male specimen from the intertidal of Cherai beach (lat.10°09′N; long.76°02′E), Kerala, India.Moderately well sorted medium sand.

Female specimen from Sakthikulangara beach (lat.8°45′N; long.76°38′E) Kerala, India. Poorly sorted sand.

Type material: Holotype: Male- PM3aa$_1$. Sl.1; Female- PM4aa$_1$. Sl. 2
Paratype: Male- PM3bb$_1$. Sl.1; Female- PM4aa$_1$. Sl. 3

Etymology : The characteristic punctuations on the body surface is very striking and hence the name.

Description

Male: L = .910mm; a = 17.2; b = 4.7; c = 12.5; Scale: 30µ

-	75	193	M	837	910µm
40	48	51	53	47	

Female: L = .880mm; a = 20.5; b = 5.7; c = 12.9; Scale: 30µ

-	113	154	?	812	880µm
30	35	35	43	38	

Body comparatively short and stout with truncate anterior end. Only a few specimens are elongated. Annulations in the form of fine striations, extent to the anterior margin. Punctuation as regular transverse rows of dots. Buccal cavity cup shaped anteriorly (15µm long) with buccal rugae, followed by a posterior region (13µm in length) supported by three stout pillars (cuticular rods). Amphids of 2.5 turns, 5 - 6µm wide (0.10c.d.) in both sexes. Three teeth visible in female, at the base of rugae. Four long cephalic setae (18 - 22µm long) and six shorter setae (6µm) present at the level of the teeth. Cervical, somatic and caudal setae absent. Oesophagus of uniform width surrounds the buccal cavity. No characteristic bulb for the oesophagus. Densely pigmented intestinal cells grouped in two rows originate behind the oesophagus. These extend to three-fourth of the body and gradually fades away. Shape of tail peculiar. Three caudal glands arranged in tandem. Tail 1. 5-1. 8a.b.d. Short (29µm long) slightly arcuate spicule seen as a pair, the proximal end of which is pointed. Distinct gubernaculum absent. No apophyses. Spicules lie entirely

PLATE – 8

EXPLANATION OF FIGURES

Fig. 29 ***Marylynnia keralensis***
c: Anterior end of female
d: Posterior end of female

Fig. 30 ***Pomponema multipapillatum***
a: Anterior end of male
b: Posterior end of male

Fig. 31 ***Paracyatholaimus chilensis***
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female

Fig. 32 ***Gammanema punctuata*** nov. sp.
a: Anterior end of male
b: Posterior end of male
c: Anterior end of female
d: Posterior end of female


Fig.29c


Fig.29d

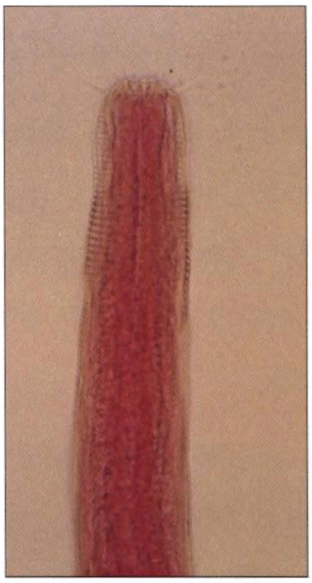


Fig.30a


Fig.30b


Fig.31a


Fig.31b


Fig.31c


Fig.31d


Fig.32a


Fig.32b


Fig.32c


Fig.32d

within the body. Pre-cloacal supplements absent. A cloacal opening at the level of spicule could not be located. However, an external opening present posteriorly. Ovaries paired and opposed. A characteristic vulvar opening could not be traced in any of the female specimens examined, probably indicating immaturity.

Remarks: Genus *Gammanema* enjoy a wide geographical distribution. Seven species have hitherto been described, among which, *Gammanema cancellatum* was recorded from the Bay of Bengal (Rao, 1969). The specimens with me do not agree with any species described under the genus *Gammanema*. *Gammanema mediterraneum* described by Vitiello (1970) from the Mediterranean is the one to which the present specimens show some resemblance with respect to values of De Man's ratio. But the original description is based on females alone. Lack of description of male and an analysis of the female figure given by Vitiello makes the present material distinct from *G. mediterraneum*. *Gammanema polydonta* Murphy, 1965 is another species that show some similarities with the specimens in hand in the possession of densely pigmented anterior half of the intestine and a broad cylindrical body of uniform width, giving it a massive appearance. But pre-cloacal supplements are present in *G.polydonta* and the location and size of the amphid is different from the one found in the local forms. In the presence of internal spicule and shape of tail, the present specimen approaches *G.conicauda* described by Gerlach (1953) from the intertidal sand of West Scotland. But the presence of pre-cloacal supplements in male and feathered setae in females distinguishes them from the specimens from this coast. The size of the amphid, densely pigmented intestinal cells, spicules placed entirely in the interior without gubernaculum and apophysis, the absence of pre-cloacal supplements and the shape of tail are features specific to the specimens before me and therefore is placed as a new species. The present record extends the distribution of the genus to the Arabian Sea.

The new species is defined as follows:

Short and stout individuals with truncate anterior end. Annulations in the form of fine striations extend to the anterior margin. Punctuation as transverse rows of dots. Cup shaped anterior part of buccal cavity is supported by rugae and cuticular pillars support the posterior region. Spiral amphid. Oesophagus devoid of posterior bulb. Pigmented intestinal cells are conspicuous. Arcuate spicules located internally. No pre-cloacal supplements. Shape of tail unique. Caudal glands arranged in tandem. Morphometrics of male and female are as follows:

Male: L = .910mm; a = 17.2; b = 4.7; c = 12.5

-	75	193	M	837	910μm
40	48	51	53	47	

Female: L = .880mm; a = 20.5; b = 5.7; c = 12.9

-	113	154	?	812	880μm
30	35	35	43	38	

Family CHROMADORIDAE Filipjev, 1917

An annulated cuticle with punctuations and various other forms of ornamentation, frequently quite complex, characterizes Chromadorids. Amphid slit like, loop-shaped or oval, but never multi spiral; buccal cavity anteriorly twelve folded, the folds usually cuticularised and called rugae; at least one dorsal tooth in the buccal cavity and often sub-ventral teeth also; testis single, anterior; ovaries paired, equal, opposed, reflexed; vulva at about mid point of body length.

Genus *PROCHROMADORELLA* Micoletzky, 1924

Prochromadorella Micoletzky, 1924: 164.

Trichromadora Kreis, 1929: 54 op Lorenzen, 1972: 298. Revision Wieser, 1954: 106.

This genus is characterized by the presence of three solid teeth; heterogenous cuticle without longitudinal rows of punctuations, sometimes with the lateral dots enlarged.

35. N35 ***Prochromadorella quinquepapillata*** (Stekhoven, 1935) Wieser, 1954

(Plate. 9: Fig. 33a, b, c & d; Plate. 17: Fig. 101a, b, c & d)

Neochromadora quinquepapillata Stekhoven, 1935: 24.

Prochromadorella quinquepapillata (Stekhoven, 1935) Wieser, 1954: 108.

Occurrence: Several male and female individuals were collected from Fort-Kochi and Sakthikulangara beaches during different seasons of the year.

Description

Male: L = 1.185mm; a = 59. 0; b = 8. 9; c = 12. 5; Scale: 20µ

-	88	132	M	1090	1185µm
13	18	18	20	18	

Female: L = 1. 3mm; a = 32. 5; b = 7. 6; c = 8. 9; Scale: 30µ

-	?	170	610	1155	1300µm
15	?	25	40	20	

Male: Body is slender, cuticle transversely striated with distinct rings on both margins of the body. Males more slender than females. Shallow buccal cavity present with distinct dorsal tooth. Minute cephalic setae (4 –5 µm long) are visible. Somatic setae not visible except for a single post-cloacal seta noticed in one of the specimens. Oesophagus with a slight swelling at the posterior end, but a distinct bulb is absent. Punctuation characterized by double rows of dots in the lateral field anteriorly. On either side of the dots, zigzag ornamentation is visible. About a quarter from the anterior region, the dots become more elongated and rod like and extent evenly to the posterior end leaving a distinct unstriated terminal tip. The tail 4.6 -5.3a. b. d. in length. Spicule measures 23µm as chord (1. 21a.b.d.); gubernaculum 15µm long. Five cup shaped pre-cloacal supplements are present, more or less equally spaced (5-7µm). The nearest papilla located at about 19µm from the spicule.

Female: Stouter and longer than males. Body ornamentation similar to that of males. Tail, 5.7 to 7.0 a. b. d. in length. Ovaries are double and opposed. Vulva located at about 46. 9 to 50 % from the anterior of the body.

Remarks: Stekhoven (1935) described this species from Zeebrugge as *Neochromadora quinquepapillata*.. Later on, Wieser in 1954, redescribed the species as *Prochromadorella quinquepapillata*. The present specimens agree remarkably well with the type description in the pattern of cuticular punctuation, presence of a solid dorsal tooth, length and type of spicule, presence of five pre-cloacal supplements and the length of tail. However, female specimens in the present collection show variation in the value of 'a' of De Man's ratio and in the absence of a distinct slit like narrow amphid is cospicuous. The specimens in hand also show some resemblance to *Prochromadorella ditlevseni* (De Man, 1922) in the number of pre-cloacal supplements, location of vulva etc. Therefore the present specimens are assigned to *Prochromadorella quinquepapillata* (Stekhoven, 1935). The present record extends the distribution of the species to tropical seas also.

Distribution: North Sea (Stekhoven, 1935); Arabian Sea (present record).

Genus *NEOCHROMADORA* Micoletzky, 1924

Trichodorina, proposed as sub genus of *Neochromadora* by Wieser, 1954: 83; raised to genus by De Coninck, 1965: 636. Revision Wieser, 1954: 83.

Cuticle is heterogeneous with lateral differentiation in the form of two or three longitudinal files of dots; buccal cavity with a hollow dorsal tooth and two subventral teeth.

36. N36 ***Neochromadora tecta*** Gerlach, 1951

(Plate. 9: Fig. 34a & b; Plate. 17: Fig. 102a & b)

Neochromodora tecta Gerlach, 1951b: 117; 1954: 60; Tietjen, 1969: 263; Warwick, 1971: 449.

Occurrence: A female individual obtained from Cherai beach in summer.

Description

Female: L = 1. 26mm; a = 29.6; b = 6; c = 7.6; v = 48%; Scale: 30µ

-	?	210	605	1095	1260µm
20	?	36	45	33	

Annulated body cuticle with lateral differentiation. A prominent large buccal cavity absent. Four 16µm long cephalic setae and six shorter setae (4µm long) lie at the anterior. A crescentic amphid, 6µm in diameter lies transversely between the bases of the cephalic setae. A large hollow tooth and two smaller teeth present. A few elongated somatic setae seen scattered, visible only at certain angles. Anterior end of oesophagus slightly swollen and thickened posteriorly. The tail, 5.07a. b. d. long is conico-cylindrical. The lateral differentiation of the cuticle consists of lateral files of enlarged dots in the middle of the body. Anteriorly, these dots are flanked by transverse rows of rounded punctuations. Halfway down the oesophagus, the dots become elongated and there appears to be two transverse rows, corresponding to each lateral punctuation. Transverse bars become distinct at this juncture. Posterior to the oesophagus, the pattern becomes indistinct and extends down like wise. A little above the region of anus, the punctuations become more prominent again and the transverse rows become single, taking the form of small rounded dots. Paired ovaries are seen.

Remarks: The specimen at my disposal agrees well with the original description of *Neochromadora tecta* given by Gerlach, (1951). Certain differences from the original description are in the location of vulva and distribution of setae. Warwick (1971) in his description of the species does not mention about the location of vulva. The detailed description of the ornamentation compares well with that of the present form, the only difference being the reduced number of body setae. The present material shows similarity with *Nechromodora alatocorpa* Hopper, 1961 in the values of De Man's ratio and disposition of vulva. But the very long cephalic setae, a feature that makes it distinct from all other members of the group is not seen in the present form. Hence the specimen in hand is referable to *Neochromadora tecta,* Gerlach 1951.

Distribution: North Sea (Gerlach, 1951; 1953; 1954); New England, USA (Tietjen, 1969); English Channel (Warwick, 1971); Arabian Sea (present record).

Family DESMODORIDAE Filipjev, 1922

Desmodorids typically have the following characters: cuticle with transverse striations but never punctuated; head region unstriated; cephalic setae in two separate circles, the posterior four always the longer; amphids spiral, usually of only one or two turns and described as loop shaped; buccal cavity anteriorly 12 folded, but not always obvious and the folds are never strongly cuticularised into rugae; oesophagus with a muscular posterior bulb; tail conical; gubernaculum without a dorsal apophysis; testis single, anterior; ovaries paired, opposed, reflexed, vulva usually situated posterior to the mid point of the body.

Genus *METACHROMADORA* Filipjev, 1918

Ichthyodesmodora Chitwood, 1951: 641 op Timm, 1961: 62; Gerlach, 1951a: 60 proposed a sub division into sub genera which is advocated by Wieser and Hopper, 1967: 273.

Metachromadora has finely striated cuticle; amphids surrounded by cuticle striations; anterior circle of six cephalic sensilla usually setiform; large dorsal tooth in the buccal cavity; posterior oesophageal bulb well developed with a thick cuticular lining often partitioned into two or three sections; pre-cloacal supplements of various forms.

Subgenus *Bradylaimus* Stekhoven, 1931

Supplements tubular.

37. N37. ***Metachromadora (Bradylaimus) suecica*** (Allgen, 1929) Schulz, 1938 **(Plate. 17: Fig. 103a & b)**

Oistolaimus suecicus Allgen, 1929: 25.

Bradylaimus parvus Stekhoven, 1931: 648 op De Coninck and Stekhoven, 1933: 66 *Metachromodora (Bradylaimus) suecica* (Allgen 1929) Schulz, 1938: 119; Gerlach, 1951a: 67; 1954b: 123; 1958: 76; Delamare *et al.* 1955: 399; Riemann, 1966: 148.

Occurrence: A female specimen was collected from Cherai beach during summer season, at a depth of 19-20cms in the low tide region.

Description

Female: L = .86mm; a = 21.5; b = 7.8; c = 10.8; v = 50%; Scale: 30µ

-	75	110	430	780	860µm
18	38	40	42	30	

Conspicuous fine striations on the body. About six 2µm long cephalic sensillae and four 5µm long (2.7h.d.) cephalic setae present. Four sub-cephalic setae located in line with the base of amphid, followed by a few rows of smaller setae. 6µm wide loop shaped amphid located at 5µm from the anterior. Amphid surrounded by striations. Tooth present. Oesophagus ends in a well-developed posterior bulb, 30µm long and 22µm wide, traversed by a cuticular lining in the middle. Nerve ring located as a faint marking near the oesophageal bulb. Tail 2.6 a.b.d. conical and ends in an unstriated terminal lip.

Remarks: The form under consideration approaches closely to *Metachromadora suecica* described by Allgen in respect of De Man's ratio, and position and diameter of amphid. However, the vulvar position of the present specimen is conspicuous, where it is observed at about 50% of the body length as against 55 to 62% in the type species. De Coninck (1959), in his description of *Metachromadora suecica* denoted the position of vulva at 51.7%. Stekhoven (1931) described the species as *Bradylaimus parvus* and the very low index of 'α' in the specimen studied by him is considered probably due to a flattening during examination. Moreover, Coninck and Stekhoven (1933) opined that since the body of the species is almost cylindrical and of same width in juvenile and adult specimens, the index 'a' varies considerably in relation to age or length. A thorough examination of the local form and a comparison with all the available literature proves beyond doubt the identification as *Metachromadora (Bradylaimus) suecica* (Allgen 1929).

Distribution: Oresund (Allgen, 1929a); North Sea (Schultz, 1938; Gerlach, 1951; Riemann, 1966; Skoolmun and Gerlach, 1971); Kiel Bay (Gerlach, 1951; 1958); Bay of Biscay (Delamare *et al.,* 1955); English Channel (Luc and De Coninck, 1959); Arabian Sea (present record).

Genus *ONYX* Cobb, 1891

Oistolaimus Ditlevsen, 1921: 4 op Gerlach, 1951: 61

Type species *Onyx perfectus* Cobb, 1891: 146

Onyx has fine cuticle striations; head not set off as a distinct capsule; amphids not surrounded by cuticle striations; buccal cavity with a long spear like dorsal tooth; posterior oesophageal bulb without thickened cuticular lining; spicules short and arcuate; pre-cloacal supplements cuticular S-shaped tubes.

38. N38 ***Onyx ferox*** (Ditlevsen, 1921)

(Plate. 9: Fig. 35a & b; Plate. 17: Fig. 104a & b)

Oistolaimus ferox, Ditlevsen, 1921a: 4.

Onyx ferox Gerlach, 1951a: 61.

Occurrence: A few female specimens were obtained from the inter-tidal region of Cherai, Fort Kochi and Arthungal beaches.

Description

Female: 0. 84mm; a = 16.8; b = 5.7; c = 9.4; v = 62.3%; Scale: 30μ

-	70	148	523	751	840µm
20	48	49	50	33	

Body comparatively short. Cuticle appears to be smooth, but fine internal striations visible under higher magnification. Body almost of equal width throughout with the body tapering gradually anteriorly and posteriorly. Distinct loop shaped amphid, 9µm wide with one and a half turns present at the anterior end with the lining of the outermost loop bending inwards to the forgoing loop 2.5µm long. Minute lateral setae (2.5µ, long) seen. Cephalic setae are arranged in two circles, the anterior one with 0.5h.d. long setae and the posterior setae are 0.7h.d. in length. Two sets of cervical setae visible around the anterior region of oesophagus. Buccal cavity with a characteristic spear shaped tooth. Oesophagus cylindrical and ends in a posterior oesophageal bulb without sclerotised internal lining. Vulvar opening does not protrude out, but distinct beneath the cuticle. Numerous minute granules scattered on the body. Tail is conical.

Remarks: The present specimen resembles the material from Auckland described by Ditlevesen (1921). The agreement is confined to the shape, diameter and location of amphid, spear like structure in the buccal cavity and general form and shape of the body with numerous granules. However, the low lips, as mentioned in the type species could not be observed in the local forms, possibly due to the inversion of the anterior most end. Notwithstanding this variation, the present material is assigned to *Onyx ferox.*

Distribution: Auckland Islands (Ditlevsen, 1921); Arabian Sea (present record).

39. N39 ***Onyx cf.perfectus*** Cobb, 1891

(Plate. 9: Fig. 36a, b, c & d; Plate. 17: Fig. 105a, b, c & d)

Onyx perfectus Cobb, 1891: 153; Filipjev, 1918: 214; Gerlach, 1954: 110, 223; 1963: 73; Delamare *et al.,* 1955: 399; Riemann, 1966: 149.

PLATE – 9

EXPLANATION OF FIGURES

Fig. 33 ***Prochromadorelle quinquepapillata***

a: Anterior end of male

b: Posterior end of male

c: Anterior end of female

d: Posterior end of female

Fig. 34 ***Neochromadora tecta***

a: Anterior end of female

b: Posterior end of female

Fig. 35 ***Onyx ferox***

a: Anterior end of female

b: Posterior end of female

Fig. 36 ***Onyx perfectus***

a: Anterior end of male

b: Posterior end of male

c: Anterior end of female

d: Posterior end of female

Fig.33a

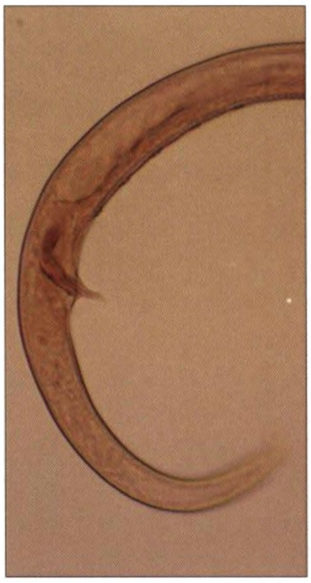


Fig.33b

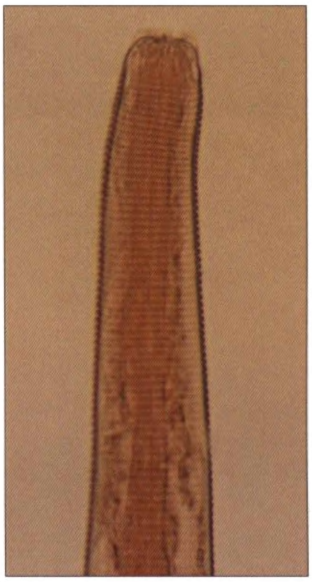


Fig.33c

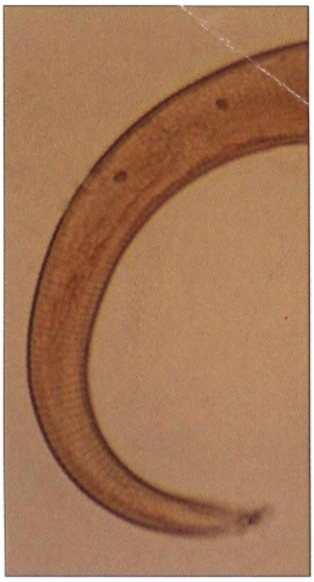


Fig.33d

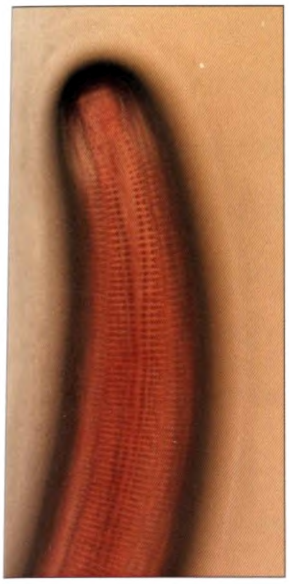


Fig.34a

Fig.34b

Fig.35a

Fig.35b

Fig.36a

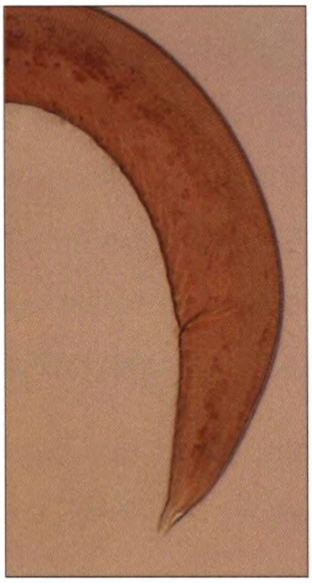


Fig.36b

Fig.36c

Fig.36d

Occurrence: Several male and female organisms were collected during summer and postmonsoon months from Veli, Cherai, Fort Kochi and Sakthikulangara beaches.

Description

Male: L = .995mm; a = 22.1; b = 7.2; c = 11.0; Scale: 30μ

-	69	138	M	905	995μm
16	37	38	45	40	

Female: L = .860mm; a = 15.6; b = 7.5; c = 10.1; v = 45.1%; Scale: 30μ

-	60	115	338	775	860μm
23	48	49	55	3	

Male: Fine cuticular striations on the body. Head truncate, six shorter (6 to 9μm) and four longer (20-22μm; 1.2h.d) cephalic setae; Minute, 3μm long labial setae are present. Single loop like amphid, 6μm (.38h.d) in diameter located at the anterior end. A spear like buccal tooth present behind the amphid. Cervical setae 15μm in length are visible. Somatic setae (6μm) are short and scattered. Oesophageal bulb, 54μm long, without distinct constriction. Tail conical with an unstriated tip. Spicules, 35-38μm as chord. Gubernaculum 17-18μm long. About 14-17 S-shaped pre-cloacal supplements are present. Supplements are spaced at 12μm from each other. Several post cloacal papillae present.

Female: Morphologically similar to male except for the variation in the relative measurements of the setae. Six smaller cephalic setae are 8μm long and the four larger setae range from 13 to 15μm. cervical setae are 9 to 10μm long. Somatic setae of unequal length and a few 3μm long caudal setae are visible. Loop like amphid is approximately 0.47h.d. A characteristic feature is the location of a distinct spear like buccal tooth behind the amphid.

Remarks: *Onyx perfectus* Cobb, 1891 reported and described by Gerlach (1963), Riemann (1966), and Warwick & Platt (1988) from different geographical locations shows variability in the relative measurements of various setae, location of vulva and the values of De Man's ratio. Species identification of the present material is mainly based on the structural details rather than the relative size, since ecotypical variability is reported in cosmopolitan species in distinctly varying ecological situations quite natural to occur. The spear like dorsal tooth in males was not as distinct as in females in the present specimens. Reimann (1966) in his description of two males have mentioned the number of pre-cloacal supplements as 14 and 17 respectively, which is exactly the case with the two male local specimens studied. In the values of De Man's ratio and location of vulva, the specimens before me come close to the one described by Gerlach (1963). The structure and relative lengths of the spicule remarkably agree with the original description. Hence present assignment to *Onyx cf.perfectus*.

Distribution: Mediterranean (Cobb, 1891; Gerlach, 1954); Black Sea (Filipjev, 1918); Bay of Biscay (Delamare *et al.,* 1955); Maldive Islands (Gerlach, 1963); North Sea (Riemann, 1966); Arabian Sea (present record).

Family EPSILONEMATIDAE Steiner, 1927

Epsilonematids have a body with a sharp ventral curvature, immediately followed by a sharp dorsal curvature giving it the characteristic epsilon shape. Ovaries are situated posterior to the dorsal curvature of the body. Rigid subventral ambulatory setae are situated just posterior to the dorsal curvature of the body (rarely absent). Cuticle coarsely striated with unstriated head capsule on which the amphids are placed. Posterior oesophageal bulb well developed.

Genus ***METEPSILONEMA*** Steiner, 1927

Type species *Rhabdogaster hagmeieri* Stauffer, 1925, designated by Steiner, 1927: 66

'Σ' shaped body; four rows of ventral ambulatory setae in the middle of the body; four cephalic setae; 6-8 sub-cephalic setae.

40. N40. ***Metepsilonema magdae*** Decraemer and Gourbault, 1989

(Plate. 10: Fig. 37a & b; Plate. 17: Fig. 106a & b)

Metepsilonema magdae Decraemer and Gourbault, 1989: 26.

Occurrence: A few specimens were collected from Cherai beach during the post monsoon season from a depth of 17-17.5 cms at low tide.

Description

Male: L = 0.238mm; a = 8.8; b = 4.8; c = 11.9; Scale: 30µ

-	?	49	M	218	238µm
7	?	22	27	10	

Female: L = 0.185mm; a = 6.2; b = 4.5; c = 12.3; Scale: 30µ

-	21	41	150	175	185µm
7	22	22	31	15	

Male: Small Σ - shaped body with the anterior and posterior regions swollen. Cuticle with 109 annulations, which change in direction ventrally at the dorsal curvature and dorsally at the ventral bend. Spiny projections of the cuticle visible at certain regions. Punctuations are present. Unstriated buccal capsule is 13µm long with a maximum width of 13µm at the posterior end. Inverted U – shaped amphid, 7µm in length almost touches the first annular plate. Four cephalic setae, 5 - 6µm long. A little behind these are the sub - cephalic setae measuring 8 - 10µm. Sub - dorsal somatic setae in the pharyngeal region have length ranging between 7 and 13µm. Single post-cloacal seta 2µm in length. Slender arcuate spicule is 30µm in length. Gubernaculum 9 -10µm long. Six small spines seen sub – ventrally around the region of the cloaca. Tail is conical, with around 7 annules.

Female: Females are slightly shorter and wider than males. Cuticle with about 105-110 annules. Annules are spaced at 3µm in the anterior and posterior region and the narrow middle region has 1-1.5µm spaced annules. Cephalic capsule is 10µm long and 10µm wide. Circular spiral amphid occupies 40% of head diameter. Sub – dorsal somatic setae range in length from 5 - 8µm. Vulva is represented by a distinctly sclerotised tubular region, 6 - 7µm in length. Tail is conical, with around 8 to 10 annules.

Remarks: *Metepsilonema magdae*, a typical inhabitant of sandy beach interstitial waters was first described by Decraemer and Gourboult in 1989.The local specimens agree reasonably well with the type description given by Decraemer and Gourbault (1989). The characters, which show very close similarity to the original description, are the shape of amphids, cuticular ornamentation and architecture and the shape and size of the copulatory spicules. However, in the location of vulva and the value of 'c' of De Man's ratio, the present specimens come closer to *Metepsilonema hardyi* Decraemer and Gourbault (1990), another species described by the same authors. It is strongly felt that the sexual dimorphism exhibited by the amphids, is an important feature to be considered for the assignment to a specific species. Therefore, the local forms are placed under *Metepsilonema magdae*.

Distribution: Grand- Terre, Quadeloupe, Guadeloupe, Atlantic Ocean (Decraemer and Gourbault, 1989); Arabian Sea (present record).

Class SECERNENTEA

Secernentea include only a few free-living marine species, belonging to the genus *Rhabditis.*They are characterized by the absence of setae and adhesive glands and reduced amphids.

Order RHABDITIDA

Family RHABDITIDAE

Genus *RHABDITIS* Dujardin, 1845

This genus belong to the class Secernentea and is widespread and common on land as free living and parasitic forms, but only three of the 70 or more known species have ever been recorded from marine localities. *Rhabditis marina,* being a bacterial feeder is quite typical of the strandline in association with rotting material. Males of these species are immediately recognizable by the combination of oesophagus shape and the presence of a bursa copulatrix.

41. N41 ***Rhabditis (Pellioditis) ehrenbaumi*** Bresslau and Stekhoven, 1940

(Plate. 10: Fig. 38a & b; Plate. 17: Fig. 106a & b)

Rhabditis ehrenbaumi Bresslau and Stekhoven, 1940: 1-74.

Occurrence: A female specimen obtained from Arthungal during the monsoon season.

Description

Female: L = 0.78mm; a = 17.7; b = 4.5; c = 10.7; v = 59.6%; Scale: 30μ

$$\frac{-\qquad 116\qquad 173\qquad 465\qquad 707}{10\qquad 34\qquad 41\qquad 44\qquad 19}\ 780\mu m$$

Body cuticle smooth. Well sclerotised 20μm long cylindrical buccal cavity is present. Amphid absent. 10 minute cephalic setae are visible. Oesophagus characteristic with distinct bulbs of equal lengths (29μm) in the middle as well as posterior. Oesophagus about 22 times body length. Tail is short and round with a pointed terminal spike. Minute setae seen on the spike. Ovaries paired and reflexed.

Remarks: The material before me is assigned to the genus *Rhabditis* since this appears to be the one to which the present material resemble quite well. In the presence of double oesophageal bulbs, the material shows relationship to *Haliplectus* and *Setoplectus* (both having double oesophageal bulbs).

PLATE – 17

EXPLANATION OF FIGURES

Fig. 99 ***Paracyatholaimus chilensis***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 100 ***Gammanema punctuata***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 101 ***Prochromadorelle quinquepapillata***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 102 ***Neochromadora tecta***

a: Anterior end of female; b: Posterior end of female

Fig. 103 Metachromadora (Bradylaimus) suecica

a & b: Anterior and posterior end of female

Fig. 104 ***Onyx ferox***

a: Anterior end of female; b: Posterior end of female

Fig. 105 ***Onyx perfectus***

a & b: Anterior and posterior end of male

c & d: Anterior and posterior end of female

Fig. 106 ***Metepsilonema magdae***

a: Male

b: Female

Fig. 107 ***Rhabditis ehrenbaumi***

a: Anterior end of female

b: Posterior end of female

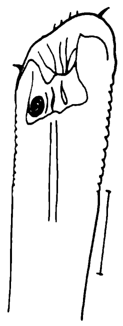
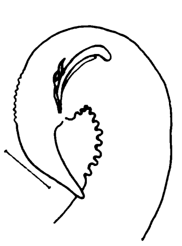


Fig. 99a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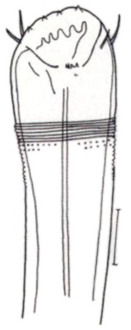
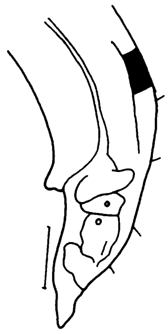


Fig. 99c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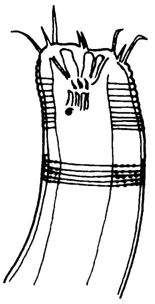


Fig. 100a

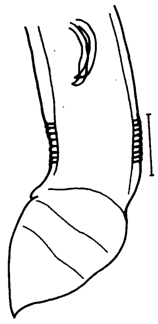
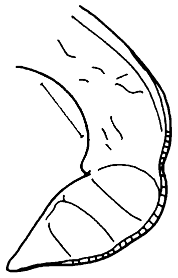


Fig. 100b


Fig. 100c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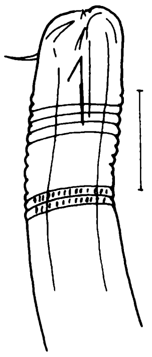


Fig. 101a

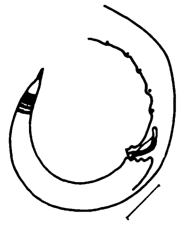


Fig. 101b

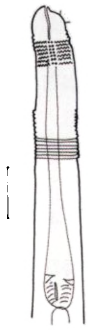
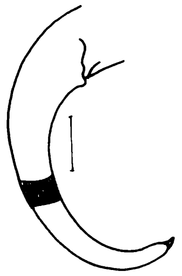


Fig. 101c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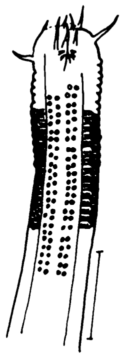


Fig. 102a

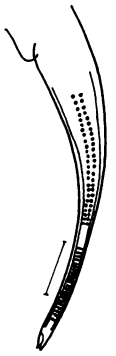


Fig. 102b

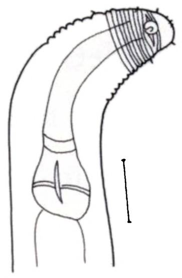


Fig. 103a

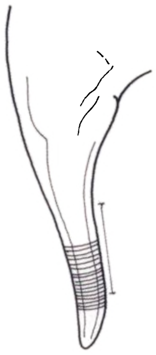


Fig. 103b

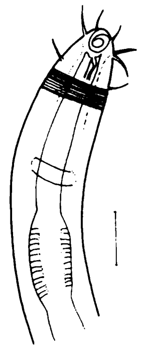


Fig. 104a

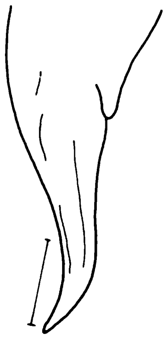


Fig. 104b

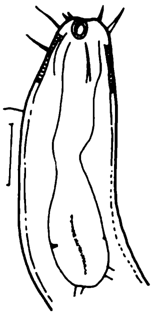


Fig. 105a

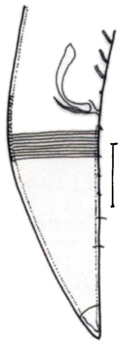


Fig. 105b


Fig. 105c

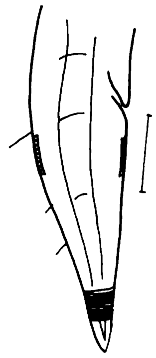


Fig. 105d

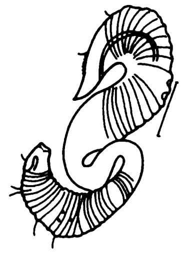


Fig. 106a

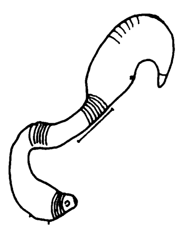


Fig. 106b


Fig. 107a


Fig. 107b

However, they lack a cylindrical buccal cavity and bursa copulatrix. The bursa copulatrix, though present in *Anoplosoma* and *Oncholaimellus*, both have a different oesophageal shape. This specimen is the only nematode in the collection that belongs to the class Secernentea. A remarkable feature of the specimen noticed is the lightly annulated nature of the cuticle in the anterior most regions. The buccal cavity of this nematode comes close to that of *Rhabditis marina* described by Bastian (1865). Although the specimen in hand share some features with *Rhabditis (Pellioditis) obesa* described by Gagarin in 2001 from Black Sea, the small size and the elongate tail (73µm) makes it distinct from the latter. Neverthless, the specimen before me resembles *Rhabditis ehrenbaumi* in several respects such as the general body form, disposition of double oesophageal bulbs, shape of tail and position of vulva. Yet the longer posterior spike of the present specimen conspicuously differs from the type form. Despite the paucity of material, especially the lack of males, which made it impossible to compare the size and structure of spicule and the gubernaculum, the similarities stated above seem to justify the inclusion of the present specimen under *Rhabditis (Pellioditis) ehrenbaumi* Bresslau and Stekhoven, 1940.

Distribution: South Wales, Plymouth, Weston-super-Mare (Bresslau and Stekhoven, 1940); Arabian Sea (present record).

4.7 POLYCHAETA

The class Polychaeta is a heterogeneous group, however no real distinction can be made between the larger benthic forms and the smaller ones found in the meiofauna. Only those polychaetes, which are able to live in interstices of sediments, are considered "interstitial". Many of the larger polychaetes like pisionidae, whose body dimensions are larger than the pore spaces of coarse sandy sediments, also are considered to be interstitial animals, since they move through the pore space by pushing aside the sand grains. Interstitial polychaetes occur in sandy and sandy muddy shores in the eulittoral regions as well as sandy sediments in sublittoral zones. There is regressive evolution in body size, number of segments and setae or modification of the body appendages in number and form which include increased function of appendages as sense organs; development of extremely long filiform appendages which serve as adhesive organs, reduced tentacles and cirri or loss of appendages. A study of the interstitial polychaetes show that the evolution of particular characters has occurred in two directions: first by regression and reduction, especially of external features; second by formation or development of internal features and particularly of species-specific behaviour. Fourteen polychaete species belonging to six families have been represented in the present study.

Family PISIONIDAE Levinsen, 1887

Pisionids are a family of polychaetes associated with interstitial marine environments. They have been recorded predominantly from warm to tropical seas and are one of the less common families recorded from benthos, probably due to lack of work on interstitial fauna of the deeper region (Hutchings, 2000). The family includes small or medium sized slender worms with numerous segments. The prostomium is either well developed with a pair of frontal antennae, a pair of lateral palps and two pairs of subdermal eyes, or has one median antenna or may be devoid of antenna. Peristomial segment with two pairs of tentacular cirri. The ventral palps remain fused to the peristomial segment. A pair of stout acicular setae projects obliquely in front of the mouth. Pharynx eversible with two pairs of chitinous jaws. Body segments uniramous, each parapodium with dorsal and ventral cirri and a setigerous lobe with one or two acicula. Setae either absent, compound or simple. The uniramous parapodia are equipped with complex copulatory appendages in the males in a specific number of middle segments. Pygidium with a pair of anal cirri.

Genus *PISIONE* Grube, 1857

Pisione Grube, 1857: 158.

Multisegmented thread like worms. Proboscis eversible with marginal papillae and four chitinous jaws. Prostomium indistinct and lacks antennae; one or two pairs of subdermal eyes located far behind. Peristomial segment with three pairs of appendages, a pair of forwardly directed elongate palps and two pairs of small tentacular cirri. Acicula of the peristomial segment project between the bases of the palps. Body segments uniramous bearing small dorsal and ventral cirri and a long setigerous lobe with simple and compound setae and a pair of acicula. Pygidium with a pair of anal cirri.

42. P1 ***Pisione gopalai*** Alikunhi, 1941

(Plate. 10: Fig. 39a & b)

Praegeria gopalai Alikunhi, 1941: 193.

Pisione gopalai Alikunhi, 1947: 105.

Occurrence: Five specimens were collected from Sakthikulangara beach from 13 cm depth in monsoon season.

Description: The specimen under consideration is 6.3mm long, 0.34mm wide (excluding parapodia), with 55 chaetigers. The buccal segment produced anteriorly into 740µm long paired palps. Dorsal cirri of the buccal parapodium are 130µm long and ventral cirri small and globular. The palps and cirri have a segmented appearance with palpocils at every joint. A pair of buccal spines, 160µm in length protrudes outwardly. The free ends of the spines are smooth and expanded. The tips of these obliquely placed buccal spines are close to each other. A pair of dark eyes located on the brain lobes corresponding to the second setigerous segment. Two pairs of jaws located between the 4th & 5th parapoda. Muscular pharynx, 150 µm wide extend to the sixth chaetigerous segment. Dorsal cirrus of second parapodium (a character of taxonomic interest) globular. The parapodia are sub biramous.

Anterior parapodia with two pre-setal lobes and further down appear to be single and broad supported by two aciculae. One of the pre-setal lobes of anteriormost parapodia is pointed, but thereafter such a pointed nature was not noticed. Five chaetae per parapodium, one simple stout and thick with expanded tip beset with minute teeth and in the remaining compound setae, the one nearer to the simple chaeta is slender and has an elongated blade with a distinct bifid tip. The posterior most three or four parapodia are short of one seta. The pygidium is distinguished by the presence of paired chordal glands on either side of the median line. The terminal pair of anal cirri seen separated at the time of fixation. The copulatory organ could not be located in the present specimen. Eventhough one specimen was observed with a single pair of copulatory organs, their structure could not be studied in detail.

Remarks: *Pisione gopalai,* described originally from the Madras beach by Alikunhi (1941), has also been reported from other parts of India (Waltair Coast, Rao and Ganapati, 1968) and South Australia (Alikunhi, 1941). The specimen in hand agrees with the description of the type species, in several morphological features of taxonomic importance. However, some remarkable differences are observed in comparison with the original description. In the possession of longer buccal spines and elongate palps, the material in hand comes close to *P. longispinulata* described by Aguado and San Martin in 2004. But the presence of five parapodial chaetae as against only 4 chaetae of *P.longispinulata* makes the local specimen distinct from the latter. Although closer examination of copulatory organ is very much needed for specific identity, the material in hand is presently assigned to *Pisione gopali* Alikunhi, 1941 for want of sufficient number of male specimens.

Distribution: Bay of Bengal (Alikunhi, 1941; Rao and Ganapati, 1968); South Australia (Alikunhi, 1941); Arabian Sea (present record).

43.P2 ***Pisione bifida*** nov. sp.

(Plate. 10: Fig. 40a & b; Plate. 18: Fig. 108a, b, c & d)

Occurrence: A set of eight specimens were collected from Cherai in monsoon month and another set of five specimens from the same beach during the post-monsoon season.

Type Locality: In medium sand 17 cm below surface, intertidal zone, Cherai beach (lat. 10°09'N long. 76°02'E) Kerala, India. Clean medium sand. Moderately well sorted.

Type material: Holotype: PM3a. Sl.1; Paratype: M3a. Sl. 1.

Etymology: The bifid nature of the posterior end is uncommon among the genus.

Description: The material under consideration is 2.7mm long and 130 to 140μm wide (excluding parapodia) with 36 chaetigers. A small prostomium visible, surrounded by buccal segment. Anteriorly directed palps are 208μm long. Buccal segment bears dorsal cirri (63μm long) and globular ventral cirri. Palpocils present on palps and dorsal cirri. Buccal spines, stout and 55μm long, project out with their anterior expanded tips abutting the neighbouring spines. A pair of irregular eyes located on the brain lobes, at the level of third setiger. Paired chitinous jaws located close to the eyes between the third and the fourth setiger. The distance between the margin of eyes and jaws is only 7μm. Pharynx extent upto the ninth setigerous segment. Hind lobes of brain remain close together and extent to the fourth setigerous segment. Paired parapodia are long with rounded pre-chaetal lobe and two aciculae. Dorsal cirrus of the second parapodium globular. Five chaetae per parapodium in the anterior and middle segments. A simple chaeta, an elongate compound seta and three falcigers. Posterior parapodia lack one falciger. The blade of the compound seta with a bidentate tip is 18μm long and the remaining three falcigers have blades 9-10μm, 10-12μm and 9μm length respectively. Pygidium semi-circular, 85x70μm with a pair of short anal lobes of 30μm length. The anal lobes at their base are 19μm apart. Copulatory organs not visible. Scale:75μ; 108c: 30μ; 108d: 20μ.

Remarks: Three species of *Pisione*, Viz *P. gopali*, *P. remota* and *P. complexa* have been reported from the east coast of India (Alikunhi, 1941; 1947; 1951). *P.gopali* and *P. complexa* have several common features; Reports on the occurrence of *P. remota* are rare from the Indian coast. The material at my disposal differs from the different species of *Pisione* described so far. The closely associated eyes and jaws, the brain lobes that did not separate widely at the distal end and the very short and stout spines with their expanded distal ends abutting each other are features unknown among the different species of *Pisione* hitherto described. Moreover the pygidium with greatly reduced and conical pygidial lobes makes it distinct from the remaining species. A specimen with a pair of copulatory organs present in the collection with the same morphological features as mentioned above proves beyond doubt that the reduced pygidial lobes are not features of an immature specimen. As the specimen was damaged during the slide preparation, study of copulatory organs could not be conducted. The lack of enough specimens with copulatory organs limits the description of the material at the morphological level.

This species is described as follows: The specimens are 2.7 to 3.0 mm long, 130 - 140 μm wide with 35 - 38 setigers. Prostomium visible. Anterior palps well developed; 63μm long dorsal cirri and globular ventral cirri for the buccal segment. The expanded anterior margins of the stout and short (55μm) buccal cirri are located very close to each other. Closely associated with a pair of eyes at the level of third setigerous segment, are present paired chitinous jaws located between the third and the fourth segment. Hind lobes of brain are close to each other. Five chaetae per parapodium in the anterior and middle segments, whereas four chaeate per parapodium in the posterior segments. Pygidium semi-circular with a pair of extremely short anal lobes (30µm long). The base of anal lobes is 19µm apart.

44. P3 ***Pisione remota*** (Southern, 1914)

(Plate. 10: Fig. 41a & b; Plate. 18: Fig. 109a & b)

Praegeria remota Southern, 1914: 47

Pisione remota (Southern) Alikunhi, 1950: 14

Occurrence: Several specimens were collected from Arthungal, Cherai and Sakthikulangara beaches in monsoon season and a few individuals from the intertidal area of Cherai and Sakthikulangara after the monsoon months.

Description: The specimen before me is 4.17mm long, 163-170µm wide having 48 setigerous segments. A reduced prostomium is present. Anteriorly directed palps measure 188µm, with palpocils at the joints. The dorsal cirri of the buccal segment, 89µm long (excluding the basal bulge of the buccal segment). The ventral cirri are flask shaped. A pair of 93µm long buccal spines projects out. Their outer margin serrated. Eyes located at the level of third setiger. Hind lobes of brain extend to fourth setigerous segment and paired jaws correspond to fifth segment. The anterior most parapodial lobe distinctly shows a pointed fillet. Since the parapodial lobes are not elongated, the setae seem to project out well beyond the margin of the parapodial lobe. Five chaetae per parapodium, a simple seta, and an elongate compound seta and three falcigers. Pharynx extends to the 7th segment. The present specimen was also devoid of copulatory organs. Another specimen with two copulatory organs observed. But since they were not well spread, their istructural details could not be elucidated. Scale: 75µ.

Remarks: *Pisione remota* has been reported earlier from the Madras beach by Alikunhi, 1950. Occurrence of this Irish species in the purely tropical environment is of great interest as it demonstrates the successful adaptation of the species to extremely difficult environments. The specimens at my disposal, eventhough agrees well with Alikunhi's species, did show certain differences. The ventral cirri of first parapodia are short unlike very long one in the Madras specimen. The pointed fillet of the first parapodial lobe of the specimen in hand is comparable with Alikunhi's specimen. The local forms also show some resemblance with *P.complexa* Alikunhi, 1947, a species that has been reported by many workers along the east coast of India. But the very long buccal spine with faintly serrated margin, extention of brain lobes to the fourth setigerous segment and the small size of the body justifies its separation from *P.complexa.* Therefore the present specimen is assigned to *Pisione remota* (Southern, 1914). The sudden spurt of polychaetes during monsoon may be one of the reasons for encountering the maximum number of individuals during this season.

Distribution: Ireland (Southern, 1914); Bay of Bengal (Alikunhi, 1950); Arabian Sea (present record).

Genus *PISIONIDENS* Aiyar and Alikunhi, 1943
Pisionella Aiyar and Alikunhi, 1940: 89
Pisionidens Aiyar and Alikunhi, 1943: 120

Elongate body with numerous segments. Prostomium well developed with a pair of frontal antennae, a pair of lateral palps and subdermal eyes. Peristomium located posterior to prostomium, bears two pairs of tentacular cirri. Two chitinous jaws. Body segments with uniramous parapodia bearing small dorsal and ventral cirri and an elongate setigerous lobe.

45. P4 ***Pisionidens indica*** Aiyar and Alikunhi, 1940

(Plate. 10: Fig. 42; Plate. 18: Fig. 110a & b)

Pisionella indica Aiyar and Alikunhi, 1940: 89

Pisionidens indica Aiyar and Alikunhi, 1943: 120; Day, 1962: 636; 1967:133; Hartmann-Schroder, 1970: 14; 1974: 540; Fauchald and Reimer, 1975:81; Bastida-Zavala, 1991:75

Occurrence: Two specimens were collected from Sakthikulangara beach in monsoon from a depth of 12.5cm.

Description: Slender vermiform body, 1.5mm long from the base of the anal cirri to the tip of the frontal antennae. Maximum width 170µm. Segments poorly defined. Prostmium well developed with a pair of indistinctly segmented frontal antennae (70µm long). Minute palpocils present on the antenna. Two pairs of circular eyes in the prostomium. The peristomium, which is fused to the prostomium, bears two pairs of tentacular cirri. Two pairs of less chitinised jaws lie further posteriorly. Nine uniramous parapodia, each with small dorsal and ventral cirri and an elongate setigerous lobe supported by an aciculum. The parapodium bears one simple and three compound setae. The large compound sets found in other pisionids absent in these specimens. The posterior parapodia are devoid of setae. Pygidium with a pair of 190µm long cylindrical anal cirri.

Remarks: Aiyar and Alikunhi (1940) described the species from the sandy beaches near Madras and Calicut (Kerala). While resembling the figures and description of *Pisionidens indica*, certain remarkable differences are noticed in the specimens collected during the present study. Conspicuous differences are presence of setae in the parapodia, lesser number of parapodia and the small size of the organisms. Adjacent to the two sets of eyespots, patch of granular substance without any definite shape is observed. Further, a set of granular markings similar to chromatophores is seen. These structures occupy a position on the anterior mid-dorsal region. It is assumed that the specimens though agree with *P.indica,* are not mature and could be the juvenile stage of *Pisionidens indica.*

Distribution: Bay of Bengal (Aiyar and Alikunhi, 1940; Rao and Ganapati, 1968); Arabian Sea (Aiyar and Alikunhi, 1940); Natal, South Africa (Hartmann- Schroder, 1970; 1974); Gulf of Mexico, Atlantic (Bastida-Zavala, 1991); Panama, Pacific (Fauchald and Reimer, 1975).

PLATE – 10

EXPLANATION OF FIGURES

Fig. 37 ***Metepsilonema magdae***

a: Male

b: Female

Fig. 38 ***Rhabditis ehrenbaumi***

a: Anterior end of female

b: Posterior end of female

POLYCHAETA

Fig. 39 ***Pisione gopalai***

a: Anterior end

b: Posterior end

Fig. 40 ***Pisione bifida*** nov. sp.

a: Anterior end

b: Posterior end

Fig. 41 ***Pisione remota***

a: Anterior end

b: Posterior end

Fig. 42 ***Pisionidens indica*** – Entire

Fig. 43 ***Saccocirrus minor***

a: Anterior end

b: Posterior end

Fig.37a

Fig.37b

Fig.38a

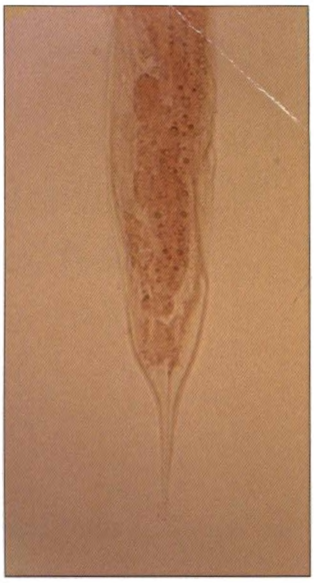


Fig.38b

Fig.39a

Fig.39b

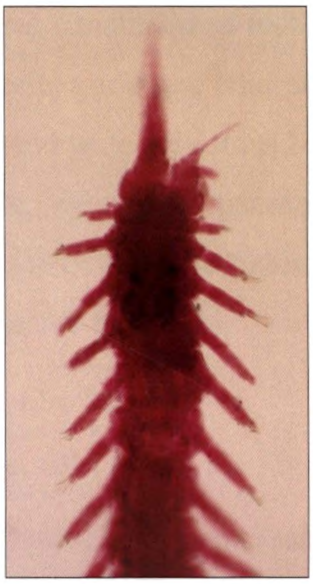


Fig.40a

Fig.40b

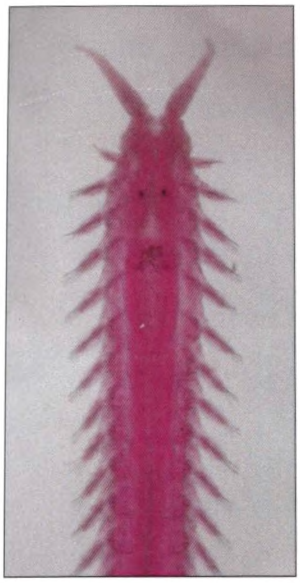


Fig.41a

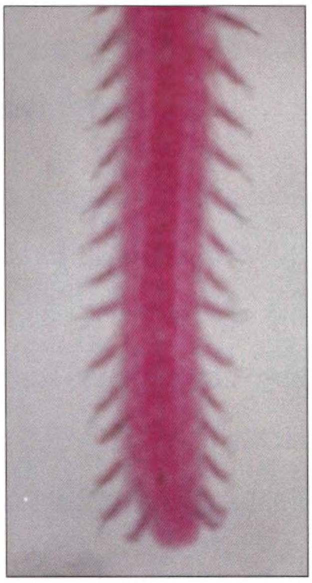


Fig.41b

Fig.42

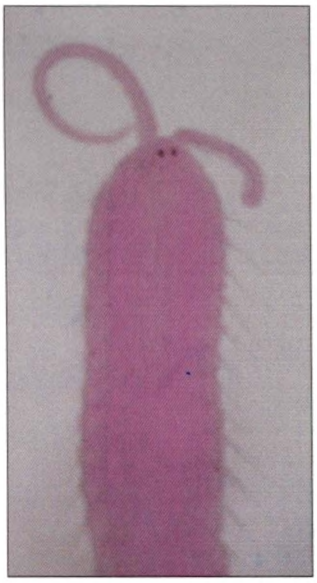


Fig.43a

Family SACCOCIRRIDAE Czerniavsky, 1881

This family has only one genus, *Saccocirrus* Bobretzky, 1871 the members of which frequent gravel sediments of turbulent surf zones. These polychaetes are highly active and are generally restricted to warm waters (Westheide, 1990).

Genus *SACCOCIRRUS* Bobretzky, 1871

The genus *Saccocirrus* has 17 described species, and is distributed world wide in eulittoral and sub-littoral coarse sand. The individuals have a long slender highly contractile body with numerous segments. Head consists of prostomium, with a pair of long canaliculated motile tentacles, basal ampullae, a pair of eyes and transversely oriented ciliated nuchal pits at its base. Prostomium is followed by an elongate achaetous buccal region (peristomium). Segments with retractile, cylindrical parapodial stumps equipped with a bundle of unjointed chaetae of different types. Pharyngeal bulb present or absent; Pygidium with adhesive structures.

46. P5 ***Saccocirrus minor*** Aiyar and Alikunhi, 1944

(Plate. 10: Fig. 43a, Plate. 11: Fig. 43b; Plate. 18: Fig. 111a & b)

Saccocirrus minor Aiyar and Alikunhi, 1944:113; Rao and Ganapati, 1968: 82; Rao, 1969: 89.

Occurrence: Many organismsms were collected from Cherai, Arthungal and Sakthikulangara beaches during the monsoon season when the temperature and salinity were low.

Description: The length of formaldehyde fixed worms range from 2.4mm to 4.0mm when fixed in formaldehyde. Number of segments 45 to 69 in the specimens examined. Width of the body is 300µ to 360µ. The conical head carries a pair of dark conspicuous eyes, convex on the inner surface and flat on the outer. The outer surface contains granular structures. The head bears a pair of canaliculated sensory tentacles (480µ to 600µ long) ornamented with short cilia. The body proper is provided with less number of cilia. The entire surface of the body is richly supplied with glandular cells. The body surface has a sculptured appearance. The body tapers slightly towards the posterior end and terminates in the pygidium. The pygidium is undivided with a median ventral groove and a pair of glandular adhesive pads. The pharynx extends up to the ninth segment. Parapodia bearing chaetae are present from the second segment onwards. The parapodial lobes do not project out in most of the segments. The posterior most eight to ten segments are devoid of parapodia. A middle parapodium bears five to seven straight setae with channelled chisel tips. Three setae are with conspicuously broad tips, two are less broad and one is slender and pointed. The length of the setae varies considerably. The perfectly smooth tipped setae are a characteristic feature of *Saccocirrus minor*. Scale: 75µ.

Remarks: These worms were first described by Aiyar and Alikunhi (1944) from the beach sands of Madras on the east coast and Cranganore on the west coast of India. The present material agrees with *Saccocirrus minor* Aiyar and Alikunhi, (1944). However, the specimens collected from the south west coast are shorter than those observed by Aiyar and Alikunhi. Similarly the pygdium possess less number of cilia. The glandular nature of the outer surface and variations in the general morphology are believed to be ecotypical variations. Not withstanding these differences, the material in hand is assigned to *Saccocirrus minor* Aiyar and Alikunhi. Salinity does not seem to play an important role in the distribution of these interstitial polychaetes, while grain size determines their occurrence. The biotope, most often, is coarse-grained sediment in the intertidal or infralittoral zones (Jouin, 1971). In the present investigation, habitats inhabited by these polychaetes are characterized by the presence of medium and coarse sand. An abundance of these species observed during monsoon in the present study has earlier been reported by Govindankutty (1967).

Distribution: Arabian Sea (Aiyar and Alikunhi, 1944); Bay of Bengal (Aiyar and Alikunhi, 1944; Rao and Ganapati, 1968; Rao, 1969).

47. P6 ***Hesionides arenaria*** Friedrich, 1937

(Plate. 11: Fig. 44a & b; Plate. 18: Fig. 112a, b, c & d)

Hesionides arenaria Friedrich, 1937: 343; Hartmann-Schroder, 1960: 74; 1974:540; Laubier, 1967: 588; Rao and Ganapati, 1967:11; 1968:82; Westheide and Rao, 1977.

Occurrence: Several individuals were collected from Arthungal and Sakthikulangara beaches at depths of 15 to 20cms during pre-monsoon, monsoon and post-monsoon seasons of the year. Scale: 75µ; 112c&d: 20µ.

Description: The worms are 1.46mm to 2.04mm in length, with the number of setigers varying from 21 to 30. Width of the body without parapodia is 80µm. The worms are reddish brown and the metamers distinctly separated. The anterior end with 11 appendages, characteristic of the genus. These include a pair each of dorsal and ventral tentacles, single median tentacle and three pairs of tentacular cirri. Dorsal and ventral tentacles are almost of equal length (40µ- 45µ). Tentacular knobs are present. Median tentacle, 70µ long, originates at the level of second tentacular cirri. Tentacular cirri are thread like and swollen at the base. The third pair of tentacular cirri, 120µm long is the longest. The notopodia and neuropodia are well spread. Each notopodium has notopodial cirrus and two distally bent notopodial simple setae of unequal length. The notopodial seta of posterior parapodia seems to be straight and pointed. The larger notopodium has approximately 5 teeth and the smaller one has 3-4 teeth. The notopodial setae do not project beyond the notopodial cirrus. Each neurpodium has five compound setae, of which two are long with expanded blades, one medium and two short. The neuropodial setae are bidentate distally. Two aciculae are noticed, of which one project out of the neuropodial lobe. Pygidium ends in a single semi-circular anal lamella, having the texture of an insect wing. Two, 290μm long anal cirri present, spindle shaped proximally and thread like distally. The pharynx extend to the region of second setigerous segment

Remarks: *Hesionides arenaria* enjoys cosmopolitan distribution. This species has evolved in such a fashion that it possesses morphological and physiological adaptations and probably genetic and non – genetic to assist it to colonise in regions having extreme environmental conditions. Westheide (1967) has remarked that relatively small vermiform body; absence of eyes, presence of adhesive anal lamella etc are specific adaptations for living in the interstitial environment. Its distribution is the widest of any interstitial polychaete species hitherto known (Westheide, 1971; 1976). Rao and Ganapati (1967; 1968) and Westheide and Rao (1977) have reported the occurrence of *H. arenaria* along the Indian coast. The present material agrees well with the description of the type specimens in most of the morphological features. However, some remarkable differences were also noticed. The original description shows that the specimens have uniformly thread like anal cirri, while the specimens in hand have anal cirri with characteristically spindle shaped proximal region. This feature has earlier been reported by Rao and Ganapati (1967) also in their findings. Another noticeable difference is the shape of the anal lamella, which, in the present forms is single and semi circular unlike the slightly bifurcated lamella in the original description. In the presence of a semi circular anal lamella, the present form resembles *Hesionides indooceanica*, although disagree in all the other cardinal characters. The absence of a strong notopodial aciculum in the local forms (which is distinct in *H.indooceanica*) also justifies the placement of the present specimens under *Hesionides arenaria*. Marked variations were not observed in the relative measurements or morphology between the specimens from varied habitats.

Distribution: Bahamas, Baltic, North Sea (Friedrich, 1937); Atlantic, Mediterranean, Pacific, Red Sea (Hartmann-Schroder, 1960,1974;Laubier, 1967); Bay of Bengal (Rao and Ganapati, 1967; Westheide and Rao, 1977) and Arabian Sea (present record).

48. P7 ***Hesionides peculiaris*** Westheide and Rao, 1977

(Plate. 11: Fig. 45; Plate. 18: Fig. 113a, b, c & d)

Hesionides peculiaris Westheide and Rao, 1977: 275.

Occurrence: The specimens were collected from the low tide region of Sakthikulangara beach during the monsoon and post-monsoon seasons of the year.

Description: Vermiform body. Total length including anal lobes is 850µm. Maximum width 90µ. Pygidial segment 60µm in diameter. 17 setigerous segments are present. Eleven appendages at the anterior end, which include two paired tentacles, a median tentacle and three pairs of tentacular cirri. Paired dorsal and ventral tentacles range in length from 40 to 45µm. Median tentacle originates at the level of the first tentacular cirri. Tentacular knobs present, but not as distinct as mentioned in the type specimens. The first two pairs of tentacular cirri are almost of equal length. The third pair of tentacular cirri is the longest. The notopodium of each parapodium has a long and short notopodial setae, notopodial cirrus and an aciculum. Longer setae extent much beyond the cirrus, having a characteristic bend with four teeth clearly visible at the bend and a long unidentate part between the tip and the serrated region. The shorter seta has 3- 4 teeth. Their tips are bidentate. Each neuropodium has five compound setae, of which three are large and two small. Their tips are slightly bidentate. One aciculum could be seen clearly. Pygidium ends in two widely spread out anal lobes, which are round distally. A pair of anal cirri, 200µm long, originates just beneath the anal lobes. Scale: 75µ; 113c&d: 20µ.

Remarks: The specimens at hand resemble remarkably *Hesionides peculiaris* described by Westheide and Rao (1977) from the east coast of India in the possession of widely separated anal lobes and the bent notopodial setae. The elongate notoseta extending well beyond the cirrus bearing three or four distinct teeth at the bend is a characteristic feature it shares with the type specimen. Eventhough tentacular lengths of the present forms show resemblance to *Hesionides minima*, the notoseta with distinct teeth confined to the bent region of the material in hand, unlike the evenly spread out four sharp teeth of *H.minima* makes the present material distinct from *H.minima.* Notwithstanding this minor difference, the local specimens are assigned to *Hesionides peculiaris*.

Distribution: Indian Ocean (Westheide and Rao, 1977).

49.P8. ***Hesionides remani*** nov.sp.

(Plate. 11: Fig. 46a & b; Plate. 18: 114a & b)

Type Locality: In medium sand 17 cm below surface, intertidal zone, Cherai beach (lat. 10°09'N long. 76°02'E) Kerala, India. Clean medium sand moderately well sorted.

Type material: Holotype - PM 3b.2 (length 770µm, 14 setigers).

Paratype – PM 3b.1 (length 700µm, 11setigers).

Etymology: The species is named *Hesionides remani* considering the pioneer work conducted by this naturalist on the interstitial fauna of various temperate and tropical beaches.

Description: The worms are 700 to 770µm in length with 11 to 14 setigers. Each segment is approximately 55µ long. The diameter ranges from 55µ to 60µ. The organisms are more or less transparent. The segmentation is indistinct anteriorly and the grooves between the segments are faint. Pharynx, 100µ long and 30µ wide extend upto the third setigerous segment. A pair of dorsal tentacles is directed anteriorly and the ventral tentacles originate laterally. Tentacular knobs present. Both dorsal and ventral tentacles are of equal length (30µ). Median tentacle 70µ long, at the level of first tentacular cirri .The first and second pair of tentacular cirri are almost of equal length, in the range of 60µ to 65µ. The third pair of tentacular cirri, which is the longest, is 85µ long. The number of parapodia corresponds to the number of segments. Each notopodium with dorsal cirrus and two notosetae of unequal length. The large notopodial seta does not extend much beyond the notopodial cirrus, which is 35µ long. The long notoseta has 4-5 teeth at the region of the bend, the first 3-4 teeth being very conspicuous. Tip is minutely bidentate; a long unidentate part is visible between the tip and the serrated region. Small notoseta with 2-3 teeth is seen. Neuropodium has five compound setae with blades of variable length. Two of them have small blades and three with large blades, bifid at the tip. Slender tapering aciculum present. Pygidium ends in two 25µ long rectangular lobes which are distally round with openings of adhesive glands. A pair of thread like anal cirri (215µ long) with broad base originates on either side of the anal lobes. One specimen with 15 segments had a pair of copulatory organ on the 10th segment. Scale: 75µ; 114b:20µ.

Remarks: A scrutiny of the characters of different species of the genus hitherto described clearly shows that the present material is morphologically distinct. Various architectural and morphological features noticed show similarities to already described species like *Hesionides peculiaris, H.arenaria* and *H.gohari.* The similarities are of the following nature. The bent of the notosetae of the specimens in hand resembles that of *H. peculiaris.* Tentacular lengths also support this. But, the anal lobes of the latter are quite distinct from the present form. One specimen with copulatory organ resembles that of *H.arenaria,* although in *H.arenaria,* the mating organ is located anteriorly (Westheide, 1977), while in the present form, the copulatory organ is in the posterior half of the body. In some features the material resemble *H.gohari,* which is a cosmopolitan species. However, the following characters distinguish the present species from *H.gohari.*The third tentacular cirrus is the longest in the local form whereas the first tentacular cirrus is the longest in *H.gohari.* There are only 4 - 5 teeth in the large notoseta in contrast to, nine very fine saw shaped teeth in *H.gohari.*The few teeth of smaller notoseta is visible in the local forms, unlike the hardly recognizable teeth of *H.gohari.* Above all, *H.gohari* has small anal lamellar lobes, whereas the specimens in hand, which are not assigned to any species, have quite distinct, completely separate and longer anal lobes. The morphological features exhibited by the present material along with the differences noticed with the described species do warrant creation of a new species to assign this material. It is noteworthy that *H.gohari,* which is a cosmopolitan species, was not found in the localities surveyed in the present investigation. This probably indicates that the material in hand is a new species hitherto not collected by previous workers. Therefore the species in hand is described as a new species, *Hesionides remani* nov. sp.

The description is as follows: The worms are small (700 – 770 μ long) with 11 to 14 setigers. The segments are 55μ long and 55 to 60μ wide. Segmentation in the anterior region is indistinct. Pharynx extends upto the third setigerous segment. Dorsal tentacles are directed anteriorly and ventral tentacles, laterally. Median tentacle originates at the level of first tentacular cirri. The third pair of tentacular cirri is the longest (85μ). The notopodia of each parapodium has dorsal cirrus and two unequal notochaetae of which the longer one does not extend much beyond the cirrus. The tip of long notoseta is minutely bidentate with 4- 5 teeth at the bent region. Small notoseta has 2- 3 teeth. Neuropodium has five compound setae with blades of variable lengths. Pygidium ends in two long rectangular lobes with openings of adhesive glands at their distal ends. A pair of long thread like anal cirri with broad originates on either side of the anal lobes.

Family PROTODRILOIDAE Purschke and Jouin, 1988

This family was formed to incorporate polychaetes represented by species with two solid mobile flexible tentacles devoid of internal canals, and merges with the basal prostomium proper. The members have neither eyes nor statocysts. Inconspicious nuchal organs. Parapodia absent. The species have metamerically arranged unjointed chaetae or adhesive glands. Pygidium bilobed.

Genus *PROTODRILOIDES* Jouin, 1966

This genus includes two species *Protodriloides chaetifer* (Remane, 1926) and *Protodriloides symbioticus* (Giard, 1904). The species possess small chaetae or segmental adhesive organs, yellowish green epidermal inclusions and anteriorly pointed non-canaliculated tentacles. These trwo species were earlier considered to be *Protodrilus* species, until Jouin, (1966) recognized their fundamental differences in tentacle morphology, reproductive biology and development.

50. P9 ***Protodriloides chaetifer*** (Remane, 1926)

(Plate. 11: Fig. 47a & b; Plate. 18: Fig. 115a & b)

Protodrilus chaetifer Remane, 1926:119; 1932: 1-36; Fauvel, 1927: 1-494; Wieser, 1957: 275; Jouin, 1962: 3065; Renaud – Debyser and Salvat, 1963: 463; Boaden, 1963:79; Bellan, 1964:5; Westheide, 1966: 203.

Protodriloides chaetifer Jouin, 1966: 139; Wolff, 1973:1-242; Boaden, 1976:461; Wolff *et al.* 1980: 94; Vanosmael *et al.* 1982; Von Nordheim, 1984: 1-20; Westheide, 1990.

Occurrence: Several individuals were collected from Fort Kochi in summer at low tide from a depth of 15 - 20 cms and a few individuals from Arthungal beach during the same period.

Description: Transparent vermiform body 2-3mm long with diameter ranging from 70μm-125μm. Body surface is characteristically wringled.

Numerous globular greenish or colourless glands, seen all over the body. Number of segments 20. A pair of non-canaliculated tentacles, 105µ-115µ long, originate from the prostomium anteriorly. Numerous short cilia present on either sides of the head and tentacles. Pharyngeal bulb present. First body segment is shorter than the remaining segments. Two pairs each of S-shaped chaetae, approximately 20µm long present from the second segment onwards. The chaetae are bifid at the tip and originate from the posterior half of the segments. Pygidium is bilobed with adhesive gland openings.

Remarks: The present material agrees well with the description of the type species reported by Westheide, 1966. *Protodriloides chaetifer* possesses sigmoid chaetae, which occur neither in *Protodrilus* nor in *P.symbioticus*. (Westheide, 1966). The presence of bifid S-shaped chaetae, greenish and colourless epidermal glands and non-canaliculated anterior tentacles are all-present in the local forms. However, the shape of the pygidial lobes and the presence of numerous short cilia on either sides of the head and tentacles anteriorly are characters not noticed in the type specimens by Westheide (1966). Wieser (1957) did notice these structures in the specimens he examined from Richmond Beach, Puget Sound. It is interesting to note the cosmopolitanism enjoyed by this species since the species is without a pelagic larval stage. It has to be assumed that distribution could be effected through transport of juveniles and adults, as a well-established group of pelagic polychaetes exist in the tropical and temperate seas.

Distribution: North Sea (Remane, 1926; Westheide, 1966; Nordheim, 1984); Puget Sound, Pacific coast of North America (Wieser, 1957); English Channel (Roscoff area); Atlantic coast of North America (North Carolina); Indian Ocean (South Africa, Natal); Arabian Sea (present record).

Family PROTODRILIDAE Czerniavsky, 1881

Elongate, thread like, multisegmented body with neither parapodia nor chaetae; a pair of mobile, flexible canaliculated tentacles (palps) arise from the prostomium; pygidium with a bilobed or trilobed adhesive appendage. Two eyes, at least in larvae and usually a pair of statocysts and two nuchal organs are present. Ventral ciliary band helps in locomotion. Pharynx prominent, ventrally located with tongue like organ and grating plate. Salivary glands distinct, extending into a variable number of segments. Bacillary glands occur in the form of spindle shaped or sigmoid shaped cells with filamentous rod like contents. This family has two genera: *Protodrilus* Hatschek, 1880 (base of head appendages distinctly separated), and *Actomus* Jouin, 1979 (gutless).

Genus *PROTODRILUS* Hatschek, 1880

Protodrilus Hatschek, 1880:1

The genus *Protodrilus* having cosmopolitan distribution, lives in intertidal and subtidal marine sandy sediments, with low detritus content. Slender, filiform body with stiff sensory cilia, ciliary tufts and often with transverse ciliary rings. Homonomous trunk segments without parapods or chaetae. Head with two very mobile tentacles, two nuchal organs, mostly statocysts, occasionally two pigmented eyes and a ventral pharyngeal apparatus. Presence of a closed system of spaces in the cephalic region is characteristic of this genus (Goodrich, 1931).

51. P10 ***Protodrilus pierantonii*** Aiyar and Alikunhi, 1944

(Plate. 11: Fig. 48a & b; Plate. 18: Fig. 116a & b)

Protodrilus pierantonii Aiyar and Alikunhi, 1944: 113; Rao and Ganapati, 1968: 82; Rao, 1969: 89.

Occurrence: A lot of five individuals were collected from Cherai and four individuals from Sakthikulangara beach in monsoon season from a depth of fifteen cm. Two more organisms were obtained from Cherai beach during the post-monsoon month.

Description: Slender vermiform body 2-3.5mm long, with 28 – 35 segments. The body segmentation is fairly distinct and the intersegmental regions could be clearly observed under the microscope. Maximum body diameter 75μ - 80μ when fixed in formaldehyde solution. The body is attennuated towards the posterior extremity. The head is distinct and carries a pair of sensory tentacles, 160μm long. Statocysts, which are extremely minute (a feature of this species), could not be located. Sensory cilia on the body are inconspicuous. Complete ornamentation of the body surface masks the internal characters. Nuchal organs, represented by two very minute ciliated depressions on either side, a little behind the base of the tentacles. Salivary glands extend back to the 16th segment. The anal segment ends in a trilobed pygidium, where the lateral lobes are distinct, 37μ long and 17.5μ wide. The third lobe is represented at the junction between the bases of the lateral lobes as a minute blunt projection. Only 2 to 3 palpocils located on the pygidium. Scale: 75μ.

Remarks: Aiyar and Alikunhi (1944) described the species from Madras beach, Gulf of Mannar and Cranganore (Cochin). Rao and Ganapati (1968) reported the occurrence of this species in Arabian Sea and Bay of Bengal. From the taxonomical point of view, the genus *Protodrilus* Hatschek, 1880 represents a difficult group of polychaetes due to lack of hard structures like chaetae and jaws (Nordheim, 1989). The few specimens locally available come close to the original description in the general morphology and presence of a three lobed pygidium. Due to the non-availability of sufficient intact mature individuals, a detailed study of the ciliary bands could not be undertaken. Still the presence of three lobed pygidium, characteristic of this species, justifies the assignment of the present forms under *Protodrilus pierantonii*.

Distribution: Bay of Bengal (Aiyar and Alikunhi, 1944; Rao and Ganapati, 1968; Rao, 1969); Arabian Sea (Aiyar and Alikunhi, 1944; present record).

52. P11. ***Protodrilus indicus*** Aiyar and Alikunhi, 1944

Plate. 11: Fig. 49a & b; Plate. 18: Fig. 117a & b)

Protodrilus indicus Aiyar and Alikunhi, 1944: 113; Rao and Ganapati, 1968: 82; Rao, 1969: 89

Occurrence: Single specimen obtained from Arthungal beach from the low tide region during summer.

Description: The worm is 2.04mm long, 80µm wide with 25 segments. Lone specimen obtained with detached tentacles. Body surface smooth without much ornamentation. Stiff cilia present at the anterior end of prostomium. A pair of statocysts as conspicuous circular areas at the base of the tentacles. Statocysts located at either end are 12.5µm apart. Eyes absent. Nuchal organs located immediately behind the head cavity. Ciliary bands are faint. Behind the base of the tentacles, on either side, group of long cilia present. Apart from short sensory cilia, elongate palpocils (20 – 25µm long) present all through the length of the body. The posterior end of body is attenuated, with a diameter of 55µm at the pygidial end. The pygidium is bifurcated, with a few cilia. Spindle shaped glands noticed, more prominent towards the lateral margins of the body. Salivary glands extent upto the 4th segment. Scale: 30µ.

Remarks: After the description of the species from the Madras coast by Aiyar and Alikunhi, many authors reported the occurrence of *Protodrilus indicus* along the east coast of India. The specimen at my disposal agrees well with the original description in general morphology. However, the pygial lobes seem shorter than the Madras specimens. Paucity of enough specimens deterred a detailed study of the reproductive organs. Despite the fact that the pygidial lobes are short (probably due to shrinkage). Disposition of the salivary glands, conspicuous statocysts, lack of eyes,

PLATE – 11

EXPLANATION OF FIGURES

Fig. 44 ***Hesionides arenaria***
a: Anterior end
b: Posterior end

Fig. 45 ***Hesionides peculiaris*** – Entire

Fig. 46 ***Hesionides remani*** nov. sp.
a: Anterior end
b: Posterior end

Fig. 47 ***Protodriloides chaetifer***
a: Anterior end
b: Posterior end

Fig. 48 ***Protodrilus pierantonii***
a: Anterior end
b: Posterior end

Fig. 49 ***Protodrilus indicus***
a: Anterior end
b: Posterior end


Fig.43b

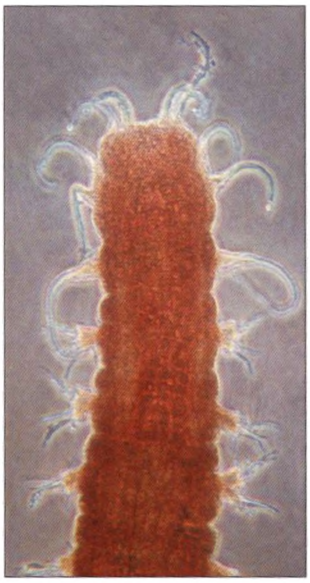


Fig.44a

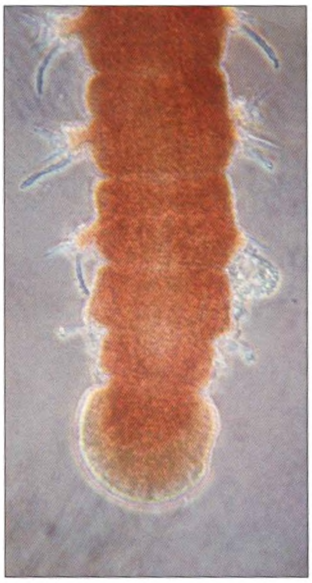


Fig.44b

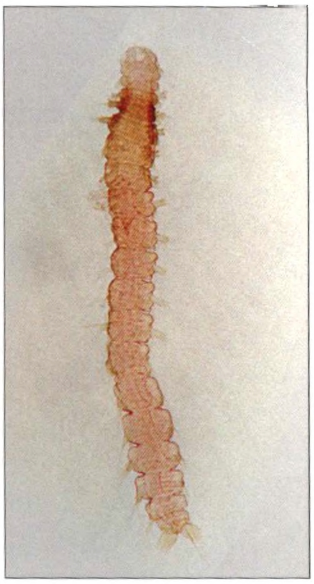


Fig.45


Fig.46a


Fig.46b


Fig.47a

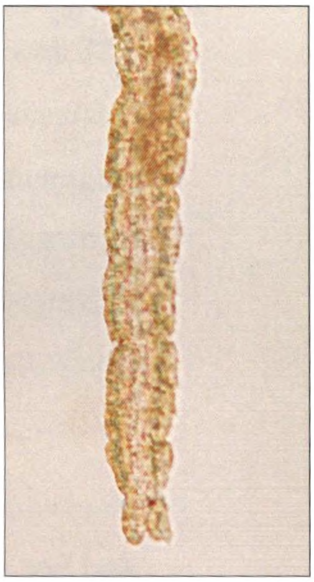


Fig.47b

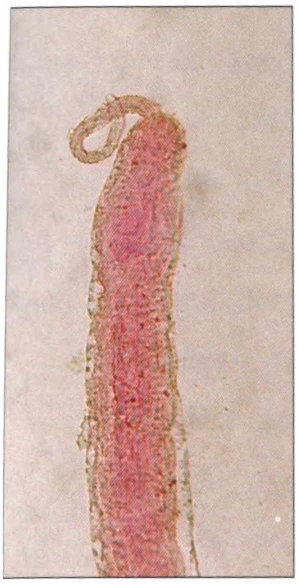


Fig.48a

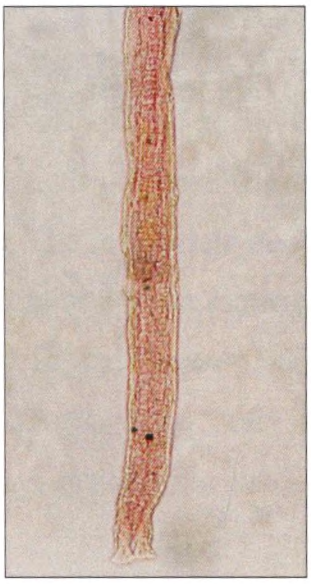


Fig.48b

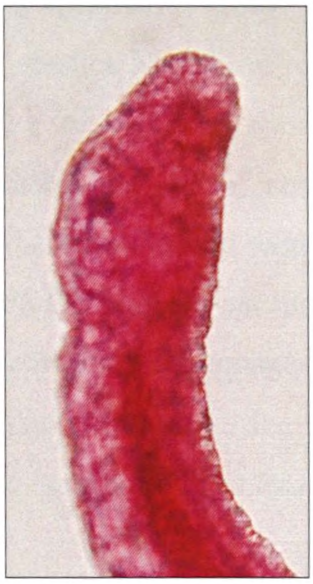


Fig.49a

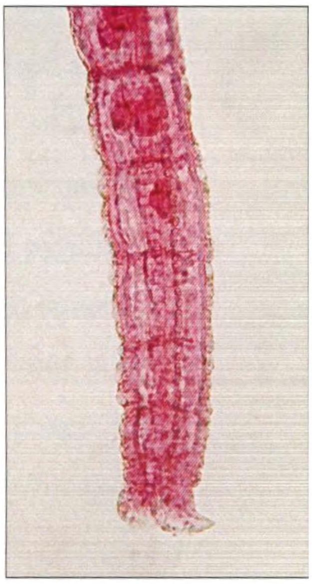


Fig49b

pattern of ciliary distribution etc are features which justify the inclusion of the material under *Protodrilus indicus* Aiyar and Alikunhi.

Distribution: Bay of Bengal (Aiyar and Alikunhi, 1944; Rao and Ganapati, 1968; Rao, 1969); Arabian Sea (Rajan, 1972; present record).

53. P12. ***Protodrilus sp.***

(Plate. 12: Fig. 50a & b; Plate. 18: Fig. 118a & b)

Occurrence: Several individuals were collected from the intertidal region of Cherai, Arthungal and Sakthikulangara beaches during different seasons of the year.

Description: The worm is 1.1 – 1.5mm long and 75 - 80μm wide with 32 – 35 segments. Diameter of the head is 65 - 70μm. A pair of canaliculated cephalic tentacles measure 170 - 210μm. Body surface has a sculptured appearance. Cilia present in the prostomium. Certain stained or pigmented regions present on the head and continue down to the anterior segments. Pygidium wider (20μ) than long (12.5μ) with 2 lobes. Palpocils not visible on the pygidium. Scale: 75μ.

Remarks: The *Protodrilus* Hatschek, 1880 represents a difficult polychaete group from the taxonomical point of view. The animals look alike and lack any hard structures such as chetae and jaws, which normally serve as important traits in most polychaete taxa (Nordheim, 1989). Of the forty (approx.) species hitherto described, four species have been reported from India. A comparison of the relative size of different species show a reduction in the length of specimens reported from India. The material in hand is also short. The formaldehyde fixed specimens had reduced pygidial lobes and deeply stained areas scattered on the body. Even though several specimens were collected, many of them were either damaged or cut into pieces that made an elaborate study difficult. Therefore, the specimen in hand is not assigned any specific status and is referred to as *Protodrilus sp.*

Family POLYGORDIDAE Czerniavsky, 1881

Slender, thread like, cylindrical body with numerous similar segments. External segmentation poorly or not at all indicated. Parapodia and chaetae absent. Body surface smooth and somewhat irridescent; external ciliation lacking, except for the nuchal slits on the head, sometimes stiff, laterofrontally directed tentacles lack internal canals. Two pigmented eyes may or may not be present. Bulb-shaped pygidium with or without appendages, mostly preterminally encircled by groups of adhesive gland openings. Anus terminal. Muscular pharyngeal bulb absent (Westheide, 1990).

Genus *POLYGORDIUS* Schneider, 1868
Polygordius Schneider, 1868: 51.

Polygordius occurs worldwide in sublittoral sands. A detailed phylogenetic speculation, Hatschek (1878, 1893) resulted in placing *Polygordius* as the most primitive annelid ((Hatschek, 1878; 1893). Marion and Bobretzky (1875) considered the chaetigerous *Saccocirrus* to be closely allied to this taxon. The long, thread like body with its smooth surface devoid of any appendages or setae makes the genus easily recognizable.

54. P13 ***Polygordius madrasensis*** Aiyar and Alikunhi, 1944
(Plate. 12: Fig. 51a & b; Plate. 18: Fig. 119a & b)

Polygordius madrasensis Aiyar and Alikunhi, 1944:113; Alikunhi, 1948:373; Rao and Ganapati, 1967: 24; 1968: 82; Rao, 1969: 89.

Occurrence: Very few specimens were collected from Cherai, Sakthikulangara and Veli beaches at depths of 13-19 cms in different seasons of the year.

Description: The worms are small and slender, 3-7mm long, after fixation in formaldehyde. The segments are externally indistinct; vary in number from 40 to 60. Body diameter is 125µm. The head is distinct and constricted into an anterior short narrow region, 90µm across, containing the brain. The posterior broad part of the head (130µm wide) bears the anterior part of pharynx. The head carries a pair of antero-lateral apical tentacles, 100µm in length. Palpocils present on the tentacles. Tentacles are non- canaliculated. Eyes are absent. Numerous granular structures seen on the surface of the body. Posteriorly, the body ends in a swollen bulb, 150µm across and has a pair of short anal cirri (40µm long). Palpocils seen on the pygidium and anal cirri. Several green pigment glands are present on the body, more conspicuous on the pygidium. Scale: 75µ.

Remarks: Aiyar and Alikunhi, 1944 described the species from the inter tidal beaches of Madras, Krusadai Island and Cranganore. The local forms agree well with the original description in the morphological features. However, the transverse band of rod-shaped hypodermal glands located in the type specimens could not be seen in the present forms. Despite this variation, the local forms are assigned to *Polygordius madrasensis*.). Eventhough, Aiyar and Alikunhi (1944) have reported the abundant occurrence of this species during the pre-monsoon when high saline conditions prevailed; the present forms were obtained during low saline periods also. However, salinity variation of interstitial water is negligible irrespective of seasons.

Distribution: Bay of Bengal (Aiyar and Alikunhi, 1944; Alikunhi, 1948; Rao and Ganapati, 1967; 1968; Rao, 1969); Arabian Sea (Aiyar and Alikunhi, 1944; present record).

55. P14 ***Polygordius uroviridis*** Aiyar and Alikunhi, 1944

(Plate. 12: Fig. 52a & b; Plate. 18: Fig. 120a & b)

Polygordius uroviridis Aiyar and Alikunhi, 1944:113; Rao and Ganapati, 1967: 24; 1968: 82.

Occurrence: Single specimen collected during monsoon season from Sakthikulangara beach dominated by a mixture of coarse and medium sand grains.

PLATE – 18

Fig. 108 ***Pisione bifida*** **nov. sp.**

a: Anterior end; b: Posterior end

c : Neuropodium; d: Falcigers

Fig. 109 ***Pisione remota***

a: Anterior end; b: Posterior end

Fig. 110 Pisionidens indica

a: Anterior end; b: Posterior end

Fig. 111 ***Saccocirrus minor***

a: Anterior end ; b: Posterior end

Fig. 112 ***Hesionides arenaria***

a: Anterior end; b: Posterior end

c: Notopodium; d: Neuropodium

Fig. 113 ***Hesionides peculiaris***

a: Anterior end; b: Posterior endc: Notopodial setae; d: Neuropodium

Fig. 114 ***Hesionides remani*** **nov. sp.**

a: Entire; b: Parapodium

Fig. 115 ***Protodriloides chaetifer***

a: Anterior end; b: Posterior end

Fig. 116 ***Protodrilus pierantonii***

a: Anterior end; b: Posterior end

Fig. 117 ***Protodrilus indicus***

a: Anterior end; b: Posterior end

Fig. 118 ***Protodrilus sp.***

a: Anterior end; b: Posterior end

Fig. 119 ***Polygordius madrasensis***

a: Anterior end; b: Posterior end

Fig. 120 ***Polygordius uroviridis***

a: Anterior end; b: Posterior end

Fig. 108a

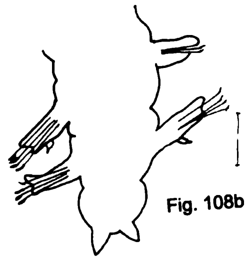


Fig. 108b

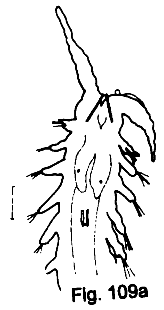


Fig. 109a

Fig. 110a

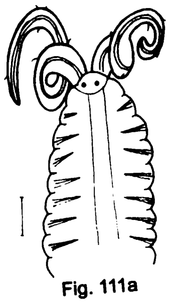


Fig. 111a

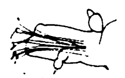


Fig. 108c

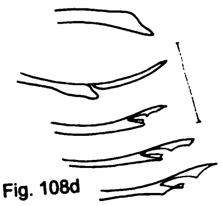


Fig. 108d

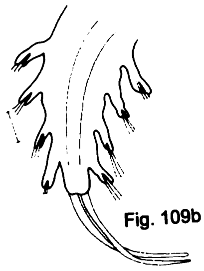


Fig. 109b

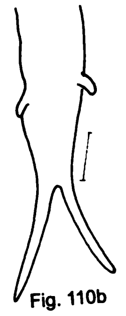


Fig. 110b

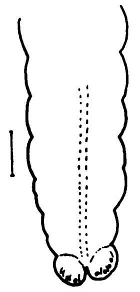


Fig. 111b

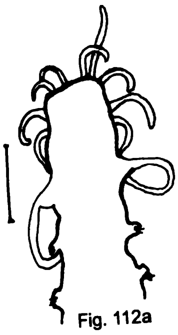


Fig. 112a

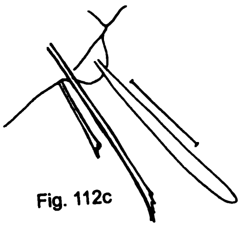


Fig. 112c

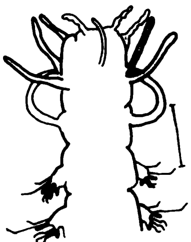
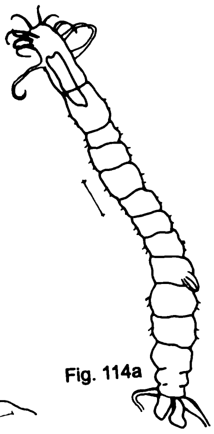


Fig. 113a

Fig. 113c



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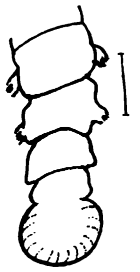


Fig. 112b

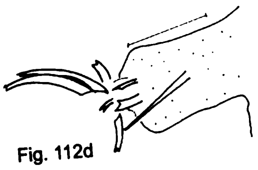
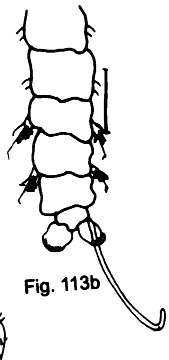


Fig. 112d



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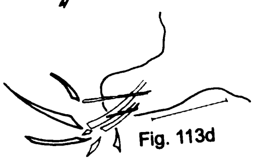


Fig. 113d

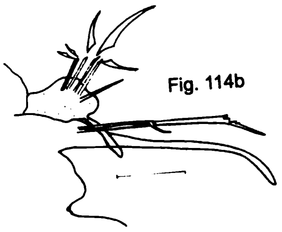


Fig. 114b

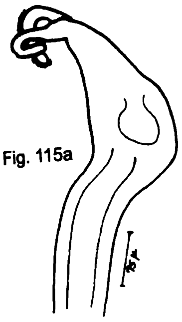


Fig. 115a

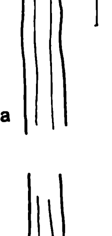


Fig. 116a

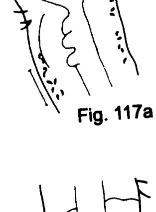


Fig. 117a

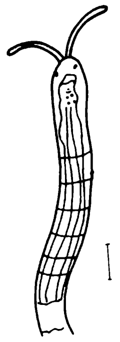


Fig. 118a

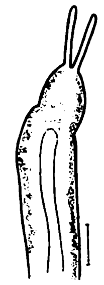


Fig. 119a

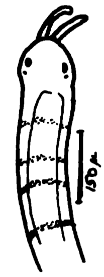


Fig. 120a

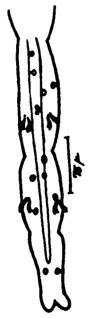


Fig. 115b

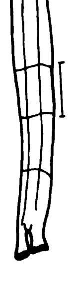


Fig. 116b

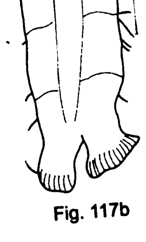


Fig. 117b

Fig. 118b

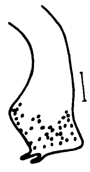


Fig. 119b

Fig. 120b

Description: Slender vermiform body 1.76mm in length excluding the cephalic tentacles. Body possesses 27 segments. Each segment is almost as broad as long. The diameter of the body is 100µm. Head diameter 90µ and the constriction of the head is not as prominent as in *P.madrasensis*. A pair of anteriorly directed cephalic tentacles 75µ long are present on the head. The head also bears a pair of irregular eyes of brownish hue. Immediately behind the eyes, markings representing nuchal organs are seen. No ciliation on the body proper. The body ends in an enlarged anal bulb 140µm across without any anal cirri. Numerous greenish granular cells, seen throughout the body with a maximum on the posterior region and the anal bulb. A conspicuous dark band of pigment granules encircles the anal bulb in the middle. Minute palpocils present on the tentacles and the pygidium.

Remarks: The present material resembles the type species in the possession of eyes, absence of anal cirri, conspicuous dark pigment band on the pygidium and the greenish granular cells. The only noticeable difference is the smaller size of the organism and fewer numbers of minute palpocils. This may be due to shrinkage during fixation. Despite these minor differences, the present specimen is assigned to *Polygordius uroviridis*. This species has also been recorded from the west coast of Kerala by Govindankutty (1967) and Rajan (1972). *P.uroviridis* enjoys a wide distribution in the tropical waters.

Distribution: Bay of Bengal (Aiyar and Alikunhi, 1944; Rao and Ganapati, 1968); Arabian Sea (Govindankutty, 1967; Rajan, 1972; present record).

4. 8 GASTROTRICHA

Gastrotricha constitutes one of the most interesting and taxonomically challenging groups of meiobenthic marine and freshwater invertebrates. In aquatic ecology, gastrotrichs are known as important components of the permanent meiofauna (Todaro *et al.*, 2006b). Marine gastrotrichs are mainly interstitial, occurring both in the intertidal and subtidal realms. They are more abundant in fine to medium grained sediments in unpolluted and less turbid waters of coastal areas (Todaro and Rocha, 2004). However, submarine caves, dysoxic sand and deep, muddy sediments may also be colonised by gastrotrichs (Leasi and Todaro, 2006; Balsamo *et al.*, 2007). In the sandy marine interstices, gastrotrichs rank third in abundance among the meiofaunal taxa following Nematoda and the harpacticoid Copepoda; their numerical abundance may reach a density up to 364 ind./ 10 cm^2 (Todaro, 1998). The phylum is cosmopolitan and includes about 700 species grouped into two orders: Macrodasyida, with 250 strap-shaped species, all but two marine, and Chaetonotida, with 450 tenpin-shaped species, of which only 150 are marine or brackish. Anatomically, their systematics is primarily based on the structure of pharynx, whose lumen is triangular in cross-sectional outline with the apex directed dorsally in the order Macrodasyida and ventrally in the order Chaetonotida. Further, the morphology and disposition of different cuticular formations, the number and arrangement of adhesive tubes and the anatomy and complexity of reproductive organs are decisive. The gastrotrich fauna of India have been recently reviewed by Naidu and Rao (2004). Approximately, seventy seven species of gastrotrichs have been recorded from India, of which forty one are exclusively marine belonging to the order Macrodasyida, while thirty six species, comprising twenty five fresh water, three brackish water and eight marine species belong to the order, Chaetonotida.

Phylum **GASTROTRICHA** Metschnikoff, 1864

Order **MACRODASYIDA** Remane, 1925 (Rao, 1970)

Family **THAUMASTODERMATIDAE** Remane, 1926

Subfamily **THAUMASTODERMATINAE** Ruppert, 1978

Genus ***PSEUDOSTOMELLA*** Swedmark, 1956

Pseudostomella Swedmark, 1956: 53; Ruppert, 1970: 121; 1978: 113.

Thaumastodermatinae with dorso-ventrally flattened body, anteriorly with a buccal appendage, dorsal surface with either longitudinal or transverse rows of triancres, tetrancres, pentancres and epidermal glands. Anterior, lateral or posterior adhesive tubes present. Pharynx with pores close to its hind end. Testes single, ovary unpaired or paired. Seminal vesicle, copulatory bursa present.

56. G1***Pseudostomella cheraensis*** Priyalakshmi, Menon and Todaro, 2007
(Plate. 12: Fig. 53; Plate. 18: Fig. 121)

Pseudostomella cheraensis Priyalakshmi, Menon &Todaro, 2007: 61- 68.

Type locality: Cherai beach, (lat.10° 09′ N, long. 76° 02′ E) Kerala, India. Clean medium sand, moderately well sorted.

Materials examined: Twelve specimens were examined by light microscopy

Holotype: One specimen of total length 295 µm collected on 15-12-2005; glycerol wholemounts on microslide, deposited at Marine Biodiversity Museum, CMFRI (Government of India), Kochi, India; ref. no: MBM-1.1.1.1

Paratype: Two specimens of length 276 µm and 223 µm respectively collected from the type locality; glycerol wholemounts on microslides, deposited at the same museum as; ref. no: MBM-1.1.1.1.1; MBM-1.1.1.1.2

Etymology: Named after the type locality which is a well known sandy beach frequented by both domestic and foreign tourists.

Description. The description is based on an adult specimen, 295 µm in total length. Width at oral cavity, neck (slightly swollen), trunk (6th pair of epidermal gland) and caudal base: 39/ 46/ 40/ 15 µm at U12, U21, U67 and U93 respectively. Head with well-developed and extended pre-buccal apparatus (pb) incurving anteromedially, characterizing the genus *Pseudostomella.* Their dorsal margin project out a little beyond the ventral margin Pre-buccal apparatus has five fleshy dorsal papillae ranging in length from 6 µm to12 µm, symmetrically arranged in 2+1+2 pattern. All papillae are with tactile cilia at the tip. Four to six smaller papillae are present along the ventral margin of the buccal palps, arranged in 2+2 or 3+3 pattern. Several sensory hairs (3 µm) present on the outer lateral margins of pre-buccal apparatus among which, a longer one measured 16 µm. Sensory hairs or lateral bristles (10 µm long) of uncertain numbers seen on the lateral margins of the body as well (U22-U91). Fig. 121. Scale: 100µ.

Epidermal glands: Eight to nine pairs of granular epidermal glands arranged along the lateral margins of the body originate at about U25 and extent up to U87.5. Their size range between 7.5 – 10 µm × 7.5 – 15 µm. The middle glands located at 8 µm apart from each other.

Cuticular armature: The entire dorsal surface from the base of buccal apparatus to the pedicles covered by rows of closely packed pentancres with an average size of 3.5 – 5 µm. They are arranged in 13 – 14 longitudinal columns in the mid- trunk region with each column containing around 58 to 60 pentancres antero-posteriorly. The tines of the ancres project out almost masking the posterior border of the body.

Adhesive tubes: Four of the six anterior adhesive tubes (TbA) seen ventrally at the base of the pre-buccal apparatus in 2+2+2 pattern measure 4 µm each. The remaining pair at the farthest end is longer. The number and pattern of TbA seem to vary. In one of the paratypes, an additional pair is seen associated with the distal pair, indicating variability in the number of TbA. Eleven pairs of lateral adhesive tubes (TbL) originate at U39 and extent upto U89, with an average length of about 7-8 µm. Of these, the anterior ten pairs areTbVL, evenly spaced and extent upto U77.6. The last pair, dorso-lateral in position is located at U89. Pedicles (20 µm long) furnished with three distal tubes (TbP), the median one (8 µm) directed slightly dorsally, while the others (5 µm) are directed slightly ventrally.

Two posteriorly directed adhesive tubes; 8-9μm long are positioned at the base of the pedicles.

Ventral ciliation: Locomotory cilia form a continuous field of transverse rows from behind the margin of mouth and extent upto the caudal base.

Digestive system: The digestive tract begins with a terminal mouth, covered dorsally by a hood like extension and opens into the pharynx, behind the pre-buccal apparatus. The pharyngeal pores could not be located. The entire digestive tract not well discernable in the holotype. The paratype showed PhIJ at U37- U38.The intestine is broad anteriorly and narrows down posteriorly. The anus opens ventrally at U89.

Reproductive system: Simultaneous hermaphrodites. A single elongate testis on the right side (as seen from above) begins behind the pharyngeo-intestinal junction and leads caudally into a narrow elongate vas deferens. The caudal organ located at U78 is pear shaped and is connected to a spherical frontal organ located at U74.8. The paratype showed two oval oocytes in the mid posterior body, of which the upper larger one measured 38x 19 μm.

Remarks: The genus *Pseudostomella* includes 13 described species; of these four: *P. klauserae* Hochberg, 2002, *P. megapalpator* Hochberg, 2002, *P. plumose* and *P. faroensis* Clausen, 2004 carry scaled triancres; six: *P. andamanica* Rao, 1993, *P. indica* Rao, 1970, *P. koreana* Lee & Chang, 2002, *P. longifurca* Lee & Chang, 2002, *P. malayica* Renaud–Mornant, 1967 and *P, roscovita* Swedmark, 1956 bear tetrancres whereas the remaining three: *P. cataphracta* Ruppert, 1970, *P. etrusca* Hummon, Todaro & Tongiorgi, 1993 and *Pseudostomella sp.* 1 [Valbonesi and Luporini, 1984] have a cuticular armature made up of pentancres. Based on the type of the cuticular covering the new species from India resemble most closely to the latter three taxa.

P. cataphracta can be distinguished from the other pentrancres-bearing species, including the new one from India, principally because it possesses a pair of ventral feet (each foot made up of 4 adhesive tubes), located in posterior region of the trunk. *P etrusca* is the only one that bears a pair of dorsal adhesive tubes on the base of the pre-buccal palp; moreover it has a much higher number of anterior adhesive tubes compared to P. *cheraensis* sp. nov. (14 vs 6). *Pseudostomella* sp1 from Somalia in contrast with the new species from India shows a pair of ventro-lateral adhesive tubes in the anterior region of the pharynx, a higher number of anterior adhesive tubes, (10 vs 6), shorter caudal pedicles and the dorsal tubes at the end of each caudal pedicle that is shorter of the two tubes that flank it.

The pattern of distribution of the representative species belonging to the genus *Pseudostomella* hitherto known clearly indicates cosmopolitanism. However, the species as such appear to have a rather narrow range, on the other hand the general absence of biogeograhic records testifying the simultaneous presence of a two or more species at a single beach (e.g. as it happens for *Tetranchyroderma*) let to hypothesize that biogeography may be influenced also by interspecific competition. In this general framework the finding of three species of Pseudostomella from a North Carolina beach (Ruppert, 1970) and the occurrence of *P. roscovita* in the Atlantic Ocean (and connected seas) and the Indian Ocean appear particularly interesting and certainly call for further investigations.

Diagnosis. *Pseudostomella* up to 295 µm in total body length, with a distinct anterior pre-buccal apparatus and an elongate bilobed caudum. Buccal palps bearing five dorsal cephalic papillae with sensory hair and 4-6 minute ventral papillae. Cuticular armature of pentancres extending from the margin of oral cavity to the base of pedicles (caudum) ornaments the entire dorsal surface. Adhesive tubes: pedicles with three distal adhesive tubes (TbP) of unequal length and an adhesive tube at the base. TbA, six in number, in 2+2+2 pattern;

TbL, 10-12 per side between U39 and U89. Nine pairs of granular epidermal glands between U25 and U87.5. Sensory hairs on the pre-buccal palps and trunk. Tactile cilia border the margin of the buccal cavity. Caudal organ pear shaped; frontal organ spherical. Oocytes located in the mid body.

Distribution: Arabian Sea (Priyalakshmi *et al.*, 2007).

Genus *TETRANCHYRODERMA* Remane, 1926

Tetranchyroderma Remane, 1926b: 625; Remane, 1936: 176 – 178; Ruppert, 1978: 112.

Thaumastodermatinae of small or large size, mostly with large mouth opening. Cephalic sensory organs with 0 – 1 pair of soft palp like organs, one pair of dorso – lateral cirrata in some species; cuticle with triancres, scaled triancres, tetrancres, pentancres or hexancres. A single testis on the right side of the body extending from the anterior part of the gut to the level of proximal end of a small caudal organ.

57. G2 ***Tetranchyroderma swedmarki*** Rao and Ganapati, 1968

(Plate. 12: Fig. 54; Plate. 19: Fig. 122)

Tetranchyroderma swedmarki Rao and Ganapati, 1968a: 48; d'Hondt, 1971: 171; Hummon, 2001: 19.

Occurrence: The specimens were collected from the intertidal region of Cherai and Veli beach during low tide.

Description: The specimens are approximately 160µm to 185µm in length. Body divided into pharyngeal and intestinal portions. PhIJ at about U35.4. Mean width of head / at neck / trunk / caudal base of a 178µm long specimen: 33 / 20 / 25 / 18 µm at U10 / U20 / U69 / U92, respectively. A pair of club shaped head tentacles are11µm in length. Anterior to it are located, a pair of elongate flagella. Sensory hairs on the head vary from 7 to 10µm in length. Body has a complete covering of pentancres. About 6 –7 pairs of irregularly shaped epidermal glands originate from U21 and extent up to U89. A fringe of sensory hairs surrounds buccal cavity. Three pairs of anterior adhesive tubes (3 - 8µm long) occur in two groups of 3+3 pattern on the ventral surface behind the mouth. Behind the anterior adhesive tubes is located a pair of 6µm long lateral adhesive tubes at U18. About 13 – 14 pairs of lateral adhesive tubes originate (.8µm - 10µm) at U37, which indicate the posterior level of pharynx. Two pedicles seen on the posterior border, each with apical tubules 5 - 7µm long and an inner tubule (7 - 8µm long) at its base. Adhesive tubules on the posterior border between the pedicles absent. Testis and ovary present.

Remarks: Ganapati and Rao (1962) in a pioneering effort reported the occurrence of gastrotrichs from the interstitial meiofauna in the intertidal sands of Waltair Coast. *Tetranchyroderma swedmarki* was described by Rao and Ganapati (1968) from the Waltair coast. The present material, while agreeing in essential features with the figures and descriptions of *T.swedmarki,* does exhibit some remarkable differences as well. The local forms are smaller in size than the type specimens. The presence of cuticular armature in the anterior most regions and the arrangement of anterior adhesive tubes are features that show variations. But the presence of pentancres, distribution of lateral adhesive tubules and the posterior pedicles support the present placement.

Distribution: Bay of Bengal (Rao and Ganapati, 1968); Arabian Sea (present record).

Family TURBANELLIDAE Remane, 1925

Genus ***TURBANELLA*** M.Schultze, 1853

Turbanella M. Schultze, 1853: 241; Remane, 1936: 173; Wieser, 1957: 376.

Turbanellidae with head bearing elongated side lobes or rounded; with rounded or triangular tail forks bearing adhesive tubes. Anterior dorsal tentacles absent; ventral feet present. Lateral tubes present, each with a long cilium. Scales absent. Head, when distinct encloses only anterior part of pharynx. Mouth cavity narrow, without cirrate papillae. Pharynx with pores at its hind end. Testes and ovaries paired. Male pore distinct from anus.

58. G3 ***Turbanella lutheri*** Remane, 1952

(Plate. 12: Fig. 55; Plate. 19: Fig. 123)

Turbanella lutheri Remane, 1952: 62; Karling, 1954: 243.

Occurrence: Several specimens were collected from the intertidal area of Veli beach during the post-monsoon season months.

Description: The specimens range between 260-320μm in length and 45-50μm in width. The body is uniformly cylindrical with a slightly tapering posterior region. The head is demarcated by a small constriction on either side. The terminal mouth is cup shaped, 9-12μm in diameter and encircled by a corona of sensory hairs. Sensory hairs border the margin of the head with the postero-lateral margin having longer hairs. The pharynx, 75μm long, is cylindrical with a posterior slightly swollen pharyngeal bulb bearing pharyngeal pores on either side. The intestine, 125-150μm long, tapers posteriorly. PhIJ at U31.6. About 15-20 pairs of lateral adhesive tubes (TbL), 5 - 8μ long, regularly arranged between U10 and U88. Each caudal lobe with 6-7 posterior adhesive tubes (TbP) of variable length. Median anal papilla absent. Numerous epidermal glands occur in double rows laterally on the body. The testes and ovaries are paired and disposed lateral to the intestine.

Remarks: The specimens at my disposal resemble remarkably with most of the characters of *Turbanella lutheri* described by Remane (1952) from Helgoland. The conspicuous difference noted was the very short length of the local forms. The specimen is therefore tagged with *Turbanella lutheri*, Remane (1952).

Distribution: Helgoland (Remane, 1952).

Genus ***PARATURBANELLA*** Remane, 1927

Paraturbanella Remane, 1927: 203; Remane, 1936: 175; Wieser, 1957: 372.

Turbanellidae with a band-shaped body, head not clearly demarked, with elongated or rounded side lobes. Posterior end of body bilobed or with a simple tail. A pair of anterior ventro-lateral feet, formed by two unequal adhesive tubes directed posteriorly. Lateral adhesive tubes absent. Antero-dorsal tentacles absent. Posterior adhesive tubes on the posterior margins of tail lobes.

59. G4 ***Paraturbanella sp.***

(Plate. 12: Fig. 56; Plate. 19: Fig. 124)

Occurrence: Several specimens were collected from the intertidal area of Veli beach during the post-monsoon season of the year.

Description: Ribbon like body 300µm in length, 60µm wide, tapers posteriorly and ends in a pair of caudal lobes. A little behind the region of head, is present, two posteriorly directed unequal adhesive tubes, representing anterior ventro-lateral feet. Pharynx with a posterior pharyngeal bulb is 100µm long. This is followed by 135µm long esophagus. Lateral adhesive tubes absent. Five posterior adhesive tubes arise laterally from each caudal lobe. An anal papilla located at the junction of two lobes. Several epidermal glands located dorso-laterally along the entire length of the body. A pair of elongate testes extent anterior to the middle of the body. Ovary placed lateral to the intestine.

Remarks: A survey of the samples collected from various beaches in three seasons during the present investigation revealed the presence of specimens under consideration only in Veli beach during the post-monsoon season of the year. The material fixed in formaldehyde was in partially contracted state. This curbed a detailed study of features such as sensory cilia and ventral ciliation. Fourteen species of *Paraturbanella* have hitherto been described, four of which occur in India. But the local forms do not resemble remarkably well with any of the species reported from India. Moreover it is unable to assign the specimens in hand to any species due to poor state of the specimens. Pending examination of intact specimens, the present species is temporarily assigned to this genus.

Order	**CHAETONOTIDA** Remane, 1925
Suborder	**PAUCITUBULATINA** d'Hondt, 1971
Family	**CHAETONOTIDAE** Zelinka, 1989
Genus	***CHAETONOTUS*** Ehrenberg, 1830
Subgenus	***Marinochaetus*** Kisielewski, 1997

Chaetonotus Ehrenberg, 1830:44; Remane, 1936: 184; Balsamo, 1983:43.

The body of the members is divided into head, neck and trunk. Body surface covered wholly or partly with unstalked scales, some or all of which bear spines of different types. Trunk with postero-lateral unbranched, unsegmented caudal furca. Ventral surface of the body with normal cilia arranged in two longitudinal bands. Cirri absent. Pharynx with bulb or bulbs, but without pores. Testes rudimentary or absent.

60. G5 ***Chaetonotus (M.) apolemmus*** Hummon, Balsamo & Todaro, 1992

(Plate. 12: Fig. 57; Plate. 19: Fig. 125)

Chaetonotus apolemmus Hummon, Balsamo & Todaro, 1992: 499.

Occurrence: A few individuals were collected from the intertidal area of Cherai and Veli beaches during the post monsoon season.

Description: Small specimens with an average length of 98μm. Body robust, with well-defined neck, trunk and caudal base. Diameter of head, neck, trunk and caudal base is 25/ 18/ 31/ 12 at U13/ U30/ U56/ U79 respectively. The PhIJ at U27.5. The intestine is 30-35μm long. The caudal fork measures 21-

23μm in length with a proximal fleshy region (5-6μm) followed by distal naked tubular part (16-17μm) that diverges obliquely and ends in pointed tip. The fleshy region appears to be covered in scales. A distinct buccal cavity, 4μ in diameter are located at the anterior end of the head. Margin of the head lined with several sensory hairs of variable lengths (5μm-10μm). The cuticular armature includes a dorsal covering of circular to oval well-defined non-overlapping scales with spines. The scales are arranged in five vertical columns antero-posteriorly and bordered on either margins of the body by additional scales. Each column has about 12-15 scales. Each scale on the dorsal surface is provided with a spine around 5μm in length. The lateral spines are comparatively longer than the dorsal ones, 5μm on the head and neck, 7-9μm in the anterior part of trunk followed by 12 to 13μm long lateral spines towards the posterior region of the trunk. The lateral spines are deeply notched. Medially, on the intrafurcal margins, a pair of short spines is visible. Reproductive system and ventral ciliation could not be verified.

Remarks: The small specimens at my disposal agree reasonably well with *Chaetonotus apolemmus* Hummon *et al.* (1992) in the shape of the body, cuticular armature, position and diameter of the oral cavity. However, much smaller size of the body and the elongate naked tubular part of furca are features, which differ from the type description. These are treated as minor differences. The authors have remarked that considerable variations occur among populations of *C. apolemmus* from different areas on the west coast of Italy in the size and pattern of scale arrangement. Interestingly, Hummon *et al.* (1992) have observed that these populations are interspersed with one another in a mosaic rather than a gradient pattern of geographical distribution. The authors also noticed variation within a population. *Chaetonotus apolemmus* is the first record from India.

Distribution: West coast of Italy (Hummon *et al.*, 1992); Arabian Sea (present record).

Genus *HALICHAETONOTUS* (Remane, 1936) Schrom, 1972

Lamellated lateral spines and keeled dorsal scales are diagnostic features of this genus.

61. G6 ***Halichaetonotus cfr. spinosus*** Mock, 1979

(Plate. 12: Fig. 58; Plate. 19: Fig. 126)

*Chaetonotus decipiens var.spinosus d'*Hondt, 1966: 1-22.

Halichaetonotus spinosus Mock, 1979: 454.

Occurrence: Eleven specimens were collected from Cherai during the post-monsoon season of the year.

Description: Body, 118µm long is divisible into head, neck and trunk with a caudal fork at the posterior end. The diameter of head, neck, trunk and caudal base are 28/22/35 and 18µm respectively. The caudal fork, with a slightly swollen base followed by adhesive tubes is 18µm in length. The head bears at its anterior margin four sets of ciliary tufts, one pair longer than the rest. From each bunch of short cilia, protrude out an elongated one. The buccal cavity (9µm in diameter), located towards the anterior end is bordered by a circlet of fine cilia. The dorsal surface of the body is ornamented with about 9 to 10 vertical rows of overlapping keeled scales. The keels protrude out as antero-posteriorly directed spines. The lateral margins of the body are characterized by the presence of lamellar setae. The length of setae increases antero-posteriorly. While the neck setae are 8µm in length, setae of the distal half of the body are 17 to 23µm long.

Remarks: While around twenty-five species of Genus *Halichaetonotus* have been described hitherto world wide, none has been reported from the Indian coast so far. The greatest impediment in studying the gastrotrichs of Indian coast is, perhaps, the difficulty in obtaining the early European taxonomic literature outside European libraries. In the body size, cuticular armature, structure of lateral bristles and disposition of ciliary tufts, the

PLATE – 12

EXPLANATION OF FIGURES

Fig. 50 ***Protodrilus sp.***
a: Anterior end
b: Posterior end

Fig. 51 ***Polygordius madrasensis***
a: Anterior end
b: Posterior end

Fig. 52 ***Polygordius uroviridis***
a: Anterior end
b: Posterior end

GASTROTRICHA
Fig. 53 *Pseudostomella cheraensis*
Fig. 54 *Tetranchyroderma swedmarki*
Fig. 55 *Turbanella lutheri*
Fig. 56 *Paraturbanella sp.*
Fig. 57 *Chaetonotus apolemmus*
Fig. 58 *Halichaetonotus spinosus*

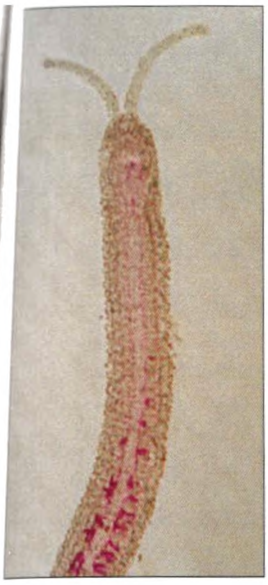


Fig.50a

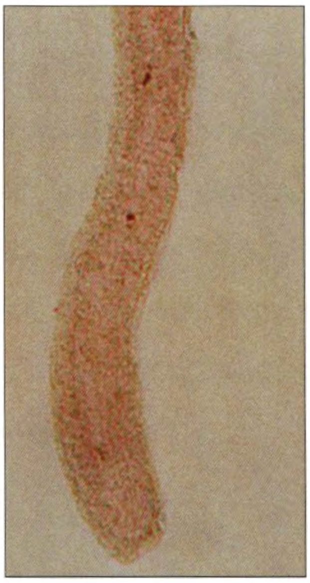


Fig.50b

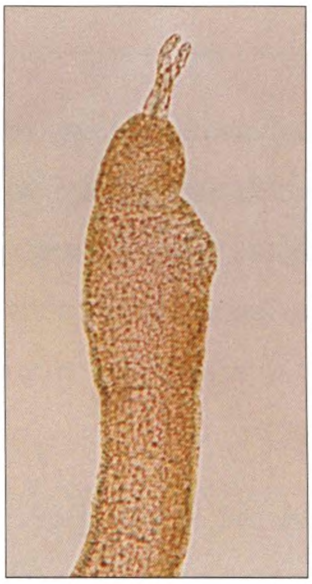


Fig.51a

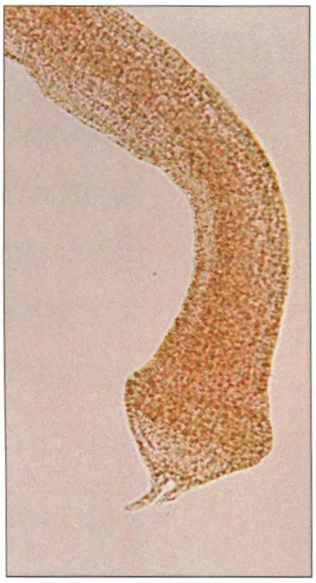


Fig.51b

Fig.52a

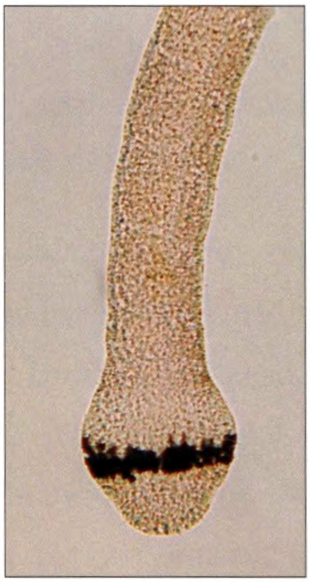


Fig.52b

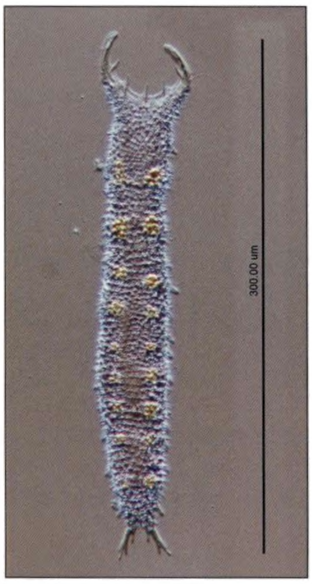


Fig.53

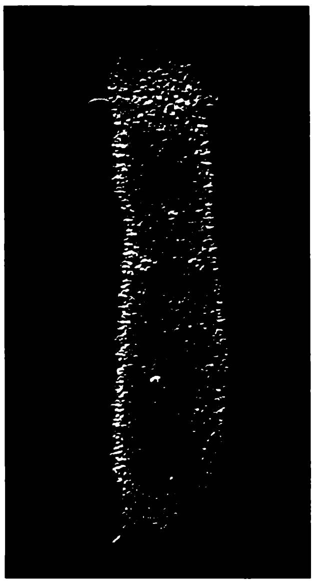


Fig.54

Fig.55

Fig.56

Fig.57

Fig.58

specimen under consideration comes close to *Halichaetonotus spinosus*. However, the ventral surface could not be studied due to the paucity of specimens. The few specimens available, does not allow comparing all the morphological traits. The morphological trait of the dorsal surface brings the specimens in hand close to *H.spinosus* and hence is assigned as *Halichaetonotus cfr. spinosus*.

Distribution: Atlantic Ocean (d'Hondt, 1966); North Sea Island of Sylt (Mock, 1979); Arabian Sea (present record).

62. G7 ***Halichaetonotus sp.***

(Plate. 13: Fig. 59; Plate. 19: Fig. 127)

Occurrence: Nine specimens were collected from Cherai beach during the post-monsoon season of the year.

Description: Chaetonotoid body, 95µm long divisible into a distinct head, an elongated neck and a broad trunk ending in a pair of caudal fork (10-12µm long). Diameter of head, neck, trunk and caudal base are 23/17/29/14 at U10.5/U36.8/U64.3 and U88.4 respectively. Cuticular armature of the body consists of 19 vertical columns of keeled scales, oval in shape that does not protrude into spines. They are arranged in 20-23 horizontal rows. The trunk scales seem to be larger than the scales on the head. The anterior margin of the head bears a few sensory cilia of variable lengths. Head and neck bears numerous short spines on the lateral margins white fours of the lateral spines on the trunk directed posteriorly are 17-20µm long. Buccal cavity (7µm wide), located at the anterior tip, is fringed with numerous short cilia.

Remarks: The material before me is assigned to Genus *Halichaetonotus* since this appears to be the genus to which the present material resembles well. Keeled dorsal scales that do not protrude into the spines are a conspicuous feature by which it differs from the previous species.

A detailed morphological study of the ventral surface could not be done due to the paucity of enough specimens. Only on examination of more material from the locality from which the present specimen was collected a specific identification would be possible. The occurrence of several *Halichaetonotus* species on the Indian coast, a genus which has not been reported so far from India, indicate inadequate exploration and insufficient sampling of the areas inhabited by gastrotrichs.

Family XENOTRICHULIDAE Remane, 1927

Head without well developed cephalon (head shield); neck constriction often hidden by covering of scales; trunk inflated and extended posteriorly into caudal furca; body without adhesive tubes except at the posterior end; head cilia 1-3 pairs of dorsal or lateral cirri or tufts of normal cirri or bristles; body often with several pairs of dorsal bristles; more than one type of cuticular covering of scales with some regions of the body naked; hermaphpoditic, with well developed testes; anus ventrally located.

Genus *XENOTRICHULA* Remane, 1927

Xenotrichula Remane, 1927b: 294; 1936:182; Ruppert, 1979: 255.

Head with either two pairs or three pairs of sensory cirri and one pair of long head tentacles; adhesive tubes limited to one or two pairs on the tail fork; mouth terminal to slightly subterminal with about twenty longitudinal folds and spines; pharynx without well developed anterior bulb; copulatory organ mid-ventral, caudal to pharyngo-intestinal junction; dorsal surface covered with intermediate and subterranean type of stalked scales; furca simple or pedunculate.

63. G8 ***Xenotrichula chaetosa*** nov. sp.

(Plate. 13: Fig. 60; Plate. 19: Fig. 128)

Occurrence: Seven specimens were collected from the intertidal region of Veli beach during the post monsoon period.

Type locality: Veli beach (lat. 8°29′N; long. 76°28′E), Kerala, India. Moderately well sorted sand.

Type material: Holotype- PM5a1. Sl. 1
Paratype - PM5a1. Sl. 6

Etymology: The presence of lateral chaetae is unusual in this genus, and hence the name.

Description: The few specimens in hand have an average length of 134µm including the caudal fork. Caudum (43µm long) has a proximal fleshy region 28µm long, followed by distal pointed adhesive tubes, 15µm in length. A distinct head, neck and trunk characterize body. The diameters and location of the body parts are as follows: oral cavity / neck / trunk (anterior)/ trunk (maximum diameter) and caudal base: 14 / 33 / 38 / 44 / 24 at U5 / U19 / U34 / U54 / U67. Head with a pair of downwardly directed cephalic tentacles, 14µm long. The sensory bristles on the anterior margin range from 14µm to 20µm in length. Spines of variable lengths border the lateral margins of the body. Ten to thirteen pairs of these lateral spines extending from the middle to the posterior region of the body are long (15µm - 18µm). About 10 –12 longitudinal rows of scales ornament the dorsal surface. The scales at the anterior region are rhomboid, followed by triangular scales posteriorly. PhIJ at U32. The anus is sub-terminal. Both the testes and ovaries are symmetrical. The testes are elongated and located anterior to the ovaries. Scale: 30µ.

Remarks: The specimen under consideration, although possess all the generic characters of *Xenotrichula*, does show a specific feature not reported hitherto. The present form is characterized by the presence of numerous bristles (setae) along the lateral margins of the body, of which the posterior ones are longer than the anterior ones. A study of the available literature shows that such a feature is not reported so far. The specimen resembles *Xenotrichula laccadivensis* described by Rao in 1991 from Lakshadweep in the possession of posteriorly directed tentacles. However, the specimen at my disposal does not agree with Rao's species in the location of gonads and certain other features. *Xenotrichula velox*, another species reported by Rao (1974, 1980b) from the east coast of India and Lakshadweep shows some proximity with the present material in the disposition of gonads and posteriorly directed tentacles. In the presence of lateral setae, the material at hand distinctly differs from other species assigned to this genera. Two pairs of cephalic bristles, a pair of backwardly directed tentacles, paired testes located laterally and extending anterior to the pharyngo-intestinal junction, stiff bristles on the lateral margins, rhomboid anterior scales and triangular scales located posteriorly are all important morphological features which make the present specimens distinct from others. Hence these specimens are assigned to a new species and christened as *Xenotrichula chaetosa* nov.sp.

The species could be described as follows: Comparatively tiny body, 120- 134μm long with a pair of adhesive tubes restricted to the caudal region. Head with a pair of posteriorly directed cephalic tentacles. Sensory bristles of the head range from 14 - 20μm in length. Lateral spines (chaetae) present along the lateral margin of the body. Two types of scales present on the body: rhomboid scales located anteriorly. The posterior surface has a covering of triangular scales. Paired testes and ovaries.

4.9 ISOPODA

The wide adaptive radiation of the Isopoda is one of the most interesting features of this crustacean group. These animals populate different habitats of the marine benthic realm. Many species belonging to different sub-orders, take a dominant role in the meiobenthos. They exhibit a variety of adaptations relevant to their specific benthic habitat. The interstitial species, living in medium to coarse sand are small, blind, colourless, and filiform with stunted appendices. Of the marine interstitial Isopods, the families, Microparasellidae and Microcerberidae are represented in the interstitial biotope of the present study area. Karaman (1933) created these two families to assign three new species of isopods that he collected from the fresh water bodies of Europe.

Family MICROPARASELLIDAE Karaman, 1933

The members of the family Microparasellidae are generally assumed to be of marine origin and the species found in the interstices might be regarded either as relics from former seas or as migrants from the sea through sub-soil coastal waters. Adjustments for meiofaunal life by the isopods probably are achieved by the considerable reduction and simplification of the organismic system in the case of isopods successfully colonizing sandy sub-tidal areas. Microparasellids by and large have evolved in such a fashion, that they have done away with planktonic larval stages during their ontogeny and have evolved towards direct development with incubation or alternatively neoteny. The phreatic isopods are usually blind, elongated and flat. They have specialized sensory organs, which are not properly investigated. Being eurythermal and euryhaline, these species that have adapted to the interstitial realm enjoy wide distribution.

Genus ***ANGELIERA*** Chappius and Delamare Deboutteville, 1954

64. ***Angeliera phreaticola*** Chappius and Delamare Deboutteville, 1952

(Plate. 13: Fig. 61; Plate. 19: Fig. 129a, b, c, d & e)

Angeliera phreaticola Chappius and Delamare Deboutteville, 1952: 1014

Brevipleonida gracilis Gnanamuthu, 1954: 257.

Occurrence: Several male and female specimens were obtained from Arthungal and Cherai beaches from a depth of 17-19cms during the post-monsoon month.

Description: The average length of the specimen is 715µ. Transluscent and slender body with seven free thoracic segments and two abdominal segments. The length of the free thoracic segments is 48, 78, 75, 83, 75, 83 and 83µm respectively and the abdominal segments 48µm and 64µm. The head, 78µm long and 71µm wide bears the cephalic appendages like antennules, antennae, mandibles, maxillae and maxillipedes. Antennule 88µm long is formed of 7 segments. The distal segment bears a long spine at its tip, an aesthete and 3-4 short spines. The penultimate segment also bears an aesthete. The antenna, 288µm long has a peduncle formed of 5 segments followed by an eight-articled flagellar region which, tapers distally ending in three spines. Several spines are also visible on different segments. About 7/10th from the anterior margin of head are located a pair of small narrow elliptical thickenings. The sides of the head are protected by the epipodites of the maxillipedes. The corners of the first thoracic segment (smallest measuring 48µm) are produced into oblique spurs. An egg filled brood pouch is visible on the ventral surface of the second and third free thoracic segments. The pereopods are more or less alike and originate from the middle of each thoracic segment. The dactylus bears two hairs like spines and two claw like spines of which one is more recurved than the other. The pleopods, borne on the ventral surface of the abdomen, do not extend outward. Posteriorly directed uropods are very distinct. Each one consists of a large protopod armed with two spines. The endopod is stout and long bearing terminally six unequal spines terminallyand three laterally. The exopodite is shorter and more slender ending in a long terminal spine and a single lateral spine. 129a :150µ; 129b,d,e :30µ; 129c: 75µ.

Remarks: The species has previously been reported from Madras (Gnanamuthu, 1954) and Waltair coast (Rao and Ganapati, 1968), Bay of

Bengal. The specimen in hand agrees very well with the description given by Gnanamuthu (1954). A comparison of different structural details confirms that local specimens are *Angeliera phreaticola* Chappius and Delamare Deboutteville, 1952.

Distribution: Italy (Chappius and Delamare Deboutteville, 1952); Bay of Bengal (Gnanamuthu, 1954; Rao and Ganapati, 1968); Arabian Sea (present record).

Family MICROCEREBRIDAE Karaman, 1933

Genus *COXICERBERUS* Wagele, Voelz & McArthur, 1995

65. ***Coxicerberus predatoris*** (Gnanamuthu, 1954)

(Plate. 13: Fig. 62; Plate. 19: Fig. 130a, b, c, d & e)

Robustura predatoris Gnanamuthu, 1954: 257.

Microcerberus predatoris (Gnanamuthu, 1954) Delamare Deboutteville, 1960: 329.

Coxicerberus predatoris (Gnanamuthu, 1954), Wagele *et al*, 1995: 733.

Occurrence: A few individuals were collected from Veli beach during summer month at a depth of 19 cms.

Description: The specimens on an average measure 570µm in length excluding the antennae and the uropods. The translucent cylindrical body is divisible into an anterior head, 88µm long and 68µm wide, followed by seven free thoracic segments and three abdominal segments. The abdomen ends in a pair of backwardly directed uropods. Each uropod consists of a basal protopod with 4 spines, a highly reduced exopod bearing two spines and a large and stout endopodite with 6 spines. The antennule, shorter than the peduncle of the antenna, consists of five segmented joints with the terminal segment bearing a long narrow aesthete, a large stout spine and three shorter spines. Each antenna consists of a five jointed peduncle followed by a flagellum constituted of five very short segments tapering to the tip. The terminal joint bears four spines of unequal length and an aesthete. Few shorter spines are seen on other segments as well. Another aesthete is seen at the base of the flagellum. Of the seven pairs of pereiopods, the first pair is chelate and the rest are alike. The different pleopods, other than the uropod could not be identified clearly.130a:75µ;bcd:30.

Remarks: Gnanamuthu, in 1952 collected several specimens of this species from the Madras beach. The species was described as *Robustura predatoris* Gnanamuthu in 1954. In 1960, Delamare Deboutteville named it as *Microcerberus predatoris*. This species was placed in a new genus *Coxicerberus* erected recently by Wagele, Voelz and Mc. Arthur (1995). The specimens in hand are in confirmity with the figures and description of *Coxicerberus predatoris* (Gnanamuthu, 1954). This species was found to colonise only the Veli beach, south west coast of India.

Distribution: Bay of Bengal (Gnanamuthu, 1954; Rao and Ganapati, 1968); Arabian Sea (present record).

4.10 KINORHYNCHA

Vermiform body enveloped with rings of cuticle was the main morphological characteristic that led to the assignment of Kinorhynch as a distinct phylum placed between the annelids and the arthropods by Dujardin (1851). It is understood that the higher taxonomic categories representing the main branches (phyla) of the phylogenetic tree, are characterized by a basic structural pattern which was laid down early and within which the seemingly endless adaptive modifications have taken place. Therefore in general, the higher categories are definable in terms of a basic structural pattern. The name 'Kinorhyncha' was introduced by Reinhard (1881). Much of the information on Kinorhyncha comes from the monograph of Zelinka (1928) and Remane (1936). Hyman (1951) has summarized the accumulated information on the phylum. Higgins (1969) made elaborate studies on the group.

Order CYCLORHAGIDA

Suborder CRYPTORHAGAE Higgins, 1968

Family CATERIIDAE Gerlach, 1956

Genus *CATERIA* Gerlach, 1956

Cateria Gerlach, 1956: 120

The genus *Cateria* is the lone genus of the family Cateriidae discovered in the interstitial zone of a marine beach near Macae, Brazil (Gerlach, 1956). Gerlach's species has been reported from the east coast of India by Rao and Ganapati (1966). Another species, *Cateria gerlachi* Higgins was discovered from the east coastr of India later by Higgins (1968). The species assigned to the genus has nine oral styles; six rows of flexible scalids on head; 14 placids poorly developed. First trunk segment circular with single dorsal plate continuing ventrally to meet a single mid-ventral plate; Denticulated segment surface; mid-dorsal spines on segments 4,5,6,8,10,11,12 and 13. Lateral spines on segments 7 to13. Everisble dorsal organ present between 7th and 8th segments.

66. ***Cateria styx*** Gerlach, 1956
(Plate. 13: Fig. 64; Plate. 19: Fig. 132)

Cateria styx Gerlach, 1956: 120; Higgins, 1968: 21; Delamare Deboutteville, 1960: 740; Rao and Ganapati, 1966: 212; 1968: 106; Rao,1969: 89.

Occurrence: Six specimens were collected from Cherai beach during the month of March in summer during low tide. Numerous individuals were collected from Cherai and from the Arthungal beach after the monsoon period.

Description: The length of the specimens, excluding the oral stylets and the tail spine, ranges from 370μ - 410μ, and the diameter varies from 70μ - 75μ. Variations were observed between the specimens examined, in the length of various spines and zonites. The curved body consists of first zonite represented by the head, with a crown of nine oral stylets of 52μ in length and smaller stylets of 32µ.. The second zonite is the neck segment with 6 placids visible laterally. The trunk consists of 11 zonites. Several rows of denticles present on various zonites. Dorsal spines, 8 in number, on zonites 4, 5, 6, 8,10, 11, 12 and 13 originate from the distal half of each zonite. Seven pairs of lateral spines are seen on either side of the body on zonites 7 to13, of which the first lateral spine is distinctly smaller than the rest. The measurements of the zonites, dorsal spines and lateral spines of one specimen is given below. Scale: 75µ.

Numberof Zonite	Zonite length *	Length of dorsal spine *	Length of lateral spine *
2	30	-	-
3	28	-	-
4	30	32	-
5	30	45	-
6	35	50	-
7	38	-	15
8	40	80	45
9	30	-	35
10	36	65	45
11	40	60	45
12	30	70	30
13	40	420	80

* measurements in micrometres

Remarks: *Cateria styx* has been recorded and described from the east coast of India by Rao and Ganapati (1966). However, ecotypical variations were noted in the specimens examined from the localities in the south west coast. The specimens recorded from the temperate region by Gerlach were larger than those examined during the present study. The nature of cuticular ornamentation, placids and crown of nine oral styles compare well with the original descriptions. The dorsal sensory organ occurring between zonites 7 and 8 in the type specimen was absent in the present forms. Rao and Ganapati (1966) also did not locate this organ in the materials examined by them. Since specimens having well protruded head with spread out scalids were not obtained intact, detailed study of scalids could not be done. Not withstanding these variations, the local specimens are included under *Cateria styx* Gerlach. The habitat of this species is characterized by medium sized sand. This species was encountered in the Arthungal beach after the monsoon, which was not inhabited by *Cateria styx* during the hot high saline period. Although the dynamics of vertical movement in the sediment was not assessed, *Cateria styx* seems to prefer relatively deeper levels than those preferred by the polychaetes.

Distribution: Brazil (Gerlach, 1956; Higgins, 1968); Angola (Delamare Deboutteville, 1960); Waltair coast, India (Rao and Ganapati, 1966); Arabian Sea (present record).

4.11 CNIDARIA

The numbers of interstitial cnidarians are small, but nevertheless the group contains interesting and very characteristic forms. Most of them belong to Hydrozoa and typical interstitial forms are the *Halammohydra* species, discovered in the Baltic and North Sea coasts of Germany, described by Remane (1927). *Halammohydra* presents a good example of a type of organization with marked adaptation to the biological demands of the interstitial environments, and their morphology deviates greatly from the normal patterns of Hydrozoa. Morphological specialization is mixed with larval features.

Order ACTINULIDA Swedmark and Teissier, 1959
Family HALAMMOHYDRIDAE Remane, 1927
Genus ***HALAMMOHYDRA*** Remane, 1927

The genus *Halammohydra* is comprised of ten species that range from 0.3 to 1.3 mm in length and are characterized by a long manubrium or gastric tube and a small aboral cone. Body is wholly ciliated with one or two rings of tentacles in multiples of four. They alternate with a ring of statocysts of lithostyle-type, which are homologous with tentacles. An ectodermal glandular invagination-the aboral adhesive organ is characteristic of the genus.

67. ***Halammohydra octopodides*** Remane, 1927

(Plate. 13: Fig. 63; Plate. 19: Fig. 131)

Halammohydra octopodides Remane, 1927: 643; Swedmark, 1956: 73; Rao and Ganapati, 1968: 82; Rao, 1969: 89.

Occurrence: Several specimens were collected from Cherai beach during post monsoon at a depth of 17 cm and two individuals were collected from Arthungal in March from a depth of 19 cms at low tide.

Description: Body barrel shaped, 150 - 200μm long, with a diameter ranging from 60 to 80μm. Tentacles, 8 in number of unequal lengths, arranged in two girdles. The short aboral tentacles measure 80-100μm and the longer sub-aboral ones measure 170 to 180μm in length. A narrow invagination is noticed at the base of the column. Statocysts not discernible in the present specimens. The reproductive organs could not be studied in the fixed specimens. Scale: 75μ.

Remarks: The material in hand resembles *Halammohydra octopodides* Remane in the small size, cylindrical shape of the body and the reduced numbers of tentacles. The aboral cone seems to be low and remain hidden by the tentacles in majority of the specimens. Other species of the same genus reported from India include *H.chauhani, H.andamanensis* and *H.sagarensis*. *H.chauhani* is more slender than the present form, has a long and thin neck, but has few tentacles. *H.andamanensis* has a spherical aboral cone. *H.sagarensis* is another species to which the present specimens show some similarity, but detailed studies of the nematocysts of live specimens are necessary to arrive at a safe conclusion. The paucity of fresh materials in hand make the respective study difficult at present and hence the local forms are tentatively assigned to *Halammohydra octopodides* Remane, 1927

PLATE – 13

EXPLANATION OF FIGURES

Fig. 59 *Halichaetonotus sp.*

Fig. 60 *Xenotrichula chaetosa* nov. sp.

Fig. 61 *Angeliera phreaticola*

Fig. 62 *Coxicerberus predatoris*

Fig. 63 *Halammohydra octopodides*

Fig. 64 *Cateria styx*

Fig. 65 *Anomalohalacarus sp.*

Fig. 66 *Scaptognathides sp.*


Fig.59

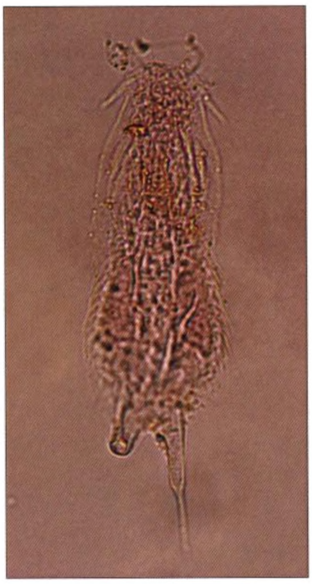


Fig.60


Fig.61

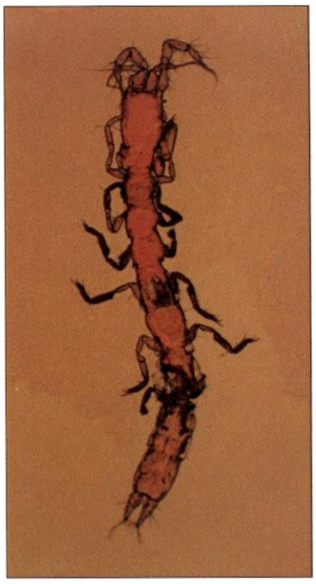


Fig.62


Fig.63

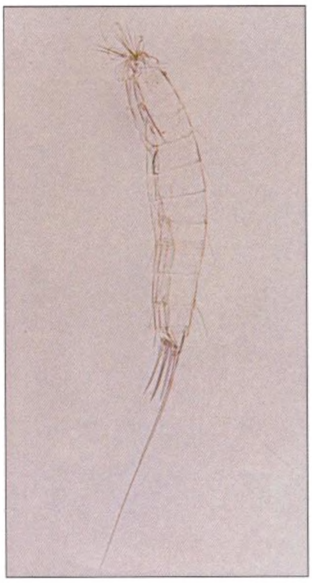


Fig.64


Fig.65

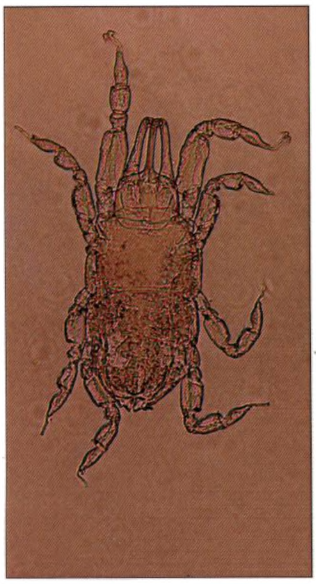


Fig.66

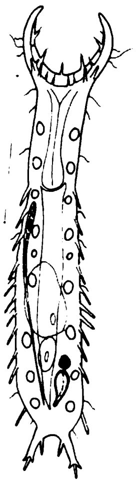
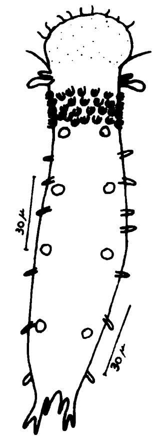


Fig. 121



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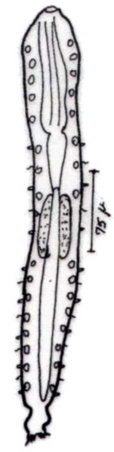

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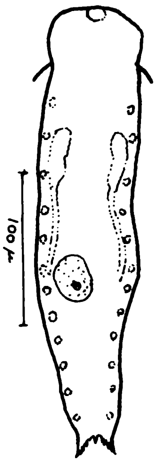

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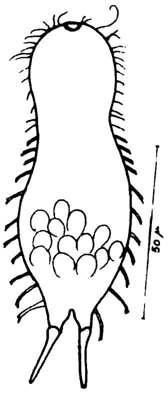


Fig. 125

Fig. 126

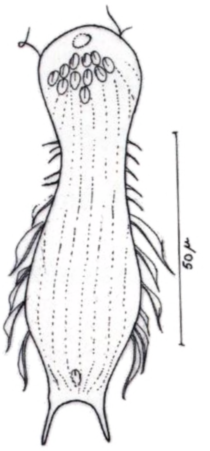


Fig. 127

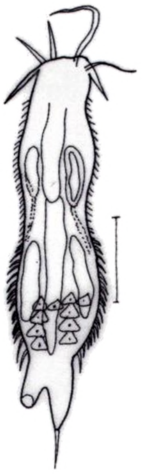


Fig. 128

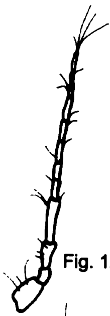


Fig. 129b

Fig. 129c

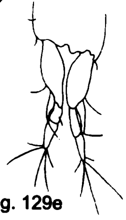


Fig. 129e

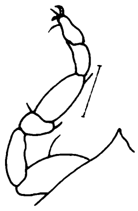


Fig. 129d

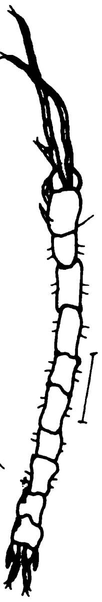


Fig. 129a

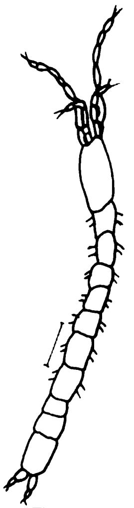


Fig. 130a

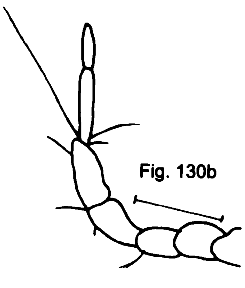


Fig. 130b

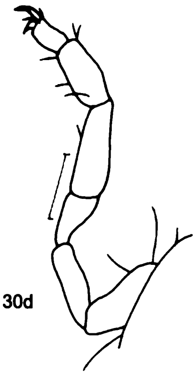


Fig. 130d

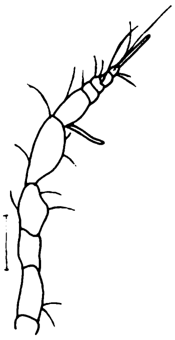


Fig. 130c

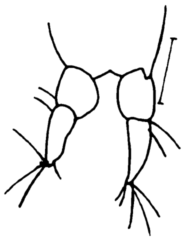


Fig. 130e

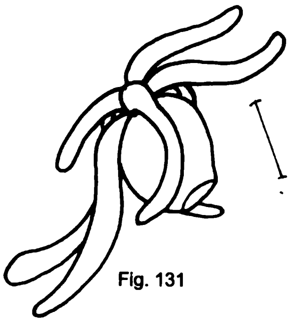


Fig. 131

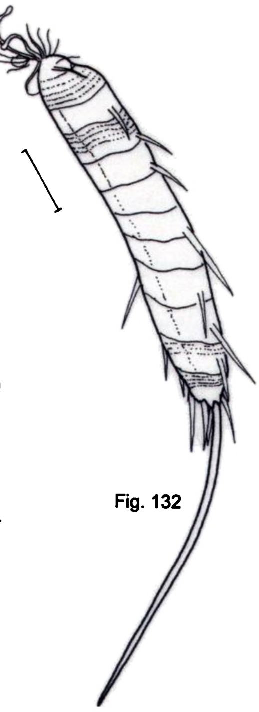


Fig. 132

Besides texture, the organic content of sediment is an important causative factor in determining the infaunal distribution since it is a dominant source of food directly for deposit feeders and indirectly for suspension feeders

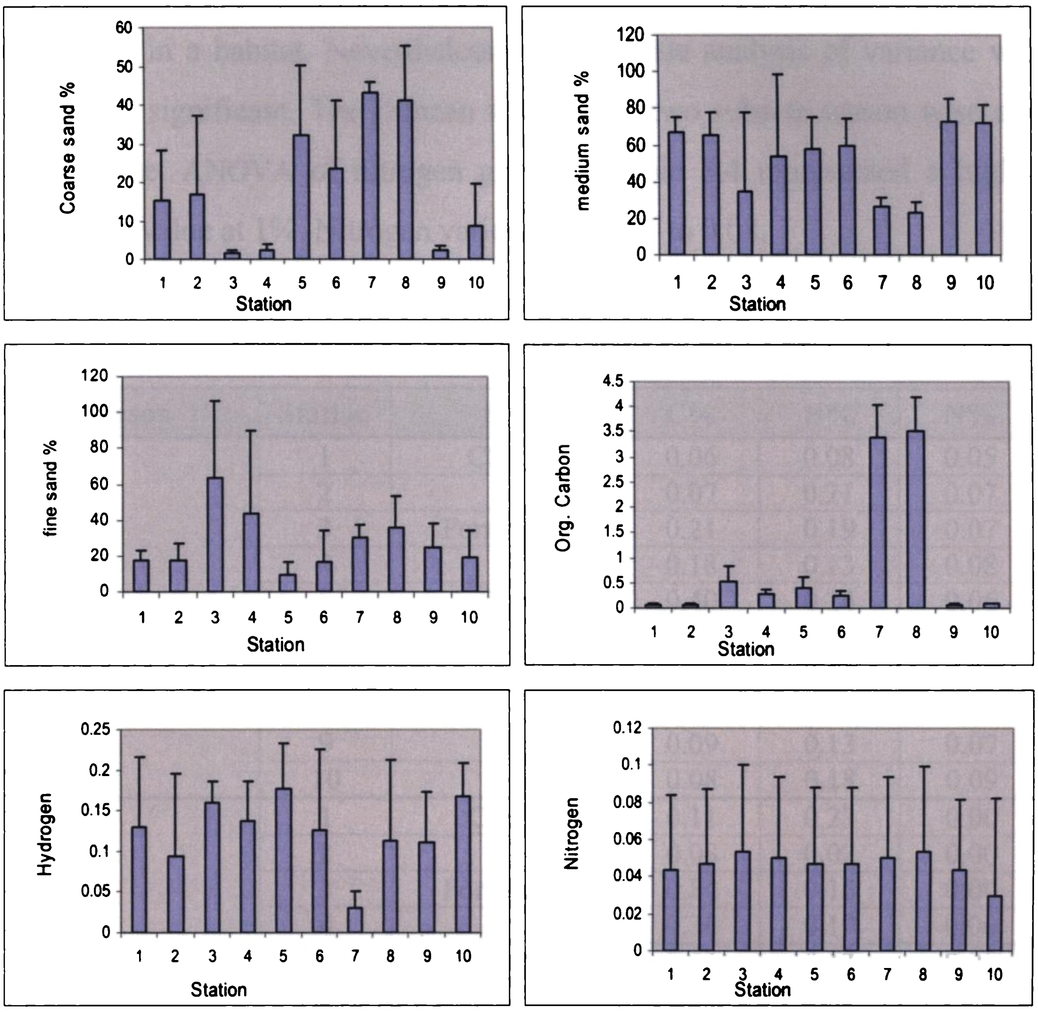


Fig. 5.1. Sediment characteristics and C: H: N (mean± sd) of the stations in the intertidal zone of the beaches in 2005- 06

The organic carbon in the study area ranged from 0.03 to 4.3% (Table 5.3). The percentage of sediment organic carbon showed high values during monsoon in the present study. An increase in the organic carbon during monsoon has been reported by Ingole and Parulekar (1998) at Seridao beach at Goa, in the west coast of India. The station in Sakthikulangara always had higher organic carbon in the sediment. This is due to heavy swash and accumulation of weeds. It was noteworthy that there was a total absence of Nitrogen at all stations during monsoon.

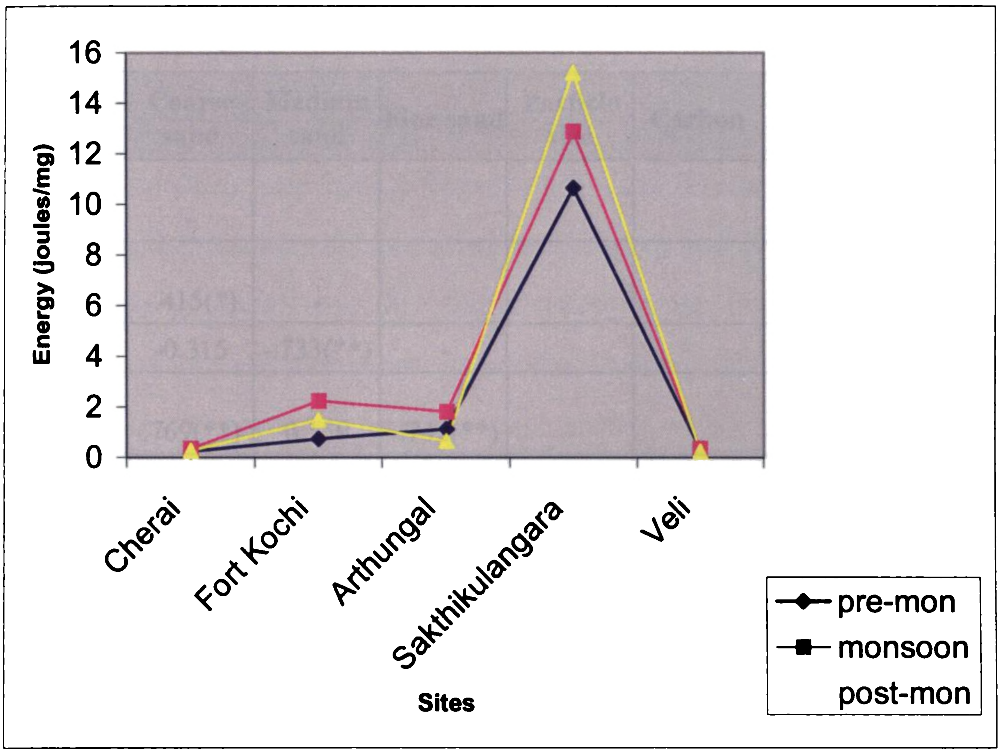


Fig. 5.2. Energy content (joules/mg) of the sediment in the locations during different seasons in 2005 - 06

The amount of energy that was available in different beaches during the period of study is illustrated in the above figure. Maximum energy was found to be present in Sakthikulangara beach in all seasons of the year. Energy in turn influences the faunal abundance and distribution of a habitat.

Pearson correlation matrix between the various sediment parameters is presented in Table 5.6. Organic carbon content in sediments showed a positive correlation with coarse sand at 1% significance. The median particle diameter of sediment is found to be positively correlated with coarse sand with 0.01 level of significance. Nevertheless, fine sand was negatively correlated with the particle size of sediments with the same level of significance.

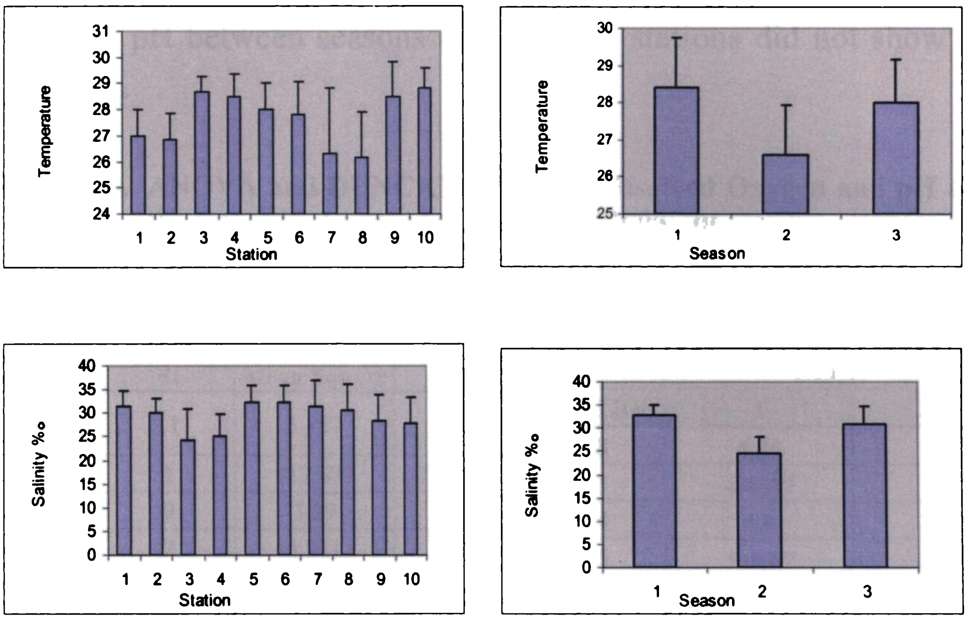


Fig. 5. 3. Mean ± Sd plots of temperature and salinity of interstitial water at the different stations of the five beaches

DISSOLVED OXYGEN

The oxygen content of interstitial water (mg/l) recorded at 10 stations during the current study is presented in table **5.7**. The dissolved oxygen values ranged from 3.1 to 8.2 mg/l with a mean of 5.52 ± 1.4 (Fig.**5.4**). The result of ANOVA of dissolved oxygen which showed variation in oxygen content between stations (ANOVA: DF=2; F=3.395) and between seasons (ANOVA: DF=9; F=2.652) was found to be significant at 1% level (Table **5.9**). The Duncan test between stations showed two subsets at 1% level of significance. Season-wise Duncan test showed lesser significance.

pH

In the present study, the pH of interstitial water at different stations was in the range of 7.1- 8.1 with a mean of 7.84± 0.35. St.1 was an exception, where pH showed a slightly acidic value during the pre-monsoon. Other than this, any specific feature in respect of pH values was not evident in the present investigation. A slight increase in pH

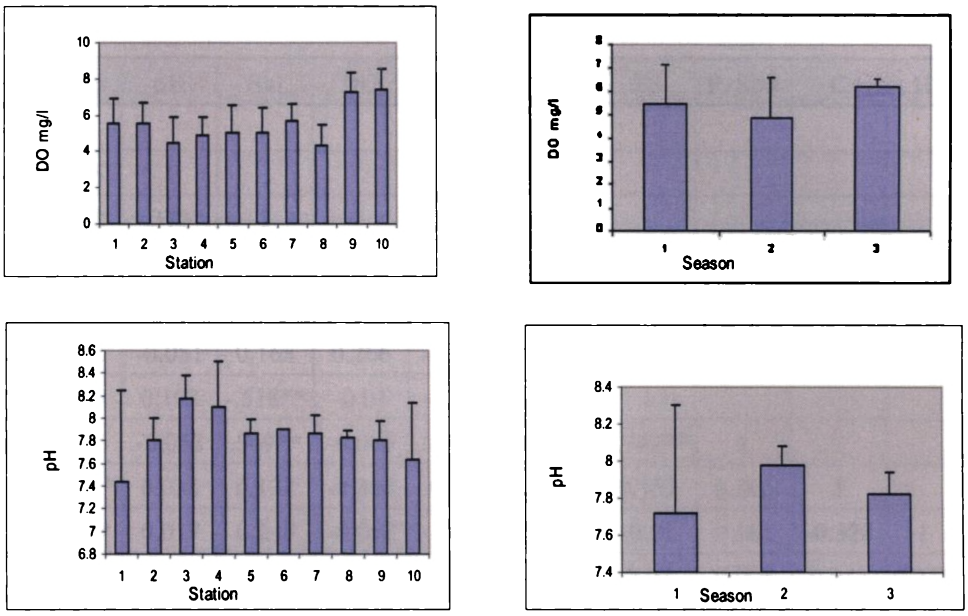
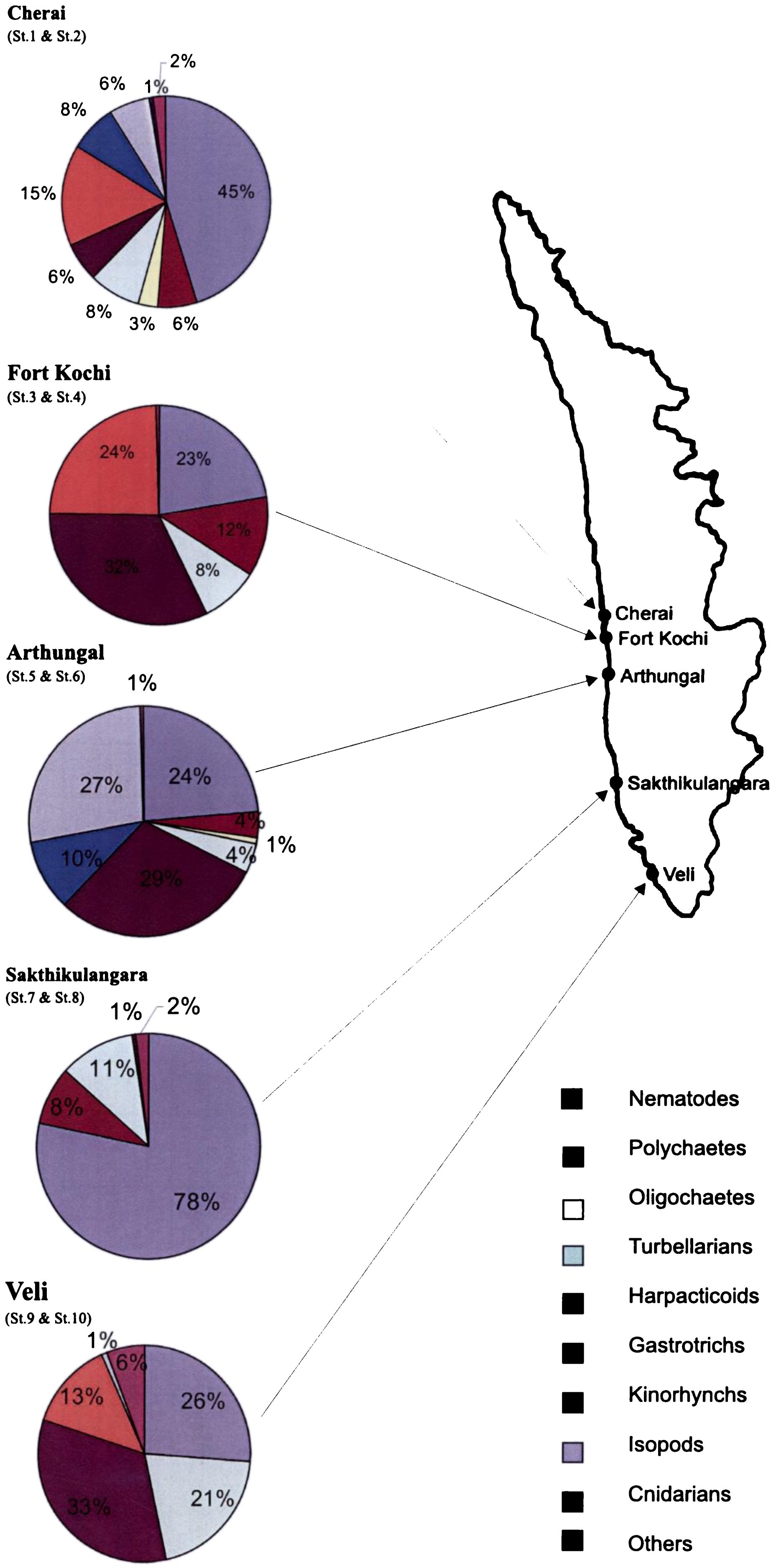


Fig. 5.4. Mean ± Sd plots of dissolved oxygen and pH of interstitial water at the different stations of the five beaches

Environmental factors such as temperature variations, photoperiod, lunar periodicity, salinity, food availability and sediment characteristics are regarded as important regulators of the reproductive cycle of marine invertebrates. Correlation analysis between hydrographic and sediment parameters were performed and the results are presented in Table **5. 10**. Pearson correlation denoted a positive correlation of temperature with hydrogen and nitrogen and an inverse relation with sediment organic carbon. Both season-wise and station-wise temperature variability as given in Fig. **5.3** denote a general decrease in temperature during monsoon. Another parameter to be significantly correlated was salinity, where a positive correlation at 0.01 level of significance could be seen between salinity and particle size and at 0.05 level of significance with coarse sand. A negative correlation was indicated between fine sand and salinity. Correlation between the parameters of interstitial water showed an inverse relation of pH with salinity

Fig. 6. 1. Percent composition (annual mean) of major faunal taxa recorded from the interstitial microcosm of the different beaches



Other groups also exhibited similarity below 60%. The only group that proved to be distinct from the rest of the taxa was Cnidaria, which formed a separate group thus showing their unrelatedness with the other interstitial taxa.

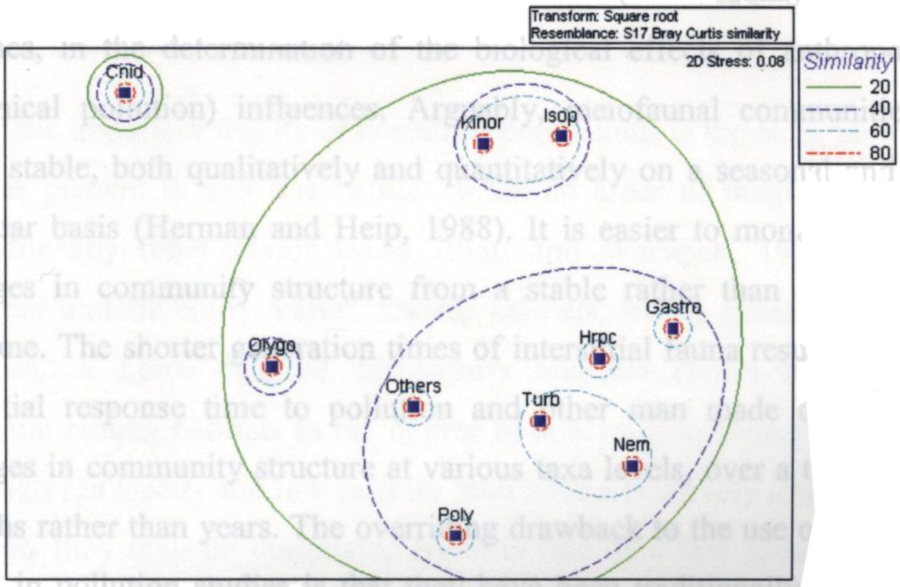


Fig.6.4. **Non-metric Multi-dimensional scaling (MDS) ordination plot (stress = 0.08) of interstitial taxa.**

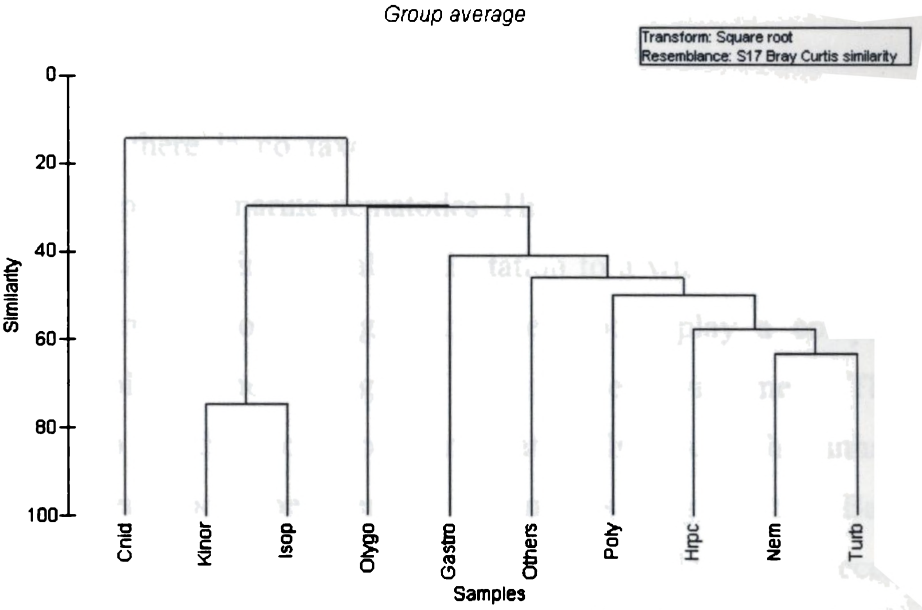


Fig. 6. 5. **Dendrogram for hierarchical clustering of interstitial taxa using group-average linking of Bray-Curtis similarity measures (solid lines represent significant delineation of groupings by SIMPROF test)**

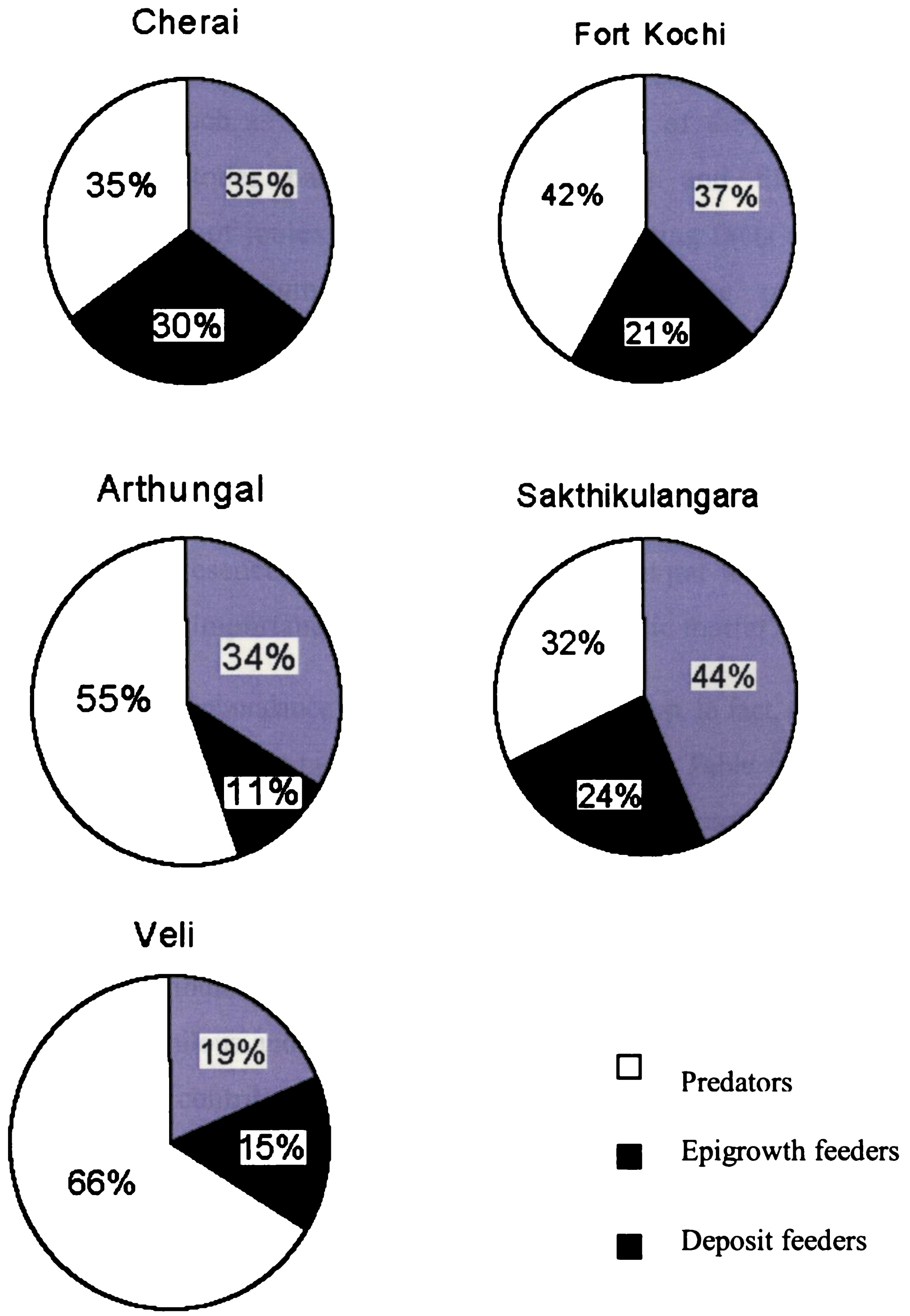


Fig. 6.6. Percentage composition (annual mean) of nematode trophic groups recorded from the beaches

Sakthikulangara beach. The domination by detritus feeders in Sakthikulangara beach could be related to the nature of the substratum and the high amount of organic matter that was available in this habitat at the time of sampling. Since non-selective deposit feeders (1B) feed on all kinds of organic debris as well as living microorganisms (Jansson, 1968), the 1B feeding group may be at an advantage in detritus dominated beach such as Sakthikulangara. A study of the community structure of nematodes based on trophic groups and the energy availability in terms of joules revealed certain interesting facts about the study locations. Maximum energy was found to be present in Sakthikulangara beach in all three seasons of the year. This commensurate with the presence of more detritus feeders in this site whereas the remaining beaches were dominated by predators as these sites had lesser energy content. Even though Cherai beach had low energy value, the presence of deposit feeders almost at par with predators is suggestive of the importance of the quality of organic matter.

Distribution and abundance of the type of trophic group, in fact, determine the contribution of nematode biomass. This is evidenced in Table 6. 7, where the bulk of the nematode biomass is contributed by the predators in different beaches in accordance with the density of predatory group. Though the deposit feeders outnumbered the other groups in Sakthikulangara beach, the maximum biomass was contributed by the predators. This is because predators are typically psammophilous and large sized forms. It is evident from the table that the biomass contributed by the deposit feeders is much less in Sakthikulangara beach, despite the fact that this group was represented by 339 individuals. Table 6.7 (represented later) shows that among the deposit feeders itself, biomass of nematodes varies widely with species, wherein, *Daptonema setifer* has a biomass of 0.62μg per individual whereas *Theristus acer*, another deposit feeder has an average biomass of only 0.09μg per specimen. *Daptonema setifer* was not present in the collection of nematodes from Sakthikulangara beach and several of this species were encountered in Cherai beach.

Table. 6.7. Mean Biomass (μg) of nematode trophic groups/100 cm^3 in the five beaches during the study

Beach	Deposit feeders (1A & 1B)	Epigrowth feeders (2A)	Predators (2B)
Cherai	131.6	100.5	399.7
Fort Kochi	31.4	20	143.3
Arthungal	67.3	16	210
Sakthikulangara	31.9	35	234
Veli	7.9	5.7	78

It is known that one of the major environmental factors affecting the distribution of meiofauna, the nematodes in particular is the granulometric composition of the substrata (Somerfield *et al.*, 1995). Sinha and Choudhary (1987) have indicated an abundance of epigrowth feeders reaching maximum densities in summer and post-monsoon seasons and deposit feeders and predatory species during monsoon, in their study area, which comprised of silt and medium to fine sand. Unlike their findings, the present investigation showed a preponderance of predators in all seasons except at Sakthikulangara beach, where detritus feeders (annual mean) dominated. Epigrowth feeders were greatly reduced in Arthungal beach in comparison with deposit feeders and predators. The substratum of the stations studied presently were devoid of silt and this strengthens the assumption that substratum is also a factor in the determination of species abundance and distribution of nematodes in an area. Ciliates are known to abound the beaches where organic debris is available in plenty associated with high dissolved organic matter content of the seawater washing the beaches. Although no data on the DOM of coastal waters of Kerala are readily available, the large number of estuaries and backwaters along with very high population density of the coastal belt of Kerala are likely to affect the DOM content of coastal waters which could be as high as 1.2 ml/l (Kinne, 1972).

Wieser (1953) infact has related the morphology of organs involved in feeding with the nature of food available and the resultant pattern of distribution. Essentially his study has helped us to relate feeding types with the trophic quality of the sediments. It has to be further elucidated whether there exist a relation between the abundance of species belonging to any feeding type with the sediment characteristics and also whether there could be temporal variation in the species abundance accompanying changes purely of trophic characteristics of the sediments.

A relation between the trophic group assemblages and the particle size of sediments was noticed in the present study (Table **6. 8.**). Pearson correlation matrix showed a positive relation at 5% level of significance between predators and particle size of sediments and a negative correlation with fine sand. This is due to the fact that predators are generally large sized nematodes and finds their survival in the fine sand difficult due to the reduced interstitial space there.

Table. 6.8. Pearson correlation matrix of sediment textural characteristics and nematode trophic groups

	TG1	TG2	TG3	TG4	Coarse sand	Medium sand	Fine sand	P. size
TG1	1							
TG2	.532(**)	1						
TG3	.504(**)	.665(**)	1					
TG4	.452(*)	.770(**)	.794(**)	1				
CS	0.241	0.231	0.25	0.254	1			
MS	-0.094	0.08	0.046	0.183	-.415(*)	1		
FS	-0.082	-0.256	-0.235	-.381(*)	-0.315	-.733(**)	1	
P. size	0.136	0.246	0.323	.410(*)	.769(**)	0.159	-.742(**)	1

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

Adenophorean nematodes could be generally grouped into enoplids, monhysterids and chromadorids based on their structural plan of organization. Functionally this classification with some exceptions is related indirectly to their mode of feeding, whereby enoplids are mostly predators; monhysterids are non-selective deposit feeders and chromadorids feed on algal mats (epigrowth feeders). Selective deposit feeders are represented in all these groups. The beaches under investigation were all sandy with sediments ranging from coarse through medium to fine (described earlier) in different cases. A medium sandy nature was noticed in general for all beaches. Of the 40 Adenophorean nematode species, enoplids were represented by twenty species, monohysterids by eight and twelve species belonged to chromadorids. The mean density of nematodes in different beaches indicated a preponderance of enoplids in four beaches, whereas in Sakthikulangara beach, monhysterids were represented in maximum numbers. This commensurate with the prevalence of maximum percentage of detritus feeders (annual mean) in Sakthikulangara in correspondance with the type of food available in the habitat and the nature of the substratum. Enoplids are typical psammophilous forms and of large size in comparison to the other two groups.

6.3.2 Community structure of nematodes

Communities of nematodes and their diversity are largely determined by sediment structure (Giere, 1993). Sediment composition in turn, often corresponds to food supply. The more microhabitats there are, the richer the nematode communities. Their distributional pattern is also modulated by other factors like salinity gradients and pollution (Wieser, 1959; Vanreusel, 1991). The pattern of prevalence of nematode communities in different beaches under study has been analysed.

An analysis of Table **6. 4** exhibiting the occurrence of different nematode species at different study sites clearly indicate the rich species diversity of Cherai beach, which outnumbered all other beaches in species richness. Cherai beach was characterized by the presence of 27 species of nematodes with almost equal contribution of all feeding groups. This was followed by Arthungal (18sp.); Veli (17sp.); Sakthikulangara (15sp.) and

Fort Kochi (13sp.) beaches. Certain species like *Daptonema setifer, Rhynchonema hirsutum, Paramonhystera albigensis* and *Theristus sp.*(Monhysterids) found abundantly in the samples collected in one season from Cherai beach were not the dominant ones in the following season. They were out numbered by other species such as *Onyx perfectus, Gammanema punctuata, Oxyonchus culcitatus, Trileptium anomala* etc. This trend was analysed in other sampling stations as well, where a species found in large numbers in a station in one season may be scanty in the following season or conversely two sampling locations with more or less same pattern of substratum were dominated by two different species. This corroborates with the observation made by some researchers (Wieser, 1960; Tietjen, 1969; 1971; Warwick and Buchanan, 1970; Warwick, 1970) who found that apparent preference by certain species and a particular substratum is not always the same in different localities. The preference varied with season as well. This change may be linked to the overall patterns of seasonal primary production or may reflect a response to the prey availability associated with temporal changes in the population of nematodes or other prey organisms. However, this aspect of nematode community dynamics requires further study. The involvement of other environmental parameters cannot be ruled out here. The above pattern of distribution was observed in most of the beaches with the species preference varying in different habitats. The influence of joint sediment type (availability of food) and salinity of interstitial water complex on the meiofauna is considered to be a reasonably good indicator to explain the apparent relationship between nematode trophic composition and their seasonal abundance (Wieser, 1959). Total or near absence of a predatory species, *Viscosia antarctica* was noticed at Cherai and Arthungal beaches in the present study.

Diversity studies form an important and basic aspect of community dynamics. Pollution being a form of ecological stress will result in a reduction in diversity of benthic community to an extent depending upon the degree of stress. The index of Shannon and Wiener (1949) was used to evaluate the diversity of nematodes in the beaches under study. The application of diversity indices for biological surveillance has been tested by several workers (Edwards *et al.*, 1972; Cook, 1976). In this index, the more uniform is the distribution between the component species, the higher would be the diversity index value. The diversity, dominance, richness and evenness which form the basis of a community structure has been examined with the data collected during the present investigation (Table **6. 9**).

Table. 6.9. Diversity indices (annual mean) of nematode species of the five beaches

Beach	**Margaleff Richness d**	**Pielou's evenness J'**	**Shannon Wiener's diversity index H' (log 2)**	**Species dominance Lambda'(1- λ)**
Cherai	3.329	0.936	3.32	0.091
Fort Kochi	1.45	0.936	2.21	0.217
Arthungal	1.762	0.966	2.59	0.146
Sakthikulangara	1.617	0.922	2.31	0.189
Veli	1.887	0.893	2.39	0.22

Maximum diversity index for Cherai (3.32), as evidenced from the table is accompanied by high species richness and evenness. Rajan *et al.* (1987) have opinioned that the richness and evenness indices show increased values in a 'healthy condition'. The higher diversity at Cherai beach signifies a degree of stability at this beach. According to Odum (1971), stability is more directly correlated to diversity than productivity. The diversity index is inversely related to the dominance index characterized by a low value for dominance (0.091) in this beach. This inverse relation has been observed by several workers (Rajan *et al.*, 1987). The above pattern was prevalent in the different beaches under study. However, Veli beach denoted a comparatively high dominance index against expectation, which may have been contributed by the presence of a predatory species, *Viscosia antarctica*. The incidence of dominant 'opportunistic' species could be attributed as a causative factor for this situation. Lambshead *et al.* (1995) analysed data on nematodes from temperate estuaries and sublittoral, bathyal, abyssal and trench and found that tropical species richness was lower than temperate and there is an inverse relationship between productivity and species richness. Nematode diversity is considered to be more powerful than meiofaunal abundance in detecting spatial variation in monitoring studies.

Taxonomic Distinctness:

Traditional diversity indices such as the Shannon entropy or the Simpson index summarise the information about the relative abundance of species within a community or sample without regard to differences between species. It is increasingly recognised that adequate measures of biodiversity should include information on the 'relatedness' of species within ecological assemblages, or the phylogenetic levels at which the diversity is expressed. Warwick and Clarke (1995) introduced the concept of taxonomic distinctness, as a measure of the average degree to which individuals in an assemblage are related to each other. Taxonomic distinctness measures provide a series of indices to achieve this, which are independent of sample size. These include indices such as Average Taxonomic Distinctness (AvTD, $\Delta+$) and Variation in Taxonomic Distinctness (VarTD, $\lambda+$), measures of species relatedness. Average taxonomic distinctness is a measure of species diversity or 'taxonomic breadth', and represents the average phylogenetic path length (Δ) between every pair of species in a sample, traced through the levels of a Linnaean taxonomic tree (Clarke and Warwick, 2001). Variation in taxonomic distinctness reflects the 'evenness' of the distribution of species across the taxonomic tree by determining the variance between each pair of species in a sample (loc.cit.). The studies reported regarding the usefulness of taxonomic distinctness for marine biodiversity assessment (Warwick and Clarke, 1998; Warwick and Light, 2002) suggest that taxonomic distinctness of degraded locations is significantly reduced when compared with those of relatively pristine locations for different groups of organisms and in different regions throughout the world. AvTD, Δ+ and VarTD, λ+ were calculated using the DIVERSE routine in the PRIMER statistical package.

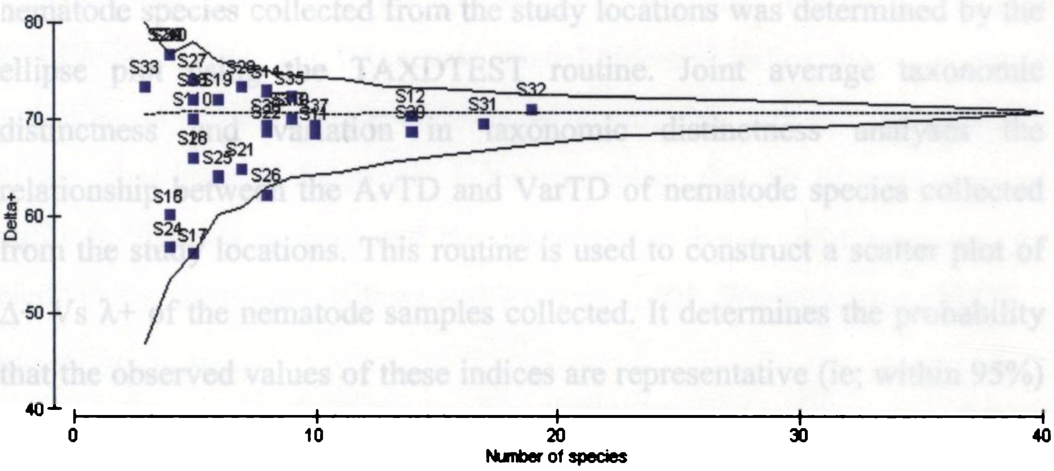


Fig. 6.7. The 95% probability funnel for the average taxonomic distinctness (Δ+) values. Expected average indicated by the dotted line in the middle of the funnel.

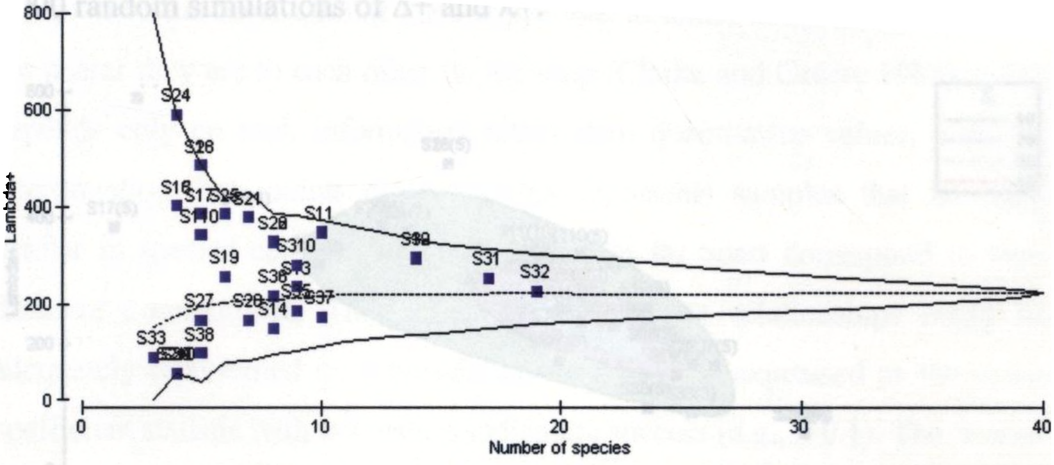


Fig. 6.8. The 95% probability funnel for the variation in taxonomic distinctness (λ+) values. Expected average indicated by the dotted line in the middle of the funnel.

AvTD(Δ+) and VarTD, (λ+), which are measures of species relatedness, are represented in Fig. **6. 7** and Fig. **6. 8** It could be seen that most of the sites are within the expected level except a few points, which are seen on the margin of the funnel plots. According to Clarke and Warwick (1998), values of taxonomic distinctness from unperturbed sites should fall within the confidence limits of the distribution, and impacted locations fall outside them. Fig. **6. 9** represents the joint comparison of both Δ+ and λ+. The relationship between the AvTD (Δ+) and VarTD (λ+) of nematode species collected from the study locations was determined by the ellipse plot using the TAXDTEST routine. Joint average taxonomic distinctness and variation in taxonomic distinctness analyses the relationship between the AvTD and VarTD of nematode species collected from the study locations. This routine is used to construct a scatter plot of Δ+ Vs λ+ of the nematode samples collected. It determines the probability that the observed values of these indices are representative (ie; within 95%) of the range of values that is expected for any subset of species (of a comparable size) drawn at random from the data of the entire study region. The 95% confidence limits for the different sized subsets of species are represented as concentric "ellipses" on the scatter plots, calculated from 1000 random simulations of Δ+ and λ+.

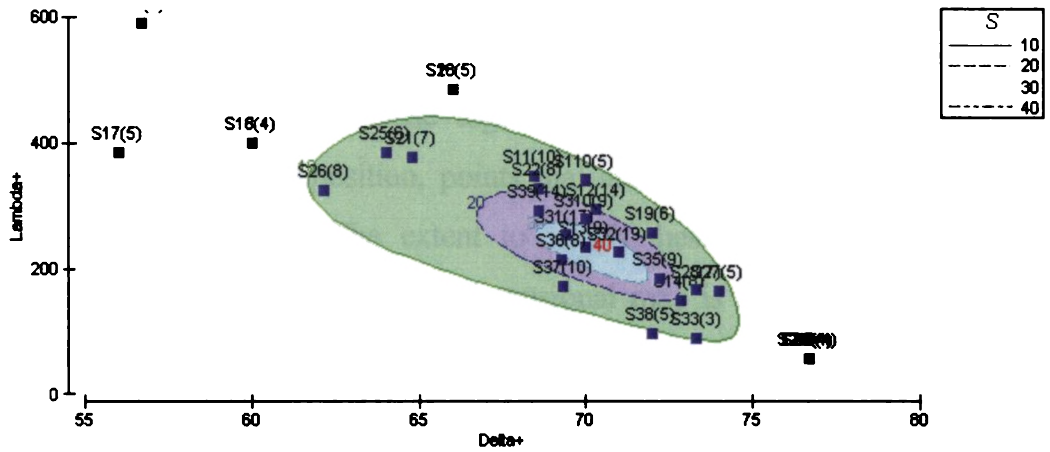


Fig.6.9. Ellipse plot showing the comparison of AvTD (Δ+) and VarTD (λ+) of nematodes at the study locations

In the joint Δ + Vs λ+ plot (Fig. **6. 9**), plots S17, S18, S28 etc. lie outside the ellipses. These represent stations at Sakthikulangara beach and indicate how different are the species from each other in this habitat. Stations outside the corresponding 95% probability ellipse are considered to represent those at which AvTD (Δ +) and VarTD (λ+) exhibit significant departure from the values expected for these indices over the entire study area. High Δ + values indicate the presence of a phylogenetically closely related species. Taxonomic diversity index is a measure of biodiversity that indicates how different are the species from each other in a habitat (Harper and Hawks, 1994). The taxonomic related diversity indices have appealing sampling properties: non-dependence on quantitative data and consideration of the relatedness of the species in an assemblage that are of great practical utility in diversity analysis and are considered as being most promising for biodiversity assessments (Clarke and Warwick, 2001; Warwick *et al.*, 2002).

Similarity indices:

The extent of temporal and spatial similarity between nematode trophic groups was worked out by similarity indices such as Multi- Dimensional Scaling (MDS) and SIMPROF tests using the numerical abundance data. Multi-dimensional scaling (MDS) is used to construct a map of the sampling sites, where the more similar the samples are in terms of species abundance, the nearer they are to each other on the map (Clarke and Green, 1988). MDS depends only on rank information rather than quantitative values, with the interpretation that, points close together represents samples that are very similar in species composition, points that are far apart correspond to very different communities. The extent to which these relationships could be adequately represented on a two-dimensional map is expressed as the stress coefficient statistic with low values indicating success (e.g., < 0.1). The 'stress' indicates how faithfully the relationships among the samples are represented in the 2D ordination plot. In the present analysis, the species data of nematodes was used for MDS analysis on seasonal scale. The red line indicates 80% similarity contour, yellow 60%, blue line 40% and green 20%. MDS plot gave a good ordination with a stress value 0.17 for the distribution of nematode trophic groups (Fig. **6. 10**). Significant clusters with more than 50% similarity could be noticed between the second and third trophic groups in Cherai beach and with Arthungal beach, which indicate the extent of similarity between the community structures of nematode trophic groups between these beaches. Clusters with less than 50% similarity also could be made out from the ordination plot.

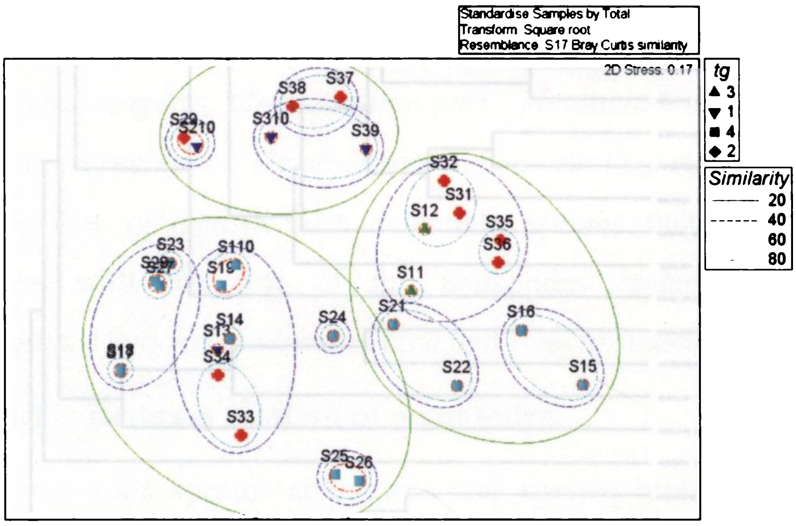


Fig. 6. 10. Non-metric Multi-dimensional scaling (MDS) ordination plot (stress = 0.17) of nematode trophic groups.

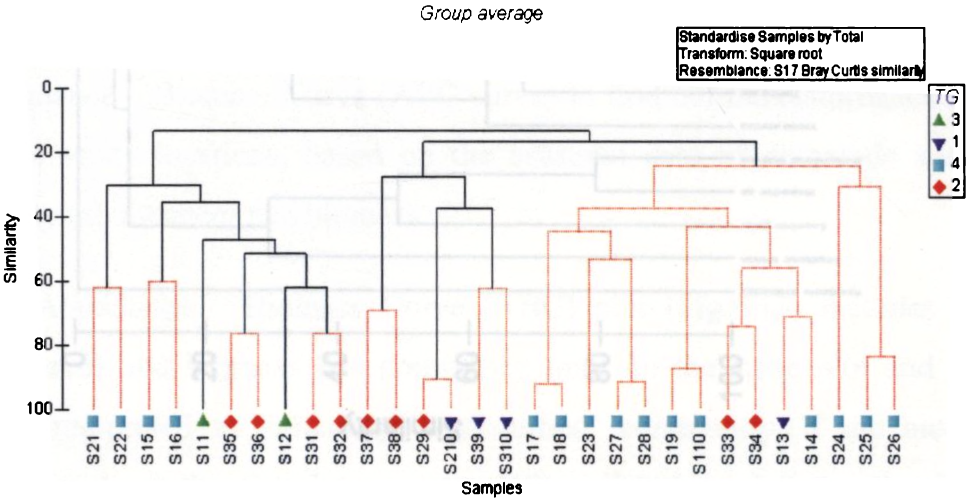


Fig. 6.11. Dendrogram for hierarchical clustering of trophic groups of nematodes using group-average linking of Bray-Curtis similarities (solid lines represent significant delineation of groupings by SIMPROF test)

Alternative multivariate analysis gives a clearer interpretation and cross checking of the association and similarities of sampling. Similarity Profile (SIMPROF) Test was done using PRIMER v6 to find the significant similarities among nematode trophic groups (Fig. **6. 11**). It revealed the same pattern of similarity as was shown in the MDS ordination plot.

In the SIMPROF Test and the resultant dendrogram between nematode species (Fig. **6. 12**), several significant clusters with similarity as high as 85% could be observed. Maximum similarity was seen between *Trissonchulus acutus - Ceramonema sp.; Trileptium anomala-Metepsilonema magdae; Mesacanthion pali - Metoncholaimus haplotretos; Epacanthion pellucidum – Gammanema punctuata; Oxyonchus culcitatus – Paramonhystera albigensis.* The nematode species that indicated least resemblance with the rest of the nematodes include *Rhabdocoma obtusicaudata, Metachromadora suecica* and *Neochromadora tecta.*

Abundance – Biomass relation of nematodes:

The nematode species abundance and species biomass were found independently for each species and the data was pooled together for analysis. As a measure to study the disturbance of the study area, the relative abundance and biomass of nematode species was plotted as Abundance – Biomass Curve (ABC curve) to find out the disturbance level of the study locations, based on the seasonal data of nematode species density (abundance) and biomass.

Abundance – Biomass Curve (ABC) plot (Fig.6.13) includes both abundance and biomass k – dominance lines on the same plot and have been interpreted as indicating 'undisturbed' community, if the biomass curve is above the abundance curve; 'gross disturbance' if the abundance curve lies above the biomass curve and 'moderate disturbance' if the two lines are largely separated.

Table. 6.10. Nematode species found in the study locations with the corresponding feeding groups (Wieser, 1953), mean individual body length, body width, wet weight and dry weight

Species	TG	L (mm)	W (mm)	V (nl)	W.W (μg)	D.W (μg)
Trissonchulus acutus	2A	1.37	0.061	2.7	3.05	0.763
Trissonchulus janetae	2A	1.94	0.053	2.89	3.27	0.816
Halalaimus capitulatus	1A	1.78	0.015	0.21	0.24	0.06
Epacanthion buetschlii	2B	2.01	0.07	5.22	5.9	1.475
Epacanthion georgei	2B	1.86	0.046	2.09	2.36	0.59
Epacanthion gorgonocephalum	2B	2.14	0.055	3.43	3.88	0.97
Epacanthion pellucidum	2B	1.73	0.028	0.72	0.81	0.2
Enoplolaimus connexus	2B	2.03	0.045	2.18	2.46	0.62
Enoplolaimus propinquus	2B	1.23	0.032	0.67	0.76	0.19
Mesacanthion pali	2B	1.76	0.038	1.35	1.53	0.38
Enoploides brunetti	2B	2.32	0.064	5.04	5.69	1.42
Oxyonchus culcitatus	2B	1.9	0.049	2.42	2.73	0.68
Trileptium anomala	2B	4.4	0.065	9.85	11.13	2.78
Phanoderma campbelli	2B	1.61	0.05	2.13	2.41	0.6
Metoncholaimus haplotretos	2B	2.37	0.058	4.23	4.78	1.19
Oncholaimus flagellatus	2B	2.27	0.051	3.13	3.54	0.88
Oncholaimus brachycercus	2B	0.92	0.05	1.22	1.38	0.35
Viscosia antartica	2B	2.08	0.059	3.58	4.05	1.01
Bathylaimus capacosus	1B	1.3	0.05	1.73	1.95	0.49
Rhabdocoma obtusicaudata	1A	1.2	0.017	0.18	0.2	0.051
Daptonema psammoides	1B	0.91	0.038	0.7	0.79	0.2
Daptonema setifer	1B	1.37	0.039	1.1	1.24	0.62
Daptonema vicinum	1B	1.15	0.04	0.98	1.11	0.28
Theristus acer	1B	0.84	0.027	0.32	0.36	0.09
Theristus sp.	1B	0.76	0.033	0.44	0.5	0.12
Paramonhystera albigensis	1B	1.53	0.036	1.05	1.19	0.3
Rhynchonema hirsutum	1B	0.52	0.025	0.17	0.19	0.05
Prorhynchonema warwicki	1B	0.583	0.031	0.3	0.34	0.08
Ceramonema africana	1A	0.13	0.025	0.37	0.42	0.105
Ceramonema sp.	1A	1.18	0.031	0.6	0.68	0.17
Marylynnia keralensis	2A	0.86	0.041	0.77	0.87	0.22
Pomponema multipapillatum	2A	0.99	0.035	0.64	0.72	0.18
Paracyatholaimus chilensis	2A	0.1	0.063	0.21	0.24	0.06
Gammanema punctuata	2A	0.895	0.048	1.09	1.23	0.31
Prochromadorella quinquepapillata	2A	1.25	0.03	0.6	0.68	0.17
Neochromadora tecta	2A	1.26	0.045	1.35	1.53	0.38
Metachromadora suecica	2A	0.86	0.042	0.8	0.9	0.23
Onyx ferox	2A	0.84	0.05	1.11	1.25	0.31
Onyx perfectus	2A	0.928	0.05	1.23	1.39	0.35
Metepsilonema magdae	2A	0.213	0.029	0.09	0.1	0.03
Rhabditis ehrenbaumi	1B	0.78	0.044	0.8	0.9	0.23

W value measures the extent to which the biomass curve lies above the abundance curve. The positive value indicates the undisturbed and negative, the disturbed condition. As the biomass curve of the graph illustrated lies above the abundance curve, the nematode community could be assumed as an 'undisturbed' one.

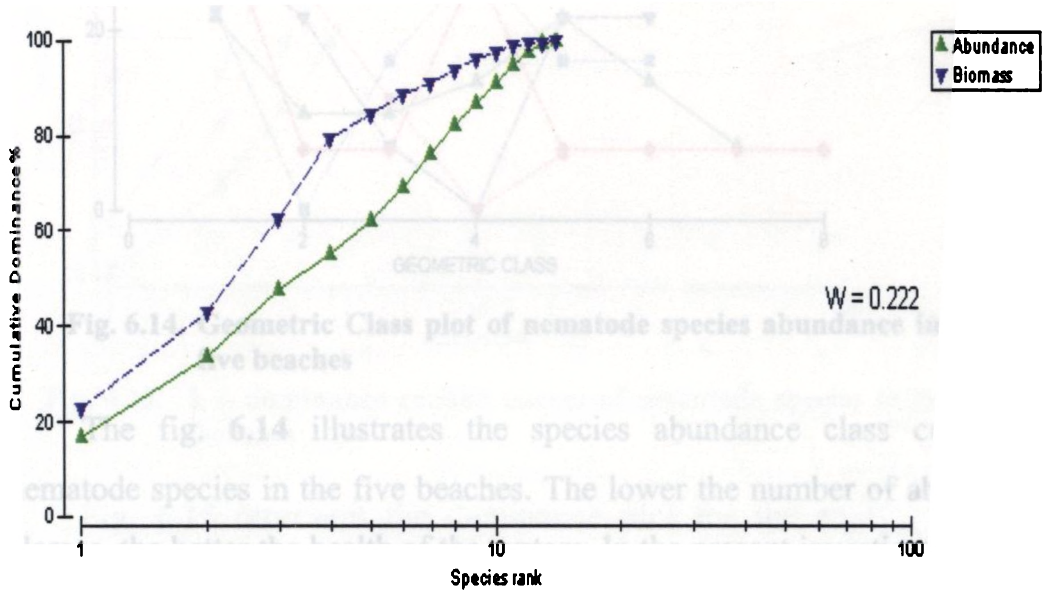


Fig. 6.13. Relative abundance and biomass of nematode species plotted as a curve, Abundance-Biomass Curve (ABC)

Geometric Class (GC) Plot:

The geometric class plots are essentially frequency polygons plotted for each sample (or a pooled set of samples) of the number of species that fall into a set of geometric (X2) abundance classes. It plots the number of species represented in the sample by a single individual (class 1), 2 or 3 individuals (class 2), 4 –7 individuals (class 3), 8 – 15 individuals and so on. It has been suggested that impact on assemblages tend to change the form of distribution, lengthening the right tail of the graph (some species become very abundant and many rare species disappears) and give a jagged curve.

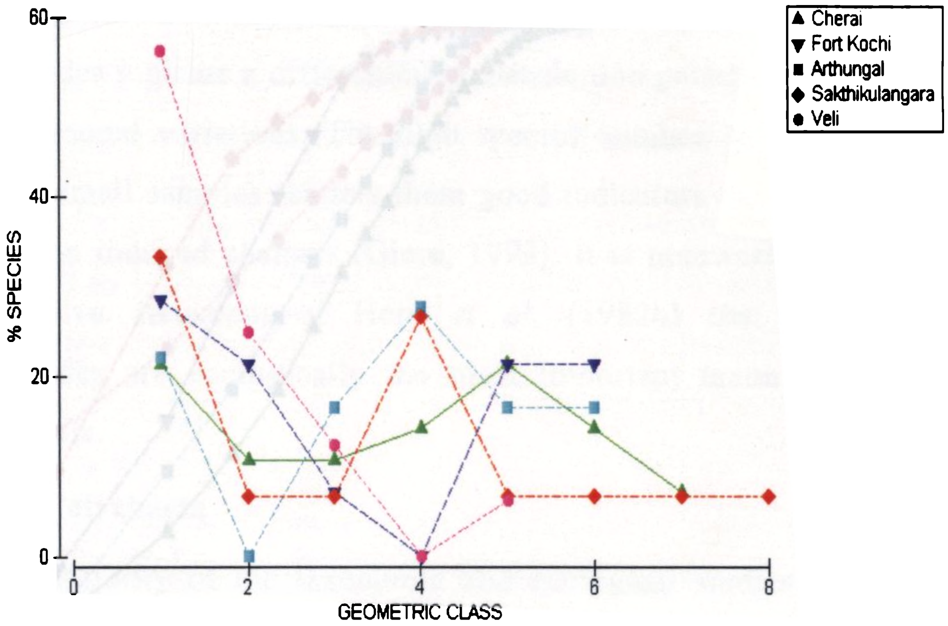


Fig. 6.14. Geometric Class plot of nematode species abundance in the five beaches

The fig. **6.14** illustrates the species abundance class curve for nematode species in the five beaches. The lower the number of abundance classes, the better the health of the system. In the present investigation, Veli beach has the least number (five) of abundance classes and a maximum of eight abundance classes are represented for Sakthikulangara. This feature highlights the peculiar nature of Sakthikulangara beach.

Dominance Plot:

Diversity profiles are presented as K-dominance curves (Lambshead *et al.,* 1983). The purpose of this distributional representation is to extract information on patterns of relative species abundance and dominance. This technique could be taken as intermediate between univariate summaries and full multivariate analysis (Clarke, 1990). The curves are presented as cumulative ranked abundance plotted against the species rank (logged axis). Shallow curves correspond to communities with high levels of dominance, whereas steep curves reflect a more balanced, diverse community.

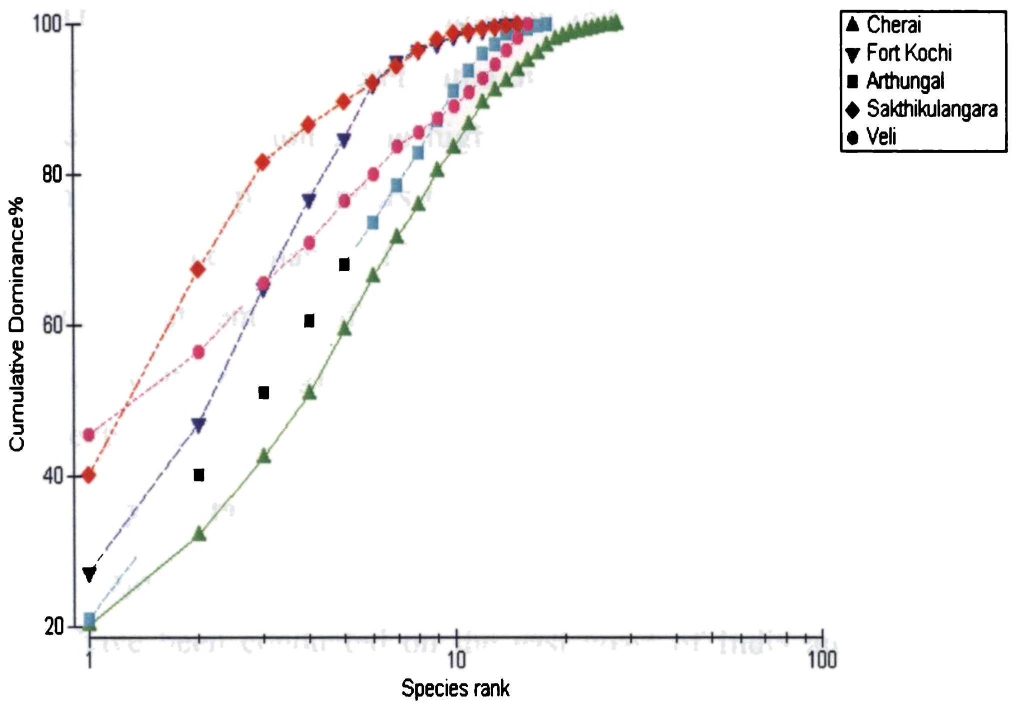


Fig. 6.15. k – dominance ranked curves of nematode species in the five beaches

Fig. **6.15** represent the dominance plot for the study locations. Station wise, the k – dominance curves corresponding to Cherai, Arthungal and Fort Kochi beaches were gently slopping 'S' shaped curves. Dominance plot is used to denote the stress to the biota. The percentage dominance of organisms was plotted against their rank cumulatively. In the stressed environment the dominance curve is 'J' shaped, showing the dominance of opportunistic species. The cumulative dominance would be 'S' shaped and drops gradually in unimpacted situation indicating the presence of conservative species. The starting point of the curve and its inclination are indicative of the diversity profile of the community. The gentle slope of the k – dominance curve indicate high species diversity. In the present graph, the slope is gentle for Cherai beach whereas a steep nature is noticed for Sakthikulangara, which is indicative of certain degree of stress in that habitat.

The intensive taxonomic radiation and ecological differentiation of nematodes indicate a differentiated distribution pattern with many local and seasonal variations. The high species number of nematodes even within small samples renders them good indicators for disturbance and pollution induced changes (Giere, 1993). It is noteworthy to quote the conclusive statement of Heip *et al.* (1982b) that "....free-living nematodes are ecologically the most important taxon in all marine sediments.......".

6.3.3 Polychaeta

Majority of the taxonomic and ecological studies of interstitial fauna have been conducted on the east coast of India and only a few studies have been attempted on the west coast. Several workers have reported the occurrence of polychaetes along the Madras coast, Waltair and Orissa coast (Aiyar and Alikunhi, 1940, 1944; Alikunhi, 1941, 1947; Gnanamuthu, 1954; Krishnaswamy, 1957; Rao and Ganapati, 1962, 1968, 1969). A study on the occurrence and distribution of interstitial polychaetes on the west coast of India was pioneered by Govindankutty (1966). Three species were reported by him with certainty. Their pattern of distribution and seasonal abundance of these individuals did not follow a definite pattern despite the fact that there was an abundance of these individuals during monsoon and that they preferred coarse sediments. Increase in density was observed during monsoon in the present study as well. Heavy swash in monsoon carry the fine sediments leaving behind larger sediments, thereby contributing to more interstitial pore spaces for polychaetes. Families like Saccocirridae, Protodriloidae, Protodrilidae and Polygordidae are no longer referred to as 'Archiannelids' and are now included under interstitial polychaete families. Being intertidal animals, they are largely eurythermic and euryhaline in habit. Reproductive activity especially breeding was found to peak during the summer months when the beaches of Kerala experiences wave washing by warm and highly saline coastal waters. Increased breeding resulted in faunal abundance of polychaetes during the monsoon season, which followed the hot summer months.

Fourteen species of interstitial polychaetes belonging to six different families have been reported in the present study. Collection of *Protodriloides chaetifer* from Fort Kochi and Arthungal beaches during the summer months in 2005 was significant since the family Protodriloidae had not been recorded earlier from the Indian coast. The occurrence of *Protodriloides chaetifer*, is the first report from the Indian coast. This is considered as due to the impact of tsunami, which struck the Indian coast in December 2004. This species was never encountered in the samples collected from the aforesaid beaches during the pre-tsunami period. The occurrence of several individuals of *P. chaetifer* in these beaches after the tsunami probably indicate that this oceanographic phenomenon might have resulted in the massive transport of marine sediments from archibenthal areas to the tidal belts of the affected beaches of various geographic areas (Priyalakshmi and Menon, 2007). These beaches are generally surf beaten characterized by fine to coarse-grained sands. Other than *P. chaetifer,* the total absence of polychaetes at Fort Kochi and Veli beaches during the monsoon and post monsoon seasons of the year is conspicuous. A relation between grain size and abundance is evident here, where the aforesaid stations were characterized by very low percentage of coarse sand. Furthermore, the polychaete density in summer, contributed by *Protodriloides chaetifer* alone corroborates (intensifies) the contention that this polychaete reached Fort Kochi beach in large numbers by water and sediment transport. Presence of polychaetes at Fort Kochi beach in summer is correlated to the higher percentage of medium sand grains found in these habitats, which obviously provided more interstitial space required for the polychaetes. Many of the larger polychaetes like members of family

Pisionidae with body dimensions greater than the pore spaces of coarse sandy sediments are considered as 'interstitial' since they move through the spaces between grains by pushing aside the grains. Generally, Pisionidae are regarded as interstitial, but Rouse and Pleijel (2001) question this categorization due to their size, up to a few centimeters, relative to the size of the sand grains they live in. Struck *et al.* (2005) favour regarding pisionids as interstitial since pisionids are most likely dependent upon pore water and the food availability between sand grains. It is justifiable to call them interstitial polychaetes as several characters of them, recognized as adaptations to the sand biotope correspond to those of the smaller inhabitants of sandy environments. Among the members of the family Pisionidae, *Pisione remota* was found to be the most common species inhabiting Cherai, Arthungal and Sakthikulangara beaches. Alikunhi (1950) has remarked that this species confines itself to the coarse sand near low water level and this holds true in the present case as well. *Pisione complexa,* reported by Govindankutty (1966) from the Kerala coast was not found in any of the beaches. It is not evident whether their absence is due to the changes caused by anthropogenic activities. A new pisionid species observed, highlight the need for a greater exploration of Indian coast to unravel the richness of the fauna of this region. *Pisione gopali,* recorded only during the monsoon, has been reported earlier by Govindankutty (1967). Pisionids are comparatively large forms among the representatives of psammophilous fauna.

Even though beaches with moderate wave action were selected for the present study, two juveniles of *Pisionidens indica*, were collected from Sakthikulangara beach, where the coarse sand was interspersed with shelly gravels. Day (1967), distinguishes the genus *Pisionidens* as an active burrower in tropical surf beaches. *Saccocirrus minor*, a typical interstitial polychaete was found in moderate numbers in beaches with large sand grains. They were encountered in all, but one beach (Veli) in the present investigation at various times. Remarkable behavioural responses to mechanical disturbance are exhibited by several species. The adhesive anal appendages and the well developed body musculature enable the adult organisms to push sand grains apart by powerful lateral undulations. Mechanically irritated *Saccocirrus* curl up into a ball and firmly attach themselves to sediment particles.

Among the hesionids, 3 species are reported in the present study, which include *Hesionides arenaria, H. peculiaris* and H. sp. (sp. novo). Species of the genus *Hesionides Friedrich* (1937) are characteristic of wave-washed sandy beaches all over the world. *H. arenaria* is said to have a worldwide distribution in tropical and subtropical beaches. Hesionids were collected from Sakthikulangara beach where the particular sediments ranged from coarse shell gravel to fine particles of sand. *H. arenaria* were also encountered in Arthungal beach during the post-monsoon season. The uneven numerical distribution often observed in sand samples may be due to their gregarious habit (Westheide and Rao, 1977).

Protodrilids were found to be present only in less numbers in the current investigation. These included *P. pierantonii, P.indicus* and an unidentified species. Protodrilids were totally absent from Fort Kochi and Veli beaches. All *Protodrilus* species possess planktonic developmental stages, which are reflected by the wider distribution of species of this genus. Their representation was poor along the south west coast of Kerala. Polygordidae constitute yet another important family of interstitial polychaetes. The reports of their recording from the Indian coast have been reviewed (Rao, 1969; Rao and Ganapati, 1968; Jouin and Rao, 1987). Of the two species observed during the current study, only one specimen of *Polygordius uroviridis* was obtained, whereas, *P.*

madrasensis was better represented. The natural habitats of these animals are under constant and serious threat due to the effects of pollution, disturbance, removal of beach sand for construction purposes etc. resulting in the elimination of many of these sensitive species from our coasts.

6.3.4 Gastrotricha

The phylum Gastrotricha is one of the lesser-known lower coelomates of microscopic animals inhabiting fresh water, brackish and marine habitats. Only scanty information is available about this group of animals from India except for the excellent attempts made by Rao (reviewed earlier). About 48 marine species have been reported from the Indian coasts and adjacent islands (Naidu and Rao, 2004). The sporadic distribution of these minute organisms and the great difficulty in handling and identifying them may be one of the various reasons resulting in this scanty information available from the Indian coasts. Marine gastrotrichs are interstitial animals occupying the space between sand grains. Because of the important role played by the interstices, the occurrence of gastrotrichs is correlated with the nature and distribution of sand particles in the intertidal and subtidal regions. intertidal and subtidal porous sands. Gastrotricha achieve high diversity in coarse, shelly, subtidal sands and some families like Macrodasyidae and Thaumastodermatidae are well represented in such areas. Families such as Chaetonotidae and Thaumastodermatidae may be well represented intertidally on exposed beaches. Xenotrichulidae is represented even in wave beaten zones. In the present survey along the coast of Kerala, gastrotrichs were well represented in Cherai and Veli beaches. Certain degree of habitat related species specificity was evident in the distribution of gastrotrichs. Species abundance was noticed in the collection during the post-monsoon period of the year, and preponderence of certain species during the summer months was a distinct feature of species distribution pattern. A species of the genus *Paraturbanella* in the Fort Kochi beach in large numbers elevated this group as such to the most dominant taxa in summer. These findings corroborates with the observations made by Govindankutty (Ph D Thesis, 1967unpublished) in his studies of gastrotrichs of the coast of Kerala. Gastrotrich was totally absent from all the locations sampled during the monsoon months.

A striking feature of the species distribution of gastrotrich was the distinct discontinuity in occurrence and abundance. About 17 species were recorded previously from the same area by previous authors (Govindankutty, 1969 and Rajan, 1972 (unpublished). During the present study, none of the above 17 species were collected from any of the five localities sampled. However, eight species were recorded for the first time during the present study. A species new to Science was also recorded. It is not clear whether this finding indicates recolonisation, disappearance or removal of gastrotrichs from the beaches of Kerala.

In the present investigation a new species of *Pseudostomella* was recorded from the Cherai beach. It was named *Pseudostomella cheraensis* (Priyalakshmi *et al.*, 2007). Another gastrotrich found in abundance was *Tetranchyroderma swedmarki*, a species that has already been recorded from the Indian coast. The remaining gastrotrich species observed in the present study included two macrodasyd species and four chaetonotid species. These have not been reported before. An interesting finding was the presence of two species that belong to the genus *Halichaetonotus,* a genus hitherto not reported from the Indian coasts. The distribution of gastrotrichs did not seem to follow any specific pattern. The presence of lone species of *Paraturbanella* in large numbers at Fort Kochi beach was an interesting phenomenon. Govindankutty and Nair (1972) have reported that the breeding of *Pseudostomella roscovita* was apparently confined to the low saline period of the monsoon as well as the medium saline period of the post monsoon. But gastrotrichs were altogether absent during the monsoon indicating that all the species recorded now are typically marine and will be either killed or removed during the monsoon months when the surface waters of Kerala coast oscillate between oligohaline and mesohaline conditions. The spatial distribution of gastrotrichs within a beach is of great ecological interest. They have varying degrees of adaptations and their power of adaptation determines their preference to colonize and thrive at a particular level of the beach (Rao, 1989b). But since organisms are living in an unstable environment subject to frequent disturbance, they always migrate seeking optimum conditions for existence. The species composition, density and distribution of gastrotricha vary considerably from area to area depending on the nature of the substratum. A few successful species always dominated in their quantitative abundance, while a majority of the remaining ones occurred in small numbers (Naidu and Rao, 2004). This was quite evident in the abundance of *Paraturbanella* species at Fort Kochi and *Tetranchyroderma swedmarki* and *Pseudostomella cheraensis* in Cherai.

6.3.5 Turbellaria

Turbellarians are ubiquitous forms in fresh water and marine habitats. This fairly large group is represented in all marine biotopes, often as one of the abundant taxa. Since the turbellarians usually have to be sexually mature before they could be identified at the species level, samples have to be taken at different seasons of the year. It is also important that they are extracted alive, as those taken from fixed samples are extremely difficult to identify. Turbellarians are fragile and their soft bodies are easily damaged. Ecological studies on turbellarians have been hindered to some extent by problems of identification. The turbellarians were represented in fair numbers in the samples collected for the present study. They constituted a major group of interstitial fauna of marine sands on the southwest coast of Kerala. However, a taxonomic enquiry was not possible owing to the great difficulty in the handling and identification of this fragile group of organisms. Only very few works on the taxonomy of turbellarians have been attempted from the Indian coast (Rao and Ganapati, 1968; Rao, 1969). Any specific pattern of distribution between stations could not be observed in the present study except for the fact that they made their presence in moderate numbers at all the beaches.

6.3.6 Kinorhyncha

One of the habitats in which kinorhynchs are found in the interstice of medium to coarse sand and gravel; either intertidal sand or high energy beaches or sub-tidal medium to coarse sand. Typically, kinorhynchs are mud dwellers and are least abundant in sandy biotopes. They are not very frequent and are very tiny and are not obtained by the usual extraction methods, since their body, covered by a strong water repellant cuticle, tends to adhere to the water surface once in contact with air. The present study revealed the presence of kinorhynchs, in samples collected after the monsoon season from Cherai and Arthungal beaches. Six individuals were collected from Cherai in summer as well. Although the dynamics of vertical movement within the sediment was not assessed, the depth (17- 20cm) from where these organisms were collected is indicative of their preference to dwell in deeper layers unlike the polychaetes, which occupied mostly in the surface layers.

Of the very few species reported from the Indian coast, such as *Cateria styx, Cateria sp.* and *Echinoderes bengalensis*, only *Cateria styx* was present on the coast of Kerala. Unlike observations made by Govindankutty and Rajan (Ph. D theses, unpublished) large number of *Cateria styx* were collected from Cherai and Arthungal beaches, where coarse to medium sand constituted the bulk of the substratum. This probably indicates a shift in the substratum and the evolutionary adaptability of the individuals that took place over the years. An observation of the data on the geographical distribution of *Cateria styx* indicate their widespread occurrence in Atlantic and Indian oceans thus conferring a eurytopic status to this species.

6.3.7 Isopoda

The isopod, *Angeliera phreaticola* was found in large numbers in the medium sands of Cherai and Arthungal beaches. Another isopod, *Coxicerberus predatoris* was confined in very small numbers in the sands of Veli beach. Unlike the reports given by Rajan (1972), where both species were found together, the present study showed their occurrence in different habitats. The substratum showed species preference whereby a particular substratum, which harboured *Angeliera phreaticola* in abundance, did not bear even a single specimen of *Coxicerberus predatoris*. Conspicuous absence during monsoon probably indicated that isopods do not inhabit sandy beaches during rainy season.

6.3.8 Cnidaria

A group with erratic distribution and rare occurrence was *Cnidaria*. Only one species was recorded from the Kerala coast. *Halammohydra octopodides* alone was encountered in the Kerala coast during the current study although this genus is represented by several species in the European coast. These forms prefer well-aerated sediments and seem to feed on nematodes and crustaceans (Clausen, 1967). Their spatial distribution (occurrence) or further interpretation could not be done since they were restricted in abundance and distribution. The erratic distribution of these aberrant groups of organisms has been reported earlier also (Govindankutty, 1966).

6.3.9 Halacaroidea

Only very few halacarids were encountered in the beaches during the present study. They belonged to two genera, *Anomalohalacarus* and *Scaptognathides.* They were collected only during the post-monsoon months from Cherai, Arthungal and Veli beaches, when the sediments were moderately well sorted and medium sized. Several researchers have observed that the halacarids make up less than 5% of the number of meiofauna specimens in sorted medium grained sands, whereas in unsorted sediments, they may increase to 15% (Bartsch and Schmidt, 1978).

6.4 A note on the Harpacticoid copepods encountered in the present study

Of the three orders of copepods, Harpacticoida dominated the interstitial habitat in the present study. Wilson (1932) was the first to relate the morphology of interstitial copepods to the environment and suggested that harpacticoids really do live in the interstitial waters, move about in wriggling motion and called this fauna 'terraquous'. Nicholls (1935) observed its morphological adaptations to the environment as elongate and cylindrical body, with modified setae to suit the interstitial habitat. Harpacticoid studies in India dates back to 1951, when Krishnaswamy made a systematic study of the group inhabiting the beach sands of Madras coast. Thereafter, several studies on harpacticoids that inhabited Madras and Waltair coasts were conducted by Krishnaswamy (1956) and Rao and Ganapati (1968; 1969). A thorough taxonomic study of the copepod fauna could not be done in the present study, due to the great difficulty experienced in their taxonomic categorisation. The study is therefore confined at the Family level. The quantum of harpacticoids present in the sandy beaches surveyed is given in Table **6. 11**. A total of 16 harpacticoid species representing 5 different families were present at different stations on the south west coast of Kerala. Family Ameiridae was represented by a single species; maximum individuals belonged to Ectinosomatidae, comprising of seven species; Leptastacidae included two species; five belonged to Leptopontiidae and one to Paramesochridae.

The absence of harpacticoids at Fort Kochi beach during the monsoon and post monsoon and their representation in good numbers during the summer is quite obvious from the table. Reduced salinity recorded at these

Table. 6. 11. Harpacticoids recorded from the study locations during 2005 - 06

Sl.	Period of Collection	Pre - Monsoon										Monsoon										Post - Monsoon									
No	Beaches	C		FK		A		S		V		C		FK		A		S		V		C		FK		A		S		V	
	Species/Station	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
1.	Ameridae sp.	○	○	○	○	●	●	○	○	○	○	○	●	○	○	●	○	●	○	○	○	●	●	○	○	●	○	○	○	○	○
2.	Ectinosomatidae sp.1	○	○	○	○	○	○	○	○	○	●	●	●	○	○	○	●	●	○	○	○	○	○	○	○	●	●	○	○	●	○
3.	Ectinosomatidae sp.2	●	●	○	○	●	●	○	○	●	●	●	●	○	○	○	○	●	●	●	○	○	○	○	○	●	○	○	○	○	○
4.	Ectinosomatidae sp.3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○
5.	Ectinosomatidae sp.4	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○
6.	Ectinosomatidae sp.5	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○
7.	Ectinosomatidae sp.6	○	○	○	○	○	○	○	○	●	●	○	○	○	○	○	○	○	○	●	●	○	○	○	○	○	●	○	○	●	●
8.	Ectinosomatidae sp.7	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	●	○	○	○	○
9.	Leptastacidae sp.1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
10.	Leptastacidae sp.2	○	○	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
11.	Leptopontiidae sp.1	●	●	○	○	●	●	○	○	●	●	●	●	○	○	●	○	●	○	○	○	●	●	○	○	●	○	○	○	○	●
12.	Leptopontiidae sp.2	○	○	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
13.	Leptopontiidae sp.3	●	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	○	○	○
14.	Leptopontiidae sp.4	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	○	○	○	○	○	○	○	○
15.	Leptopontiidae sp.5	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	●
16.	Paramesochridae sp.	○	○	○	○	○	○	○	○	●	●	○	○	○	○	○	○	○	○	●	●	○	○	○	○	●	●	○	○	●	●

● = Present; ○ = Absent; **C** = Cherai; **FK** = Fort Kochi; **A** = Arthungal; **S** = Sakthikulangara; **V** = Veli stations in monsoon and post-monsoon could have resulted in the absence of harpacticoids.An analysis of the distribution of harpacticoid families at different stations reveals the distribution to be erratic. Many studies of the ecology of meiobenthic harpacticoid copepods have established the distribution of species to be non-random (Gray and Reiger, 1971) and that different species have been found to inhabit sediment matrices of different particle diameter (Noodt, 1969). Even though sediment particle diameter is likely to be an important dimension of the niche of interstitial Harpacticoida (Gray, 1974), no correlation exists between the sediment particle diameter and the diameter of the interstitial pore (Crisp and Williams, 1971) due to the irregularity of the shape of the particles comprising the sediment matrix. Moreover the sediment particle diameter may act upon the interstitial fauna through modification to such variables as the interstitial drainage rate and not assert a direct effect itself. In the inconstant environment of an unconsolidated layer of sediment, there may be no relationship between the polymetric sediment characteristics and the state of the interstitial pore, the living space of the mesopsammic species. Hartzband and Hummon (1974) has remarked that the environmental stability or constancy is a more important determinant of the structure of the meiofauna communities than the properties of the sediment matrix where as in the consolidated layer of sediment or in sediment matrices of low energy environments, association between species and sediments of particular granulometry are to be expected. Moore (1979) has remarked that their occurrence may be related directly to the sediment particle diameter, if the sediment is well sorted and with low silt content. An attempt has been made in the present study to find any relation between interstitial harpacticoid community and sediment particle diameter. A positive correlation between the harpacticoids and the medium sand is evident in the present study. Though a cosmopolitan distributional pattern occurs remarkably often-in soft-bodied marine meiobenthos such as interstitial polychaetes, ciliates, gnathostomulids, gastrotrichs etc, it is less common in "hard meiofauna" like harpacticoids (Giere, 1993). Within harpacticoids in general, Wells (1986) states "interstitial species tend to show a higher degree of endemism (76%) than primarily epibenthic or phytal species (63% and 68% respectively)". None are truly cosmopolitan, though a few have a rather wide distribution.

6.5 The Nematode / Copepod Ratio as an Indicator of Pollution

6.5.1 Introduction

Responses of meiofaunal communities to perturbation including pollution have been less well studied than those of macrofauna. Because of their different biological characteristics, it cannot be assumed that meiofaunal responses will be qualitatively the same as those of the macrofauna, and some important differences have already been noticed by way of a shift towards larger sized species of meiofauna under polluted conditions (Warwick, 1988). Since meiofaunal diversity is maintained largely by a high degree of feeding specializations on particles of different size, shape and quality, physical perturbation is likely to play a less important role.

Many interstitial faunal investigations on pollution effects are based on a divergent reaction of the two main taxa, nematodes and harpacticoids. The general notion has been referred to the different trophic niche occupied by the two groups (Montagna *et al.*, 1989). Raffaelli and Mason (1981) first proposed the use of the nematode to copepod ratio as a tool for biomonitoring. Investigating a Scottish west coast beach Raffaelli and Mason (loc. cit.) showed that the overall ratio of nematodes / harpacticoid copepods increased with increasing degree of pollution due to the reduction of the more sensitive harpacticoids. Although, they realized that this N/C ratio would shift depending on variations in the grain size distribution, they contended that if this trend have to be generalized for all sandy eulittoral coasts, a value > 100 would indicate pollution. The value of this technique subsequently became the topic of discussion amongst meiobenthologists, with some (Coull *et al.*, 1981), arguing that it was an over generalisation and others (like Warwick, 1981) suggesting modifications to improve its utility. Lambshead (1984) cast doubts on the usefulness of the ratio by pointing out the difficulties in separating the effect of pollution on the ratio from the effects of other environmental variables. The ecological spectra of the individual species within nematodes and harpacticoids are too diverse and are influenced independently by a complex set of environmental parameters to stand for a universal validity. Too many other factors besides pollution play a decisive role. This led Warwick (1981) to a refinement of the N/C ratio taking into account the various feeding types involved. Based on the examination of mouthparts and the armature of the buccal cavity; he could show that the epigrowth feeders react different from predators and deposit feeders. Their separation would certainly add precision to the nematode/copepod ratio. The feeding behaviour of harpacticoid copepods has been less well studied and evidences suggest that the epibenthic species are raptorial feeders (Marcotte, 1977) and interstitial forms browse on the surface of sand grains, scraping off the epiflora (Noodt, 1971; Feller, 1980). Both these types of feeding can be equated with type 2A of the nematodes, so that only the nematodes in this feeding category are dependant on the same food source as the copepods. The ratio was thus modified to include harpacticoids and only those nematodes dependant on the same food source and occupying the same microhabitat (Type 2A or epigrowth feeders) (Warwick, 1981; Shiells and Anderson, 1985). Warwick (1981), based on his studies suggested that an indication of pollution might be given by ratios around 40 for fine sediments and 10 for sand.

6.5.2 Material and Methods

The nematodes were categorized into 4 feeding types based on the structure of their buccal cavities (Wieser, 1953; Warwick, 1981). The nematode to copepod ratio was calculated by dividing the number of nematodes (Type 2A) in a sample by the number of harpacticoid copepods (Lee *et al.*, 2001). When there were no copepods present in a sample, the number of nematodes present was used to represent the ratio; where nematodes were absent but copepods present the ratio was zero, and zero was also used where both groups were absent. Data was interpreted using simple graphical representation.

6.5.3 Result

The numerical abundance of nematodes, copepods and N (2A)/C ratio in the ten stations sampled is presented in Table **6. 12.**

Table. 6.12. Density of nematodes (2A), copepods and N/C ratio in the five beaches

Season	Station	Nematode	Copepod	N(2A)/C
pre-monsoon	1	31	84	0.4
	2	49	8	6
	3	244	952	0.3
	4	24	947	0.02
	5	0	166	0
	6	14	140	0.1
	7	18	0	18
	8	12	0	12
	9	2	43	0.04
	10	1	53	0.01
monsoon	1	0	6	0
	2	6	36	0.2
	3	0	0	0
	4	0	0	0
	5	1	4	0.25
	6	0	3	0
	7	161	9	18
	8	264	8	33
	9	2	7	0.3
	10	1	21	0.05
post- monsoon	1	351	133	2.6
	2	614	186	3.3
	3	0	0	0
	4	7	0	7
	5	27	746	0.04
	6	166	1073	0.6
	7	106	28	3.8
	8	13	0	13
	9	36	110	0.33
	10	3	168	0.02

The ratio showed some fluctuation between beaches. Sakthikulangara beach was characterized by the absence or near absence of copepods. It is evident from the Fig. **6. 16** that N (2A)/C ratio represented a value beyond 10 only for this beach.

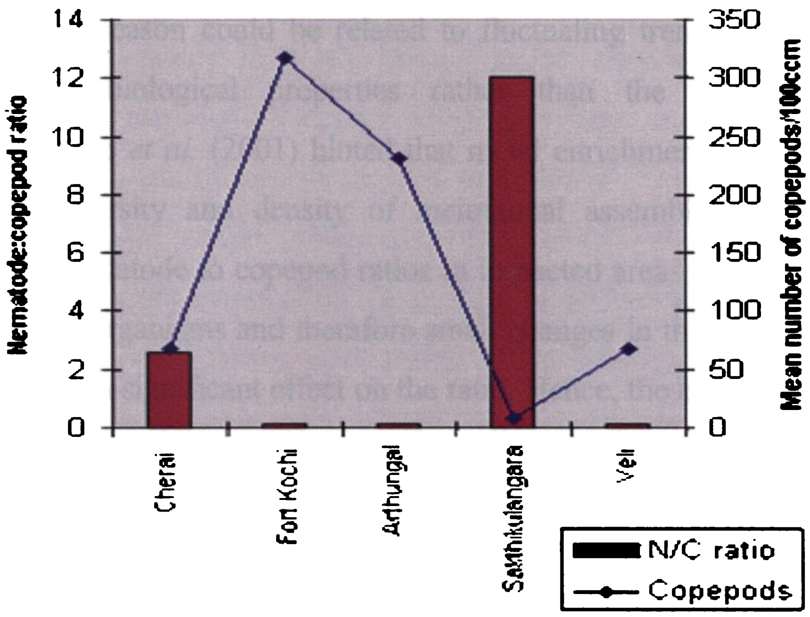


Fig. 6.16. Nematode to copepod ratio (bars) and the mean number of harpacticoid copepods (line) over the range of beaches sampled. The three divisions of the graph were proposed by Lee *et al.* (2001)

6.5.4 Discussion

The nematode / copepod ratio (Raffaelli and Mason, 1981) with modifications (Warwick, 1981; Shiells and Anderson, 1985) was used as an index to monitor pollution of selected beaches. A value beyond 10 obtained for Sakthikulangara beach could be considered as an indication of some pollution in this beach. Presence of radioactive pollutant, thorium is characteristic of this beach (based on secondary data). The beaches under discussion were all medium to high-energy oceanic beaches. Copepods are generally sensitive to metal pollution and decline rapidly with increasing metal concentrations (Hicks and Coull, 1984). The role of other environmental variables like grain size and salinity in structuring the harpacticoid community cannot be ruled out in this context. Differential responses within the communities of nematodes and copepods, showing adaptations by individual groups, are probably better indicators of stress at the community level than the simple ratio between their abundance. Ansari and Ingole (2002), in their studies on the effect of an oil spill on intertidal meiofauna at Goa, India, suggested that the fluctuation of N/C ratio with season could be related to fluctuating trend in the physico-chemical and biological properties rather than the concentration of hydrocarbon. Lee *et al.* (2001) hinted that metal enrichment generally drives down both diversity and density of meiofaunal assemblages. Thus, it is possible that nematode to copepod ratios in impacted areas are based on very low number of organisms and therefore small changes in the density of either taxa could have a significant effect on the ratio. Hence, the evidence presented here does not support the use of nematode to copepod ratio as a stand-alone method for biomonitoring purpose on high-energy open ocean beaches, but could be an indication of some impact of pollution.

An analysis of the results of various environmental variables and community structure of different sites revealed some interesting facts. Sakthikulangara beach stands apart from the rest of the beaches under study, in respect of the granulometric studies, trophic group community structure of nematodes, faunal density and certain other features. The sediments of this beach, which ranged from coarse through medium to fine sands, were found to be poorly sorted. Organic carbon values were high at Sakthikulangara beach. Unlike all other beaches, such as Cherai, Fort Kochi, Arthungal and Veli, where predators dominated the habitat among nematodes, non-selective deposit feeders were the predominants of Sakthikulangara beach. As a rule, there is a diminution of faunal density of a habitat during the monsoon due to the unfavourable climatic, hydrographic and edaphic factors. Surprisingly, a reverse trend was noticed in the present study in respect of the faunal abundance of Sakthikulangara beach where numerical abundance of several taxa were found to be more in the samples collected during the monsoon months. Above all, as a reflection to all this, the nematode: copepod ratio (N (2A)/ C), which is considered as a possible indicator of pollution, crossed the value of 10, which is indicative of possible disturbanceof a habitat.

Pollution studies using meiofauna is generally hampered by the lack of appropriate univariate measures of community stress. However, a few copepod and nematode taxa are known to be associated with organic enrichment of a fairly gross nature. Copepods have been assumed to be more sensitive to pollution effects than nematodes (Raffaelli and Mason, 1981), leading to high copepod nematode ratio in such situations. However, such response is not predictable in sublittoral sediments, where nutrient enrichment may have the reverse effect of increasing copepod numbers relative to nematodes. This is particularly so where dissolved oxygen is not depleted appreciably in the overlying water. At present, not enough empirical evidence is available to establish predictable changes in trophic organization in response to pollution (Heip *et al.,* 1985).

Though pollution tests have not been conducted and N/C value cannot be taken as a sole means of indicator of pollution, various features observed and analysed during the course of this study depict a deviation of Sakthikulangara beach from normalcy. All these factors collectively highlight a different scenario of Sakthikulangara beach, which initiate to pursue more extensive study of this beach. Cherai beach, on the other hand, an important tourist spot comes to the limelight in the maximum diversity and abundance of interstitial taxa. Not alone in abundance, in diversity also Cherai beach outstripped all other beaches in having representatives of most of the interstitial taxa. Hence, more anthropogenic related studies of these two beaches could be pursued to bring out more fascinating conclusions on the peculiarities of Sakthikulangara and Cherai beaches.

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Chapter -7

Summary and Conclusion

The oceans in their expanse cover, seven – tenths of the Earth's surface. Despite being restricted in size, the littoral zone or the intertidal zone (beach) has the greatest variation in environment factors of any marine area. Stemming from this variation, a tremendous diversity of life, which may be as great as or greater than that found in the more extensive sub tidal habitats exist in this realm. The sandy beaches harbour diverse and abundant assemblage of marine organisms. Besides macro fauna, microscopic organisms belonging to the lower and higher invertebrate taxa profusely inhabit these beaches. The ecological realm where these animals exist is known as the interstitial environment, which in principle includes the pore spaces in between the sand grains containing copious supply of nutrient rich oxygenated seawater. An astonishing diversity of taxa could be found within the interstitial fauna.

Granulometric studies of beach sediments provide a wealth of information on the intrinsic properties of sediments and help to look into the nature and energy flux of the multifarious agents transferring the sediments. The grain size composition is a key factor in the distribution of interstitial taxa, which in turn depends on exposure to currents and waves. Sampling was done at ten stations in five beaches of Kerala (Cherai, Fort Kochi, Arthungal, Sakthikulangara and Veli) during three seasons of the year. The textural characteristics of beach sediment like grain size, nature of sediment and the chemical elements like organic carbon, hydrogen and nitrogen were analyzed. In general, medium sand dominated at all stations (in three seasons) with some exceptions. Mean particle size was low in monsoon except at Sakthikulangara beach and this is reflected in the reduced faunal density in those stations. Sediments varied from very well sorted to moderately sorted at all stations. In Sakthikulangara beach, the sediments were found to be poorly sorted in all seasons. Although several studies have shown that habitats with coarse sediment particles contain lesser organic carbon and fine sand harbour more carbon, the present study revealed a positive correlation between organic carbon content in sediments and coarse sand. The significance of the shape of the sediments comes into the picture where more angular grains can harbour much more carbon than smooth surfaced grains (or fine sand). Particle size of sediment is not the sole factor in carbon determination to provide maximum food for interstitial population. There is a multitude of factors, which are important in tidal beaches. Despite the fact that the amount of energy (Joules/ mg) available for organisms was maximum in Sakthikulangara beach, the faunal density and composition indicate that the quality of organic matter plays an important role in controlling benthic communities rather than the quantity. Pearson correlation matrix of sediment parameters from the study stations indicated the median particle diameter of sediment to be positively correlated with coarse sand with 0 .01 level of significance. ANOVA was conducted between stations for different parameters (variables) of the sediments. The Duncan test is a Post Hoc Test to substantiate the significance and variability of the data. The more the subsets, the greater would be the variability. DUNCAN TESTS were conducted between stations for different parameters (variables) of the sediments and were found to be significant mostly.

Observations of the hydrographic parameters such as temperature, salinity, dissolved oxygen and pH at the time of sampling in the study locations were analyzed and correlated with environmental and biotic parameters. Except for the reduction in temperature during the monsoon a marked variation could not be observed. Salinity of interstitial water was high in summer (36 ‰) in comparison to the lowest salinity value (18‰)

recorded during the monsoon month with a mean of 29.4 ± 4.8. Decreased salinity due to the influence of monsoon contributed to a reduction in the interstitial faunal reduction, except at Sakthikulangara beach. Higher dissolved oxygen values observed at Veli beach is in congruence with Jansson's (1966) report that ODR values may be high in sand of 200 - 300µm. pH plays only a minor role in the marine biome for the interstitial fauna, since the slightly alkaline sea water is well buffered against pH fluctuations. ANOVA of various hydrographic parameters were found to be highly significant at 1%.

Meiofauna present in the sediment samples were separated by suspension – decantation method (Wieser, 1960) and the organisms were sorted and counted groupwise into major taxa. Annual mean showed the dominance of nematodes in Cherai and Sakthikulangara beaches, whereas the other three beaches were dominated by harpacticoid copepods. Taxonomic studies of selected groups such as Nematoda, Polychaeta, Gastrotricha, Kinorhyncha, Cnidaria and Isopoda were conducted. The community structure of the interstitial fauna of beaches was analyzed in the present study. Species diversity was estimated according to the Shannon-Wiener H' (log2) diversity, Margaleff richness (d) and Pielou's evenness (J') indices. Shannon diversity index was maximum (2.027) at Cherai. The higher the diversity value, the more the richness. This was evident at Cherai beach, which was characterized by the presence of all the interstitial taxa. Sakthikulangara beach on the other hand, had the least diversity index, but high dominance value. Similarity indices such as Non- Metric Multidimensional scaling and cluster analysis were done and significant similarities were observed between Kinorhynch-Isopod and Turbellaria – Nematoda.

A total of sixty seven species were identified which included 41 species of nematodes, 14 polychaete species, 8 gastrotrich species, 2 species of isopods, a cnidarian and a kinorhynch species. Seven species have been described as new to science. Nematodes were represented by 6 orders, 15 families and 30 genera. Of the 40 Adenophorean nematode species, 20 belong to Enoplida, 8 monhysterids and 12 species were chromadorids.

A study of the community structure of nematodes was attempted and the analysis revealed that there is variation among habitats in the degree of species dominance. The higher diversity index observed at Cherai beach signifies a degree of stability at this beach Nematode fauna on the coast of Kerala is rich in numerical abundance and variety of species though, the density of some of the forms is low. Similarity indices were also calculated. As a measure to study the disturbance of the study area, the relative abundance and biomass of nematode species was plotted as Abundance – Biomass Curve (ABC curve) to find out the disturbance level of the study locations, based on the seasonal data of nematode species density (abundance) and biomass. The nematode community was assumed to be 'undisturbed' since the biomass curve was above the abundance curve.

Free-living nematodes partition the environment in various ways, of which food partitioning is the most crucial. The nematodes collected from different beaches were classified based on four feeding groups as proposed by Wieser (1953). The relative proportion of each of these feeding groups in any one community will depend on the nature and balance of the available food, which in turn is correlated with the sediment type. Trophic group 2B were the dominant (15 sp.) ones, followed by the epigrowth feeders, 2A (12 sp.). 1A and 1B constituted 4 and 9 species respectively. In terms of species, the maximum number, covering all the 4 feeding types, characterized Cherai beach. It could be summarized that predators / omnivores (2B) and non-selective deposit feeders were invariably present in all beaches in different seasons of the year. In Sakthikulangara beach, epigrowth feeders (2A) were also well represented. The mean density of nematodes in different beaches indicated a preponderance of enoplids except at Sakthikulangara beach.

Enoplids are typical psammophilous forms and of large size in comparison to monhysterids and chromadorids. This in turn contributed to an increased biomass of the habitat. Cherai beach outnumbered all other beaches under study, in species richness. A general trend analysed in different sampling stations is that a species found in large numbers in a station during one season may be scanty in the following season or conversely two sampling locations with more or less same pattern of substratum was dominated by two different species.

Though a taxonomic study of harpacticoids was not conducted, identification at the family level revealed the presence of sixteen species of copepods and the distribution was found to be erratic. A positive correlation between harpacticoids and medium sand was evidenced by Pearson correlation matrix analysis. High salinity favoured by harpacticoids was reflected by the near absence or reduction of harpacticoids during the monsoon collection.

Many interstitial faunal investigations on pollution effects are based on a divergent reaction of the two main taxa, nematodes and harpacticoids. Raffaelli and Mason (1981) showed that the overall ratio of nematodes / harpacticoid copepods increased with increasing degree of pollution due to the reduction of more sensitive harpacticoids. The nematode / copepod ratio (Raffaelli and Mason, 1981) with modifications (Warwick, 1981; Shiells and Anderson, 1985) was used as an index to monitor pollution of the selected beaches. A value beyond 10 obtained for Sakthikulangara beach could be considered as an indication of some pollution in this beach. But the role of other environmental variables like grain size and salinity in structuring the harpacticoid community cannot be ruled out in this context.

An analysis of the results of environmental variables and community structure of different sites revealed some interesting facts. Sakthikulangara beach stands apart from the rest of the beaches under study, in respect of the granulometric studies, trophic group community structure of nematodes, faunal density and certain other features. As a rule, there is a diminution of faunal density of a habitat during the monsoon due to the unfavourable climatic, hydrographic and edaphic factors. Surprisingly, a reverse trend was noticed in the present study in respect of the faunal abundance of Sakthikulangara beach, where the numerical abundance of several taxa were found to be more in the samples collected during the monsoon months. Unlike all other beaches, such as Cherai, Fort Kochi, Arthungal and Veli, where predators dominated the habitat among nematodes, non-selective deposit feeders were the predominants of Sakthikulangara beach. Above all, as a reflection to all this, the nematode: copepod ratio (N (2A)/ C), which is considered as a possible indicator of pollution, crossed the value of 10, which is indicative of possible disturbance of a habitat.

Though pollution tests have not been conducted and N/C value cannot be taken as a mere test of indicator of pollution, various features observed and analyzed during the course of this study depict a deviation of this beach from normalcy. All these factors collectively highlight a different scenario of Sakthikulangara beach, which initiate to pursue more extensive study of this beach. Cherai beach, on the other hand, an important tourist spot comes to the limelight in the maximum diversity and abundance of interstitial taxa. Maximum nematodes were procured from this beach in all seasons of the year. Of the 41 nematode species identified, 27 species were present in Cherai beach. Not alone in abundance, in diversity also Cherai beach outstripped all other beaches in having representatives of most of the interstitial taxa. Hence, more anthropogenic related studies of these two beaches could be pursued to bring out more fascinating conclusions on the peculiarities of Sakthikulangara and Cherai beaches.

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APPENDIX

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A new species of *Pseudostomella* (Gastrotricha: Macrodasyida: Thaumastodermatidae) from a sandy beach of Kerala, India

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Abstract

During an interstitial faunal survey along the south-west coast of Kerala, India, gastrotrich fauna were found in abundance. Together with species of the genera *Xenotrichula*, *Halichaetonotus* and *Tetranchyroderma*, were present several undescribed thaumastodermatid gastrotrichs belonging to the buccal palp bearing genus *Pseudostomella*. Adults of the new species are characterized by the following traits: total body length of about 300 µm; cuticular armature made up of medium sized pentancres covering the entire dorsolateral surface; pre-buccal, grasping palps bearing five, large papillae dorsally and 4-6 smaller papillae ventrally; adhesive apparatus made up of six anterior, 22-24 ventrolateral, two dorsolateral and six posterior adhesive tubes; caudal organ pear-shaped; frontal organ spherical. *Pseudostomella cheraensis* sp. nov. is the fourth taxon of the genus known from India; however, all the previous species reported hitherto from India have tetrancres instead of pentancres.

Key words: interstitial; meiofauna; taxonomy; gastrotrichs; Arabian Sea

Introduction

Gastrotricha constitutes one of the most interesting and taxonomically challenging groups of meiobenthic marine and freshwater invertebrates. Traditionally gastrotrichs are considered, on morphological basis, either to be a separate phylum or to belong to the Aschelminthes, and are believed to be closely related to Rotifera (Brusca & Brusca, 1990) or the Nematoda (Ruppert & Barnes, 1994). More recently, they have been associated on molecular ground with the Platyzoa (Todaro *et al.* 2006a). In aquatic ecology, gastrotrichs are known as important components of the permanent meiofauna (Todaro *et al.*, 2006b).

Marine gastrotrichs are mainly interstitial, occurring both in the intertidal and subtidal realms. They are more abundant in fine to medium grained sediments in unpolluted and less turbid waters of coastal areas (Todaro & Rocha, 2004). However, submarine caves, dysoxic sand and deep, muddy sediments may also be colonised by gastrotrichs (Leasi *et al.*, 2006; Todaro *et al.*, 2006b, c; Balsamo *et al.*, 2007). In the sandy marine interstices, gastrotrichs rank third in abundance among the meiofaunal taxa following Nematoda and the harpacticoid Copepoda; their numerical abundance may reach a density up to 364 ind./10 cm^2 (Todaro, 1998).

The phylum is cosmopolitan and includes about 700 species grouped into two orders: Macrodasyida, with 250 strap-shaped species, all but two marine, and Chaetonotida, with 450 tenpin-shaped species, of which only 150 are marine or brackish.

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The gastrotrich fauna of India have been recently reviewed by Naidu & Rao (2004). The present report is on a new species of *Pseudostomella* found during an interstitial faunal survey along the south west coast of Kerala, India.The genus *Pseudostomella* was first created by Swedmark (1956) based on a specimen discovered from Roscoff in France, thirteen species have subsequently been described (Clausen, 2004); of these four are endemic or occur also along the Indian coasts; they are: *P. roscovita* Swedmark, 1956, *P. malayica* Renaud-Mornant, 1967, *P. indica* Rao, 1970, *P. andamanica* Rao, 1993. All these species possess only tetrancres whereas the species described here is characterized by the presence of pentancres uniformly distributed dorsally.

Material and methods

Sediment sampling employing a corer was done in the Cherai beach (lat.12° 97′ N; long.77° 56′ E), Kerala State, located on the south-west coast of India (Fig.1). The core samples were obtained from the mid tide level at a depth of 17 cm. Temperature (28°C) and salinity ($31^{\circ}/_{00}$) of the interstitial water were recorded. The animals were narcotized *in situ* by adding 7% magnesium chloride solution and subsequently fixed in 5% sea water formalin. The fauna was extracted by decantation following the technique adopted by Pfannkuche & Thiel (1988). The specimens of gastrotrichs were dehydrated through graded ethanol series and mounted on slides using glycerol and the slides were sealed with a sealant. Specimens were examined under a Magnus 100× oil immersion objective (India) or with Nomarski differential interference contrast optics using an Eclipse 90i Nikon microscope (Italy). During DIC observation, the specimens were photographed with a DS-5Mc Nikon digital camera. Measurements were taken using an ocular micrometer or derived directly from microphotographs.

ABBREVIATIONS (after Ruppert, 1991; Hummon *et al.*, 1993; Clausen, 2000).

Co = caudal organ; CP = caudal pedicle; DP = dorsal papilla; E = egg; eg = Epidermal gland; Fo = frontal organ; Lt = total length from the anterior tip of pre-buccal extension to posterior tip of caudum or pedicles including adhesive tubes; U = percentage unit of total length used for the location (U-) from anterior to posterior; pb = Pre-buccal apparatus; PhIJ = junction between pharynx and intestine; Pp = pharyngeal pore; T = testis; TbA = anterior adhesive tube ; TbL = lateral adhesive tube ; TbVL = ventro-lateral adhesive tube; TbDL = dorso-lateral adhesive tube; TbP = posterior adhesive tube; VP = ventral papilla.

Systematics

Order Macrodasyida Remane, 1925 [Rao & Clausen, 1970]
Family Thaumastodermatidae Remane, 1926
Genus *Pseudostomella* Swedmark, 1956

Pseudostomella cheraensis sp. nov.

(Figs 2, 3)

Type locality. Cherai beach, (lat.12° 97′ N, long. 77° 56′ E) Kerala, India. Mid-tide region in clean medium sand, moderately well sorted.

Materials examined. Twelve specimens were examined by light microscopy.

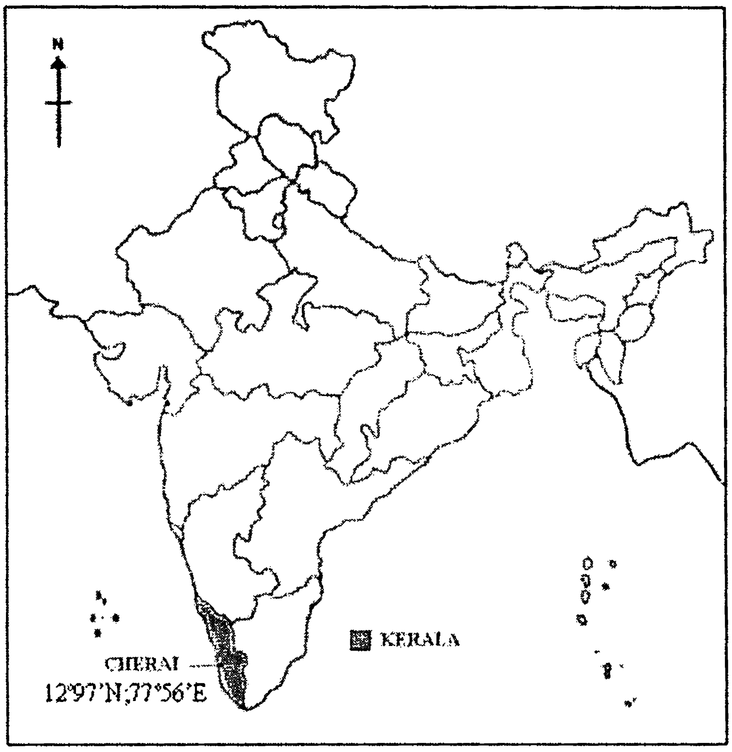

FIGURE 1. Map showing the sampling site on the south-west coast of India.

Holotype. One specimen of total length (Lt) 295 µm collected on 15-12-2005; glycerol wholemounts on microslide, deposited at Marine Biodiversity Museum, CMFRI (Government of India), Kochi, India; ref. No: MBM - 1.1.1.1

Paratype. Two specimens of length 276 µm and 223 µm respectively collected from the type locality; glycerol wholemounts on microslides, deposited at the same museum as; ref. No: Paratype1: MBM - 1.1.1.1.1; Paratype 2: MBM - 1.1.1.1.2

Etymology. Named after the type locality which is a well known sandy beach frequented by both domestic and foreign tourists.

Diagnosis. *Pseudostomella* up to 295 µm in total body length, with a distinct anterior pre-buccal apparatus and an elongate bilobed caudum. Buccal palps bearing five dorsal cephalic papillae with sensory hair and four-six minute ventral papillae. Cuticular armature of pentancres extending from the margin of oral cavity to the base of pedicles (caudum) ornaments the entire dorsal surface. Adhesive tubes: pedicles with three distal adhesive tubes (TbP) of unequal length and an adhesive tube at the base. TbA, six in number, in 2+2+2 pattern; TbL, 10-12 per side between U39 and U89. Nine pairs of granular epidermal glands between U25 and U87.5. Sensory hairs on the pre-buccal palps and trunk. Tactile cilia border the margin of the buccal cavity. Caudal organ pear shaped; frontal organ spherical. Oocytes located in the mid body.

Description. The description is based on an adult specimen, 295 µm in total length. Width at oral cavity, neck (slightly swollen), trunk (6th pair of epidermal gland) and caudal base: 39/ 46/ 40/ 15 µm at U12, U21, U67 and U93 respectively. Head with well-developed and extended pre-buccal apparatus (pb) incurving anteromedially, characterizing the genus *Pseudostomella*. Their dorsal margin project out a little beyond the ventral margin. Pre-buccal apparatus has five fleshy dorsal papillae ranging in length from 6 µm to12 µm, symmetrically arranged in 2+1+2 pattern. All papillae are with tactile cilia at the tip. Four to six smaller papillae are present along the ventral margin of the buccal palps, arranged in 2+2 or 3+3 pattern. Several sensory hairs (3 μm) present on the outer lateral margins of pre-buccal apparatus among which, a longer one measured 16 μm. Sensory hairs or lateral bristles (10 μm long) of uncertain numbers seen on the lateral margins of the body as well (U22-U91).

Epidermal glands: Eight to nine pairs of granular epidermal glands arranged along the lateral margins of the body originate at about U25 and extent up to U87.5. Their size range between 7.5–10 μm × 7.5–15 μm. The middle glands located at 8 μm apart from each other.

Cuticular armature: The entire dorsal surface from the base of buccal apparatus to the pedicles covered by rows of closely packed pentancres with an average size of 3.5-5 μm. They are arranged in 13-14 longitudinal columns in the mid-trunk region with each column containing around 58 to 60 pentancres antero-posteriorly. The tines of the ancres project out almost masking the posterior border of the body.

Adhesive tubes: Four of the six anterior adhesive tubes (TbA) seen ventrally at the base of the pre-buccal apparatus in 2+2+2 pattern measure 4 μm each. The remaining pair at the farthest end are longer. The number and pattern of TbA seem to vary. In one of the paratypes, an additional pair is seen associated with the distal pair, indicating variability in the number of TbA. Eleven pairs of lateral adhesive tubes (TbL) originate at U39 and extent up to U89, with an average length of about 7-8 μm. Of these, the anterior ten pairs are TbVL, evenly spaced and extent up to U77.6. The last pair, dorso-lateral in position is located at U89. Pedicles (20 μm long) furnished with three distal tubes (TbP), the median one (8 μm) directed slightly dorsally, while the others (5 μm) are directed slightly ventrally. Two posteriorly directed adhesive tubes, 8-9 μm long, are positioned at the base of the pedicles.

Ventral ciliation: Locomotory cilia form a continuous field of transverse rows from behind the margin of mouth and extent up to the caudal base.

Digestive system: The digestive tract begins with a terminal mouth, covered dorsally by a hood like extension and opens into the pharynx, behind the pre-buccal apparatus. The pharyngeal pores could not be located in the holotype but were seen at the base in the paratypes. The entire digestive tract not well discernable in the holotype. The paratype showed PhIJ at U37- U38. The intestine is broad anteriorly and narrows down posteriorly. The anus opens ventrally at U89.

Reproductive system: Simultaneous hermaphrodites. A single elongate testis on the right side (as seen from above) begins behind the pharyngeo-intestinal junction and leads caudally into a narrow elongate vas deferens. The caudal organ located at U78 is pear shaped and is connected to a spherical frontal organ located at U74.8. The paratype showed two oval oocytes in the mid posterior body, of which the upper larger one measured 38×19 μm.

Taxonomic affinities. The genus *Pseudostomella* includes 13 described species; of these four: *P. plumosa* Ruppert, 1970, *P. klauserae* Hochberg, 2002, *P. megapalpator* Hochberg, 2002 and *P. faroensis* Clausen, 2004 carry scaled triancres; six: *P. roscovita* Swedmark, 1956, *P. malayica* Renaud-Mornant, 1967, *P. indica* Rao, 1970, *P. andamanica* Rao, 1993, *P. koreana* Lee & Chang, 2002 and *P. longifurca* Lee & Chang, 2002 bear tetrancres whereas the remaining three: *P. cataphracta* Ruppert, 1970, *Pseudostomella* sp. 1 [Valbonesi & Luporini, 1984] and *P. etrusca* Hummon, Todaro & Tongiorgi, 1993 have a cuticular armature made up of pentancres. Based on the type of the cuticular covering the new species from India resembles most closely to the latter three taxa.

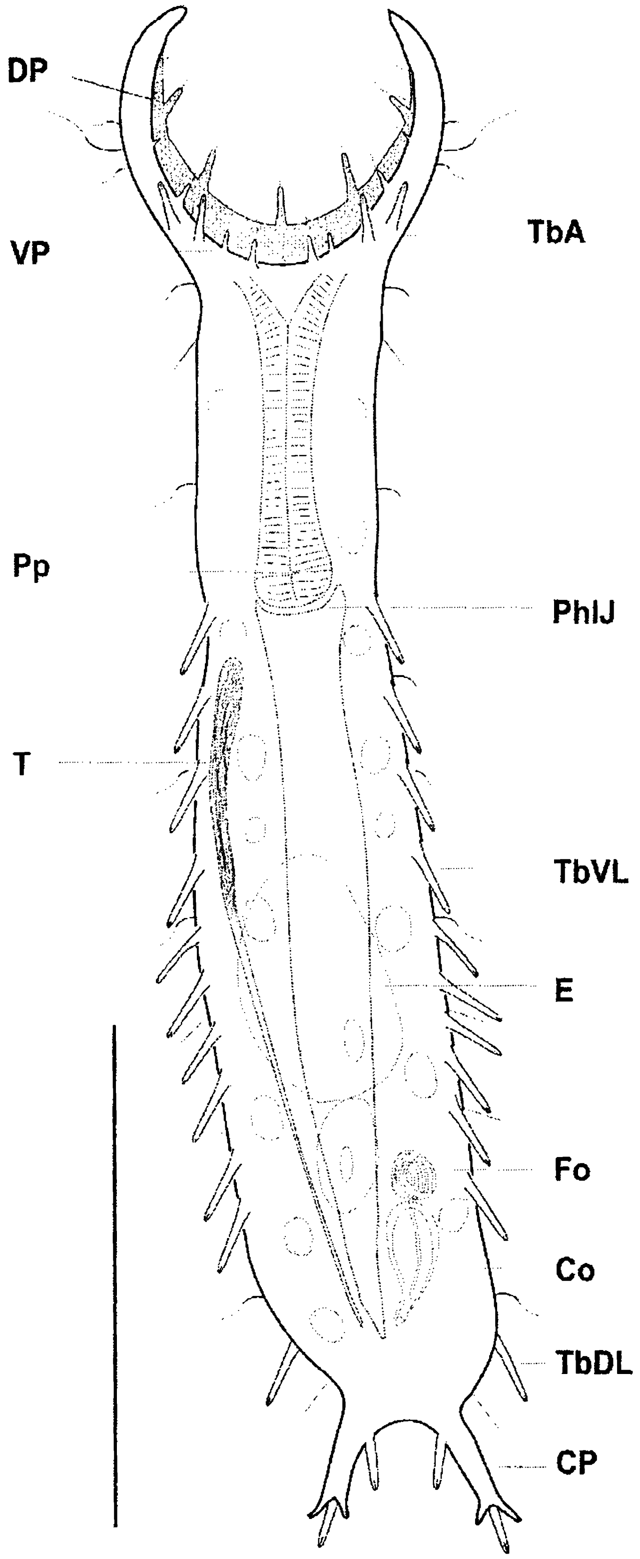

FIGURE 2. *Pseudostomella cheraensis* sp. nov. – Drawing of the habitus as seen from the ventral side. Scale bar: 100 μm.

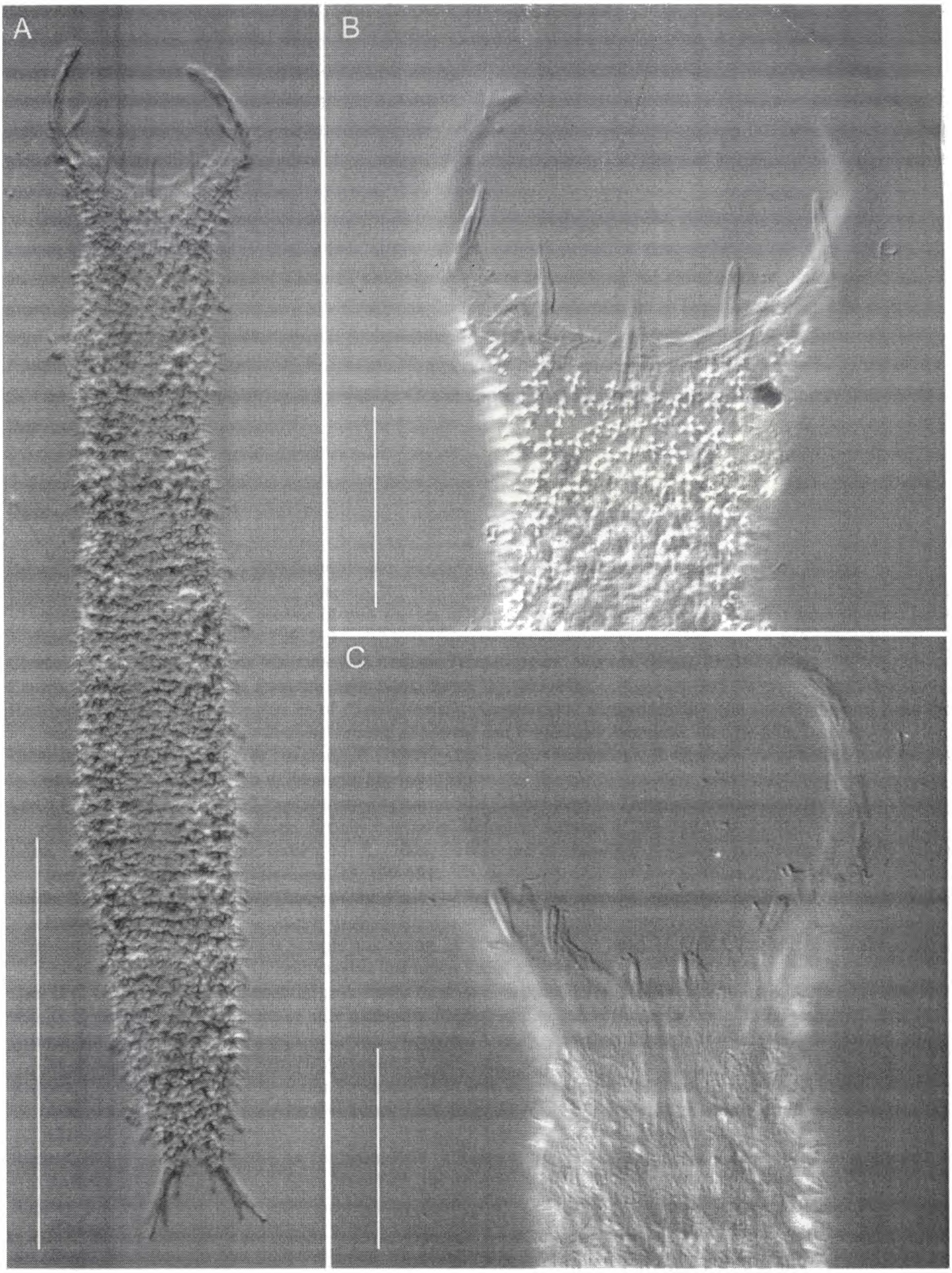

FIGURE 3. *Pseudostomella cheraensis* sp. nov. – DIC optics - A, habitus, dorsal view; B, anterior end, dorsal view, showing the arrangement of the pentancres and papillae of the pre-buccal palps; C, anterior end, ventral view, showing the arrangement of the anterior adhesive tubes. Scale bars: A, 100 µm; B, C, 25 µm.

Pseudostomella cataphracta can be distinguished from the other pentrancres-bearing species, including the new one from India, principally because it possesses a pair of ventral feet (each foot made up of four adhesive tubes), located in posterior region of the trunk. *P etrusca* is the only one that bears a pair of dorsal adhesive tubes on the base of the pre-buccal palp, moreover it has a much higher number of anterior adhesive tubes compared to P. *cheraensis* sp. nov. (14 vs 6). *Psudostomella* sp. 1 from Somalia in contrast with the new species from India shows a pair of ventro-lateral adhesive tubes in the anterior region of the pharynx, a higher number of anterior adhesive tubes, (10 vs 6), shorter caudal pedicles and the dorsal tubes at the end of each caudal pedicle that is shorter of the two tubes that flank it.

The pattern of distribution of the representative species belonging to the genus *Pseudostomella* hitherto known clearly indicates cosmopolitanism. However, the species as such appear to have a rather narrow range, on the other hand the general absence of biogeograhic records testifying the simultaneous presence of two or more species at a single beach (e.g. as it happens for *Tetranchyroderma*) let to hypothesize that biogeography may be influenced also by interspecific competition. In this general framework the finding of three species of *Pseudostomella* from a North Carolina beach (Ruppert, 1970) and the occurrence of *P. roscovita* in the Atlantic Ocean (and connected seas) and the Indian Ocean appear particularly interesting and certainly call for further investigations.

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Note

Sediment transport and bioinvasion - Possible impact of Tsunami - *Protodriloides chaetifer* an example

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Abstract

The occurrence of *Protodriloides chaetifer* (Remane, 1926) on the Indian coast is recorded for the first time from the sandy beaches of Fort Kochi (9°48' N and 76°5' E) and Arthungal (9°30'N and 76°23'E). These interstitial polychaetes are characterized by the presence of segmented vermiform body, non- canaliculated tentacles, greenish and colourless epidermal glands, paired, segmentally arranged S- shaped bifid chaetae and bilobed pygidium bearing adhesive glands.Massive transportation of marine sediments brought about by the devastating tsunami might have led to the bioinvasion of this species to this tropical coast. This species was conspicuously absent in the samples collected from the same localities during the pre-monsoon period of 2003-2004.

Protodriloidae (Purschke and Jouin, 1988) is a recently erected family to include the genus *Protodriloides* under which two species such as *Protodriloides chaetifer* (Remane, 1926) and *Protodriloides symbioticus* (Giard, 1904) described earlier have been assigned by Purschke and Jouin (1988). These were earlier placed in the genus *Protodrilus* with no specific status. Jouin (1966) felt the necessity to introduce the genus *Protodriloides* to place these species owing to very clear cut morphological peculiarities not encountered in the group of aberrant psammophilous polychaetes.Species belonging to the family Protodriloidae have been recorded previously from the North Sea, English Channel, Irish Sea, French Atlantic Coast, West Greenland, Mediterranean, Atlantic Coast of North America, Pacific Coast of North America and Indian Ocean (South Africa, Natal). However, no species has ever been recorded from the tropical coast of Indian Ocean.The present record implies cosmopolitanism,which is interesting since the species is without a pelagic larval stage. The present finding probably indicates bioinvasion of *P. chaetifer*, to the tropical coast.

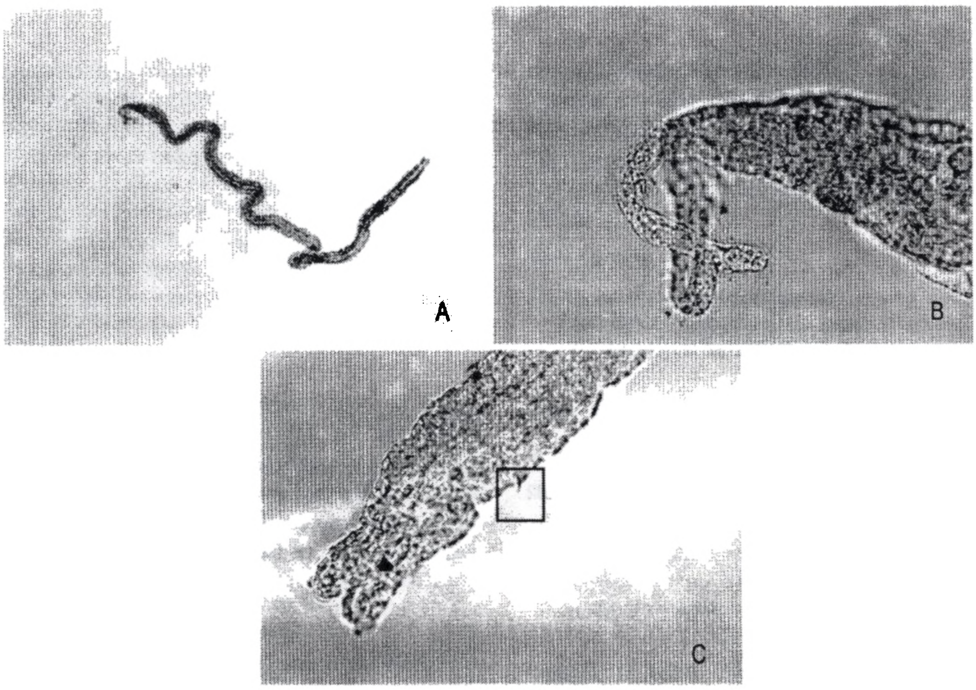
Materials and methods

Beach sediment samples collected after the tsunami from Fort Kochi (lat.9° 48' N; long.76° 5' E) and Arthungal (lat.9°30' N; long.76° 23'E) on the south-west coast of Kerala, revealed the occurrence of several interstitial polychaetes. The fauna in the samples were narcotized *in situ* by adding 7% $MgCl_2 6H_2O$ and subsequently fixed in 5% buffered formalin. Rose Bengal stained organisms were extracted by decantation technique (Pfannkuche and Thiel, 1988). Semi-permanent slides were made by impregnating the specimens in glycerol. Morphological studies were carried out using 100X oil immersion objective of Magnus microscope. Sediment textural analysis was carried out by Dry Sieving Method (Buchanan, 1984). Sediment organic carbon was measured with CHN analyzer. Hydrographic parameters like temperature, *p*H, salinity and dissolved oxygen were also recorded.

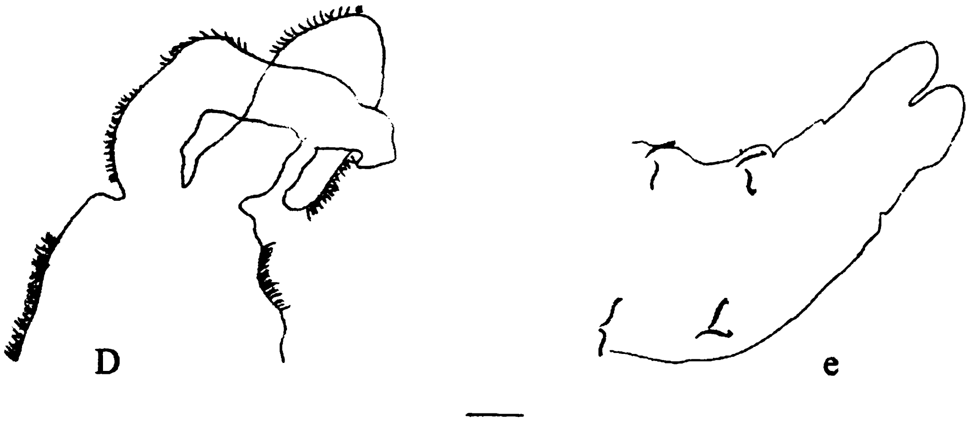
Results

Of the several interstitial polychaete families hitherto known, Protodriloidae has not been recorded so far from Indian Coast. The present study reveals the occurrence of *P.chaetifer* in the sediment samples collected along the coast of Kerala (Figs. 1&2). Textural analysis indicated that the sediments were constituted of medium sand and a mixture of coarse and medium sand. The organic carbon content of sand measured 0 .18% - 0 .4%. The interstitial water was typically marine.

Diagnosis: The specimens of *P. chaetifer* measured 2-3mm with a diameter ranging from 70m to 125m. Body surface characteristically wrinkled. Numerous globular greenish or colourless epidermal glands seen all over the body. Number of segments, 20. A pair of non-canaliculated tentacles, 105m to 115m long, originates from the prostomium anteriorly. Numerous short cilia present on either sides of the head and tentacles. Pharyngeal bulb present. First body segment much shorter than the remaining segments. Two pairs each of S-shaped chaetae approxi-



1) Fig. 1. Photomicrographs of *Protodriloides chaetifer*
A Entire, B. Anterior end, C. Posterior end



2) Fig. 2. Camera Lucida drawings of *Protodriloides chaetifer*
D. Anterior end. E. Posterior end. Scale bar: 30 μm

mately 20m long, present from the second segment onwards. The chaetae are bifid at the tip and originate from the posterior half of the segments. Pygidium bilobed with adhesive gland openings. The adhesive glands concentrated in the pygidium enable the organisms to remain attached to the substrate even when the sediment is eroded by the wave action. The chaetae are stretched out and form points of attachment of momentary duration . Regular tidal migrations have been observed in *P. chaetifer* (Meinke and Westheide, 1979).

Discussion

Kerala, with a remarkable straight coastline of 560km, is oriented in NNW – SSE direction. The beaches are generally surf beaten characterized by fine to coarse grained sands.Extensive samplings done during the pre-tsunami period along the beaches of Fort Kochi and Arthungal has not yielded specimens of *P. chaetifer*. However, collections made on 14.03.05 from these beaches showed a density distribution of 600 and 10 individuals/ 100 cc. sediments respectively. Tsunamis are major geomorphic crisis, since they cause extensive erosion, sediment transport and deposition. The occurrence of several individuals of *P.chaetifer* from these beaches after the Tsunami probably indicates bioinvasion of a subtle nature due to this bizarre oceanographic phenomenon, which resulted in the massive transport of marine sediments from archibenthal areas to the tidal belts of the affected beaches of various geographic areas. The peculiar morphology of the animal facilitates fast adhesion to sand grains and transport to wider geographical areas by massive sediment transport, that occurred during the recent tsunami. Subsequent collections done during the monsoon and post-monsoon seasons did not reveal the presence of this species.

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