# DEEP SEA MEIOBENTHIC COMMUNITY OF THE CONTINENTAL SLOPE FROM 200-1000 M DEPTHS OF EASTERN ARABIAN SEA, WITH A FOCUS ON FREE LIVING NEMATODES

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*By*

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# DEEP SEA MEIOBENTHIC COMMUNITY OF THE CONTINENTAL SLOPE FROM 200 – 1000M DEPTHS OF EASTERN ARABIAN SEA, WITH A FOCUS ON FREE LIVING NEMATODES

*Ph.D. Thesis under the Faculty of Marine Sciences*

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**Front Cover**
Free living nematode *Paramirolaimus damodarani* Jacob et al., 2015, collected onboard *FORV Sagar Sampada* from the study area.

# *Declaration*

I hereby declare that the thesis entitled **"Deep sea meiobenthic community of the continental slope from 200 – 1000m depths of Eastern Arabian Sea, with a focus on free living nematodes"** is a genuine record of research work done by me under the supervision and guidance of **Dr. R. Damodaran**, Retired Professor, Department of Marine Biology, Microbiology and Biochemistry, Cochin University of Science and Technology and no part thereof has been presented for the award of any other degree, diploma or associateship in any University or Institution earlier.

Kochi - 682 016
November, 2017

**Jini Jacob**
(Reg. No.3622)

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I strongly believe that everything happens for a reason, but reasons are unknown at the time of incidence. Only the turning wheels of time have the power to reveal these reasons to us. I thank all the reasons and the creator of all these reasons…the Almighty.

**Jini**

TO

ST. ANTHONY OF PADUA

# CONTENTS

# LIST OF ABBREVIATIONS

| | |
|---|---|
| **ANOVA** | Analysis of Variance |
| **ASOMZ** | Arabian Sea Oxygen Minimum Zone |
| **CCA** | Canonical Correspondence Analysis |
| **CMLRE** | Centre for Marine Living Resources & Ecology |
| **CTD** | Conductivity – Temperature – Depth |
| **DO** | Dissolved Oxygen |
| **EAS** | Eastern Arabian Sea |
| **FORVSS** | Fishery & Oceanographic Research Vessel *Sagar Sampada* |
| **NEAS** | North Eastern Arabian Sea |
| **OC** | Organic Carbon |
| **OM** | Organic Matter |
| **OMZ** | Oxygen Minimum Zone |
| **PCA** | Principle Component Analysis |
| **POC** | Particulate Organic Carbon |
| **PRIMER** | Plymouth Routines in Multivariate Ecological Research |
| **SEAS** | South Eastern Arabian Sea |
| **SIM** | Spring Inter Monsoon |
| **SM** | Summer Monsoon |
| **WIM** | Winter Monsoon |
| **WoRMS** | **WoRMS** World Register of Marine Species |

# Chapter I

# INTRODUCTION

Contents

Marine ecosystems are among the largest of Earth's ecosystems and a great proportion of all life on Earth lives in the ocean. The habitats studied in marine biology include everything from the thin layers of surface water to the depths of the oceanic trenches. The marine ecosystem consists of two distinct but mutually dependent provinces: the pelagic, incorporating the water column and benthic, comprising of the sediment matrix. The sea floor is covered with marine sediments and forms the single largest ecosystems in terms of area (Snelgrove, 1998; Bacci et al., 2009; Tyler et al., 2016). Based on recent estimates, the marine environment harbours 0.7 to 1.0 million species. Among these, 2, 26,000 are presently known and 7, 00,000 are in collections anticipating description (Appeltans et al., 2012). Marine species are awesomely benthic (98%) rather than pelagic (2%). The benthic province incorporates the entire sea floor, from intertidal area up to the deepest trenches, and its most signifying feature is the heterogeneity in environmental features. Hedgepeth (1971) defined four major physiographic features of the sea floor as continental shelf (areas with depth <200 m), continental slope (200-2000 m), continental rise (2000-4000 m) and abyssal plain (>4000 m). The continental shelf diverges in width from a few to hundreds of kilometres and generally extends to a water depth of 200. The continental slope is the zone of the ocean bottom between the continental shelf and continental rise which is characterized by a sharp gradients in depth over short distances. At the edge of the continental slope, the bottom levels out gradually to form the area labelled as the continental rise (Figure. 1.1).

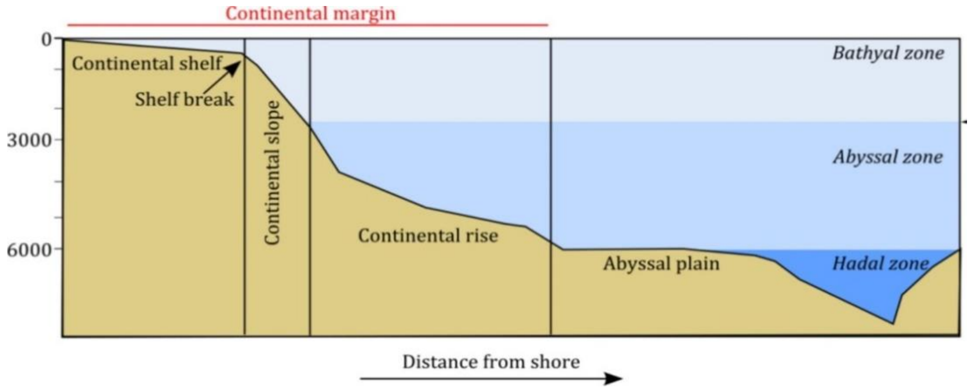


**Figure. I .1** Cross-section of the ocean floor showing physiographic and ecological depth zones. (Based on Thistle, 2003).

The continental margins, which include the continental shelf, slope and rise, are considered as the transition between the continents and the ocean. This is reasonably a narrow zone (100–4000 m depth) accounting for about 15% of the seafloor, covering three million square kilometers. This province is characterised by extreme topographical heterogeneity, sharp environmental gradients and tectonic activity (Levin et al., 2001; Carney, 2005). Continental margins play a key role in global biogeochemical cycles. They provide habitats for diverse faunal communities (Levin et al., 2010; Vanreusel et al., 2010a; Levin & Sibuet, 2012) and are considered as one of the potential hotspots of biodiversity (Weaver et al., 2004; Dell'Anno & Danovaro, 2005; Danovaro et al., 2009a).

## I. 1. Abiotic environment of the deep-sea

The deep-sea benthic environment commences from the shelf break, which for most oceanic regions is situated around 200 m water depth (Thistle, 2003). Several general abiotic characteristics of the deep-sea benthic environment are known from previous scientific expeditions (Gage & Tyler, 1991; Thistle, 2003). The deep-sea is characterized by extreme physical properties and such an environment has a substantial role in the life history of its fauna (Gage & Tyler, 1991).

Pressure is one of the principal environmental factor exerting on deep-sea organisms. For every 10 m depth the hydrostatic pressure surges by 1 atmosphere (atm). Even though most of the deep-sea is under pressures between 200 and 600 atm, pressure commonly ranges from 20 to 1,000 atm. With greater depth, the deep-sea experience much lower temperature. Temperatures in bathyal or abyssal or any depth specification mostly range between -1 °C and 4 °C, with the exception of bottom waters in the Red Sea (up to 21.5 °C) and the Mediterranean (13 °C), as well as near cold seeps and hydrothermal vents. Salinity variation is minimal, with the exception of brine pools and some areas with high evaporation (e. g. the Mediterranean Sea and Red Sea). Currents near the deep-seabed are mostly slow ($< 10$ cm $s^{-1}$) (Thistle, 2003).

In marine ecosystems, oxygen plays a vital role in the distribution patterns of organisms, from microbes to marine mammals (Gilly et al., 2013). The surface layers of the ocean generally acquire oxygen through diffusion from the atmosphere. At high latitudes this water descends to the ocean floor, distributing oxygen to the deep-sea. Long periods of inaccessibility to the surface with continuing respiration, sluggish circulation and oxygen-poor source waters can result in a decline of dissolved oxygen (DO) concentrations at intermediate depths (Levin, 2003). In some of the major oceans where primary production by photosynthesis is very high owing to processes like upwelling, a massive quantity of organic matter (OM) is produced. The decay of this high OM utilizes great amount of oxygen causing a dramatically low

DO levels relative to the nearby region. All these processes lead to the development of persistent low-oxygen zones in the oceans called oxygen minimum zones (Helly & Levin, 2004; Fuenzalida et al., 2009; Paulmier & Ruiz-Pino, 2009). This oxygen minimum zone (OMZ) usually occurs at depths about 200 to 1,000m, depending on local hydrodynamic and geographic settings. These zones are found world-wide, characteristically along the western coast of continents. They are widespread, permanent features in many areas of the Indo-Pacific, eastern Pacific, and eastern South Atlantic (Levin, 2003; Helly & Levin, 2004), and are expanding in recent years, due to the anthropogenic influences (Diaz & Rosenberg, 2008, Stramma et al., 2010).

Among the world OMZs, those in the Pacific and Indian Oceans are strongest, with oxygen concentration falling between 0.5 mlL$^{-l}$ to zero at its core. In the Atlantic Ocean DO values are at <45 µmol_kg $^{-1}$, i.e. ~1 mlL$^{-l}$ (Gilly et al., 2013). All OMZs exhibit a similar oxygen profiles, but the DO levels, thickness and depth of occurrence may vary regionally (Helly & Levin, 2004). Among the OMZs, the Arabian Sea OMZ is the thickest (1230m) and most intense in terms of mean DO concentrations and about 285000 km$^2$ of continental margin (in the depth zone 100-1500 m) is impacted by it (DO <20 µmol_kg $^{–1}$, Stramma et al., 2010; Acharya & Panigrahi, 2016). Although OMZs are formed in the water column, their effects are experienced sturdily at the sea floor (Levin et al., 2000; Devol & Hartnett, 2001).

## I. 2. Food supply to the deep-sea

An important characteristic of the deep-sea environment is the absence of sunlight. Hence, the deep-sea is mostly a heterotrophic system, excluding the chemosynthetic habitats such as hydrothermal vents and cold seeps. At these habitats primary production depends on chemosynthetic bacteria which use hydrogen sulphide and methane to fix carbon (Van Dover, 2000). In the absence of photosynthesis and chemosynthesis, the deep-sea bottom fauna rely on organic matter produced in the euphotic zone that sinks through the water column and ends up at the seafloor (Rowe & Staresinic, 1979; Gage & Tyler, 1991). The processes that relate to the conveyance of organic matter produced in the euphotic zone to the seafloor are collectively termed “the biological pump” (Ducklow et al., 2001). The particulate organic matter (POM) comprises phyto and zoodetritus, in addition to bacteria, protists and faecal pellets (Gage, 2003). The efficiency of the biological pump (i.e. amount produced vs. amount transported) fluctuates substantially between geographic regions (Lutz et al., 2002; Buesseler et al., 2007) and seasons (Lutz et al., 2007). The amount of POM that eventually ending up at the deep-sea floor depends on water depth, sinking velocity and decomposition rate of the POM particles (De La Rocha & Passow, 2007). The biological pump is inefficient in the deep-sea, because on an average only 0.5 - 2 % of surface primary production reaches the deep-sea floor (Lutz et al., 2002; Buesseler et al., 2007), making this an energy deprived environment.

The quantity and quality of settling organic matter is the most noteworthy determinant of the standing stock and composition of the deep-sea benthos (Ruhl & Smith, 2004; Wei et al., 2010). The continental slope environment has been recognized to be a site of remineralization and burial of huge quantities of organic carbon (Premuzic et al., 1982; Walsh et al., 1985). The impact of pelagic processes, such as primary production and the subsequent sedimentation on the benthic ecosystem and vice versa is termed as benthic-pelagic coupling. Sedimentation episodes have been shown to disturb the organisms associated with deep-sea sediments, manifested as enhanced biomass or metabolic activity (Danovaro et al., 1999; Pfannkuche et al., 1999; Sommer & Pfannkuche, 2000; Brown et al., 2001), or shifts in the vertical distribution within the sediment column (Shimanaga et al., 2000; Sommer & Pfannkuche, 2000; Veit-Kohler et al., 2011). The OM content in sediments depends on the quantity of OM produced per given unit of time, degree of conservation or preservation of OM and the rate of sedimentation (Trask 1939).

Continental slopes are the sites of accumulation of high concentrations of organic matter. The enhanced organic matter is usually caused by a combination of river-induced nutrient input, the coupling of pelagic and benthic systems, and local or regional upwelling of fertile, highly productive deep water (Mantoura et al., 1991; Biscaye et al., 1994). The higher organic matter in the shallower and deeper areas may be attributed to the fine-grained nature of the sediments (Paropkari et al., 1987). Within OMZ impingeed regions in the Arabian Sea, Ingole et al., (2010) reported silty sediments with higher organic carbon. Kolla et al., (1981) found that high OM content in the sediments of the Indian continental margins is primarily due to its preservation, which results from the impingement of OMZs and from the high sedimentation rates. In addition, it could be attributed to the fine grained nature of the sediments (Trask, 1939) coupled with higher rates of sedimentation in these regions, which prevents its destruction through rapid burial (Subbarao, 1960). Higher concentrations of organic carbon in the Arabian Sea OMZ was observed along upper slope (150–1500 m depth) sediments (Marchig, 1972; Von Stackelberg, 1972; Kolla et al., 1981; Paropkari et al., 1987, 1992, 1993a,b, 1994). In the Arabian Sea organic carbon enrichments of >8% with maxima of up to 12–16% (Paropkari et al., 1987, 1992, 1993a,1994) are reported even in areas where productivity is low to moderate (<0.50 gCm-2 day-1). Cowie et al., (2009) reported that it is common to find sediments containing 4 to 20% of organic carbon in OMZs.

## I.3. Deep-sea benthic biodiversity

The diversity of marine life is possibly as great as or greater than that found on land, but is far less recognized. At the phylum level, marine biodiversity is twice as that of the land's; of the 33 described phyla, 13 are absolutely marine (May,1988). Important phyla such as echinoderms, ctenophores, chaetognaths, pogonophores and brachiopods are exclusively marine. High diversity on continental margins has been known since the 1960s (Hessler & Sanders, 1967). In the past few decades, considerable attention has been given to the study of tropical continental margin benthic biodiversity (Flach & Thomsen, 1998; Soltwedel, 2000; Tselepides et al., 2000; Cook et al., 2000; Neira et al., 2001a,b; Muthumbi et al., 2004; Palma et al., 2005; Gooday et al., 2009; Hughes et al., 2009; Sellanes et al., 2010; Ingole et al., 2010; Sajan et al., 2010; Abdul Jaleel et al., 2014; Joydas & Damodaran, 2014; Raman et al., 2014; Abdul Jaleel et al., 2015; Baldrighi & Manini, 2015; Soto et al., 2015; Singh & Ingole, 2016; Rosli et al., 2017; Ansari et al., 2017).

The term benthos was coined by Haeckel, adapted from the Greek which stands for ‘depths of the sea’. The fauna found living at the sea floor can be classified into two major groups rendering to the areas they customarily inhabit - benthic and benthopelagic fauna. The benthic fauna (benthos) are the organisms found living on or within the seabed either for feeding, breeding or for resting at any time during their life history. The benthopelagic fauna are those organisms found living in the water column directly above the sea bed. Research on benthic ecology date back to the middle of the eighteenth century and one of the pioneers to study benthos was Carl von Linnaeus (1707-1778). All the initial studies on benthos were focused only on the qualitative aspects, i.e. the list of species dwelling on or in a given type of bottom. It was John Petersen (Petersen, 1911; 1913; 1918) who first categorised animal communities of sea bottom as epifauna (those living on the surface of the substratum) and infauna (within the substratum). Three functional groups of benthos are recognised, the infauna, epifauna and hyper-benthos, i.e. organisms living within the substratum, on the surface of the substratum and just above it (Pohle & Thomas, 2001).

Benthos incorporates an enormous variety of organisms. For convenience of studies, they are classified into several rather overlapping categories based on habitat, individual size, and taxonomy. All these classifications are arbitrary and vary according to authors (Thiel, 1975). Based on the habitat, benthic organisms could be divided into soft-bottom benthos and hard-bottom benthos. Soft-sediment habitats are common in coastal areas throughout the world, but only a small fraction of the benthos that reside on or are buried in sediments has been described (Snelgrove et al., 1997; Snelgrove, 1999). Depending on the size benthic fauna are classified into macrofauna - all organisms having a size larger than 500 µm; meiofauna – all organisms within a size range from 63 µm to 500 µm; microfauna – all organisms having a size smaller than 63 µm. This classification based purely on the mesh size of the sieves used to separate them. The smallest of all size group, microfauna, includes those organisms that are not retained in the finest sieve used (63 µm) for meiofauna separation which includes bacteria and most protozoans. For meiofauna, the lowest size credited is 63 µm and the upper limit depends upon the mesh size of the sieve used for segregating macrofauna from meiofauna. Taxonomically, meiofauna are composed of nematodes, foraminifera, crustaceans such as ostracods and harpacticoid copepods, gastrotrichs, kinorhynchs etc. (Fenchel, 1978). Important taxonomic groups represented among macrofauna are the polychaetes, crustaceans and molluscs, along with echinoderms and other minor phyla such as echuroids, sipunculids etc.

Meiofauna serve as food (energy) to higher trophic levels performing as an intermittent trophical level from micro to macrofauna (Coull, 1990; Service et al., 1992; Feller & Coull, 1995). They are accountable for about five times more of total benthic metabolism rather than the macrofauna. Their rapid reproduction stabilizes the trophic level (Giere & Pfannkuche, 1982; Hicks & Coull, 1983, Coull, 1990; Heip et al, 1985; Smith & Coull, 1987, Nelson & Coull, 1989) from micro to macrofauna. They also play a crucial role in remineralization of organic matter by enhancing the rate of carbon mineralisation by stimulating microbial activity (Alongi, 1989, 1990; Gee & Somerfield, 1997; Montagna et al., 1995, Moens et al., 2007, Pape et al., 2013a). Because of the short generation time, meiofauna contribute a greater portion of standing stock than macrofauna. Meiofauna were considered as a self-contained system, encompassing all functional groups such as detritivores, scavengers, herbivores and carnivores. Nematodes which are the dominant taxa among the meiofauna, are the most abundant metazoan organism in the earth’s crust. Meiofauna shows quick responses to perturbation, pollution, disturbance and climate change (Coull & Chandler, 1992; Balsamo et al., 2012; Pusceddu et al., 2014; Zeppilli et al., 2015a). Parker (1975) and Raffaelli & Mason (1981) proposed that ratio of nematode and copepod (N/C ratio) can be used for assessing the habitat deterioration and environmental perturbations. Meiofauna are known to be sensitive indicators to pollution. High population density, sedentary life style and short lifecycles has made meiofauna as suitable pollution indicator organisms (Higgins & Thiel, 1988, Giere, 2009).

## I. 4. Significance of the present study

Studies on meiofauna date back from the eighteenth century before the name ‘Meiofauna’ was recognized. The first work was taxonomic account of Chaetoderma by Loven (1844) and later Dujardin (1851) identified kinorhyncha. The next significant stage was the introduction of the term “interstitial fauna” by Nicholls (1935), for the organisms living in the interstitial spaces between all types of sediment particles. Later, Remane (1940) projected the equivalent term “mesopsammon”. The widely recognized term “meiofauna” was coined by Mare (1942). Even though meiofaunal study have a long history, it has been mostly neglected owing to its laborious nature. In the 19th century, with the development of effective sampling gears and methodology, study of meiofauna gained momentum. Petersen (1913) and Mortensen (1925) developed the sediment sampling devices such as grabs and dredges, respectively for subtidal sampling of infauna and epifauna. Moore & Neil (1930), Moore (1931), Nicholls (1935), Remane (1940) and Mare (1942) were recognized as the forerunners of meiofaunal research and Remane is considered as the father of meiofaunal research. He documented the occurrence of good populations of meiofauna from various habitats and motivated numerous students to meiobenthic research through the establishment of International Association of the Meiobenthology and German School of Meiobenthology.

Although deep-sea expeditions launched in the late 1860s (Ramirez-Llodra et al., 2010), the first study of deep-sea meiofauna was only carried out a century later (Wigley & McIntyre, 1964). They quantitatively scrutinised on deep-sea meiofauna beyond the shelf break in the north Atlantic. Quantitative deep-sea meiofauna studies up to the early 1980s was summarised by Thiel (1983) and a decade later Tietjen (1992) augmented the information focusing studies conducted in the 1980s. More recently Soltwedel (2000) compiled an overview of meiofaunal studies from the 1970s to the late-1990s. These authors abridged patterns of benthic standing stock (abundance and biomass) along bathymetric gradients, horizontal and vertical distribution in the sediments, and seasonal patterns along the Atlantic, north west Indian, north and south west Pacific Oceans and Mediterranean Sea.

Thiel (1983) noted the relation amongst productivity levels and meiofauna standing stock along bathymetric gradients in various oceans (Atlantic, Indian Ocean, Mediterranean Sea). He also designated a shift in the vertical distribution of meiofauna with sediment depth. Meiofauna were mostly concentrated in the upper 5 cm and exhibited a consistent decrease from surficial sediment to deeper sediments, and this gradient in faunal distribution was found to be connected with the changes in food availability. However, the deviation from this observed pattern can occur in a region where there is high a biologically mediated processes like bioturbation (Thiel, 1983). Tietjen (1992) summarised trends in distribution of meiofaunal standing stock along bathymetric gradients in the Atlantic, Pacific and Indian Oceans. Inter relationships between meiofaunal abundance and biomass, along with relationships between standing stocks of meiofauna to other benthic size groups were also discussed. He noted a substantial decline in meiofaunal abundance and biomass with water depth in the Atlantic Ocean. In addition to this meiofauna standing stocks mostly showed a positive relationship with organic matter input and surface productivity.

Meiofaunal standing stocks are found to decrease with increasing water depth, both at the scale of ocean basins and globally (Thiel, 1983; Tietjen, 1992; Soltwedel, 2000). These patterns are closely related to declines in food availability with depth (Tietjen, 1992; Soltwedel, 2000); nevertheless, abiotic factors such as hydrographic parameters and varying sediment types can also impact decreasing trend of standing stock (Soltwedel, 2000). This negative relationship of meiofauna standing stock and water depth is primarily reflected in the abundance and biomass of two dominant metazoan taxa, i.e. nematodes and harpacticoid copepods. Therefore, each region needed to be explored discretely (Soltwedel, 2000). This understanding helped to stimulate further investigations of deep-sea meiofauna in other parts of the world, where meiofaunal communities remained either incompletely described or poorly known.

In recent years, studies on deep-sea meiofauna has expanded to the eastern and southwest Pacific Ocean, the Sea of Japan, the central Indian Ocean, the south Atlantic, and areas off the Antarctic Peninsula. Also augmenting studies have been conducted in extreme habitats such as seamounts (Pusceddu et al., 2009; Zeppilly et al., 2013, 2014; Covazzi Harriague et al., 2014), cold seep (Robinson et al., 2004; Van Gaever et al., 2004) and hydrothermal vents (Copley et al., 2007; Gollner et al., 2010, 2015; Uejima et al., 2017). In addition to concentrating on patterns related to water depth (Vanreusel et al., 2000; Hughes & Gage, 2004; Sevastou et al., 2013; Pusceddu et al., 2016), regions (Lambshead et al., 2002; Tselepides et al., 2004), vertical gradients in the sediment (Neira et al., 2001b; Van Gaever et al., 2004) and seasons (Danovaro et al., 2000; Shimanaga et al., 2004), these studies also concentrated on the effect of deep-sea habitats (Vanreusel et al., 2010a), the relative importance of different spatial scales (Gambi & Danovaro, 2006; Bianchelli et al., 2013; Danovaro et al., 2013; Ingels & Vanreusel, 2013; Gambi et al., 2014), colonisation pattern in the deep-sea (Gallucci et al., 2008; Guilini et al., 2011; Zeppilli et al., 2015b), and disturbance on meiofaunal communities (Pusceddu et al., 2014).

Dispersal and colonisation processes play a significant role in structuring meiofaunal species diversity. Meiofauna may passively disperse over large distance through the water column caused by hydrodynamic forces (Boeckner et al., 2009), even though their ability to actively disperse in the water column is limited. This passive dispersal can promote recolonisation of more distant locations and may explain their widespread geographic distribution (Bik et al., 2010). Sediments rich in organic matter have been shown to enhance nematode colonisation in the deep-sea (Gallucci et al., 2008). Studies on marine nematodes also have shown that type of substratum, reduced chemical exposure (Zeppilli et al., 2015b), variability in microhabitats, and biological interactions (Cuvelier et al., 2014) can influence nematode colonisation. The distribution of meiofaunal communities is also stimulated by disturbance (Schratzberger et al., 2009). Physical disturbance can occur at various spatial and temporal scales including events induced by physical (i.e. erosion, sediment deposition, turbidity current, glacial fjord, benthic storm, earthquakes; Lambshead et al., 2001a; Canals et al., 2006; Somerfield et al., 2006; Schratzberger et al., 2009), or biological (i.e. bioturbation and predation; Hughes & Gage, 2004; Kristensen & Kostka, 2013), or anthropogenic sources (i.e. fishing and mining; Schratzberger et al., 2009; Hein et al., 2013; Martín et al., 2014; Ramirez-Llodra et al., 2015). Physical perturbation can be beneficial, by stimulating bacterial activity and helping to distribute organic matter into deeper sediment (Olafsson, 2003; Hughes & Gage, 2004). However, physical disturbance can also negatively impact meiofauna communities directly or indirectly. The passage of surface sediments along with strong bottom currents can lead to an unstable sediment substrate, while frequent resuspension with high sedimentation rates can also cause meiofauna to be buried by settling sediments, all of which can decrease the diversity by increasing the dominance of certain disturbance-tolerant species (Garcia et al., 2007; Martín et al., 2014; Pusceddu et al., 2014). In addition, anthropogenic disturbance caused by bottom trawling or deep-sea mining can have pronounced effects on deep-sea soft sediment communities, where the rates and magnitudes of these alterations often significantly exceed those of natural disturbances (Schratzberger et al., 2009; Miljutin et al., 2011; Martín et al., 2014). Deep-sea meiobenthic communities are poorly known, compared to the shallow shelf counterparts and also compared to deep-sea macro and megafauna (Gage and Tyler, 1992).

Meiofauna are largely understudied in many parts of the world, and particularly so around the Indian subcontinent. Major studies on benthic fauna in India was initiated by by Annandale (1907), followed by Panikkar & Aiyar (1937), Kurien (1953, 1967, 1972), Seshappa (1953), Ganapati & Rao (1959, 1962). Thiel (1966), McIntyre (1968) and Sanders (1968) studied meiofauna quantitatively from the Indian coast. Majority of the meiofaunal studies reported around the Indian subcontinent are regional works conducted in shallow coastal areas, estuarine waters and mangroves swamps. Many workers studied meiofauna of different coastal areas and backwaters of west coast (Damodaran, 1973; Ansari et al., 1977; Ansari, et al., 1980; Aziz & Nair, 1983; Reddy & Hariharan, 1985, 1986; Ingole et al., 1992; Ansari & Parulekar, 1993; Mani et al., 2008; Nagelkerken et al., 2008) and east coasts of India (Ganapati & Sharma, 1973; Sharma & Ganapati, 1975; Ansari & Parulekar, 1981; Ansari, et al., 1982, Rao, 1986a & b; Rao & Murthy, 1988; Vijayakumar et al., 1991, 1997; Chatterji et al., 1995).

Earlier studies on the benthos from the Indian coasts had many limitations such as limited number of samples (Harkantra et al., 1980) and employing only dredges (Neyman, 1969). Lack of proper sampling vessels and gears were the main limitation in the off shore setting. In addition to this, the lack of expertise is also contributing to the impediments. Parulekar et al., (1982) compiled the all available information from various surveys conducted along the Indian EEZ until that date. Ansari & Parulekar (1981) and Ansari et al., (1980) studied meiofaunal composition at a depth of 840-2000 m in Goa and Andaman Sea, respectively. Ingole et al., (2005) studied on deep-sea metazoan meiofaunal assemblage to understand the re-colonization pattern in Central Indian Ocean Basin (5000 to 5500 m depth). An experimental design to study deep-sea meiofaunal assemblage was described by Sharma (1999) and Sharma et al., (2001). After a sediment disturbance, Ingole et al., (2000; 2001) found that approximately 40% of the benthic population can be lost immediately. Various studies have observed that nematode: copepod (N:C) ratio can be used as an index to estimate environmental conditions (Ingole et al., 2000; 2005; Ansari and Ingole, 2002; Ingole & Koslow, 2005). Further, it was also reported that harpacticoid copepods are sensitive to environmental changes when nematode shows resistance to rapidly changed environment (Ansari, 2000; Ansari & Ingole, 2002).

Sajan et al., (2007) worked out the standing stock of meiofauna and their community structure with reference to free living nematodes for the entire shelf region of the west coast of India. Depth linked pattern of meiofaunal distribution for the west coast shelf were analysed by Sajan et al., (2010). Concurrently, the infaunal macrofauna of shelf region was also investigated (Joydas, 2002; Jayaraj et al., 2007, 2008 a&b; Joydas & Damodaran, 2009). Macrobenthic polychaete community structure of entire Indian west coast shelf is also available (Joydas et al., 2009). A similar study from the bathyal region (188-1100m) off south west coast of India revealed that between 7ºN and14º 32'N that the macrobenthic standing stock and polychaete community structure showed bathymetric and latitudinal zonation, chiefly owing to variability in sediment nature and oxygen availability (Abdul Jaleel 2012; Abdul Jaleel et al., 2014).

## I. 5. Benthic studies in relation to OMZs

The OMZ core is controlled by a distinctive group of organisms such as meiofauna and bacteria, and is unfavourable to all but a few hypoxia-tolerant macro and megafaunal species. At the upper and lower boundaries of OMZs, relatively oxic conditions support an abundant, progressively more 'normal' benthic community. A number of studies have been carried out on impacts of the OMZs on bathyal benthic megafauna and macrofauna in the Pacific and Atlantic Oceans, namely Chile margin (Gallardo et al., 2004; Palma et al., 2005; Quiroga et al., 2005; Sellanes et al., 2007, 2010); Peru margin (Levin et al., 2002; Gutierrez et al., 2006); off Namibia (Zettler et al., 2009, 2013). Reviews are also available, discussing macrobenthic community patterns and diversity across different OMZs world-wide (Diaz & Rosenberg, 1995; Levin & Gage, 1998 ; Rogers, 2000 ; Levin et al., 2001 ; Gray et al., 2002; Levin et al., 2002; Levin, 2003; Levin et al., 2009a; Gooday et al., 2010 ; Levin & Sibuet, 2012).

As far as the benthic community is considered, limited studies are available on meiofauna dispersal in the OMZ settings. In the bathyal sediments beneath the oxygen minimum zone (OMZ) in the south eastern Pacific (off Callao, Peru) an indirect positive effect of low oxygen is described by Niera et al., (2001) leading to enhanced faunal density, as a result of decrease in predators and competitors, along with a high quantity and improved quality of available food, which was in turn recognized to the preservation of organic matter under low oxygen conditions. Similarly, a quantitative study of meiofauna in the eastern South Pacific OMZ off Chile found high average abundance despite the high quality and quantity of food. Meiofaunal assemblages became more diverse with increasing bottom-water oxygenation (Veit-Köhler et al., 2009).

In the northern Indian Ocean benthic communities associated with OMZ were studied by various workers, but an overwhelming majority of these were focused on larger mega and macrofaunal groups. Macrobenthic communities of the Arabian Sea OMZ have been studied along the Oman margin in the NW Arabian Sea (Levin et al., 2000), the Pakistan slope (Gooday et al., 2009; Hughes et al., 2009; Levin et al., 2009b; Murty et al., 2009) and in the  shelf as well as slope regions off west coast of India (Ingole et al., 2010; Hunter et al., 2011, 2012; Levin et al., 2013; Abdul Jaleel et al., 2014, 2015; Joydas & Damodaran, 2014). The benthos impacted by the comparatively weaker but spatially extensive Bay of Bengal OMZ was described by Raman et al., (2014). Benthic fauna under OMZs have developed morphological and physiological adaptations to maximize oxygen uptake (Childress & Seibel, 1998; Levin, 2003). Oxygen thresholds have been documented, below which most taxa are eliminated through physiological intolerance to hypoxia and above which selected taxa are able to take advantage (Levin et al., 2009a). In the deep-sea environments impinged with OMZs, species richness is low and dominance is high (Levin & Gage, 1998; Menot et al., 2010a).

In comparison to temperate habitats, the ecology of meiofauna in tropical areas still needs to be explored (Ansari et al., 2017). To date there are limited studies on meiofaunal community structure and distribution pattern along the continental margin of northern Indian Ocean impinged with OMZ. A study conducted by Cook et al., (2000) on the deep Oman margin, impacted with OMZ, revealed that the quality of food was the major predictor of nematode abundance than oxygen concentration. Along four bathymetric transects in the Western Indian Ocean off the Kenyan coast, metazoan meiofauna and nematode densities, were varied in relation with water depth (20 m, 50 m, 500 m, 1000 m and 2000 m), since they were lowest at mid-depth (500–1000 m) coinciding with the minimum oxygen level (Muthumbi et al., 2004). An exclusive study over a perpendicular bathymetric transect surrounding the OMZ (34 to 2546m) from the Indian western continental margin discovered the existence of a low-oxygen tolerant community which can take advantage of the abundant food in such environments (Singh & Ingole, 2016). While studying a few bathymetric stations within and outside the OMZ area of western continental margin, northern Arabian Sea, Ansari et al., (2017) backed the earlier hypothesis that meiofauna abundance is intensely enhanced by quantity and quality of food supply rather than low oxygen, and there was a virtual absence of predators and competitors under low oxygen conditions of the OMZs.

Earlier studies on benthic foraminifera have shown that some foraminiferal species thrive well in organically enriched, oxygen-depleted environments. Foraminifera are possibly the best-studied taxon within oxygen minimum zones but are often treated as separate assemblage, the protistan meiofauna (Buzas & Gibson, 1969; Lagoe, 1976). Detailed reviews of foraminifera in oxygen-deficient poor habitats are available (Gupta & Machain-Castillo, 1993; Bernhard, 1996; Bernhard & Sen Gupta, 1999; Bernhard et al., 2000). A number of experimental studies also have addressed the responses of foraminiferal community to oxygen depletion (Moodley & Hess, 1992; Alve & Bernhard, 1995; Moodley et al., 1997; 1998 a,b). Foraminifera are found to be dominated numerically over metazoan meiofauna and macrofauna in oxygen-deficient settings (Gooday et al. 2000). Nematode community structure along a central Chile margin OMZ showed higher individual biomass of nematodes in deeper sediment layers along the oxygenated sites. The concentration of nematodes in deeper sediment layers, as along with the high nutritional quality of the deeper layers, propose a differential resource partitioning of the available food, through which interspecific competition is reduced in the OMZ region (Neira et al., 2013).

The general consensus is that metazoan meiofauna are less affected by hypoxia rather than macro and megafauna in OMZs (Levin et al., 1991; Neira et al., 2001a). Within the meiofauna, nematodes have been suggested to be the most tolerant to low oxygen concentrations (Cook et al., 2000; Giere, 2009). Also they are adapted to extreme environments through detoxification strategies and high anaerobic capacity (Veit-Köhler et al., 2009).

## I.6. Main Objectives

For the continental slope eastern Arabian Sea (EAS) margin, off western India, no concentrated effort has been made to study the quantitative as well as qualitative composition of meiofauna and their links to the key environmental factors. Information on the faunal assemblages of free living nematodes in relation to with the abiotic factors that regulate species composition, abundance or their diversity from the EAS margin, is also lacking. The present work is intended to fill this gap by covering northern part of the West coast of India from Off Goa to Off Porbander for the meiofauna standing stock in relation to various environmental variables over three depths (200 m, 500 m and 1000 m). Free living nematode communities along the entire slope region of the Eastern Arabian Sea (Off Cape Comorin to Porbander) is analysed with sampling from 200m to 1000m depth. Systematic descriptions of free living nematodes collected from the Eastern Arabian Sea (EAS) continental margin is also provided, including the descriptions of novel species.

- To understand the standing crop of meiofauna and its spatial as well as temporal variation along the North Eastern Arabian Sea (NEAS) continental margin from 200 to 1000m depth.

- Systematic account on free living nematodes from the Eastern Arabian Sea (EAS) continental margin (from 200-1000m).

- To study the species composition and community structure of free living nematodes along the EAS margin and its environmental linkage.

- To develop baseline data on the marine free living nematodes of the continental slope of EAS margin.

To achieve the above goals 5 dedicated cruises were conducted onboard *FORV Sagar Sampada* along the continental slope off West coast of India, as a part of the-CMLRE MoES (Government of India) programme on Marine Living Resources in India's Exclusive Economic Zone (EEZ). Marine Living Resources in India's Exclusive Economic Zone (EEZ). The study covered sites extending from Off Cape Comorin to Off Porbander, falling under 16 transects with a distance of $1^0$ between two transects.

# Chapter II

# MATERIALS AND METHODS

Contents

## II. 1. Study area

The study area was positioned on the continental slope region in the eastern Arabian Sea margin, west coast of India. The **Arabian Sea** is a part of the northern Indian Ocean restricted on the eastern side by India, on the north by Pakistan and Iran, on the west by the Arabian Peninsula, on the south, roughly, by a line running from the South extremity of Addu Atoll (Maldives), to the eastern extreme of Ràs Hafun (Africa, 10°26'N). It was located between lattitudes 8 to 24ºN and longitudes 50 to 77ºE. The shelf area off Arabian Sea is moderately extensive with maximum width of 160 kms in the north (Mumbai) and minimum width of 48 kms off Cranganore (Kerala). The gradient along the shelf is gradual and low (0.50). The area (>40 m) is sedimentlogically characterized by silt and clay deposits and rich in organic matter (Nair and Pylee, 1968). The shelf break along the eastern Arabian Sea region occurs between 80 and 110 m. The sediments along the shelf edge are largely composed of biogenic oozes of foraminiferan or globigerina tests.

The Arabian Sea has an area of $6.2\times10^6$ km and covers about 1% of the global ocean surface. Yet, approximately 5% of the global phytoplankton production is concentrated in this area. In many places, Arabian Sea is deeper than 3000 m (max. depth 4652 m) and the basin is more or less enclosed in the south by three ridges (Central Indian Ridge, Carlsberg Ridge, and Chagos–Laccadive (or Maldive) Ridge). Therefore, bottom water enters Arabian Sea basin from the west, through the Owen Fracture Zone, rather than from the south (Tomczak and Godfrey, 1994). Land-derived (Terrigenous) deposits cover the major part of the continental slope up to a depth of about 2,700 m. Below this, sediment deposits consists of biogenous origin (foraminifera as well as radiolarian oozes) while basins beyond 4,000 metres are covered by red clay. The eastern Arabian Sea is characterised by intense coastal upwelling during southwest monsoon, along with reversed circulation and mixed layer deepening at the time of the north east monsoon (Qasim, 1977, 1982). The seasonal upwelling results in high surface productivity and conveyance of increased particle flux to the sea bottom (Qasim, 1977, 1982; Sen Gupta and Naqvi, 1984).Very high mean annual particulate organic carbon fluxes into the deep-sea have been observed for the northern and western Arabian Sea (Witte, 2000). The high organic production and limited sources of water replenishment results in rapid utilization of dissolved oxygen and there by developing an intense and unusually deep oxygen minimum layer in the water column between depths of 100 m and 1300 m, where oxygen concentrations are <0.5ml $^{-1}$ (Wyrtki, 1973; Qasim, 1982; Helly and Levin, 2004).The hypoxic layer at intermediate depths has significant impacts on the quantity and quality of organic matter reaching the deep sea floor resulting in settling of unrecycled organic matter (Angel, 1984; Cowie, 2005). In regions where OMZ is in contact with the sediments of the continental margin there is an intense impact on the distribution and biomass of bottom fauna. When considering the vertical particle flux and processes that occur in the benthic boundary layer and within the surface sediments, the Arabian Sea continental margin along with its surface sediments are of greatest importance (Walsh, 1991; Naqvi and Jayakumar, 2000; Cowie, 2005).

## II. 2. Sampling locations

For the convenience in sampling, the eastern Arabian sea (EAS) margin was allocated into 16 transects with 3 stations representing 200 m, 500 m and 1000 m depths in each transect (*in toto* 48 stations - Cape Comorin, Trivandrum, Kollam, Kochi, Ponnani, Kannur, Mangalore, Coondapore, Karwar, Goa, Ratnagiri, Dabhol, Off Mumbai 1, Off Mumbai 2, Veraval and Porbander. The geographical position of the sampling stations fixed between latitude 7°01’N- 21°30’N and longitude 67°28’E- 77°15’E. The geographical positions of the 48 stations are given in Table II. 1.

## II. 3. Methodology

### 2.3.1 *Sample collection*

Three dedicated cruises (Cruise No.219 & 225, Cruise No. 228 & 233 and Cruise No. 254) were carried out onboard (Fisheries and Oceanographic Research Vessel) FORV Sagar Sampada of CMLRE, Ministry of Earth Sciences, Government of India for collecting sediment samples for the present study on the meiobenthos. Sediment samples from three different pre determined depth ranges (200 m, 500 m and 1000 m) of respective transect was obtained using a modified Smith McIntyre grab having a bite area of 0.2m$^2$ (Figure II. 2. A.). Each transect was spaced out one degree latitude. Sea-Bird CTD (Figure II. 2. B.) was used for obtaining data on hydrographical parameters such as temperature and salinity whilst Winkler’s method was used for estimating oxygen onboard in the lab. Instantaneously after the grab hauling the undisturbed nature of sample was ascertained. The sub samples for analysis of meiobenthos was taken from the undisturbed grab. The sub sampling were carried out using a glass corer with an internal diameter of 2.5 cm and a length of 30 cm (Figure II. 2. C.)from the middle of each grab sample.

Replicate core samples from different grab haulings of each station were processed separately in the laboratory and data were pooled for analyses. The core samples were fragmented in to segments of 4 cm in order to investigate the vertical distribution of the meiofauna. The samples were *in toto* transferred in to 250 ml plastic vials, immediately fixed with 7% Magnesium Chloride and preserved in 5-7% buffered formalin (buffered formalin is used in order to prevent the leaching of calcarious exoskeleton of the benthic foraminiferans). Samples were properly labelled and conveyed to shore laboratory for further analysis. Samples for the analysis of sediment texture and organic matter content were also acquired from each station from the same grab sample. Roughly 150 gm of wet sediment from each station was taken for this purpose and it was oven dried at 60 $^0$C for overnight.

| Name of the transect | Station No | Depth (m) | Latitude (N) | Longitude (E) |
|---|---|---|---|---|
| **Off Cape Comorin** | 0 | 200 | 7.10’ | 77 .19’ |
| | 1 | 500 | 7.07’ | 77 .06’ |
| | 2 | 1000 | 7 .06’ | 77 .05’ |
| **Off Trivandum** | 3 | 200 | 8 .28’ | 76 .28’ |
| | 4 | 500 | 8 .28’ | 76 .16’ |
| | 5 | 1000 | 8 .28’ | 75 .26’ |
| **Off Kollam** | 6 | 200 | 8 .42’ | 75 .44’ |
| | 7 | 500 | 8 .42’ | 75 .32’ |
| | 8 | 1000 | 8 .42’ | 75 .26’ |
| **Off Kochi** | 9 | 200 | 9 .50’ | 75 .34’ |
| | 10 | 500 | 9 .50’ | 75 .26’ |
| | 11 | 1000 | 9 .50’ | 75 .16’ |
| **Off Ponnani** | 12 | 200 | 10 .50’ | 75 .10’ |
| | 13 | 500 | 10 .50’ | 75 .00’ |
| | 14 | 1000 | 10 .50’ | 74 .52’ |
| **Off Kannur** | 15 | 200 | 11 .56’ | 74 .28’ |
| | 16 | 500 | 11 .56’ | 74 .22’ |
| | 17 | 1000 | 11 .56’ | 74 .15’ |
| **Off Mangalore** | 18 | 200 | 12 .46’ | 73 .56’ |
| | 19 | 500 | 12 .46’ | 73 .50’ |
| | 20 | 1000 | 12 .46’ | 73 .38’ |
| **Off Coondapore** | 21 | 200 | 13 .58’ | 73 .24’ |
| | 22 | 500 | 13 .58’ | 73 .15’ |
| | 23 | 1000 | 13 .58’ | 73 .09’ |
| **Off Karwar** | 24 | 200 | 14 .32’ | 73 .10’ |
| | 25 | 500 | 14 .32’ | 73 .00’ |
| | 26 | 1000 | 14 .32’ | 72 .52’ |
| **Off Goa** | 27 | 200 | 15 .25’ | 72 .48’ |
| | 28 | 500 | 15 .25’ | 72 .39’ |
| | 29 | 1000 | 15 .25’ | 72 .31’ |
| **Off Ratnagiri** | 30 | 200 | 16 .18’ | 72 .25’ |
| | 31 | 500 | 16 .18’ | 72 .14’ |
| | 32 | 1000 | 16 .18’ | 72 .04’ |
| **Off Dabhol** | 33 | 200 | 17 .24’ | 71 .20’ |
| | 34 | 500 | 17 .24’ | 71 .12’ |
| | 35 | 1000 | 17 .24’ | 71 .08’ |
| **Off Mumbai 1** | 36 | 200 | 18 .30’ | 70 .26’ |
| | 37 | 500 | 18 .30’ | 70 .14’ |
| | 38 | 1000 | 18 .30’ | 70 .06’ |
| **Off Mumbai 2** | 39 | 200 | 19 .34’ | 69 .48’ |
| | 40 | 500 | 19 .34’ | 69 .27’ |
| | 41 | 1000 | 19 .34’ | 69 .22’ |
| **Off Veraval** | 42 | 200 | 20 .30’ | 69 .43’ |
| | 43 | 500 | 20 .30’ | 69 .31’ |
| | 44 | 1000 | 20 .30’ | 69 .19’ |
| **Off Porbander** | 45 | 200 | 21 .30’ | 68 .00’ |
| | 46 | 500 | 21 .30’ | 67 .42’ |
| | 47 | 1000 | 21 .30’ | 67 .28’ |

**Table. II. 1** Stations sampled in the EAS margin with depths and geographic positions.

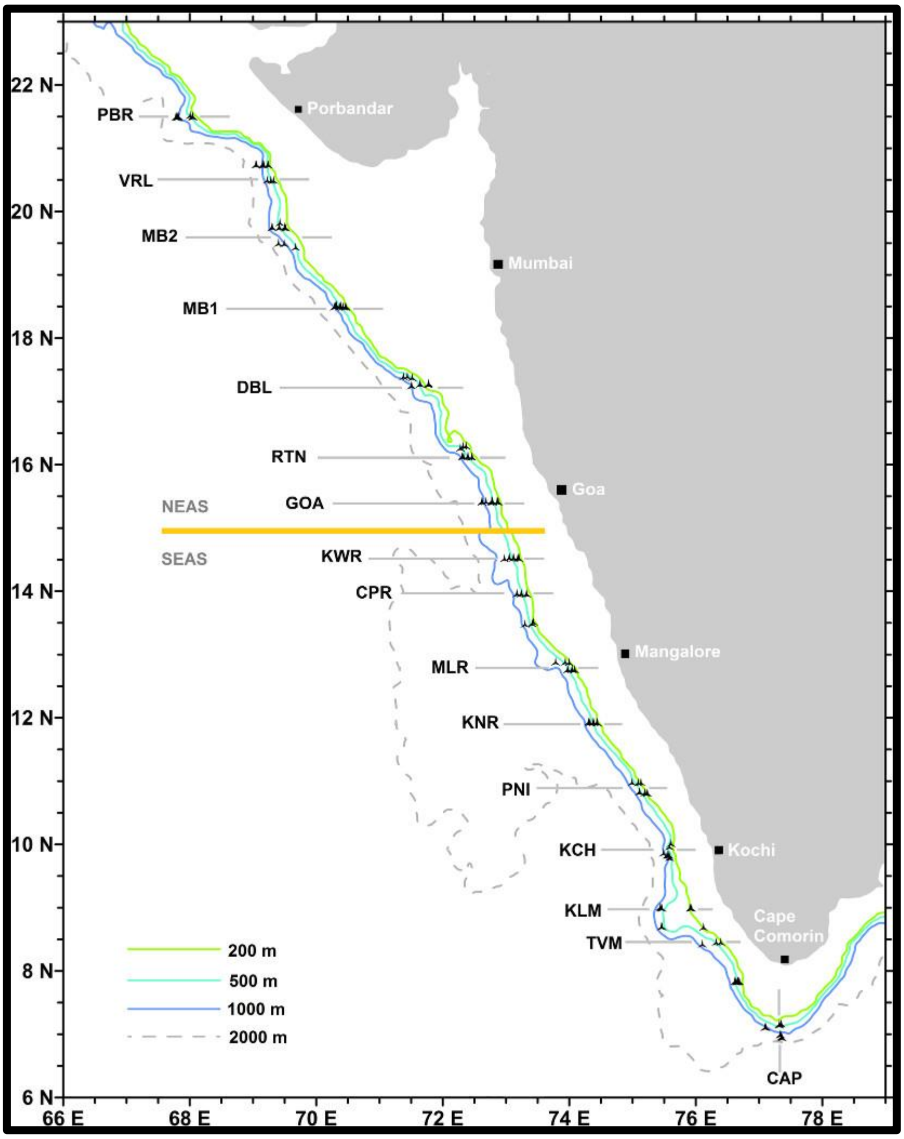


**Figure II.1.** Map showing locations of sampling

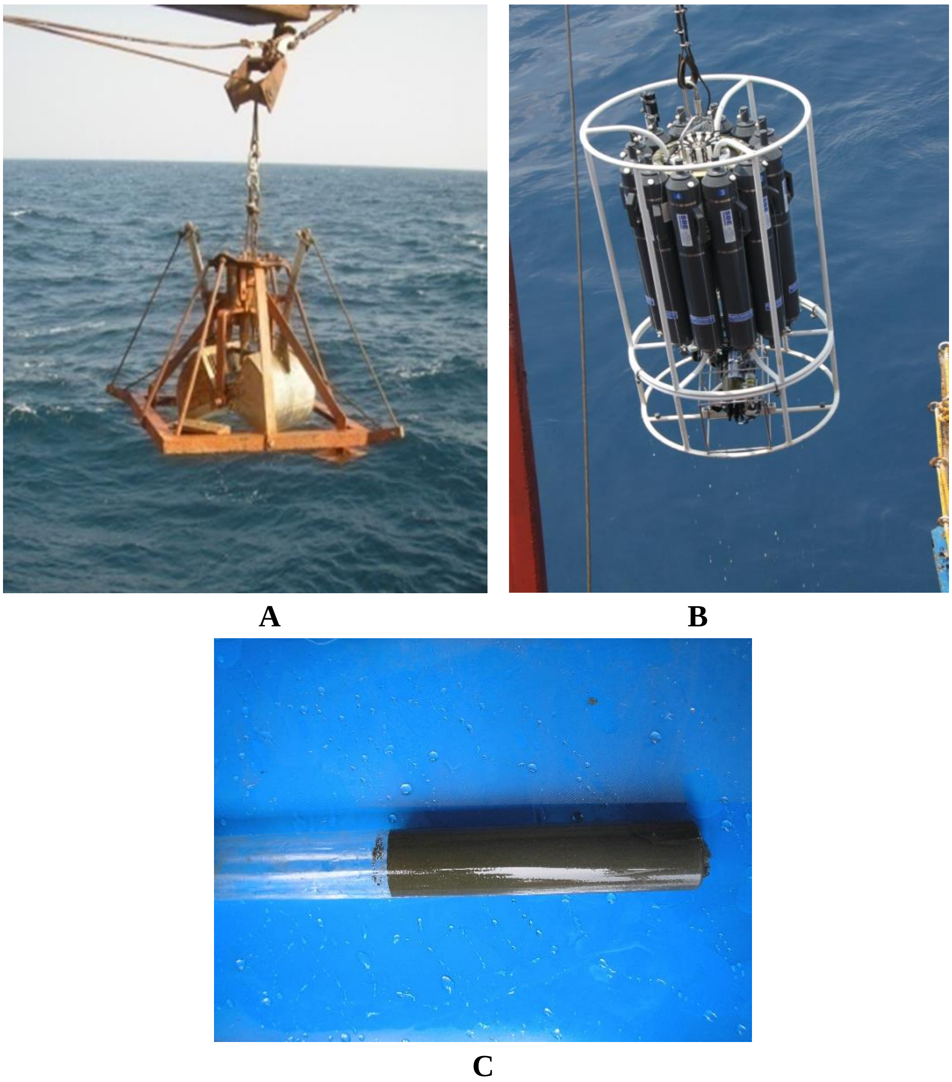


**Figure II. 2. A.** Modified Smith McIntyre Grab; **B**. CTD Rosette; **C.** Glass core subsample

### **II.3.2. Textural Analysis**.

At the shore laboratory the samples were analysed for sediment particle size on particle size analyzer (Sympatec, Germany). The percentage of each grade (sand, silt, clay) was calculated.

## II.3.3. Estimation of Organic matter content

The organic matter content of the sampling sites were estimated based on the wet oxidation method of El Wakeel and Riley (1957). Organic matter was expressed as % of sediment dry weight examined.

## II.3.4. Analysis of biological samples

### *II.3.4.1. Meiobenthos Extraction*

In addition to the fauna, the fixed samples contain a mixture of formalin, sediment grains, shells and organic detritus. On arrival at the shore laboratory, the sediment samples were processed through a set of two sieves; the upper one of 500 μ and the lower with 63 μ. Meiofauna free tap water was used to extract the fauna from the sediment sample. Residue retained over 63 μ sieve was back washed into a glass container and the same preserved in 70% alcohol or 4% neutral formalin. Several extraction methods (i.e. decantation, elutriation, separation in a density gradient using e.g. Ludox) have been described for the quantitative isolation of meiofauna organisms from sediments (Higgins & Thiel, 1988). However, no single extraction technique will remove all the specimens of all taxa from a given sample. Therefore, sieving and subsequent hand sorting under a low power microscope is most frequently used to extract the bulk of meiofauna from the fixed samples. Prior to extraction selective staining of fauna for recognition and discrimination between dead shells and freshly sacrificed animals were carried out. For this purpose, fixed samples were bulk stained with Rose Bengal (Higgins and Thiel, 1988). The stained meiobenthos are sorted within 1-2 hour since over staining would make it difficult to remove and would impair the structural analysis under the microscope. The general methodology was that the residue over 63 μ sieve was decanted and all the meiobenthic animals present were manually sorted out and enumerated group wise using a binocular stereo microscope. Organisms were identified to major taxa such as nematode, foraminifera, crustacean etc. All the other taxa appearing in few numbers or meagrely represented from the stations (eg. kinorhynca, polychaeta, turbellaria, oligochaeta) were treated as ‘others’. The numerical abundance (as individuals) and biomass (in mg) of meiofaunal organisms were expressed in 10 $cm^{-2}$. Species level identification was conducted on the free living nematodes, whereas the other groups were identified to higher taxa only. Since the nematode fauna showed high variation (0-864 ind/10cm$^2$ ) in numerical density throughout the sampling, they were identified regardless of their numerical representation among stations. All the nematodes obtained during the three cruises were subjected to taxonomic identification.

### *II.3.4.2. Numerical density and Biomass*

The total number of organisms in the sample represented by different groups was calculated and expressed as numbers per 10 cm$^2$. The biomass of meiobenthos (mg/10 cm$^2$) was determined using a high precision electronic balance (e.g. Sartorius) as followed by Mare (1942). For comparison wet weight of nematodes were again calculated from measurements of length and width assuming a specific gravity of protoplasm in to 1.13 (Baugley et al.,, 2008). The wet weight value of nematodes was agreeing well with the reports.

### *II.3.4.3. Microscopic slide preparation of Nematodes*

Prior to the detailed study on the systematics of nematodes, the fixed animals were processed in anhydrous glycerine and permanent slides were prepared. For this purpose nematodes were transferred to a cavity block containing by volume 5% glycerine, 5% pure ethanol and 90% water (Seinhorst, 1959 ; Vincx, 1996), almost covering it with a cover glass and leaving it within a desiccator for few days until the ethanol and water fully evaporated leaving the animals in pure glycerine. So the dehydrated nematodes then transferred to a fresh drop of glycerine on a slide and cover glass was added supported by glass rods of appropriate diameter. The cover glass sealed permanently.

Using a high power (Nikon E600 series trinocular research) microscope equipped with a 100 X oil immersion lens, examination was carried out. Drawing tube was used for making drawings of the specimen. In order to measure the features of nematodes a properly calibrated ocular micrometer was used. For straight measurements a calibrated ocular micrometer was used. The oesophagus was measured from the anterior end of the body and the head diameter was measured at the level of first circle of cephalic setae. The morphology of the head structures of both sexes and copulatory organs of males were carefully examined, as they were essential for fixing the taxonomy (Wieser and Hopper, 1967).

Taxonomic fixing of free-living nematodes were carried out by using standard literature, Bremerhaven checklist of aquatic nematodes I and 1I (Gerlach and Riemann, 1973, 1974); Lunds Chile expedition reports (Wieser, 1953, 1954, 1956, 1958) synopses of free living marine nematodes I, 11 and III (Platt and Warwick, 1983, 1988, 1998) and recent online literatures (NeMys).

#### *II.3.4.4. Trophic structure*

Feeding groups of nematodes were worked out based on the buccal cavity and armature of the animal. Based on the type of buccal cavity nematode feeding groups were isolated into four groups identified by Wieser. On the basis of which four feeding guilds were delineated, i.e. selective deposit feeders (small and toothless or no buccal cavity; feeding type 1A), non-selective deposit feeders (medium-large, toothless buccal cavity; feeding type 1B), epistrate feeders (small-medium buccal cavity with small tooth or teeth; feeding type 2A) and predators/scavengers (large buccal cavity with large teeth or mandibles; feeding type 2B) (Wieser, 1953).

### II.3.5. Statistical data analysis

Various diversity indices are widely used in ecology for comparison of communities on spatio-temporal scale. The discriminating ability of diversity indices vary, depending on the type of study being conducted and on other aspects of the samples. The diversity and community structure of the present study analysed using different approaches, which include univariate (species richness, Shannon-Wiener diversity, species dominance and evenness), multivariate (Multi-Dimensional Scaling) and graphical methods (species area plots, k-dominance curves etc.). In the present study, statistical software PRIMER 5 & 6 (Plymouth Routines in Multivariate Ecological Research) and SPSS 17 was used for the data analysis and representation.

### II.3.5.1. The Univariate Methods

The Univariate methods include a set of species coefficients or diversity Indices. The following diversity indices were carried out for the estimation of community structure of free-living nematodes. The species identification for other groups were not worked out in detail. Therefore community study was not attempted for other meiofaunal groups.The species richness is often given simply as the total number of species. Margalef's index (Margalef, 1958) is the measure of total number of species present for a given number of individuals. Species richness d =(S-1)/ Log (N) where N= total number of individuals; S= total number of species. Species diversity was measured by Shannon-Wiener index (Shannon & Weaver, 1949) expressed as species diversity H'= -SUM ($P_i^X$ Log (Pi) where $P_i$ is the proportion of the total count arising from the $i^{th}$ species. Equitability or evenness was measured by Pielou's evenness index (Pielou, 1975) expressed as J' = H'/ Log (S) where H' is the Shannon diversify; log S - maximum possible value of Shannon index. Species dominance was measured by Simpson's index (Simpson, 1949) expressed as species dominance $\lambda' = \{SUM_i\ N_i\ (N_i-1)\} / \{N\ (N-1)\}$ where $N_i$ is the number of individuals of species.

### II.3.5.2. Multivariate Methods

Multivariate analyses are conducted to determine whether biological assemblages respond to different types of disturbances by small, but consistent changes in the relative abundances of species. These are characterized by comparisons of two or more samples on the extent to which these samples share particular species, at comparable levels of abundance. In order to discern whether the number of species collected over the whole study is satisfactory to describe the species composition of the area, a species accumulation plot was used, which plots the cumulative number of species against the cumulative number of samples (grabs). Varying species estimators (such as CHAO1, CHAO2, Jacknife, UGE, SOBS etc., available in PRIMER 6) were used to predict the true number of species that would be obtaining as the number of samples tend to be infinity. Clustering analyses try to find species to groups, while ordinations attempt to place them spatially so that similar species are close and dissimilar ones are far. Generally used classification method is cluster analysis. Ordination technique used in the present study was

Multidimensional Scaling (MDS). The nematode species list was processed by group average cluster analysis and non-metric multidimensional Scaling (NMDS) ordination.

#### *II.3.5.2.1. Principal Component Analysis (PCA)*

PCA was carried out to identify trends of variation of environmental characteristics across the study area. It uses an ordination plot to project the points of highest similarities closer together while samples more dissimilar are more apart.

#### *II.3.5.2.2. Cluster analysis*

Cluster analysis was performed to find out the similarities between different groups. Widely used clustering technique is the hierarchical agglomerative method. The results of cluster analysis are represented by a tree diagram or dendrogram with the x- axis signifying 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) with suitable (square root) transformation was used to produce the dendrogram.

#### *II.3.5.2.3. nMDS (Non - metric Multi Dimensional Scaling)*

The Shepard (1962) and Kruskal (1964) method of nMDS was used to find out the similarities (or dissimilarities) amongst each pair of species to produce a 'map', which would ideally show the configuration of species in a specified number of dimensions, and attempts to satisfy all the conditions imposed by similarity matrix.

#### *II.3.5.2.4. SIMPER procedure*

The similarities or dissimilarities were explained by using the SIMPER procedure in order to ascertain the species contributing to the similarity or dissimilarity.

# Chapter III

# ABIOTIC ENVIRONMENT OF EASTERN ARABIAN SEA MARGIN

## III.1. INTRODUCTION

All living things exist only as parts of a complex entity, made up of interacting abiotic and biotic elements. Their activities are strongly influenced by the external circumstances. In a certain environment, physicochemical or abiotic factors are the key determinants of existence for an organism. The boundaries of the 'niche' or functional position of any organism depend on the variation of abiotic parameters (Kinne, 1963). The important abiotic factors which play crucial role in life history of benthic animals are hydrographical parameters (temperature, salinity and dissolved oxygen), sedimentological parameters (Sand, Silt and Clay) and organic matter content of the sediment. Sea floor sediments are in continuous interaction with the overlying water, which is in turn liable for the most abiotic factors such as dissolved oxygen, dissolved and particulate organic matter within the sediment regime. Because several environmental parameters of marine environment usually vary together, the effects of variation of a single factor is occasionally evident in natural conditions. The composition of meiofauna in the benthic realm is determined by the conditions of the overlying water (Giere, 1993).

Temperature controls the rate of fundamental biochemical processes in organisms and there by variations in the environmental temperature can impact organismal as well as community level processes (Brown et al., 2004; Allen et al., 2006). Any change in temperature is certain to affect the many chemical processes taking place in plant or animal tissue, and so affects organisms as a whole. The continuous circulation of the oceans and their enormous heat capacity make sure that the extent of temperature variation in the sea is small despite great geographical and seasonal differences in absorption and radiation of heat (Tait, 1968). Deep-sea experience much lower temperature. Seasonal and inter-annual variations in temperature are nearly unknown in the deep sea. Overall, the metabolic rates of all organisms increase with an increase in the ambient temperature to the level of tolerance of the organisms.

Salinity is also an important factor regulating meiofaunal distribution in sediments. Salinity is remarkably constant throughout the depths of the deep sea. As seen with temperature, meiofaunal organisms exist under all salinity regimes from fresh water to brine seep areas.

Oxygen is another vital factor among the physicochemical parameters, influencing distribution and habitat conditions of meiofauna. Bottom water oxygen concentrations in the deep sea differ from near zero to over 7ml/l (Rex et al., 1993). When the supply of oxygen to the bottom is troubled by various conditions like column stratification or increased consumption rates without much replenishment phenomena like hypoxia (DO<0.5ml/l) may occur.

When describing the habitat of meiobenthos, grain size is a major factor, since it directly decides spatial and structural environments and indirectly regulates the physical and chemical milieu of the sediment (Rex et al., 1993). The size, shape and composition of sediment particles control the water flux through sediments, which in turn controls the physical as well as chemical regime within the sediments. In this network of abiotic factors that influence the habitat of meiobenthos, grain size plays a crucial role. Sediments in the marine environment either terrigenous or biogenic in origin. Coarse sediments of terrigenous origin are commonly found on the continental slope and rise, by the transportation of turbidity currents and sediment slumps. Biogenic sediments are chiefly the hard skeletal parts of planktonic as well as benthic organisms. Sediments comprised of more than 30% such skeletal components are termed oozes. This may be either calcareous (tests of foraminiferans, coccolithophores and pteropods) or siliceous (tests of radiolarians and diatoms) origin. Calcareous oozes are the most common biogenic sediment (Rothwell, 2005; Huneke & Mulder, 2011).

Along with sediment texture the other important parameter is organic matter content, since it signifies a potential source of food directly for deposit feeders and indirectly for suspension feeders. The benthos below the euphotic zone in most areas absolutely dependent on the supply of organic matter from the pelagic system. The hydrographic as well as biological processes along the water column will define the quantity and quality of food to the benthic fauna (Smetacek, 1984). High benthic biomass and density in near shore areas can be attributed to the rich primary production in near shore waters. Continental slopes are the sites of accumulation of high quantity of organic matter. The enhanced organic matter is generally resulted from a combination of river-induced nutrient input, the coupling of pelagic and benthic systems, and local or regional upwelling of fertile, highly productive deep water (Mantoura et al., 1991; Biscaye et al., 1994). Recent investigations in Quaternary sediments of the Pacific and Atlantic oceans indicate that primary productivity is the principal control for the formation of organic rich deposits (Calvert et al., 1992; Calvert and Pedersen 1992). The present chapter gives an account of the hydrographical as well as sedimentological parameters of the slope area of Eastern Arabian Sea margin, West coast of India.

## III.2. RESULTS

The core variables on the abiotic environment of the study area were data on bottom water temperature ($^0$C), salinity, dissolved oxygen (ml/l), sediment texture (percentages of sand, silt and clay particles) and organic matter (%) content of the sediment. The following is a brief account of the hydrographical as well as sedimentological conditions prevailing in the eastern Arabian Sea margin. Environmental data from the voyages of *FORV Sagar Sampada* during various cruises *FORVSS* 219, 225, 228, 233 and 254 are subjected to Principal Component Analysis (PCA) in order to describe possible spatiotemporal variations in the sediment and hydrographical parameters. Hydrographical as well as sedimentological variables along the EAS margin was described previously by various authors (Abdul Jaleel, 2012; Neil. S. C., 2013; Abdul Jaleel et al., 2014; Anilkumar et al., unpublished).

### III.2.1. Bottom water temperature (Figure III.2)

During 2003-2004 (*FORVSS* 219 and 225) along the EAS margin the bottom water temperature varied from 6.8$^{0}$C (off Cape, 1000 m) to 19.9$^{0}$C (Veravel, 200 m) with a mean value of temperature 12.17±3.603$^{0}$C. Within each depth range of entire west coast, water temperature varied appreciably. The bottom water temperature was decreasing with increasing depth. For entire west coast at 200 m depth observed range of variation was 19.9$^{0}$C (Veravel) and 12.7$^{0}$C (Kollam) with a mean temperature of 16.30±2.036$^{0}$C. For south west coast bottom water temperature varied between 12.73 $^{0}$C (Kollam) and 16.73$^{0}$C (Karwar) with a mean of 14.94±1.36$^{0}$C and for north west stations temperature variation was from 16.11$^{0}$C (Mumbai 1) to 19.86$^{0}$C (Veravel) with a mean 18.03±1.27$^{0}$C. In the stations around 500 m from entire west coast temperature range was from 13.85$^{0}$C of Mumbai 2 to 9.97$^{0}$C of Kannur with mean temperature of 11.65±1.001$^{0}$C. Along south west coast temperature range was from 9.97$^{0}$C (Kannur) to 11.74$^{0}$C (Mangalore) with a mean temperature of 11.09±0.59$^{0}$C; and in north west observed range of temperature was 11.53$^{0}$C (Ratnagiri) to 13.85$^{0}$C (Mumbai 2) with a mean value of temperature 12.38±0.97$^{0}$C. In the stations around 1000 m depths for the entire west coast the temperature showed variation from 9.3$^{0}$C of Mumbai 1 to 6.8$^{0}$C of Cape with mean temperature of 8.23±0.770$^{0}$C. For the southern part of west coast, temperature varied from 6.80 $^{0}$C (Cape) to 8.41$^{0}$C (Kochi) with a mean temperature of 7.94±0.83$^{0}$C and for north western part temperature varied from 7.69$^{0}$C (Goa) to 9.33$^{0}$C (Mumbai 1) with a mean value of temperature 8.60±0.53$^{0}$C. Based on mean temperature for each of the depth categories, it was possible to show differences between northwest and southwest locations. The bottom water temperature profile of cruise 219 and 225 shows relative higher temperature towards northern part of west coast.

During the second sampling at the year 2004-2005 (*FORVSS* 228 and 233), bottom temperature along EAS margin varied from 16.1 $^{0}$C off Porbander and Cape, (200 m) to 6.9$^{0}$C off Kollam (1000 m) with a mean temperature 11.73±2.962$^0$C. Within each depth range of entire west coast, temperature varied considerably. The temperature decreased with increase in depth. For entire west coast, between depths around 200 m, observed range was from 14.6$^0$ C (off Ratnagiri and Mumbai 1) to 16.1 $^0$C (Off Porbander) with a mean value of temperature 15.17±0.589$^0$C. From southern part of west coast the 200 m depth showed variation of bottom water temperature from 14.46$^0$C (Karwar) to 16.06 $^0$C (Cape). The mean temperature of west coast at 200 m depth was 15.04±0.57$^0$C. In the northern part of west coast temperature varied between 14.60$^0$C (Mumbai 1) to 16.13$^0$C (Porbander) with a mean temperature value of 15.33±0.62$^0$C. For 500 m depth of entire west coast bottom temperature ranged from 9.86$^0$C of Trivandrum to 13.23$^0$C of Cape with a mean temperature 11.71±0.915$^0$C. In south west coast it was from 9.87$^0$C (Trivandrum) to 13.23 $^0$C (Cape) with mean temperature 11.23±0.89$^0$C. In north west coast observed temperature range was from 11.63$^0$C (Goa) to 13.16 $^0$C (Porbander) with mean value of temperature 12.32±0.51$^0$C. The 1000 m depth stations of entire west coast showed temperature variations from 6.86$^0$C of Kollam to 10.2$^0$C of Veravel with mean temperature of 8.32±1.127$^0$C. From southern part of west coast, 1000 m depth showed variation of bottom water temperature from 6.86$^0$C (Kollam) to 8.83 $^0$C (Kannur) with a mean temperature 7.59±0.64$^0$C. In north west coast bottom temperature ranged from 7.82$^0$C (Goa) to 10.20$^0$C (Mumbai 3) with a mean value of 9.25±0.92$^0$C. In the second sampling bottom water temperature at 500 m and 1000 m depth stations shows higher values towards northern part of the west coast.

In the third sampling during 2007 (*FORVSS* 254) temperature variation between different stations of west coast varied from 7.3$^0$C of Kollam (1000 m) to 17.3$^0$C of Porbander (200 m) with a mean 12.00±2.73$^0$C. The bottom water temperature decreased with increasing depth. At 200 m depth temperature of entire west coast ranged between 12.8$^0$C (Kochi) to 17.3$^0$C (Porbander) with a mean 15.23±1.25$^0$C. From south west temperature varied from 12.84$^0$C (Kochi) to 15.45 $^0$C (Trivandrum) with mean value 14.46±0.91 $^0$C. In northwest variation was from 15.14$^0$C (Cape) to 17.33$^0$C (Porbander) with a mean temperature of 16.22±0.89$^0$C. In 500 m depth stations bottom water temperature ranged from 10.6$^0$C (Ponnani) to 13.1$^0$C (Porbander) with a mean 11.69±0.819$^{0}$C. From south west temperature ranged between 10.62$^{0}$C (Ponnani) and 11.65$^{0}$C (Coondapore) with a mean 11.07±0.35$^{0}$C. In north west coast temperature varied from 11.93$^{0}$C (Goa) to 13.09 $^{0}$C (Porbander) with a mean of 12.49±0.44$^{0}$C. In the 1000 m depth stations temperature range was from 7.26$^{0}$C (Kollam) to 10.21$^{0}$C (Porbander) with mean value of 9.08±0.893 $^{0}$C. From south west coast temperature variation was from Kollam (7.26$^{0}$C) to Karwar (9.09$^{0}$C) with a mean of 8.42±0.57$^{0}$C. In north west coast temperature was 9.57$^{0}$C (Goa) to 10.21 $^{0}$C (Porbander) with a mean value of 9.93±0.27$^{0}$C. From the *FORVSS* 254 also bottom water temperature increased towards northern transects of west coast.

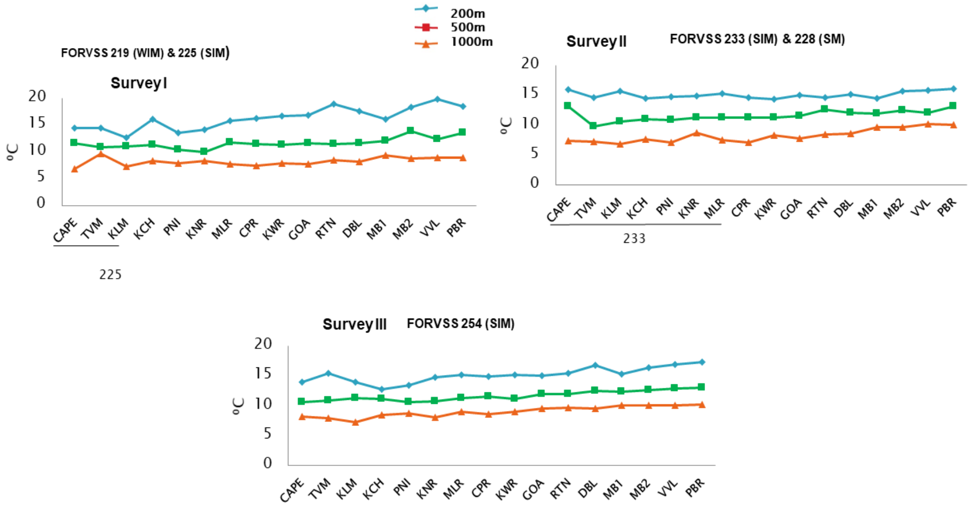


**Figure III.2.** Bottom water temperature along EAS margin

### III.2.2. Bottom water Salinity (Figure III.3)

During *FORVSS* 219 & 225 bottom water salinity varied from 35.98 (Cape, 1000 m) to 35.81 (Porbander, 500 m) with a mean salinity of 35.28±0.201.Within each depth range, salinity did not showed much variation. At depths around 200 m, observed range was 34.98 (Cape) and 35.6 (Veravel) with a mean salinity of 35.25±0.167. In south west coast salinity variation was from 34.98 (Cape) to 35.25 (Kannur) with mean salinity of 35.15±0.09. From north west of 200 m depth range salinity varied from 35.21

(Dhabol) to 35.61 (Mumbai 3) with a mean value of 35.37±0.17. In 500 m depth stations salinity variation ranged from 35.10 (Cape) to 35.8 (Porbander) with a mean value of 35.4±0.232. From south west coast of 500 m depth salinity varied from 35.10 (Cape) to 35.42 (Karwar) with a mean salinity 35.23±0.12 and in north west coast at 500 m depth salinity varied from 35.49 (Ratnagiri) to 35.81 (Porbander) with a mean value of salinity of 35.62±0.13. In 1000 m depth the salinity varied from 34.95 (Cape) to 35.40 (Off Mumbai1) with mean value of salinity 35.19±0.141. In south west the salinity at 1000 m depth varied from 34.95 (Cape) to 35.14 (Mangalore) with a mean salinity 35.09±0.07. From north west coast salinity ranged from 35.18 (Goa) to 35.40 (Mumbai 1) with a mean salinity of 35.32±0.08. Along west coast region there was not much variation in salinity. It was 35 almost everywhere with a slight variation. Even though variation of salinity was negligible it showed an increase towards northern part of the west coast.

Along the EAS margin, salinity in second sampling (*FORVSS* 228 & 233) varied from 34.96 (Cape, 1000 m) to 35.8 (Porbander, 200 m) with mean salinity of 35.30±0.220. Within each depth range, salinity did not vary appreciably. Between stations at depths 200 m observed range was 34.96 (Cape) and 35.8 (Porbander) with a mean value of 35.33±0.244. In 200 m depth stations of south west coast salinity ranged from 34.97 (Cape) to 35.33 (Karwar) with mean salinity 35.16±0.11. From north west coast the range of salinity was between 35.33 (Goa) and 35.84 (Porbander) with mean salinity 35.56±0.17. At 500 m depth of entire west coast salinity was between 35.08 (Trivandrm) to 35.7 (Veravel) with mean salinity 35.36±0.203. From south west statons at a depth of 500 m, salinity ranged from 35.09 (Cape and Trivandrum) with a mean salinity 35.22±0.11 and from that of north west salinity range was between 35.45 (Goa) and 35.68 (Veravel) with a mean value of 35.57± 0.09. In 1000 m depth range salinity ranged between 34.96 (Cape) to 35.2 (Goa) with a mean salinity of 35.20±0.190. In 1000 m depth stations of south west coast salinity ranged from 34.97 (Cape) to 35.20 (Karwar) with mean salinity 35.06±0.08. From north west coast range of salinity was between 35.20 (Goa) and 35.51 (Veravel) with mean salinity 35.38±0.13.

During *FORVSS* 254 salinity ranged between 35.01 of Kollam to 36.03 of Porbander with mean salinity of 35.35±0.256. There was not much fluctuation in bottom water salinity.

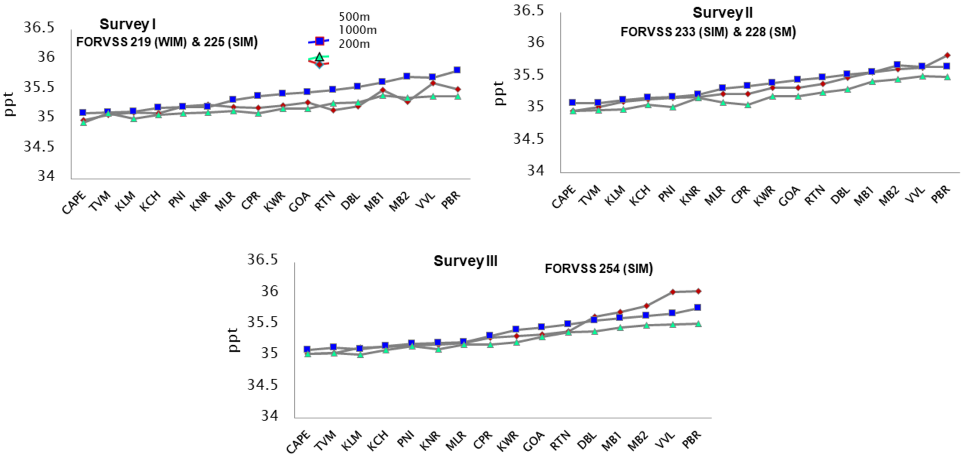


**Figure III.3.** Bottom water salinity along EAS margin

The salinity at 200 m depth ranged between 35.02 (Cape) to 36.03 (Porbander) with a mean value of 35.40±0.330. From south west coast salinity ranged from 35.03 (Cape) to 35.31 (Karwar) with mean salinity 35.17±0.09 and from north west coast salinity showed variation from 35.35 (Goa) to 36.03 (Porbander) with mean value of 35.70±0.27. In 500 m depth salinity varied from 35.09 (Cape) to 35.8 (Porbander) with mean salinity of 35.38±0.226. At south west coast salinity from 500 m depth showed variation from 35.09 (Cape) to 35.41 (Karwar) with mean salinity of 35.21±0.10 and from that of northwest coast salinity varied from 35.45 (Goa) to 35.77 (Porbanar) with mean salinity 35.60±0.11. Salinity distribution at 1000 m depth varied from 35.01 of Kollam to 35.52 of Porbander with a mean value of salinity 35.26±0.179. From south west coast at 1000 m depth ranges bottom water salinity varied from 35.02 (Kollam) to 35.22 (Karwar) with mean salinity 35.12±0.07. At north west coast salinity ranged between 35.31 (Goa) to 35.52 (Porbander) with mean salinity 35.44±0.08. Comparatively higher salinity can be observed from transects of northern side of west coast.

**III.2.3. Bottom water oxygen** (Figure III.4)

During *FORVSS* 219&225 along EAS margin the bottom water dissolved oxygen varied from 0.1ml/l (Karwar-200 m and Coondapore-200 m) to 1.3ml/l (Mumbai 1 1000 m) .Within each depth range, dissolved oxygen varied considerably. In depth stations around 200 m, DO value ranged from 0.11ml/l (Karwar) to 1.05ml/l (Ratnagiri) with a mean value of oxygen 0.5 ml/l. Form south west stations oxygen values varied from 0.11 ml/l (Karwar) to 0.68 ml/l (Kochi) with mean value 0.40 ml/l. In stations from north west, oxygen ranged from 0.48 ml/l (Veravel and Porbander) to 1.05 ml/l ( Ratnagiri) with a mean value of 0.66 ml/l. The depth stations above 500 m, showed variation from 0.16 ml/l (Veravel) to 0.83 ml/l (Cape) with a mean value of 0.5 ml/l. From 500 m depth stations of south west oxygen value ranged from 0.19 ml/l (Karwar) to 0.83 ml/l (Cape) with a mean value of 0.46 ml/l and that of north west, oxygen range was from 0.16 ml/l (Veravel) to 0.81 ml/l (Mumbai 2). In the depth stations around 1000 m oxygen value ranged from 0.23 ml/l (Karwar) to 1.3ml/l (Mumbai 1) with a mean value of 0.7 ml/l. In south west, oxygen value varied from 0.23 ml/l (Karwar) to 1.12 ml/l (Cape) with a mean value of 0.69 ml/l. From the north west, oxygen ranged from 0.47 ml/l (Porbander) to 1.27 ml/l (Mumbai 1) with a mean value of 0.74 ml/l. Comparatively higher concentration of DO was observed at 1000 m depth stations.

Dissolved oxygen during *FORVSS* 228 & 233 varied from 0.16ml/l (Veravel 500 m) to 1.4ml/l (Coondapore 200 m). Within each depth range, dissolved oxygen varied considerably. Through depth stations located around 200 m dissolved oxygen values ranged between 0.23ml/l (Kannur) to 1.4ml/l (Coondapore) with a mean value of 0.66 ml/l. From the southern transects of 200 m depth the oxygen level ranged between 0.23 ml/l (Kannur) and 1.40 ml/l (Coondapore) with mean oxygen value 0.65 ml/l and in north west coast oxygen varied from 1.1 ml/l (Ratnagiri) to 0.5 ml/l (Veravel and Porbander) . The observed range of DO in 500 m depth was 0.16 ml/l (Veravel) to 0.88

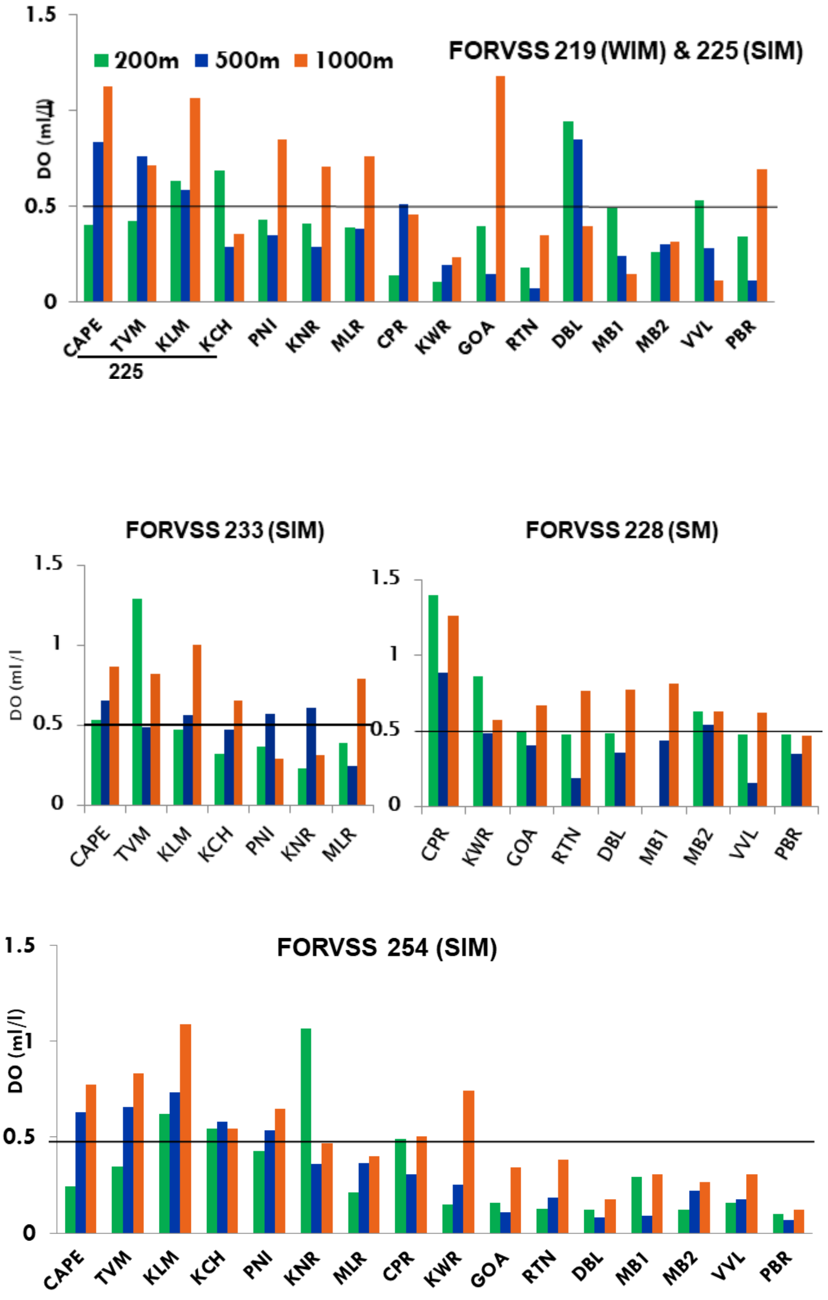


**Figure III.4.** Bottom water dissolved oxygen along EAS margin ml/l (Coondapore) with mean value of 0.52 ml/l. For south west coast observed range of dissolved oxygen was from 0.9 ml/l (Coondapore ) to 0.2 ml/l (Mangalore) and for north west coast it was from 0.2 ml/l (Veravel ) to 0.8 ml/l (Mumbai 2). Dissolved oxygen in 1000 m depth range varied from 0.29 ml/l (Ponnani) to 1.27ml/l (Mumbai 1) with an average oxygen value of 0.74 ml/l. In the Southern part of the west coast observed variation was from 1.3 ml/l (Coondapore) to 0.3 ml/l (Ponnani and Kannur) and in northern part, the variation was from 0.5 ml/l (Porbander) to 1.3 ml/l (Mumbai 1).

During *FORVSS* 254 dissolved oxygen varied from 0.07 ml/l (Porbander) to 1.09 ml/l (Kollam).The distribution of dissolved oxygen varied according to depth. In depth stations around 200 m DO value ranged between 0.10 ml/l (Porbander) to 1.07ml/l (Kannur) with a mean oxygen level of 0.3 ml/l. From southern part of the west coast oxygen ranged from 1.1 ml/l (Kannur) to 0.1 ml/l Karwar and from northern part of west coast, variation was from 0.3 ml/l (Mumbai 1) to 0.1 ml/l (Mumbai 2, Ratnagiri, Dhabol and Porbander). From 500 m depth stations variation of DO was from 0.07ml/l (Porbander) to 0.73ml/l of Kollam. For south west coast observed range was from was from 0.7 ml/l (Trivandrum and Kollam) to 0.3 ml/l (Karwar and Coondapore) and for north west coast observed range of oxygen was from 0.2 ml/l (Mumbai 2, veravel and Ratnagiri) to 0.1 ml/l (Goa, Dhabol, Mumbai1 and Porbander). Depth wise distribution of DO in 1000 m showed variation from 0.12 ml/l (Porbander) to 1.09 ml/l (Kollam). For southern transects observed range of dissolved oxygen was from 1.09 ml/l (Kollam) to 0.4 ml/l (Mangalore) and for the northern transects observed variation was from 0.1 ml/l (Porbander) to 0.4 ml/l (Ratnagiri).

### III.2.4. Sediment Texture

The following is a brief account of the sediment texture the EAS margin. Overall, the ratio of sand, silt and, clay varied depending on location and depth. During *FORVSS* 219&225, 47 stations were examined for sediment nature. The most important textural class noticed at a great majority of stations (27) during that time was clayey silt. However, composition-wise there were appreciable differences. At 200 m, sand (%) varied between 4.67% (Veravel) and 92.64 % (Kollam); silt 0.2% (Trivandrum) and 57.9% (Dhabol) and clay

5.1% (Kollam) and 37.7% (Veravel). From southern part of west coast, clay (%) varied between 5.06% (Kollam) and 37.62% (Coondapore); silt 0.22% (Trivandrm) and 42.08% (Kochi) and sand 28.15% (Karwar) and 92.64% (Kollam). The predominant textural classes within this depth were silty sand, clayey-silt and sand. From northwest coast sand (%) varied between 4.64% (Veravel) and 64.27% (Ratnagiri); silt 17.61% (Ratnagiri) and 57.88% (Dhabol) and clay 14.66% (off Mumbai 2) and 37.67% (Veravel). The predominant textural classes within this depth were silty sand and clayey-silt. Above 500 m, sand (%) varied between 1.81% (Dhabol) and 88.10% (Cape); silt 3.62% (Trivandrum) and 69.88% (Kannur); clay 11.89% (Trivandrm) and 39.24% (Veravel). From south west coast sand (%) varied between 5.71% (Karwar) and 96.10% (Cape); silt 3.62% (Trivandrum) and 69.88% (Kannur); clay 11.89% (Trivandrm) and 38.87% (Ponnani), Clayey silt was predominant textural class. In north west coast, sand (%) varied between 1.81% (Dhabol) and 44.60% (off Mumbai 1); silt 33.93% (off Mumbai 1) and 63.93% (Dhabol) and clay 21.48% (off Mumbai 1) and 39.24% (Veravel). Clayey silt was the predominant textural class. Within depths 1000 m, sand (%) varied between 1.60% (Coondapore) and 42.15 % (Cape); silt 26.66% (Cape) and 69.78% (Kannur) and clay 22.42 % (Trivandrum) and 39.63% (Porbander), predominant textural class being clayey silt and clayey sand. From south west coast sand (%) varied between 1.60% (Coondapore) and 42.15% (Cape); silt 26.66%(Cape) and 69.88% (Mangalore) and clay 22.42% (Trivandrm) and 39.41% (Ponnani), Clayey silt was predominant textural class. In north west coast sand (%) varied between 1.81% (Dhabol) and 44.60% (off Mumbai 1); silt 33.93% (off Mumbai 1) and 63.93% (Dhabol) and clay 21.48% (off Mumbai 1) and 39.24% (Veravel), Clayey silt being still the predominant textural class.

During *FORVSS* 228&233 along west coast, 47 stations were examined for sediment nature. The most important textural class noticed at a great majority of stations (19) during that time was clayey silt. However, there was considerable variation in composition. At 200 m of entire west coast, sand (%) varied between 24.25% (veravel) and 81.35% (Kochi); silt 1.46% (Kochi) and 55.04% (Veravel) and clay 9.88% (Trivandrm) and 25.60% (Coondapore). From the south west coast the sand (%) varied between

48.58% (Kannur) and 81.35% (Kochi); silt 1.46% (Kochi) and 34.50% (Mangalore) and clay 9.88% (Trivandrm) and 25.60% (Coondapore). The predominant textural classes within this depth were silty sand, clayey sand and sand. At the north west coast sand (%) varied between 24.25% (veravel) and 75.02% (Dhabol); silt 2.89% (Dhabol) and 55.04% Veravel) and clay 11.61% (Ratnagiri) and 22.09 % (Dhabol). The predominant textural classes within this depth were silty sand, clayey sand and sand. In 500 m depth, sand (%) varied between 7.21% (Mangalore) and 83.63% (Kollam); silt 7.63% (Dhabol) and 66.29% (Kannur) and clay 6.67% (Karwar) and 31.53% (Veraval), clayey silt was most predominant textural class. Others were silty sand and sand. In southern transects from 500 m depth sand (%) varied between 7.21% (Mangalore) and 83.63% (Kollam); silt 7.73% (Kollam) and 66.29% (Kannur) and clay 6.67% (Karwar) and 27.30% (Mangalore), clayey silt was most predominant textural class. From northern transects sand (%) varied between 7.90% (Veravel) and 63.84% (Dhabol); silt 7.63% (Dhabol) and 61.65% (Goa) and clay 19.82% (Porbander) and 31.53% (Veraval), clayey silt was most predominant textural class from northern west coast. Within depths 1000 m, sand (%) varied between 2.26% (Veravel) and 35.56% (Cape); silt 3.55% (Ratnagiri) and 67.05% (Kochi) and clay 16.54% (Ratnagiri) and 39.80% (Mangalore), the predominant textural class being clayey silt followed by sandy silt. In southern transects from 1000 m depth of west coast sand (%) varied between 3.39% (Mangalore) and 35.56 % (Cape); silt 43.79 % (Cape) and 67.05% (Kochi) and clay 20.38% (Coondapore) and 39.80% (Mangalore), predominant textural class being clayey silt followed by sandy silt. From north west coast sand (%) varied between 2.26% (Veravel) and 79.91 % (Ratnagiri); silt 3.55 % (Ratnagiri) and 65.49% (Veravel) and clay 16.54% (Ratnagiri) and 35.25% (Veravel), predominant textural class being clayey silt followed by sandy silt.

During *FORVSS* 254 along west coast 46 stations were examined for sediment nature. The most important textural class noticed at a great majority of stations (25) during that time was clayey silt followed by sand. However, it showed considerable variation in composition. At 200 m, sand (%) varied between 4.59% (Porbander) and 94.16% (Trivandrum); silt 3.68% (Trivandrum) and 70.94% (Veravel) and clay 2.16 % (Trivandrum) and

27.28% (Porbander). The textural classes obtained were sand, silty sand, and clayey silt. From south west coast sand (%) varied between 47.29% (Coondapore) and 94.16% (Trivandrum); silt 3.68% (Trivandrum) and 38.41 % (Coondapore) and clay 2.16% (Trivandrum) and 17.27% (Kannur).The major textural class was sand and silty sand. From the north west coast sand (%) varied between 4.59% (Porbander) and 90.34% (off Mumbai 2); silt 4.60% (off Mumbai 1) and 70.94 % (Veravel) and clay 2.62% (off Mumbai 1) and 27.28% (Porbander). Majority of stations from 200 m depth of north west coast was sandy in nature. All the other stations showed sandy silt sediment. At 500 m, sand (%) varied between 3.04% (Mangalore) and 90.46% (Kollam); silt 5.40% (Kollam) and 76.07% (Mumbai 2) and clay 4.15% (Kollam) and 22.89 % (Ponnani). From the south west coast sand (%) varied between 3.04% (Mangalore) and 90.46% (Kollam); silt 5.40% (Kollam) and 74.77% (Mangalore) and clay 4.15% (Kollam) and 22.89% (Ponnani). From north west coast sand (%) varied between 4.49% (Mumbai 2) and 46.88% (Porbander); silt 37.81% (Porbander) and 76.07% (Mumbai 2) and clay 15.30% (Porbander) and 21.20 % (Dhabol). The predominant textural class was clayey silt. For depths 1000 m, sand (%) varied between 0.72% (Mumbai 2) and 30.91% (Cape); silt 53.64% (Cape) and 75.23 % (Mumbai 2) and clay 15.45% (Cape) and 26.40% (Porbander). From southern part of west coast sand (%) varied between 2.56% (Kochi) and 30.91% (Cape); silt 53.64 % (Cape) and 74.77 %(Ponnani) and clay 15.45% (Cape) and 25.41% (Kannur), The predominant sediment texture was clayey silt and silt. In northern part of west coast sand (%) varied between 0.74% (Mumbai 2) and 14.61% (Dhabol); silt 61.86 % (Dhabol) and 75.23% (Mumbai 2) and clay 18.39% (Ratnagiri) and 26.40%.

### **III.2.5.Organic matter** (Figure III.5)

Overall, sediment organic matter (%) during *FORVSS* **219 &225** for entire west coast varied between 0.95% (Mangalore 200 m) and 11.94% (Goa, 500 m) with a mean value of 5.04±2.71%. The organic matter percentage tends to increase with depth. In the case 200 m depth range, organic matter (%) varied between 0.95% (Mangalore) and 5.19% (Mumbai 1) (mean 2.87±1.36%); 500 m, 1.96% (Cape, Trivandrum) and 11.94% (Goa) (mean

6.12±3.21%); 1000 m, 3.66% (Karwar) and 9.39% (off Mumbai 2) (mean 6.18±1.87%) .

Based on mean percentage value of organic matter for each of the depth categories, it was possible to show differences between northwest and southwest locations. The organic matter percentage of cruise 219 and 225 shows relative higher organic matter percentage towards northern part of the west coast. At 200 m depth organic matter percentage of south west coast ranged from 0.95% (Mangalore) to 4.75% (Cape) with a mean percentage 2.16±1.16% where as organic matter percentage variation of north west coast at 200 m depth was from 2.52% (Veravel) to 5.16% (Porbander) with a mean percentage 3.78±1.05%. In 500 m depth stations, organic matter percentage of south west coast ranged from 1.96% (Cape, Trivandrum) to 5.52% (Ponnani) with a mean percentage 3.81±1.29%. The organic matter percentage variation of north west coast at 500 m depth stations was from 4.52% (Off Mumbai 1) to 11.94% (Goa) with a mean percentage 8.76±2.63%. At 1000 m depth stations organic matter percentage of south west coast ranged between 4.18% (Mangalore) to 9.15% (Trivandrum) with a mean percentage 5.31±1.70% where as at north west coast the organic matter percentage varied 5.0% ( veravel) to 9.39% (Off Mumbai 2) with a mean percentage 7.30±1.52%.

During *FORVSS* **228&233** organic carbon along EAS margin varied between 0.83 % (Kochi and Mangalore-200 m) and 12.88% (Mumbai 2, 1000 m) with an over all mean value 5.47±3.22%. In the case of 200 m depth range, organic matter (%) varied between 0.83% (Kochi, Mangalore) and 6.33% (Ratnagiri) (mean 2.81±1.26%); 500 m, 0.95% (Mumbai 1) and 12.82% (Mumbai 2) (mean 6.30±3.46%);1000 m, 2.20% (Porbander) and 12.88 % (Mumbai 2) (mean 7.14±2.59%). It is noteworthy that organic matter levels remained increasing with depth. Notably high values of organic matter level have been observed from stations off (Mumbai 2, Dhabol, Mumbai 1) 1000 m and (Mumbai 2, Goa, Ratnagiri, Ponnani) at 500 m depth.

During *FORVSS* 228&233 mean percentage value of organic matter for each depth categories, showed differences between northwest and southwest locations. The organic matter percentage of cruise 228 and 233 shows relative higher organic matter percentage towards northern part of the west coast. At 200 m depth organic matter percentage of south west coast ranged from 0.83% (Mangalore) to 3.32% (Karwar) with a mean percentage 2.03±1.01% where as the organic matter percentage variation of North West coast at 200 m depth was from 2.67% (Goa) to 6.32% (Ratnagiri) with a mean percentage 3.97±1.57%. In the 500 m depth stations, organic matter percentage of south west coast ranged from 1.72% (Kollam) to 9.49% (Ponnani) with a mean percentage 5.97±2.28%. The organic matter percentage variation of north west coast at 500 m depth stations was from 0.95% (Off Mumbai 1) to 12.82% (Off Mumbai 2) with a mean percentage 6.73±4.76%. At 1000 m depth stations organic matter percentage of south west coast ranged between 5.70% (Cape) to 8.19% (Kochi) with a mean percentage 6.79±0.78% where as at north west coast organic matter percentage varied 2.20% (Porbander) to 12.88% (Off Mumbai 2) with a mean percentage 7.60±3.95%.

During *FORVSS* **254** organic matter from 0.95 % (Cape, 200 m) and 17.56% (Mumbai 2, 500 m) with a mean value of 7.90±4.14%. Organic matter showed a trend of increased values at 500 m and 1000 m depth stations when compared to 200 m. When depth stations of 500 m and 1000 m taken in to consideration, 500 m depth stations showed notably high values (Mumbai 2, Dhabol, Mumbai 1, ponnani). The mean values for different depth ranges were as follows 4.72±3.18% (200 m); 10.21±4.23 % (500 m); 8.84±2.77% (1000 m). From 200 m depth range of entire west organic matter varied from 0.95% (Cape) to 11.63% (Dhabol). At 500 m depth west coast as a whole organic matter ranged from 2.02% (Veravel) to 17.56% (Mumbai 2). In 1000 m depth of entire west coast variation of organic matter was from 3.32% (Porbander) to 11.87% (Mangalore and Ponnani).

From third sampling (*FORVSS* 254) based on mean percentage value of organic matter for each depth categories, it was possible to show differences between northwest and southwest locations. The organic matter percentage of third sampling at 200 m and 500 m shows relative higher organic matter percentage towards northern part of west coast. At 200 m depth organic matter percentage of south west coast ranged from 0.95%

(Cape) to 7.71% (Karwar) with a mean percentage 3.59±2.44% where as the organic matter percentage variation of north west coast at 200 m depth was from 2.73% (Off Mumbai 1) to 11.63% (Dhabol) with a mean percentage6.17±3.59%. In the 500 m depth stations, organic matter percentage of south west coast ranged from 4.51% (Kollam) to 12.22% (Ponnani) with a mean percentage 9.59±2.47%. The organic matter

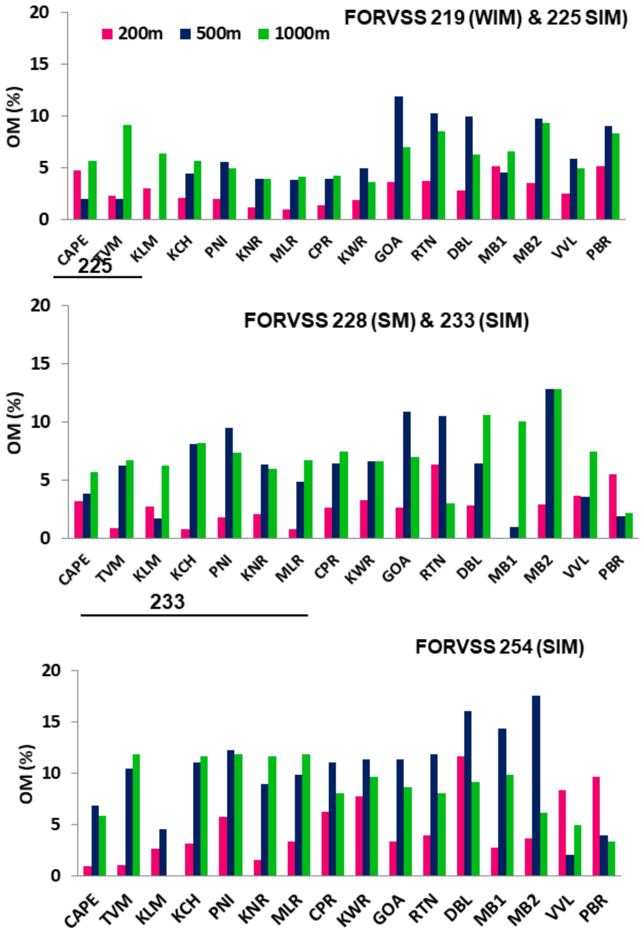


**Figure III.5.** Sediment organic matter along EAS margin

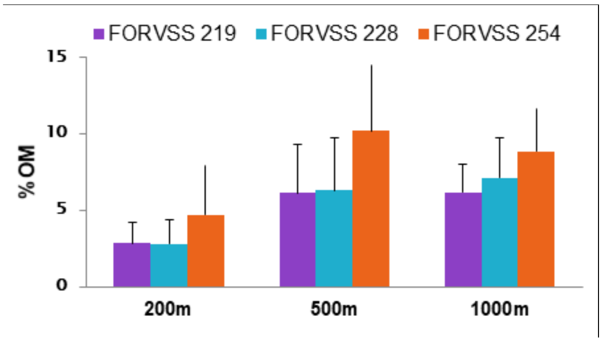


**Figure III.6.** Depth wise distribution of mean organic matter along EAS margin

percentage variation of North West coast at 500 m depth stations was from 2.02% (Veravel) to 16.02% (Dhabol) with a mean percentage 11.02±5.94%. At 1000 m depth stations organic matter percentage of south west coast ranged between 5.82% (Cape) to 11.87% (Ponnani, Mangalore, Cape) with a mean percentage 10.30±2.28 % where as at north west coast organic matter percentage varied 3.32% (Porbander) to 9.85% (Off Mumbai1) with a mean percentage 7.17±2.40%.

### III.2.6.Principal Component Analysis (PCA)

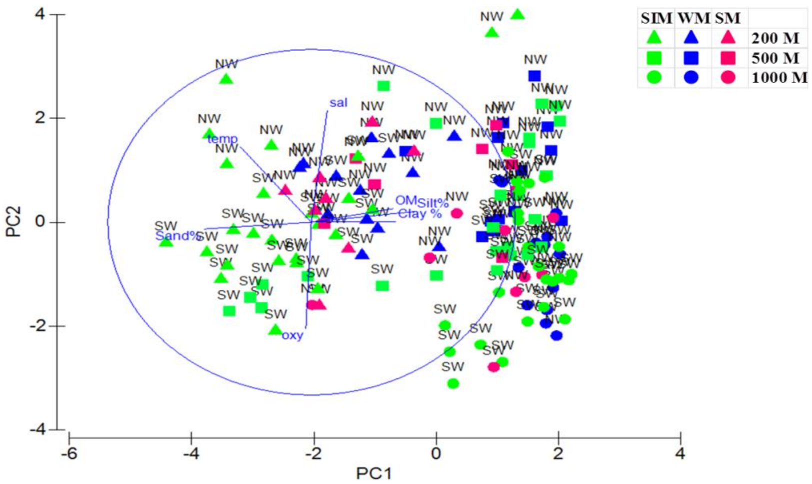


**Figure III.1.** Principal Component Analysis (PCA) ordination of environmental variables along EAS margin

PCA is a useful tool enabling ordination of environmental variables in ecology analysing data sets to summarize their main characteristics. Sets of seven environmental variables were subjected to PCA to obtain detailed information on the pattern of variation. The pattern of variation in environmental data in relation to depth and season was depicted in PCA ordination using two important PC axes [Figure III.1]. The Eigen value and ratios of explained variances are presented in Table III.1 & 2, where principal component variance is in progressive decline.

| PC | Eigenvalues | %Variation | Cum.%Variation |
|---|---|---|---|
| 1 | 3.31 | 47.3 | 47.3 |
| 2 | 1.78 | 25.5 | 72.7 |
| 3 | 0.729 | 10.4 | 83.1 |
| 4 | 0.522 | 7.5 | 90.6 |
| 5 | 0.325 | 4.6 | 95.2 |

**Table III.1.** Eigen values and percentages of explained variability of each axis

| Variable | PC1 | PC2 | PC3 | PC4 | PC5 |
|---|---|---|---|---|---|
| **Temperature** | 0.349 | 0.437 | -0.254 | 0.305 | -0.572 |
| **Salinity** | -0.078 | 0.647 | 0.043 | 0.512 | 0.393 |
| **Oxygen** | 0.027 | -0.615 | -0.064 | 0.779 | -0.055 |
| **Organic Matter** | -0.403 | 0.078 | 0.684 | 0.184 | 0.052 |
| **Clay %** | -0.415 | 0.003 | -0.664 | 0.037 | 0.391 |
| **Silt%** | -0.509 | 0.062 | -0.037 | 0.033 | -0.535 |
| **Sand%** | 0.527 | -0.04 | 0.143 | 0.037 | 0.271 |

**Table III.2.** Coefficients in the linear combinations of variables making up PC's)

The first three components represent most of the total variance which explained 83.1% of total variance between stations. Sand and silt percentage contributed significantly to the PC1 (Eigen value 3.31), which accounted for 47.3% of variance in data. Second axes (Eigen value 1.78), which explained 25.5% of total variance, consisted primarily of hydrographical variables, viz. bottom water temperature, salinity and DO. PC3 ordination was contributed by organic matter and clay percentage. The PC4 axis was consisted primarily of hydrographical features such as oxygen and salinity whereas PC5 axis was chiefly of temperature and textural component silt percentages. The sand percentage ordinated in PC1 axis shows greater quantity towards shallow depth. Also a higher temperature is observed from shallow sites. Salinity is also high in 200 m – 500 m sites. Clay, silt and organic matter percentages were observed from deeper 500 and 1000 m depth sites. The oxygen concentration of bottom water found to be higher in deeper stations especially in the southern region.

## III.3. DISCUSSION

In the present study a decrease in water temperature with water depth was observed during the three cruises. However latitudinal variation in temperature was limited, though a slight increase was observed towards the northern region. In deeper waters of Arabian Sea an increase in temperature was noticed from south to north by Qasim (1982) albeit a decrease of temperature noticed in the surface waters. Recently, the study on the Indian Ocean circulation (Benny and Mizuno, 2000) has also showed a warm water advection from equator towards Dwaraka region. A slightly higher temperature recorded in the southern most Arabian sea may be related to the intrusion of the Arabian Sea mini warm pool developed prior to the onset of south west monsoon season (Seetaramayya and Master, 1984).

Among the hydrographical parameters, salinity showed least variation with respect to latitudinal as well as depth wise scale. Eventhough small, a general increase in salinity at 500 m depth was observed. Latitudinally it showed a progressive increase from south to north. The higher salinity noticed in the north west coast can be due to the inflow of the waters of higher salinity from the north (Wyrtki, 1971). Agreeing to Schott and Fischer (2000), there is a south ward transport of Persian Gulf water below the surface layer in the 200-500 m depth range and that of Red Sea water below 500 m. The Persian Gulf water mass is warmer and more saline which reaches the northern region and have higher temperature rather than the southern region in this depth strata (Wyrtki, 1971). The Red Sea and Persian Gulf water intrusion to the Arabian Sea at the sub surface level leave this semi enclosed basin more saline than any other part of the Indian Ocean. According to Varma et al., (1980) Persian water was present at about 300 m. During the north east monsoon season, low saline water of Bay of Bengal joins the northward flowing equatorial Indian Ocean water and jointly flows as a northward surface current along the west coast of India (Pankajakshan and Ramaraju, 1987). The lower salinity of the area might be due to the invasion of the low saline waters from Bay of Bengal to the south west coast (Darbyshire, 1967; Wyrtki, 197). Hareesh Kumar and Mathew (1997) noticed that this low saline water could be traced up to $17^0$N.

The dissolved oxygen concentration showed a general increase with respect to depth. In general west coast as a whole, the level of the dissolved oxygen during the sampling period showed a decrease with depth till mid depths (600-800 m) and the deeper layers at 1000 m depth strata were more oxygenated. However the variations were more prominant regionally than depth wise. In the southern transects the DO values increased gradually with increasing depth but in the northern transects the dissolved oxygen values were higher in 1000 m depth and 200 m depth when compared to 500 m depth stations. Many of the depth stations in all the depth strata showed dissolved oxygen values <1ml/l and even <0.5ml/l. The northern stations showed considerable depletion of oxygen. This depletion of oxygen in the northern sector may be attributed to the oxygen minimum layer described by Sen gupta et al., (1977, 1980) and Quasim (1982). Permanently hypoxic water masses in the open ocean, referred to as oxygen minimum zones are impinging on a large area of seafloor along the continental margins of the eastern pacific, Indian and western Atlantic Oceans (Helly and Levin, 2004). Earlier Ingole and Koslow (2005) reported a decreasing trend in the oxygen concentrations towards the northern region along the Arabian Sea and Bay of Bengal. The area characterised by strong up welling. Oxygen minimum zones usually form where high surface productivity leads to increased organic matter flux which sinks and degrades, depleting the oxygen within the water column. OMZ formation is also strongly subjective to sluggish circulation, long residence times and the existence of oxygen-depleted source waters (Sarmiento et al., 1988). One of the largest and thickest OMZs of the world occurs along the Arabian Sea, where 285,000 $km^2$ of continental margin floor is impacted by oxygen minimum waters, between depths of 150 and 1500 m (Cowie et al., 1999; Helly & Levin, 2004; Acharya & Panigrahi, 2016) and the Arabian Sea OMZ accounts for 30% of the world's margins that are impacted by extreme hypoxia (<0.2ml/l; Helly & Levin, 2004). The present findings are in accordance with these previous studies.

The nature of substrata along the EAS margin showed considerable variation. Different types of substrata namely clayey silt, sandy silt, sand, clayey sand, silty sand, silt, silty clay were observed from the EAS margin as a whole. Though, seven types were observed, clayey silt, silty sand, sandy silt, and sand was the major sediments. Sediment texture in the continental slope region showed a heterogeneous pattern of distribution. It was found that in many stations clayey silt fractions dominated the continental slope regions. As expected with the increase in depth, sand seemed to replaced by the finer sediment, mainly with silt or fine sediment fraction increased with depth. In general sediment grain size varies as a function of water depth (Bennet et al., 1999). This was in accordance with the studies from the studies from the continental margins of other ocean sites including Weddel sea, off Antarctica (Isla et al., 2006). The present study showed that sand fraction was negatively correlated with depth. The sediment texture at 200 m depth strata was sandy and the deeper stations showed less sand content. In the present study the silt fraction of the sediment positively correlated with depth. A bulk quantity of the sediment load is delivered to the oceans by rivers. Such input of terrigenous sediments shows strong latitudinal trends which results in a distinct pattern of increasing accumulation rates from north to south. Enormous quantity of sediments (about 5% global runoff) is transported to the oceans by the rivers in India (Chakrapani et al., 1995). Thorne et al., (1993) reported that the texture of sediment delivered at the river mouth was silty clay with only 15-20% of usually fine to very fine sand. Coarse sediment fraction studies along the west coast of India by Murty et al., (1968) also have showed that there existed a separate zonation with regard to their distribution, and much of the slope sediments were covered with silty clay or clayey silt fractions. Regional studies of the marine sediments from the northern Indian Ocean (Kolla et al., 1981) also have shown the influence of major rivers of the west coast of India on deep sea sedimentation. As described by Rao and Rao (1995), the Indus derived sediments are conveyed on to the outer shelf of western India and to a lesser extent to the continental slope area.

The distribution of organic carbon along the Arabian Sea was discussed earlier by various workers (Marchig, 1972; Kolla et al., 1981; Paropkari et al., 1987, 1992, 1994; Calvert et al., 1995). Previous studies observed higher concentrations of organic carbon along upper slope (150–1500 m depth) sediments where the oxygen minimum zone (OMZ) impinges on the sea floor (Marchig, 1972; Von Stackelberg, 1972; Kolla et al., 1981; Paropkari et al., 1987, 1992, 1993a,b, 1994). In the Arabian Sea, organic carbon enrichments of >8% with maxima of up to 12–16% (Paropkari et al., 1987, 1992, 1993a,1994) are encountered even in areas where productivity is low to moderate (<0.50 g C -2 day-1). ). Cowie et al., (2009) opined that it is common to find sediments comprising 4 to 20% of organic carbon in OMZs. Within OMZ impacted areas, sediments are characterised by a high organic carbon content (Ingole et al., 2010) and preservation (Smallwood et al., 1999; Vandewiele et al., 2009; Woulds and Cowie, 2009). Ingole et al., (2010) observed silty sediments with higher organic carbon from 1001m, Coondapur (4.4%). Mendez (2007) reported a organic matter maxima of 20% from the south eastern Gulf of Carolina. In the eastern Arabian Sea, Rao and Wagle (1997) reported organic content up to 8% in the margin sediments. Paropkari et al., (1987) opined that the organic matter present in the continental margin of western India is principally composed of marine origin.

Present study showed considerable variation of sediment OM with respect to depth as well as latitude. The distribution of organic matter on the EAS margin during the present investigation showed that in general the organic matter in the sediment increased as the depth increased. In general, more organic matter is retained in the finer sediments. Most of the stations showed clayey silt sediment nature. Especially the deeper stations showed considerably high percentages of finer particles like silt and clay. In accordance to this observation, present study has recorded low organic matter value in the depth range of 200 m where the percentage of sand was comparatively high. The organic matter content in the sediment was high, above this depth range. However, the highest mean value was noticed in the 500 m depth. Calvert et al., (1995) has recorded that the inner shelf sediments of eastern Arabian Sea possibly have low organic matter content because of the heavy dilution of marine organic material by relatively organic poor clays. Latitudinal variation in the amount of organic matter among the stations at 200 m depth region was not prominent. However at 500 m and 1000 m depth stations the organic matter showed a gradual increase towards the northern region. The organic matter in the sediments ranged between 0.83- to 17% which was fairly higher when compared to the organic realm. Paropkari et al., (1987, 1994) have reported organic carbon enrichments of 5-8% with maximum up to 12-16% even in areas where productivity is low to moderate.

The organic matter content in sediments depends on three factors such as (Trask, 1939): (i) the quantity of organic matter produced in the surface waters in a given unit of time, (ii) degree of conservation or preservation of organic matter and (iii) rate of sedimentation. The higher organic matter in the shallower and deeper areas may be attributed to the fine-grained nature of the sediments and to the variation in the benthic productivity (Paropkari et al., 1987). While studying the organic matter in the Honavar area, Narayana and Venkatesh Prabhu (1993) noticed that the grain size and biological productivity are the crucial contributing factors for the variation in OM.

Organic matter which is not stored on the shelf is generally transferred by waves and currents over the shelf edge on to the continental slope and canyons (Fisher et al., 1996). Since continental slopes are important depocentres of organic carbon (Jahnke, 1990). Depth wise distribution of the organic matter mirrors the existence of variable conditions along the EAS margin through different periods. The sediment organic carbon contents in the Atlantic slope also increased with increasing water depth and decreasing grain size (Bennet et al., 1999).

It is widely accepted that in sediments, the organic matter is mainly sticked to the fine grained fraction. Organic matter in the sediment depends on the texture of the sediments and higher organic matter content is associated with finer fractions of sediment than coarser ones. The present study has shown relatively high OM values in 500 m depth zone. The association between organic matter and grain size is considered to be due to the adsorption capacity of organic matter onto clays and the similarity in the settling velocity of organic particles and clays (Kemp, 1971) whereas, Kidwai and Nair (1972) have appended the associated reducing condition, to aid the preservation of organic matter. Hobbs (1982) has reported that association between clay content and the organic carbon is probably the result of great surface area presented by a large volume of clay particles and of the chemically active nature of clays. Ransom et al., (1998) also found that organic matter is mainly attached to clay materials. As a result clay and silty clay have relatively higher organic material content rater than sand and clayey sand (Paropkari, 1979; Paropkari et al., 1978; De Haas et al., 2002).

Sediment organic carbon is mainly formed by the total carbon flux, the rate of mixing and the organic matter degradability. Kolla et al., (1981) have stated that the high organic matter content in the sediments of the EAS margin is primarily due to its preferential preservation, which result from the impingement of low oxygenated water on the sea floor and from the high sedimentation rates. But Calvert et al., (1991) suggest that anoxic condition in the water column may not be a prerequisite for the preservation of organic matter in marine sediments. Organic carbon reaches maximum concentrations at 200 m 1600 m depth, where most of the depth is influenced by a strong oxygen minimum zone. Most of the organic matter that reaches down is mineralized by benthic animals. Structural individualities of benthic communities can give important indirect and time bound information about the quantity and quality of organic materials settling the area and the burial of organic matter in the sediments (Flach and Heip, 1996).

The biochemical composition of the organic matter could be assumed as an estimate of the material possibly available to benthic biota (Danovaro et al., 1993; Fabiano et al., 1995). Understanding of sub littoral meiobenthos has increased considerably during recent decades, and attempts have been made to relate standing stocks with various environmental factors. The flux of organic matter from surface productivity to the seafloor has been demonstrated to employ considerable control on benthic standing stocks (Soltwedel, 2000). The energy content of sedimentating organic matter generally decreases with increasing water depth because of the degradation processes within the water column. The increase of organic matter could be attributed to the preservation of deposited organic matter by fine grained nature of the sediments and similarity in settling velocity of fine grained sediments and organic matter (Trask, 1939) coupled with higher rates of sedimentation in these regions, which prevents its destruction by rapid burial (Subbarao, 1960).

# Chapter IV

## STANDING CROP OF MEIOBENTHOS

Contents

### IV. 1. INTRODUCTION

Investigations on benthic communities have a long history. Written records of significant biological observations concerning marine organisms began with the early Greek philosophers, most notably Aristotle. Renewed interest in natural history began to increase by the 16th century and over the next few hundred years, many studies carried out by amateur naturalists. Investigations with respect to benthos advanced well only in the late 18th and early 19th centuries when the use of various dredging devices became popular. A new era in benthic study began during early 1900's. It was connected with the detailed investigations of Petersen (1913, 1915 and 1918) and Petersen & Jensen (1911) in the Danish waters. Their work initiated a number of other investigations on benthic fauna in different parts of the world. But most of these studies were restricted to macrobenthos owing to the relative ease in investigation.

The works of Remane (1933), Mare (1942) and Weiser (1953, 1960) on meiobenthos have been considered as pioneer investigations in the field of meiobenthology. The smallest components of metazoan life, the meiofauna, are benthic organisms classically defined as passing through a 500 µ mesh and being retained on a 63 µ mesh. In shallow-water habitats, meiofauna can contribute significantly to the benthic standing stock and also serve as food for secondary consumers (Coull, 1988; Giere, 1993). The composition and development of the meiofauna in various biotopes depend greatly on the prevailing environmental settings. The environmental variables which they encounter are manifold and complex. One of the important environmental factor is grain size which is in turn determine the interstitial space in the sediment. Many investigations revealed that grain size can act as a distribution barrier among meiofauna (Wieser, 1956, 1959). A significant factor in the nutritional biology of the meiofauna is the availability of organic matter. Their food may consist of organic detritus, bacteria, diatoms and protozoans. Benthic bacteria have long been thought to be a major food source for meiofauna (Boucher & 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 in particular for nematodes (McIntyre et al., 1970; Tietjen et al., 1980; Montagna et al., 1983) and copepods (Marcotte, 1986). Reduced meiofaunal abundance in regions with low concentrations of organic matter and bacterial density pinpoint their role as the primary food source (Montagna et al., 1983; Montagna, 1984; Rudnick et al., 1985).

Studies on the quantification of organisms was introduced to deep sea research by Zenkevitch (1963) on the Soviet R. V. Vityaz, followed by the classic work of Sanders et al. (1965) on macrofauna. The subtidal benthos show large spatial and temporal variations in standing crop (Jumars & Gallagher, 1982; Rowe, 1983). Compared to the macrofauna, little is known about the diversity of the meiofauna in marine sediments (Higgins & Thiel, 1988; Giere, 2009). 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 & Reise, 2000). Only the future will tell how many species there are and which environments are more diverse. Meiofaunal densities and biomass are generally known to decrease with increasing water depth. Several environmental and biological factors play an important role in determining distribution and abundance of meiofauna. The richness and diversity of benthic fauna in a site can be an excellent indicator of environmental characteristics of that region.

Our knowledge of the benthic realm lags behind that of terrestrial environment. Among the limited studies, a majority have been on subtidal and shallow water ecosystems, while giving limited attention to deep sea bottom fauna. Similarly, much information is available on the benthos of temperate zones, information along the tropics especially, that of Indian waters is insufficient. Investigations of Annandale (1907) in brackish water ponds of Port Canning, Bengal turned over a new leaf in the history of Indian benthic explorations. Although studies on bottom living organisms have been made in the early part of the 20th century, the qualitative and quantitative work using suitable sampling equipment is more recent. The knowledge on benthos along the coasts of India has increased considerably during recent decades. As far as west coast of India is concerned, majority of the benthic studies have been localized in and around various estuaries and in coastal waters. Very few studies have been attempted by meiobenthologists of India in a comprehensive manner covering a vast area. Among these, the first was that of Sajan et al., (2010), which covered the entire western continental shelf of India from Cape Comorin to Dwaraka, and from 30 m to 200 m depth. They analysed the standing stock of meiofauna in relation to environmental variables. The study reported meiofaunal abundance range from 8 Ind.10 cm$^{-2}$ to 1208 Ind.10 cm$^{-2}$ and biomass range from 0.07 mg 10 cm$^{-2}$ to 6.11 mg 10 cm$^{-2}$ from the western continental shelf as a whole. In their study, the dominant meiofaunal group, the nematodes contributed 88 % of the total abundance and 44 % of the biomass. They also reported harpacticoid copepods as second major taxon, contributing 8 % of both biomass and abundance. Ansari et al., (2017) reported an abundance range of meiofauna from 25 Ind.10 cm$^{-2}$ to 164 Ind.10 cm$^{-2}$ from 8 stations located in the OMZ areas of western continental margin, northern Arabian Sea.

In the Indian scenario, it is clear that there are limited studies on the standing stock of meiofauna and their distribution pattern. The present investigation will provide a base line data on the spatio-temporal pattern in the distribution of meiofauna and their environmental linkage along the deep continental margin of the north eastern Arabian Sea (NEAS) between 200 and 1000 m. This chapter describes the patterns in abundance and biomass of meiofauna in spatio-temporal scales along with the quantitative contribution of various taxonomic groups of meiofauna.

## IV. 2. RESULTS

Quantitative as well as qualitative data on the meiofauna along north eastern Arabian Sea margin (western continental slope of India, Latitude 15.25ºN-21.30ºN; Longitude 67.28ºE- 72.48ºE) were acquired by analysing, 125 core samples collected over an extensive latitudinal (15. 25’N to 21. 30’N) as well as bathymetric range (200 to 1000 m water depth), during three surveys (FORVSS 219, 228, 254) in three seasons [Winter Monsoon (WM), Summer Monsoon (SM), and Spring Inter Monsoon (SIM)] from 21 sampling sites.

Abundance of meiobenthos during the study is given in Tables IV. 9-11. Twelve diverse taxonomic groups were encountered among meiofauna during the study. Nematodes (49 %) were the dominant group, followed by foraminiferans (43 %) and crustaceans (5 %) (Figure. IV.1). Since individual contribution of copepods, isopods, ostracods, halacarid mites and nauplius larvae were meagre, they were together treated as ‘crustaceans’; other groups like kinorhynchs, ciliates, terebellarians, gastrotrichs, gnathostomulids and polychaetes were also represented and accounted for 3 % of the total abundance. Over all the abundance of meiofauna in the study area varied between 0 (FORVSS 228, Mumbai 1, 520 m) and 4755 Ind.10 $cm^{-2}$ (FORVSS 219, Dhabol, 200 m) with an overall mean of 232.4±614.2 Ind.10 $cm^{-2}$. Biomass of meiofauna was estimated on wet weight basis after sorting and enumeration of all organisms into major groups viz. nematodes, foraminifera, crustacea, and other organisms. Only metazoan meiofauna was considered for biomass estimation, while foraminiferans (protozoan meiofauna) were excluded. Biomass of metazoan meiofauna ranged from 0 (FORVSS 228, Mumbai 1, 500 m; FORVSS 254, Dhabol, 200 m) to 4.181 mg $10cm^{-2}$ (FORVSS 219, Dhabol, 200 m) with a mean of 0.492±0.659 mg $10cm^{-2}$ (Tables IV. 4-6). In the present study as a whole, nematodes contributed 69 % to total biomass of metazoan meiofauna, while crustaceans and other groups contributed 18 % and 13 %, respectively (Figure IV. 2).

A statistical tool, ANOSIM was performed to test for significant variations in abundance and biomass of meiofauna with depth, latitude, season etc.. Numerical abundance of meiofauna found to decrease drastically from winter monsoon to spring inter monsoon. The variation among winter monsoon (FORVSS 219) and spring inter monsoon (FORVSS 254) was more prominent (ANOSIM Global R=0.413, P=0.2 %) than that of winter monsoon & summer monsoon (FORVSS 228) (R=0.352, P=0.1 %).

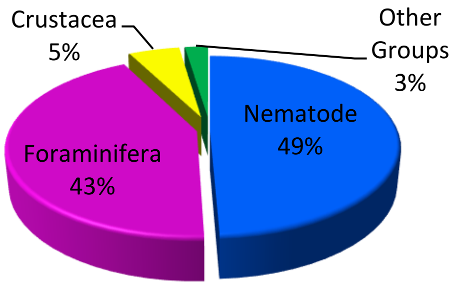


**Figure IV.1.** Composition of total meiofauna (protozoan & metazoan) abundance collected during the study (all depths) as a whole

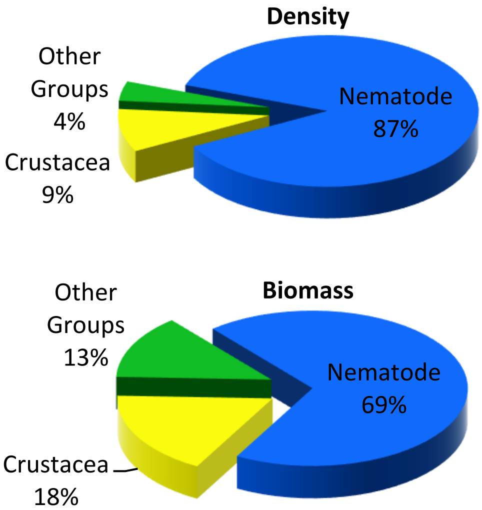


**Figure IV. 2.** Composition of total metazoan meiofauna abundance & biomass during entire study (all depths)

Highest of variation in abundance was observed from summer monsoon to spring inter monsoon (R=0.543, P=0.2 %). During FORVSS 254 (May 2007, SIM), reasonably low abundance was observed. With latitudes, variation in abundance were statistically significant (R= 0.323; P =0.1 %). Even though statistically not significant (R=-0.103; P=93.7 %), there variation in abundance was observed with depth as well. Biomass of meiofauna also varied significantly with season (R=0.264, P=0.1 %) and did not showed any significant variation with respect to depth (R=0.014, P=25 %).

### IV. 2. 1. Abundance of meiobenthos

Abundance is the number of individuals in a given area (or volume) and is widely used as an important characteristic of biological communities to infer relationships between the community and its environment.

**a) Bathymetric variation:** At 200 m depth, the mean abundance was 967±1718 Ind.10 $cm^{-2}$ in the WM (FORVSS 219). During SM (FORVSS 228) mean abundance at 200 m depth decreased to 375±301 Ind.10 $cm^{-2}$ and the lowest mean abundance for 200 m depth class from all the seasons sampled was reported in SIM, 128±140 Ind.10 $cm^{-2}$ (FORVSS 254) (Table IV.7; Figure IV.4). High mean abundance in the WM resulted from an exceptionally dense patch of meiofauna from a single station (Dhabol). The mean abundance at the 500 m depth group were 168±103 Ind.10 $cm^{-2}$, 242±279 Ind.10 $cm^{-2}$ and 53±41 Ind.10 $cm^{-2}$ for the WM, SM and SIM, respectively. At the 500 m depth category, abundance of meiofauna during WM shows a drastic drop down from 200 m whereas in SM and SIM, the bathymetric change in abundance was gradual (Table IV.7, Figure IV.4.). While the mean abundance at the 1000 m depth category were 143±81 Ind.10 $cm^{-2}$ (WM), 115±109 Ind.10 $cm^{-2}$ (SM) and 42±26 Ind.10 $cm^{-2}$ (SIM). Even though there was variation in numerical abundance among different depth classes of the three seasons sampled, none of them was statistically significant (R= -0.103; P =93.7 %).

Meiofaunal abundance in NEAS margin showed a decreasing trend with increase in depth, with a high abundance in the shallow 200 m sites (Table IV.7; Figure IV.3) and gradually decreasing towards higher depths. Even though meiofaunal abundance showed bathymetric variation irrespective of the season, it was statistically not significant (R=-0.103; P=93.7 %).

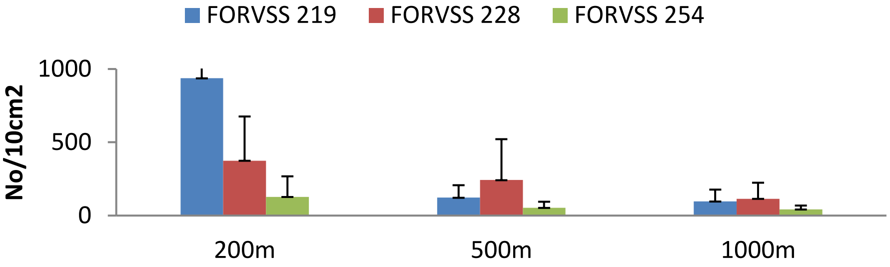


**Figure IV.3.** Mean abundance of meiofauna at the three depth classes

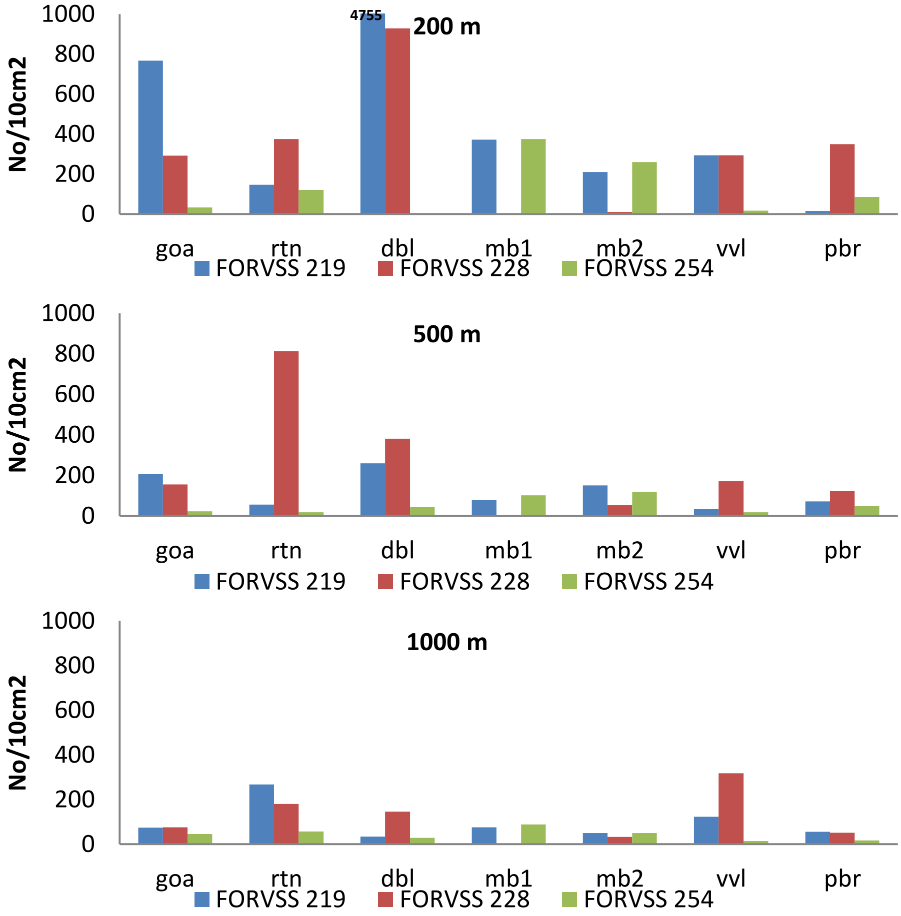


**Figure IV.4.** Abundance of meiofauna at each sampling site (for three depth classes in three surveys)

**b) Latitudinal and temporal variation:** The bathymetric transects in the study area were positioned about 1° apart. Distinctive distribution patterns and faunal composition of meiofauna was noticed at various transects. Abundance and biomass of meiofauna at each site during the three surveys is presented in Tables IV.1-6.

Latitudinal variation in numerical abundance of meiobenthos at each site is presented in Figure IV.4. The variation in abundance between latitudes were statistically significant (R= 0.323; P =0.1 %). Some transects showed considerable variation. The southwardly positioned transects, especially Goa, Ratnagiri and Dhabol had relatively high meiobenthic abundance, while the northernmost transect (Porbander), had the lowest abundance. In all transects, mean meiobenthic abundance decrease with increase in depth and were highest at the shallow sites (~200 m) and the reduction in abundance was not significant (R= -0.103; P =93.7 %) may be due to transect like Porbander, which showed lowest abundance at intermediate depth 500 m (74±84 Ind.10 cm$^{-2}$) instead of 1000 m. The mean abundance at 200 m depth category was lowest at Porbander (150±175.9 Ind.10 cm$^{-2}$) and highest at Dhabol (1895.2±2519.6 Ind.10 cm$^{-2}$). At the 500 m depth category, the lowest value was recorded at Mumbai 1 (60.2±53.4 Ind.10 cm$^{-2}$) and highest at Ratnagiri (295.9±448.4 Ind.10 cm$^{-2}$) and at 1000 m sites, the densities were lower at Porbander (40.82±21.31 Ind.10 cm$^{-2}$) and highest at Ratnagiri (168.35±105.62 Ind.10 cm$^{-2}$).

Temporal variation in abundance was more prominent at Goa and Dhabol 200 m. At these sites, high abundance was recorded during WM (FORVSS 219) 4755 Ind.10 cm$^{-2}$ and 767 Ind.10 cm$^{-2}$ respectively, while abundance was very low during SM (FORVSS 228) (929 Ind.10 cm$^{-2}$ and 292 Ind.10 cm$^{-2}$) and SIM (FORVSS 254) (34 Ind.10 cm$^{-2}$ and 2 Ind.10 cm$^{-2}$, respectively) (Figure IV.4.). At Ratnagiri 200 m, comparatively high abundance was recorded during SM (376 Ind.10 cm$^{-2}$), but during WM and SIM relatively low densities were recorded here (146 and 120 Ind.10 cm$^{-2}$ respectively). Mumbai 1 site shows rather low variation with regard to sampling survey (Figure IV.4.). Mumbai 2 has high abundance during WM (211 Ind.10 cm$^{-2}$) and during SIM (260 Ind.10 cm$^{-2}$) while at SM has very low numerical abundance (10 Ind.10 cm$^{-2}$). Veravel exhibited more or less similar abundance in WM and SM but extremely low abundance in SIM (16 Ind.10 cm$^{-2}$). The northernmost site Porbander shows high abundance during FORVSS 228 (349 Ind.10 cm$^{-2}$) while FORVSS 219 (15 Ind.10 cm$^{-2}$) and FORVSS 254 (86 Ind.10 cm$^{-2}$) shows rather low abundance.

At the intermediate depth category (500 m), relatively high abundance was recorded at Ratnagiri and Dhabol (813 and 381 Ind.10 cm$^{-2}$, SM). These two sites also showed considerable variation in abundance with the seasons. At this depth, majority of the sampling sites showed high meiofaunal abundance in SM and lowest abundance in SIM (Ratnagiri, Dhabol, Veravel and Porbander) (Tables 14). Goa, Mumbai 1 and Mumbai 2 consistently showed same trend in abundance distribution as that of 200 m depth category. At deeper sites (1000 m), abundance did not vary greatly between latitudes, with highest abundance at Ratnagiri (168 ±106 Ind.10 cm$^{-2}$) and lowest abundance at Porbander (41±21 Ind.10 cm$^{-2}$). Goa, Dhabol and Veravel showed high abundance in FORVSS 228 (SM) while lowest abundance is reported from FORVSS 254 (SIM). The deeper stations off Ratnagiri (267 Ind.10 cm$^{-2}$), Mumbai 2 (50 Ind.10 cm$^{-2}$) and Porbander (55 Ind.10 cm$^{-2}$) had highest abundance during FORVSS 219 and relatively lower densities were observed during FORVSS 228 and FORVSS 254 at these sites.

Between the seasons, numerical abundance of meiofauna along the NEAS margin were found to vary significantly. Overall, in the study area lowest abundance was recorded from SIM (range: 2-376 Ind.10 cm$^{-2}$ with a mean abundance of 128±140 Ind.10 cm$^{-2}$). A very high abundance of meiofauna was observed during WM with unusual peak in abundance at few sites (range: 15-4823 Ind.10 cm$^{-2}$ with a mean abundance of 967±1718 Ind.10 cm$^{-2}$). The meiofaunal abundance decreased drastically from WM (FORVSS 219) to SIM (FORVSS 254) (ANOSIM Global R=0.413, P=0.2 %) rather than the decrease from WM & SM (FORVSS 228) (R=0.352, P=0.1 %). In addition to a significant seasonal variation, abundance of meiofauna in the NEAS margin showed a significant variation towards latitudes (R= 0.323; P =0.1 %) with comparatively abundant fauna towards southern sites. In general meiofauna abundance decreased in the sites located towards the northern latitudes.

### IV. 2. 2. Biomass of metazoan meiobenthos

**a) Bathymetric variation:** Overall lowest mean biomass was found at 500 m depth (FORVSS 254; 0.152±0.138 mg $10cm^{-2}$) and highest at 200 m (FORVSS 219; 1.104±1.431 mg $10cm^{-2}$) (Figure IV.6). The variation of biomass of metazoan meiofauna among different depth groups was not statistically significant (Global R=0.014, P=25 %).

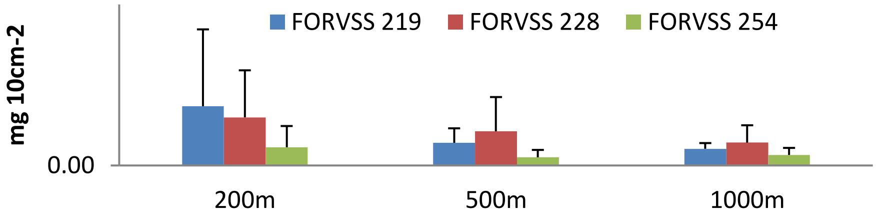


**Figure IV.5.** Mean biomass of meiofauna (for three depth classes in three surveys)

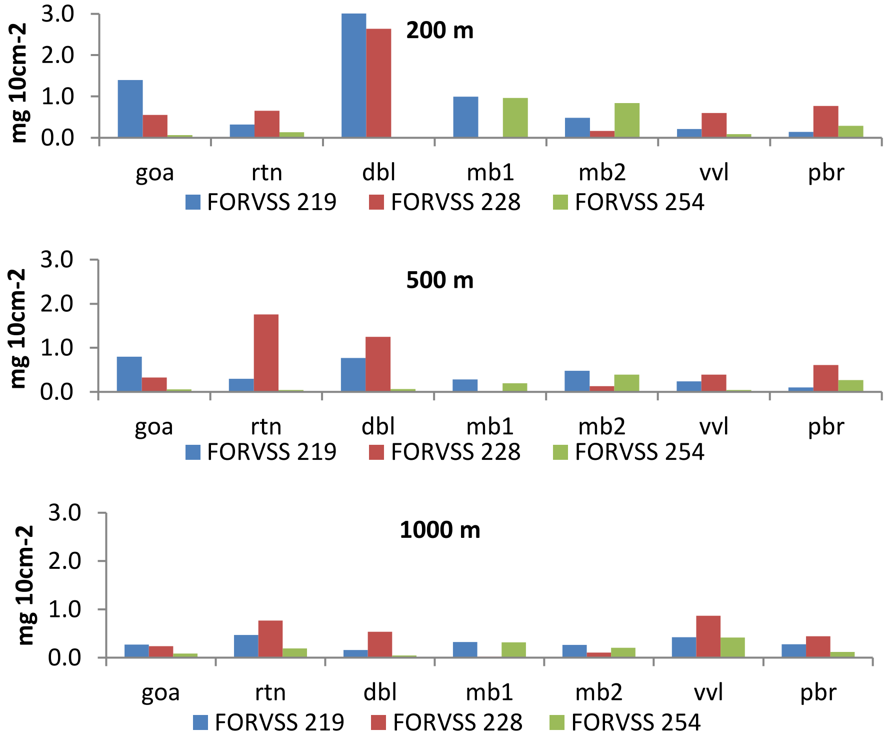


**Figure IV.6.** Biomass of metazoan meiofauna at each sampling site (for three depth classes in three surveys)

At 200 m depth classes the mean biomass was 1.104±1.0 mg $10cm^{-2}$, 0.897±0.876 and 0.340±0.396 mg $10cm^{-2}$ during FORVSS 219, FORVSS 228 and FORVSS 254 respectively (Table IV.8, Figure IV.6). While at intermediate depth (500 m) mean biomass values for the FORVSS 219 was 0.422±0.270 mg $10cm^{-2}$. In FORVSS 228 and FORVSS 254, the value was 0.637±0.638 mg $10cm^{-2}$ and 0.152±0.138 mg $10cm^{-2}$ respectively. The 1000 m depth category the mean values were 0.311±0.105 mg $10cm^{-2}$, 0.426±0.324 mg $10cm^{-2}$ and 0.196±0.131 mg $10cm^{-2}$ during FORVSS 219, FORVSS 228 and FORVSS 254 respectively.

Even though the general trend in bathymetric distribution of metazoan meiofauna biomass in the NEAS margin showed a general decreasing trend with respect to depth, it was not statistically significant (Global R=0.014, P=25 %).

**b) Latitudinal and temporal variation:** Total biomass of metazoan meiofauna varied with latitudes but the differences were not statistically significant (Global R=0.038, P=13.2 %). At 200 m depth category, mean biomass was lowest at Veravel (0.300±0.266 mg $10cm^{-2}$) and highest at Dhabol (2.939±3.102 mg $10cm^{-2}$).

Variation in total biomass with seasons at this depth was most prominent at Dhabol and Goa (Figure IV.6). Comparatively low biomass were obtained from the northern most transects Veravel and Porbander (0.300 and 0.400 mg $10cm^{-2}$). In the 500 m depth category, the mean metazoan meiofaunal biomass was relatively high at Ratnagiri (0.700±0.923 mg $10cm^{-2}$) and low at Mumbai 1 (0.159±0.144 mg $10cm^{-2}$). A remarkable observation during entire study was the occurrence of high meiofaunal biomass at the 200 m site off Dhabol during the WM and SMs. In the SIM the biomass was 0 for this site since the foraminiferans were excluded from the biomass estimation and only 2 individuals of foraminifera represented meiofauna of this site on FORVSS 254. Biomass values were lowest at the 1000 m depth category, with values ranging between 0.191±0.080 mg $10cm^{-2}$ (Mumbai 2) and 0.569±0.259 mg $10cm^{-2}$ (Veravel). At this depth class, transects such as Ratnagiri, Veravel and Dhabol showed high temporal variations (Figure IV.6).

Biomass of metazoan meiofauna showed significant seasonal variation (Global R=0.225, P=0.1 %). Mean biomass for WM (FORVSS 219) was 0.6126±0.8769 mg 10 cm$^{-2}$ and that of SM (FORVSS 228) was 0.6408±0.6335 mg 10cm$^{-2}$ ( R=0.39, P=0.1 %). The mean biomass of SIM was (FORVSS 254) very low than the other two season (0.2294 ±0.054 mg 10cm$^{-2}$). Variation of biomass in metazoan meiofauna between WM and SM was found to be prominent (Global R=0.368, P=0.1 %) when compared to WM and SIM (Global R=0.279, P=0.1 %).

In general, along the NEAS margin biomass of meiofauna was found to be decreasing towards northern latitudes but the variation was not significant (Global R=0.038, P=13.2 %). Despite the lack of significant latitudinal variations, the biomass distribution of meiofauna showed considerable seasonal variation (Global R=0.225, P=0.1 %).

### IV. 2. 3. Abundance and biomass of major faunal groups

Meiobenthos are ubiquitous in deep-sea soft sediments and exhibit high abundance compared to larger-sized invertebrates. They constitute an important component of the total fauna in the deep sea that a small amount of sediment is enough to define their community structure.

While meiobenthos are represented by organisms from diverse phyla, the nematodes, foraminiferans and crustaceans were the major contributors to the total abundance and biomass of meiofauna. Other groups include kinorhychs, terebellarians, polychaetes and ciliates in minor abundance. Various taxa exhibit different patterns of abundance across the continental margin, owing to influence of diverse environmental factors. The percentage contribution of major groups to the abundance and biomass of meiofauna at each depth category are shown in Figure IV.7&8.

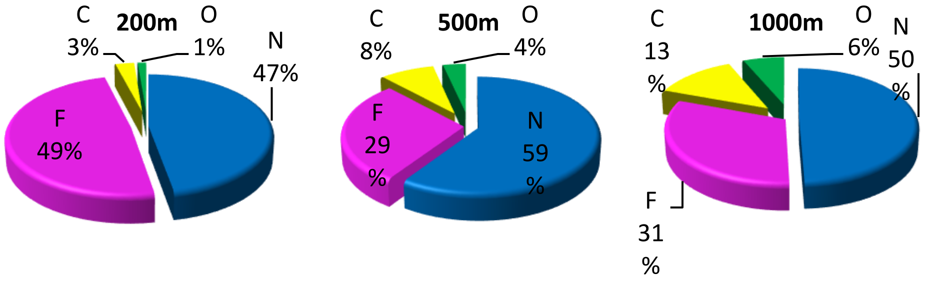


**Figure IV.7.**Contribution of faunal groups to abundance of meiofauna (protozoan & metazoan) at each depth N: Nematodes, F: Foraminiferans, C: Crustaceans & O:Other Groups

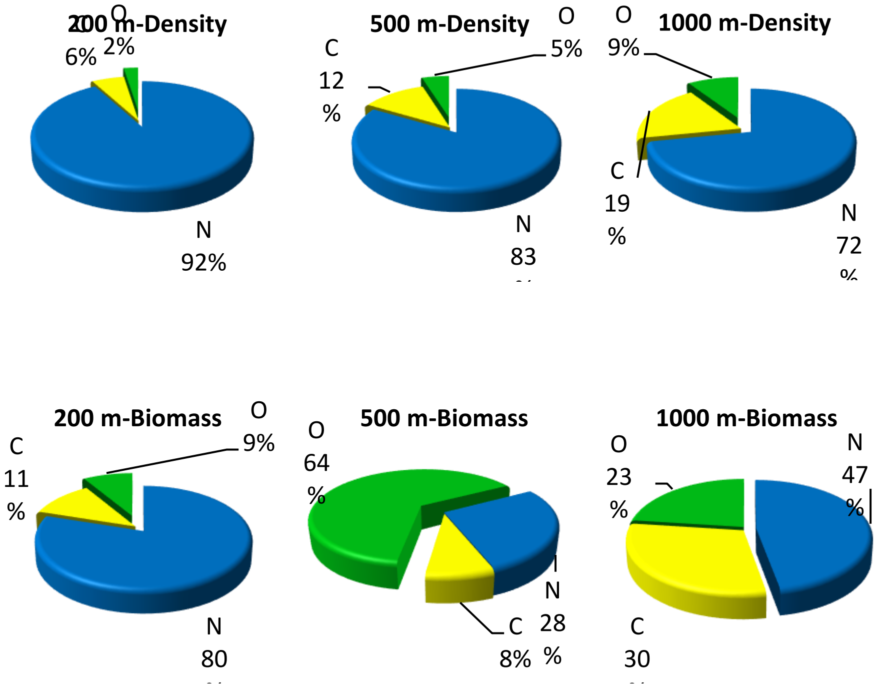


**Figure IV.8.** Contribution of faunal groups to abundance and biomass of metazoan meiofauna alone at each depth N: Nematodes, F: Foraminiferans, C: Crustaceans & O: Other Groups

**a) Nematodes**

Nematodes were the most dominant group in terms of number of individuals, representing 49 % of all organisms collected during the study. The abundance of nematodes reflected that of meiofauna as a whole. Abundance of nematode ranged from 0 (FORVSS 228, Mumbai 1 500 m; FORVSS 254, Dhabol 200 m) to 1732 Ind.10 cm$^{-2}$ (FORVSS 219, Dhabol 200 m) in the entire study (Tables IV.1-3). There was no significant difference in nematode abundance between seasons (Global R=0.005, P=37.2 %), latitudes (Global R=0.059, P=2.5 %) and depth (Global R=0.029, P=10.1 %). The mean abundance of nematode varied with respect to depth and mean value was found to be high at 200 m (226±289.6 Ind.10 cm$^{-2}$) and lowest at 1000 m (41.93±25.6 Ind.10 cm$^{-2}$), with an middle value at 500 m (82.8±66.7 Ind.10 cm$^{-2}$). Mean nematode abundance for north eastern Arabian Sea was found to be 114.6±251.24 Ind.10 cm$^{-2}$. The relative abundance of this group was 47 %, 59 % and 50 %, at 200 m, 500 m and 1000 m respectively (Figure IV.7).

The mean abundance of nematodes in the 200 m depth was 348±619.5 Ind.10 cm$^{-2}$, 253±304.5 Ind.10 cm$^{-2}$ and 75.8±104.7 Ind.10 cm$^{-2}$ during first (WM), second (SM) and third (SIM) surveys, respectively. Along 500 m depth, the mean abundance was relatively high during FORVSS 228 (167.5±194 Ind.10 cm$^{-2}$) when compared FORVSS 219 and FORVSS 254 (54±72.5 Ind.10 cm$^{-2}$ and 26.8±35.2 Ind.10 cm$^{-2}$, respectively). At the 1000 m depth also mean abundance was maximum in the FORVSS 228 (61.6±56.4 Ind.10 cm$^{-2}$) followed by the FORVSS 219 (41.1±30.8 Ind.10 cm$^{-2}$) and FORVSS 254 (23.1±31.9 Ind.10 cm$^{-2}$) surveys.

Mean nematode abundance at each site is depicted in Figure IV.9. At the 200 m depth class, highest mean nematode abundance was found from Dhabol (863.9±865.8 Ind.10 cm$^{-2}$), while the lowest abundance was at Pobander (60.5±80.10 Ind.10 cm$^{-2}$). Variation in abundance between seasons was noticed at all stations except for Mumbai 1. Nematodes were found in high abundance at Dhabol during the WM (1731.63 Ind.10 cm$^{-2}$) and SM (860.20 Ind.10 cm$^{-2}$), while this group was absent at the same site during the SIM.

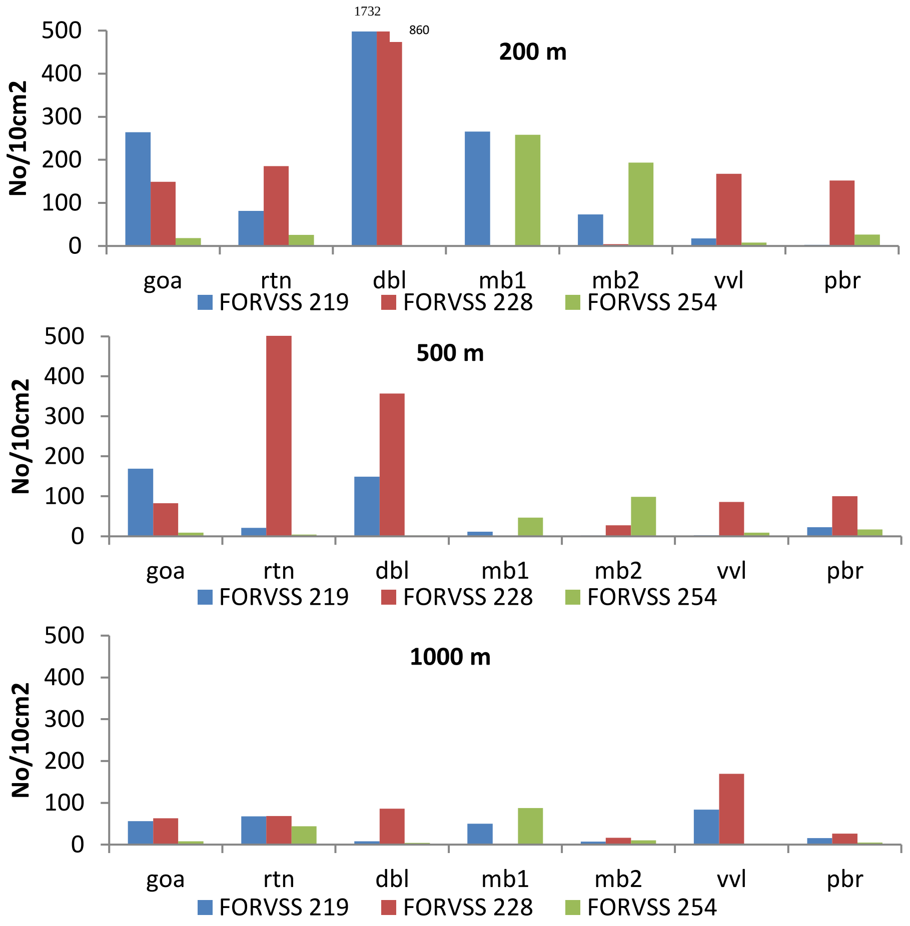


**Figure IV.9.** Abundance of nematodes at each sampling site in the three seasons

Also at Goa, the abundance of nematode showed similar trend in distribution with meagre abundance at SIM. The sites off Ratnagiri and Veravel showed higher abundance during FORVSS 228 (185.71 Ind.10 cm$^{-2}$; 167.35 Ind.10 cm$^{-2}$) followed by FORVSS 219 (81.63 Ind.10 cm$^{-2}$; 17.35 Ind.10 cm$^{-2}$) and FORVSS 254 (25.51 Ind.10 cm$^{-2}$; 8.16 Ind.10 cm$^{-2}$) survey. In contrast, at Mumbai 1 there was negligible variation with season. At Mumbai 2, the abundance of nematodes was low (4.08 Ind.10 cm$^{-2}$) during the FORVSS 228, while it was relatively high in the FORVSS 254 (193.88 Ind.10 cm$^{-2}$) and FORVSS 228 (73.47 Ind.10 cm$^{-2}$) surveys. At Porbander, the abundance of nematodes ranged between 152.04 Ind.10 $cm^{-2}$ (FORVSS 228) and 3.06 Ind.10 $cm^{-2}$ (FORVSS 219). At the 500 m depth category, lowest nematode abundance was recorded at Mumbai 1 (19.39±24.51 Ind.10 $cm^{-2}$) and highest at Ratnagiri (181.63±292.63 Ind.10 $cm^{-2}$). The abundance of this group was comparatively high in the southern transects, especially Ratnagiri, Dhabol and Goa. At the 1000 m depth category, nematode abundance was lowest at Mumbai 2 (11.22±4.68 Ind.10 $cm^{-2}$) and the highest at Veravel (85.03±83.68 Ind.10 $cm^{-2}$). Except Mumbai 2 and Porbander, all other deeper (1000 m) sites had more or less similar densities of nematodes. The biomass of nematodes ranged between 0 (FORVSS 254, Dhabol 200 m) and 5.602 mg 10$cm^{-2}$ (FORVSS 219, Dhabol 200 m) (Table 12-14) (Figure 28).

There was no significant difference in the biomass of nematodes between seasons (Global R=0.096, P=0.8 %) and depth (Global R=0.05, P=5.1 %). The variation among latitudes were also insignificant (Global R=0.003, P=39.6 %). The mean biomass decreased with increasing depth and the value was 0.721±0.883 mg 10$cm^{-2}$ at 200 m, 0.268±0.204 mg 10$cm^{-2}$ at 500 m and 0.147±0.081 mg 10$cm^{-2}$ at 1000 m. In the entire study nematode biomass showed a decreasing trend with depth.

Biomass of nematodes for each sampling site is presented in Figure IV.10. Among the 200 m sites, temporal variation in abundance was prominant at Dhabol and Mumbai 1. During the FORVSS 219 collection, these sites had the highest numerical abundance that reflected in the biomass also. However, at this depth, comparatively high biomass was recorded off Dhabol in the FORVSS 219 and FORVSS 228, while no nematode recorded in the FORVSS 254.

At 200 m depth stations mean biomass ranged from 0.167 mg 10$cm^{-2}$ (Porbander) to 2.657 mg 10$cm^{-2}$ (Dhabol). During the FORVSS 219 average biomass of nematodes for 200 m depth category was 1.134±2.003 mg 10$cm^{-2}$. In the FORVSS 228 and FORVSS 254s average nematode biomass (200 m) decreased to 0.757±0.804 mg 10$cm^{-2}$ and 0.372±0.372 mg 10$cm^{-2}$.

In the 500 m depth stations biomass of nematodes decreased than that obtained from the 200 m depth. Mean nematode biomass at 500 m depth class ranged from 0.066 mg 10$cm^{-2}$ (Mumbai 1) to 0.570 mg 10$cm^{-2}$ (Dhabol). In

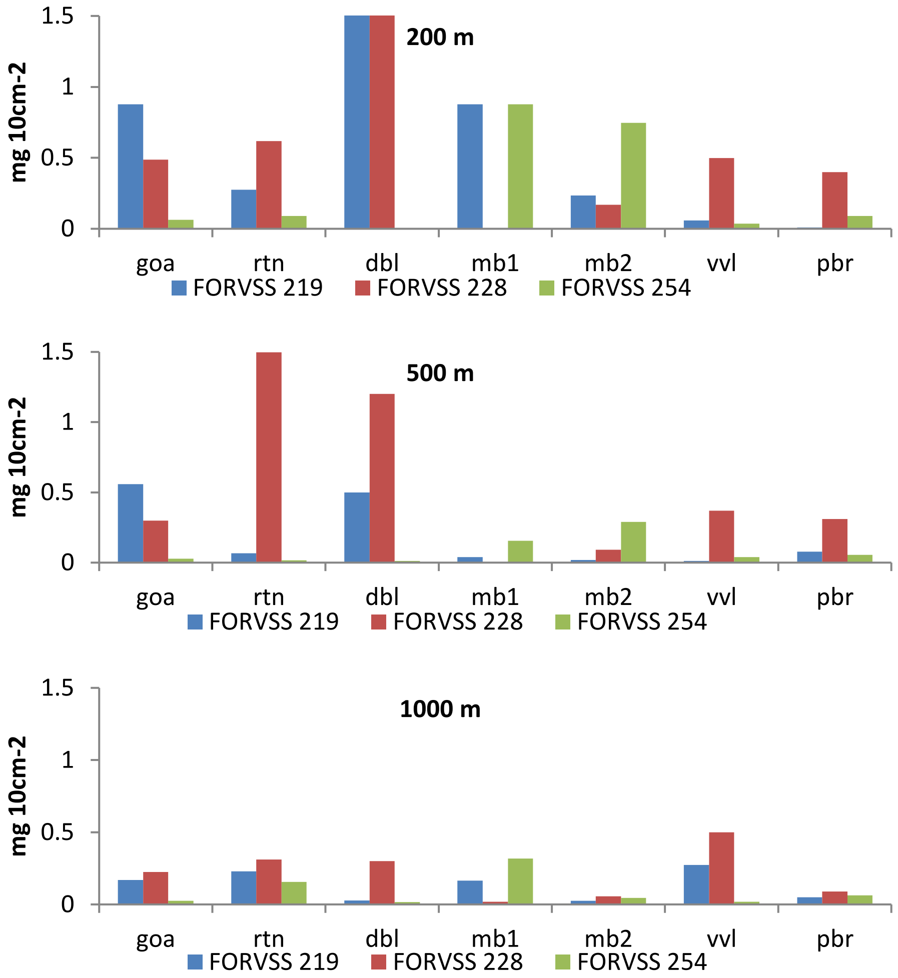


**Figure IV.10.** Biomass of nematodes at each sampling site

the 500 m depth stations the average biomass value during the three collections is as follows, 0.181±0.239 mg $10cm^{-2}$; 0.538±0.576 mg $10cm^{-2}$; 0.085±0.0103 mg $10cm^{-2}$. In the FORVSS 219 and FORVSS 228, consistently high biomass were observed off Dhabol.

From the 1000 m depth category the mean biomass of nematode ranged from 0.042 mg $10cm^{-2}$ (Mumbai 2 ) to 0.231 mg $10cm^{-2}$ (Ratnagiri). At 1000 m depth stations the average biomass value for the depth was 0.134±0.101 mg $10cm^{-2}$; 0.214±0.172 mg $10cm^{-2}$; 0.196±0.111 mg $10cm^{-2}$.

Spatially nematode biomass varied from 0.127±0.053 mg $10cm^{-2}$, Porbander to 1.114±1.356 mg $10cm^{-2}$, Dhabol. Biomass of nematodes decreased towards the extreme north with high biomass values in the southern region but the distribution pattern was statistically insignificant.

### b) Foraminifera

Foraminiferans were the second important group in terms of number of individuals, contributing 43 % of all organisms collected during the study. Abundance of foraminifera varied between 0 (FORVSS 219, Goa &Veravel, 500 m; FORVSS 228, Mumbai 1, 500&1000; FORVSS 254, Mumbai 1, 1000 m) and 2935 Ind.10 $cm^{-2}$ (FORVSS 219, Dhabol 200 m) in the entire study (Figure IV.11). There was no significant difference in foraminifera abundance between seasons (Global R=0.001, P=38.8 %), depth class (Global R=0.062, P=1.1 %) and latitude (Global R=0.013, P=26.9 %).The average abundance of foraminifera varied with depth and the mean value was found to be highest at 200 m (234±335.9 Ind.10 $cm^{-2}$) and lowest at 1000 m (26.38±27.7 Ind.10 $cm^{-2}$), with an intermediate value at 500 m (40±25.7 Ind.10 $cm^{-2}$). Mean foraminifera abundance for the entire study was found to be 100±209 Ind.10 $cm^{-2}$. The relative abundance of this group was 49 %, 29 % and 31 %, at 200 m, 500 m and 1000 m respectively (Figure IV.7).

The mean abundance of foraminifera at 200 m was 552.6±1059.6 Ind.10 $cm^{-2}$, 107.3±75.7 Ind.10 $cm^{-2}$ and 43.5±40.5 Ind.10 $cm^{-2}$ during FORVSS 219, FORVSS 228 and FORVSS 254s, respectively. At 500 m depth, the mean abundance was relatively high during FORVSS 228 (67.05±97.701 Ind.10 $cm^{-2}$) when compared FORVSS 219 and FORVSS 254 (35.27±37.55 Ind.10 $cm^{-2}$ and 17.6±18.05 Ind.10 $cm^{-2}$, respectively). At the 1000 m depth also, the mean abundance was maximum in the FORVSS 228 (34.54±48.77 Ind.10 $cm^{-2}$) followed by the FORVSS 219 (31.19 ±58.5 Ind.10 $cm^{-2}$) and FORVSS 254 (13.41±11.61 Ind.10 $cm^{-2}$) surveys.

Highest mean foraminifera abundance was observed at Dhabol (990.14±1684.11 Ind.10 $cm^{-2}$), while the lowest abundance was at Pobandar (1.02±1.77 Ind.10 $cm^{-2}$). Variation in abundance between seasons was noticed at all stations. At the 200 m depth, fForaminifera were found in high abundance at Dhabol during the FORVSS 219 (2934.69 Ind.10 $cm^{-2}$) and

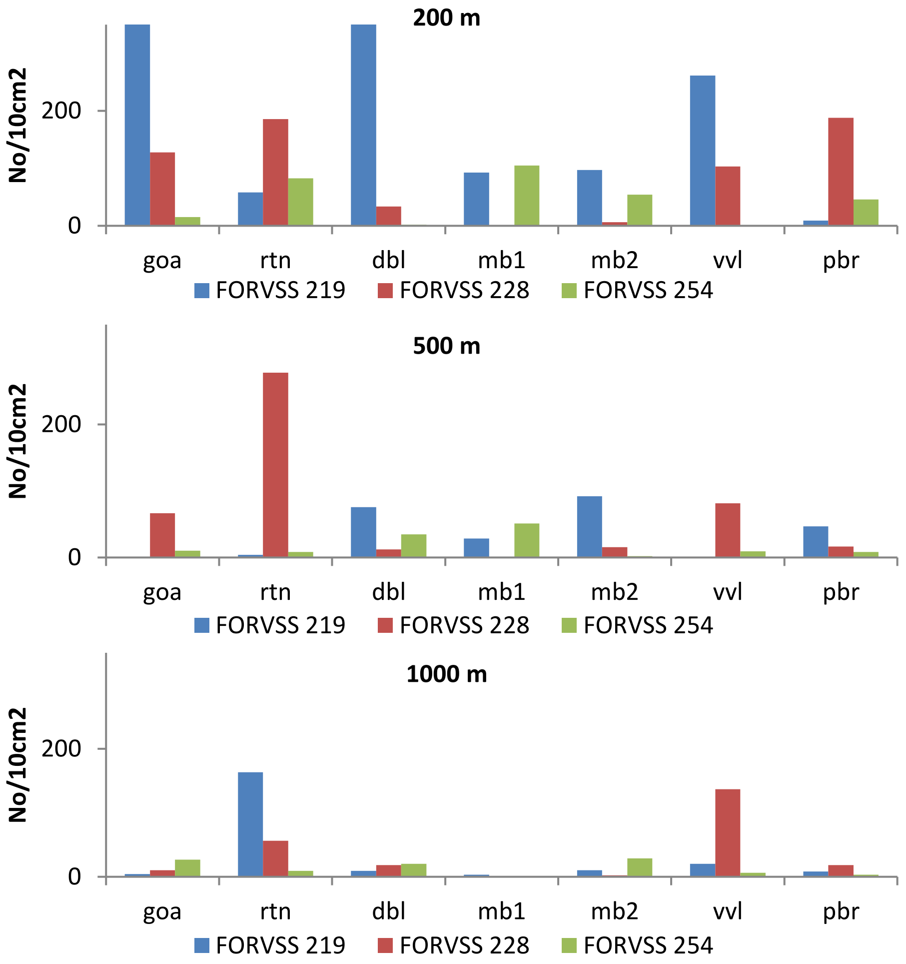


**Figure IV.11.** Numerical abundance of foraminifera at each sampling site

FORVSS 228 (33.67 Ind.10 cm$^{-2}$) survey, but very less number of foraminiferas could obtain from Dhabol during the FORVSS 254 (2.04). Also at Goa and Veravel transects the abundance of foraminifera showed similar trend in distribution with meagre abundance at FORVSS 254. The sites Ratnagiri and Porbander showed higher abundance during FORVSS 228 (185.71 Ind.10 cm$^{-2}$; 187.76 Ind.10 cm$^{-2}$) followed by FORVSS 254 (82.65 Ind.10 cm$^{-2}$ ; 45.92 Ind.10 cm$^{-2}$ ) and FORVSS 219 (58.16 Ind.10 cm$^{-2}$ ; 9.18 Ind.10 cm$^{-2}$ ) survey. In contrast, at Mumbai 1 there was negligible variation with survey. At Mumbai 2, the abundance of foraminiferas was low (6.12

Ind.10 cm$^{-2}$) during the FORVSS 228, while it was relatively high in the FORVSS 219 (96.94 Ind.10 cm$^{-2}$) and FORVSS 228 (54.08 Ind.10 cm$^{-2}$) surveys. At the 500 m depth category numerical abundance of foraminifera was more or less evenly distributed, Lowest foraminifera abundance was recorded at Porbander (23.81±20.44 Ind.10 cm$^{-2}$ ) and highest at Ratnagiri (96.60±156.72 Ind.10 cm$^{-2}$ ).

At the 1000 m depth category, foraminifera abundance was lowest at Mumbai 1 (1.02±1.77 Ind.10 cm$^{-2}$) and the highest at Ratnagiri (76.19±78.98 Ind.10 cm$^{-2}$ ).Veravel also showed comparatively higher abundance of foraminifera (54.42±71.64 Ind.10 cm$^{-2}$ ). Except Mumbai 1 and Veravel, all other deeper (1000 m) sites had more or less similar densities of foraminifera.

### c) Crustaceans

Crustaceans were chiefly represented by the harpacticoid copepods, ostracods, halacarids and nauplii stages of various crustaceans. Despite having high numerical abundance of total meiofauna, crustaceans were poorly represented from the SM (FORVSS 228) and SIM (FORVSS 254). Average abundance of crustaceans from the FORVSS 219, FORVSS 228 and FORVSS 254 was 29±22.5 Ind.10 cm$^{-2}$ , 4±8.4 Ind.10 cm$^{-2}$ and 4±4.8 Ind.10 cm$^{-2}$ respectively. The highest abundance observed for crustacean fauna was 86 Ind.10 cm$^{-2}$, off Goa (WM, 200 m). (Tables IV.1-3). There were no significant differences between depth classes (Global R=-0.016, P=79 %) and between latitudes (Global R=0.015, P=27.4 %), while the differences in abundance of crustaceans between seasons was found to be statistically significant (Global R= 0.229, P=0.1 %). The mean abundance of crustaceans was 13.6±12.2 Ind.10 cm$^{-2}$ at 200 m, 11.6±6.1 Ind.10 cm$^{-2}$ at 500 m and 10.98±5.5 Ind.10 cm$^{-2}$ at 1000 m. Though mean abundance varied within a narrow range among the three depths, crustaceans became relatively more abundant with increasing depth, i.e. they denoted about 3 % of meiofauna at 200 m, 8 % at 500 m and 13 % at 1000 m (Figure IV. 7).

The highest observed biomass of crustacean was 0.502 mg 10 cm$^{-2}$ (FORVSS 219, 200 m) (Tables 12-14) with a mean of 0.186±0.140 mg 10 cm$^{-2}$. At 200 m, mean biomass value ranged between 0.003±0.005 mg 10 cm$^{-2}$

(Porbander) and 0.172±0.286 mg 10 $cm^{-2}$(Goa) (Mangalore) with a mean of 0.085±0.73 mg 10 $cm^{-2}$. At 500 m the range was 0.008±0.008 mg 10 $cm^{-2}$ (Porbander) to 0.154±0.186 mg 10 $cm^{-2}$ (Mumbai 2) with a mean of 0.077±0.44 mg 10 $cm^{-2}$ and at 1000 m the range was from 0.027±0.027 mg 10 $cm^{-2}$ (Goa) to 0.194±0.177 mg 10 $cm^{-2}$ (Veravel) (mean, 0.093±0.056 mg 10 $cm^{-2}$). There were no significant differences in biomass of crustaceans between depth classes (Global R=-0.022, P=86.6 %) and between latitudes (Global R=0.013, P=26.5 %), while the differences in biomass of crustaceans between seasons showed statistically significant difference (Global R= 0.225, P=0.1 %). Crustaceans contributed about 3 %, 8 % and 13 % to the total biomass at different depth regions such as 200 m, 500 m and 1000 m respectively (Figure IV.8).

### IV. 2. 4. Influence of environmental variables on standing crop

From the previous chapter it is evident that environmental parameters and sediment characteristics vary with depth and latitudes in the study area. Values of abundance and biomass were tested for correlation with the measured environmental variables using Pearson’s correlation. Sediment texture characteristics and hydrographical parameters were used for this analysis. Results of the analyses are presented in Table 17.

**a) Abundance:** Abundance of meiofauna showed a positive correlation with bottom water dissolved oxygen (r=0.327, p<0.097). Abundance of nematodes showed a strong negative relationship with depth (r=-0.263, p<0.039) but showed a positive correlation with dissolved oxygen content (r=0.310, p<0.014). Abundance of foraminifera was positively correlated with dissolved oxygen (r=0.315, p<0.013). Crustaceans displayed a positive correlation with clay fraction of sediment (r=0.292, p<0.021) while other groups showed significant negative correlations with silt (r=-0.268, p<0.035).

**b) Biomass:** Biomass of metazoan meiofauna was positively correlated with bottom water dissolved oxygen (r=- 0.320, p<0.011) and the major component, the nematode, also displayed similar trend with oxygen (r=-0.294, P=0.020). Nematode biomass negatively correlated with depth (r= -0.296, P=0.020) and silt content (r= -0.269, P=0.035).The biomass of metazoan meiofauna did not show any correlation with no other environmental variables.

## IV. 3. DISCUSSION

Meiobenthic communities in the present study were composed of 12 taxa viz. nematodes, foraminifera, harpacticoid copepods, halacarid crustaceans, kinorhynchs, ciliates, turbellarians and polychaetes. Of the 12 taxonomic groups present, the most dominant and consistent group was free-living nematodes (49 %) followed by foraminiferans (43 %). Among the metazoan meiofauna, nematodes tend to be relatively more abundant in the deeper stations (1000 m), while other taxa reach their highest relative abundances at the shelf edge (200 m). In a recent study, Ansari et al., (2017) reported as many as fifteen taxonomic groups of meiofauna from the OMZ area of the northern Arabian Sea, among which the most abundant and widely distributed taxa were nematode (30.7-91.5 %), harpacticoid copepods (4.2-31.5 %), polychaetes (1.8-19.2 %), turbellarians (0-4.0 %) and foraminifera (0-4.0 %). A total of 8 stations sampled from OMZ areas (501 m, 799 m, 800 m, 703 m, 900 m) and outside the OMZ (1956 m). The samples were collected using a submersible *Shinkai 6500* with robotic arms. The observations were based on only one set of samples and used a sieve fraction of lower size limit 45µm. Ansari et al., (2017) recorded greater diversity of meiofaunal taxonomic groups (10 taxa), at the deepest station (1956 m) with highest oxygen values while the least number of groups were found at 700 m where the oxygen was low.

Dominance of nematodes in meiobenthic community was recorded from different parts of the world (Ansari et al., 2001; 2017; Riera & Hubas, 2003; Robert et al., 2005). In a comprehensive study from the shelf region of the west coast of India (Sajan et al., 2010), the dominant group were nematodes (84.47 %) and harpacticoid copepods (7.88 %). In their study foraminifera abundance was meagre. The same observations were made by Ansari et al., (2012) from the south east coast continental shelf of India where the percentage contribution was as follows Nematodes-57 %, copepods-15 % and foraminiferans-14 %. Previously Ansari (1978) and Rodrigues et al.,

(1982) reported foraminifera as numerically second dominant group from the Arabian Sea and Bay of Bengal in the shallow sub tidal region. A notable reduction in the foraminifera community from the Arabian Sea was observed by Ansari et al., (2017) in the slope region of EAS margin. The present study reports foraminifera abundance almost equal to that of nematodes. Similar other studies conducted in the OMZ impacted margins of the Arabian Sea OMZ shows fairly high densities of this protistan meiofauna. Foraminifera are commonly occurring constituents of deep-sea benthic communities (Gooday, 1986; Gooday et al., 2000). In some cases, benthic foraminifera are known to be very abundant in the bathyal to abyssal zones (Sen Gupta et al., 1981; Bernhard et al., 2000; Gooday, 2002). From the eastern Arabian Sea margin unusual abundance (3982 ind 10 $cm^{-2}$) of foraminifera from a water depth of 540 m was reported more recently (Enge et al., 2014). In the deep sea, foraminifera can dominate the meiofauna, yet most studies on meiobenthos usually deal only with metazoan meiofauna and the foraminifera are neglected or treated as a separate entity, i.e. as protozoan (protistan) meiofauna. Coull et al. (1977) report percentage contribution of nematodes and foraminifera from various depths and found that with increase in depth the percentage of foraminifera is increasing and at the deeper stations their percentages out-number the nematodes. Coull et al., (1977) also observed 45 % of nematodes and 30.8 % of foraminifera from 400 m depth off North Carolina. At 800 m depth, foraminifera was 33 % and nematodes 59 % and at 4000 m foraminifera contributed 65.2 % and nematodes only 30.2 %. In the deep sea, the overall trophic and productive processes must be reconsidered, since 50-80 % of the meiofaunal species and 30 % of their biomass may consist of foraminifera (Shirayama & Horikoshi, 1989). Studies performed in the Pakistan margin (Jannink et al., 1998; Maas, 2000; Schumacher et al., 2007; Gooday et al., 2009), Oman margin (Hermelin & Shimmield, 1990; Gooday et al., 2000) and OMZ sediments in the Arabian Sea reports foraminifera as abundant components of the benthic community. Their abundant occurrence in OMZ sediments, with ability to utilize fresh labile organic matter and tolerance to low oxygen concentrations suggest that benthic foraminifera might play an important role in carbon cycling in OMZ sediments in the Arabian Sea. Benthic foraminifera play an eminent role in the deep sea benthic community. Many species are bacterivorous or even digest small animals. They are considered heavy grazers on bacteria and their biofilms (Bernard & Bowser, 1992). A study on the microbial population of the slope region of the west coast of India, from the similar sites showed high abundance of microbial population in the same site where the numerical abundance of forminifera out-numbered the abundance of nematodes (Neil, 2013; FORVSS 219, Dhabol 200 m and FORVSS 228 Ratnagiri 200). Most benthic forams live in the surface layers and are versatile in microhabitat selection. They react to food supply, current exposure or oxygen availability (Enge et al., 2014). Many of them can occur down to 30 cm depth in the sediment, even in oxygen depleted sediments, where they cluster in the micro oxic zones around animal burrows (Thomsen & Altenbach, 1993). They can also live facultatively anaerobic for extended periods of time (Bernard, 1996; Moodley, 1997; Bernhard & Sen Gupta, 1999), which may become increasingly relevant as oxygen depleted areas continue to expand. Hence may be in the present study also their abundance more or less equalled that of nematodes. The present study area, continental slope of Eastern Arabian sea lies in a permanent oxygen minimum zone and all the stations show oxygen value less than 1ml/L. May be due to this copepods were numerically low in the slope sediments when compared to the shelf samples (Sajan, 2003) since copepods are unable to tolerate low oxygen concentration (Wells, 1988). Deep-water areas with depleted oxygen concentrations or sulfidic conditions are known to have communities exceeding foraminiferan biovolume than that of metazoan meiofauna (Buck & Barry, 1998; Bernhard et al., 2000). Both soft shelled and hard shelled foraminifera have been found under permanent anoxia in the black sea. Under low oxygen organic enrichment conditions, a few opportunistic species form a low diversity, high abundance community. They make a central contribution to the cycling of organic matter in the deep sea bottom (Larkin et al., 2006).

In the present study, the average biomass of metazoan meiofauna of the western continental slope of India was 0.524±0.861 mg 10 $cm^{-2}$ and the average population abundance of meiofauna from west coast of India was 235±393 Ind. 10 $cm^{-2}$. The mean abundance in the study area varied between 41±21 Ind. 10 $cm^{-2}$ (Porbander,1000 m) and 1895±2520 Ind. 10 $cm^{-2}$ (Dhabol, 200 m). The meiofaunal abundance observed in the slope region of eastern

Arabian Sea are comparable with the studies conducted from other deep sea sites like the Western Indian Ocean, Kenyan continental slope (276-944 Ind. 10 cm$^{-2}$, Muthumbi et al., 2004), the south Sandwich Trench from a depth range 750-6300 m (354 to 1675 Ind. 10 cm$^{-2}$, Vanhove et al, 2004), Peru margin OMZ region from 300 to 1210 m depth range (440-1517 Ind. 10 cm$^{-2}$, Neira et al., 2001a), Drake's Passage from 2274 to 5194m (75 to 2731 Ind. 10 cm$^{-2}$, Gutzmann et al., 2004),) Porcupine Sea Bight and abyssal plain (NE Atlantic) at 500 m intervals between depths of 500 m and 4 850 m (315 -2604 Ind. 10 cm$^{-2}$, Pfannkuche.,1985), north western Mediterranean (Gulf of Lions) from a depth 672- 2367 m (36 to 1005 Ind. 10 cm$^{-2}$, De Bovee et al., 1990), the north and south Aegean Sea (Eastern Mediterranean) from 153 to 1271 m (128 to 1251 Ind. 10 cm$^{-2}$, Lampadariou & Tselepides, 2006), Porcupine abyssal plain (346 to 1074 Ind. 10 cm$^{-2}$, Kalogeropoulou et al., 2010), Chatham Rise in the Pacific Ocean from 350–2600 m (93 to 1454 Ind. 10 cm$^{-2}$, Grove et al., 2006) and the Ross Sea, Antarctica (192 to 1191.2 Ind. 10 cm$^{-2}$, Fabiano & Danovaro.,1999). Majority of meiofaunal research from the deep sea (beyond 200 m depth) has been carried out in the various part of Atlantic Ocean. Some of these investigations have dealt exclusively with the metazoans while others have included foraminifera within the scope of the meiobenthos. In general high to very high densities of meiofauna particularly nematode have been reported from OMZ areas (Cook et al., 2000; Neira et al., 2013). Nevertheless from the Arabian Sea OMZ region, Ansari et al., (2017) reported an abundance reduction of 3-8 times lower than other OMZ areas of the world.

In the past decades there has been a significant increase in the amount of information on the deep-sea meiofauna distribution. Patterns of diversity in the deep sea are much more complicated than previously thought. It is known well that, as a rule, the abundance of meiobenthos generally decreases with water depth (Soltwedel, 2000; Mokievsky et al., 2007). This appears to be true for the meiobenthos as a whole and for individual component taxa. Limited food resource and/or poor quality has been cited as the most important factor causing decreasing densities for meiobenthos with increasing water depth (Jensen, 1988; Vincx et al., 1994). Meiofauna abundance was significantly correlated with water depth, a trend that has been observed worldwide (Tietjen, 1992; Soltwedel, 2000; Aller et al., 2002; Gutzmann et al., 2004;

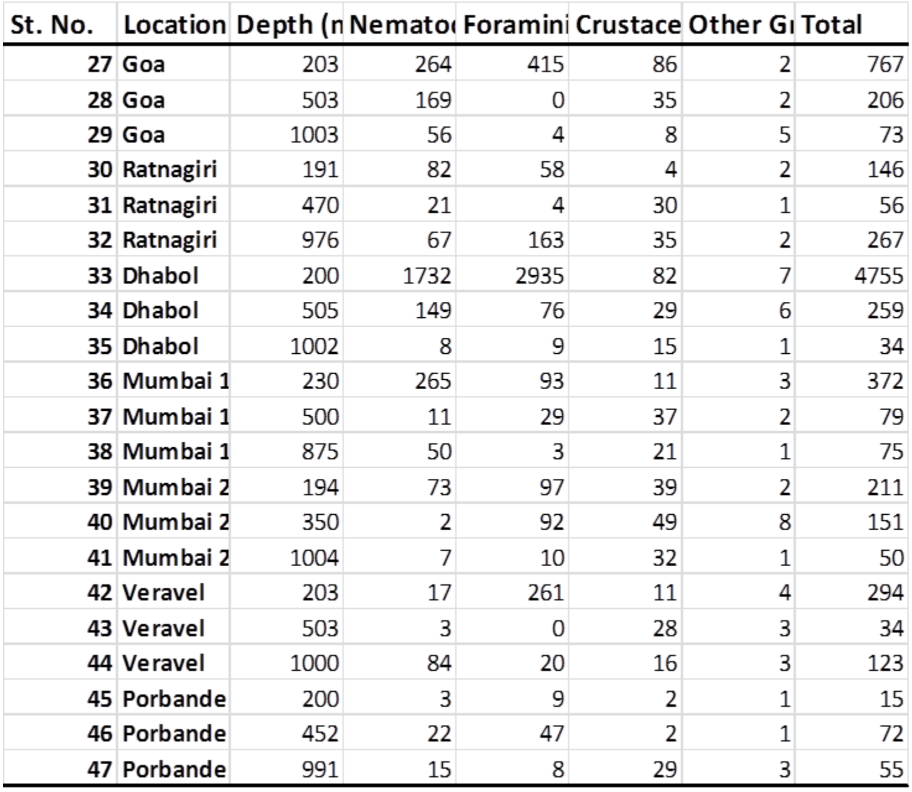
Netto et al., 2005). Depth-related trends are attributed to a decreasing supply of organic matter with increasing depth and distance from land (Thiel, 1978; Pfannkuche, 1993; Danovaro et al., 1995; Gooday et al., 1996; Relexans et al., 1996; Soltwedel, 1997; Fabiano & Danovaro, 1999; Shimanaga & Shirayama, 2000; Gooday, 2002). But in the present study even though a reduction in abundance was observed towards deeper stations, it was not statistically significant. This may be due to the anomaly in the 500 m depth of WM (FORVSS 219) and SIM (FORVSS 254) in which the depth wise gradation pattern was more or less similar or there was little variation in fauna from 500 m to 1000 m. Qualitative (Rex, 1981) and quantitative (Etter & Grassle, 1992) sampling studies indicated that diversity-depth patterns in the deep sea are unimodal with a peak at intermediate depths and depressed diversity at upper bathyal and abyssal depths. However, unimodal patterns do not appear to be universal (Rex et al., 1997, Stuart et al., 2003) and where they do occur in other basins have been attributed to varied environmental gradients (Paterson & Lambshead, 1995, Cosson-Sarradin et al., 1998).

Here in the present study meiofauna showed inter annual variability with low abundance at the time of the 3rd survey (SIM, FORVSS 254, 2007). Throughout the north eastern Arabian Sea margin, relatively high OM was observed during third survey (FORVSS 254, SIM) but instead of an increased meiofauna response in relation to the high organic matter, their abundance fall to a range from 2 to 376 ind/10cm$^2$ with a mean abundance of 128±140 ind/10cm$^2$. This may be due to the strong influence of hypoxic condition preceded over (<0.2ml/l) in the NEAS during III Survey (SIM). As a whole, in the north eastern Arabian Sea margin, distribution of meiobenthic standing crop was highly patchy or heterogeneous as previously observed (Warwick & Buchanan, 1971; Grassle & Morse Porteous, 1987; Rice & Lambshead, 1994). World over temporal variation in deep-sea meiobenthos has been studied at only a few sites and most have been of duration 5 to 10 years. (Guidi-Guilvard, 2002; Gooday, 2002; Hoste et al., 2007; Kalogeropoulou et al., 2010). It is a known fact that seasonal deposition of phytodetritus to the deep-sea floor increases the abundance, activity and biomass of small faunal groups such as meiofauna (Pfannkuche et al., 1999). A rapid response of these smaller size-fractions of the benthic community might be expected. The spatial patchy distribution of meiofauna (Rice & Lambshead, 1994) seems to be linked to the patchy distribution of phytodetritus to the sea floor and their vertical distribution in the sediments may also be affected by the presence of phytodetritus at the sediment surface (Lambshead et al., 1995). Significant seasonality of meiofaunal standing stock, influenced by inter-annual fluctuations in the input of phytodetritus and organic particles to the deep-sea bed, has been reported previously (Pfannkuche, 1993; Danovaro et al., 2000, 2001; Galero`n et al., 2001; Lampitt et al., 2001; Vanreusel et al., 2001; Gambi & Danovaro, 2006).

Abundance of meiofauna in the present study showed a positive correlation with bottom water dissolved oxygen. In the OMZ areas of Peru margin meiofaunal densities are enhanced by an indirect positive effect of low oxygen, involving a reduction of predators and competitors along with preservation of organic matter leading to high food availability and quality (Neira et al., 2001a). Thus it is assumed that within the OMZ, the oxygen limitations might directly control meiofaunal composition at higher taxonomic levels (Neira et al., 2001b). However there are contrasting reports from investigations on meiofauna in OMZs around the world, which emphasise the absence of oxygen minimum effect in structuring meiofauna communities. They have noted strong correlation between food quality and abundance of meiofauna. A recent study on metazoan meiofauna in Arabian Sea OMZ showed insignificant relation to dissolved oxygen suggesting that the oxygen does not control the distribution and abundance of meiofaunal standing stock (Ansari et al., 2017). According to Neira et al., (2013) bottom water oxygen and sediment organic matter are the two factors that display sharpest gradient in OMZ areas of Chile margin.

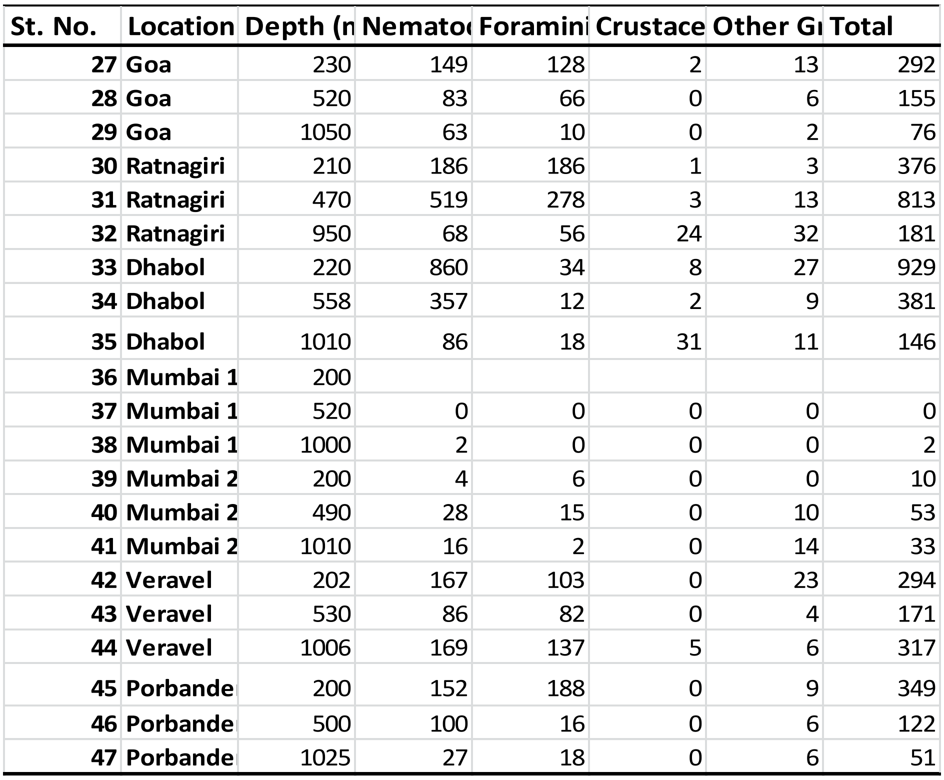
In the present study, both the dominant meiofaunal components nematodes and foraminifera showed a positive correlation with dissolved oxygen availability. Muthumbi et al., (2004) noted the impacts of oxygen levels on nematode from the Indian Ocean, where densities were correlated with oxygen concentrations in the overlying water, with low abundance at mid-depth (500–1000 m) coinciding with the minimum oxygen level. From the Arabian Sea, Cook et al. (2000) reported that DO has no effect on the nematode community in the OMZ areas, and that instead, food quality appears to be the major predictor. Thiel et al. (1989) noted an elevated abundance of nematodes on aggregates of freshly deposited phytodetritus in the NE Atlantic (4500 m), suggesting that metazoan meiofauna can colonise and utilize freshly deposited material rapidly.

Higher percentages of nematodes and foraminifera are found from the OMZ impinged margin sediments of north eastern Arabian Sea (present study) along with a decreased abundance of a rather oxygen sensitive group, the crustaceans. A similar study conducted in the continental shelf region of eastern Arabian Sea reported crustaceans as the second dominant taxon in the meifaunal communities (Sajan, 2003). Since the shelf region are characterised by relatively higher oxygen concentrations, it is assumed that hypoxic (OMZ) conditions in the NEAS margin exert additional pressure on more sensitive benthic groups like crustaceans. Abundant food and absence of predators and competitors provide a more favorable condition for the nematodes and foraminifera. Previous reports suggest that behavioural changes and mortality are common in sensitive groups such as crustacean when exposed to induced hypoxia and anoxia (Miller et al., 2002; Levin, 2003; Haselmair et al., 2010). Ansari et al. (2017) reported two set of Arabian Sea OMZ meiofauna, one for the OMZ impinged area and the other for the non OMZ area. Also they have opined that the changes in the meiofaunal taxa recorded could be due to sediment characters, bottom temperature, DO or food availability.



| St. No. | Location | Depth (n | Nemato | Foramini | Crustace | Other G | Total |
|---|---|---|---|---|---|---|---|
| **27** | **Goa** | 203 | 264 | 415 | 86 | 2 | 767 |
| **28** | **Goa** | 503 | 169 | 0 | 35 | 2 | 206 |
| **29** | **Goa** | 1003 | 56 | 4 | 8 | 5 | 73 |
| **30** | **Ratnagiri** | 191 | 82 | 58 | 4 | 2 | 146 |
| **31** | **Ratnagiri** | 470 | 21 | 4 | 30 | 1 | 56 |
| **32** | **Ratnagiri** | 976 | 67 | 163 | 35 | 2 | 267 |
| **33** | **Dhabol** | 200 | 1732 | 2935 | 82 | 7 | 4755 |
| **34** | **Dhabol** | 505 | 149 | 76 | 29 | 6 | 259 |
| **35** | **Dhabol** | 1002 | 8 | 9 | 15 | 1 | 34 |
| **36** | **Mumbai 1** | 230 | 265 | 93 | 11 | 3 | 372 |
| **37** | **Mumbai 1** | 500 | 11 | 29 | 37 | 2 | 79 |
| **38** | **Mumbai 1** | 875 | 50 | 3 | 21 | 1 | 75 |
| **39** | **Mumbai 2** | 194 | 73 | 97 | 39 | 2 | 211 |
| **40** | **Mumbai 2** | 350 | 2 | 92 | 49 | 8 | 151 |
| **41** | **Mumbai 2** | 1004 | 7 | 10 | 32 | 1 | 50 |
| **42** | **Veravel** | 203 | 17 | 261 | 11 | 4 | 294 |
| **43** | **Veravel** | 503 | 3 | 0 | 28 | 3 | 34 |
| **44** | **Veravel** | 1000 | 84 | 20 | 16 | 3 | 123 |
| **45** | **Porbande** | 200 | 3 | 9 | 2 | 1 | 15 |
| **46** | **Porbande** | 452 | 22 | 47 | 2 | 1 | 72 |
| **47** | **Porbande** | 991 | 15 | 8 | 29 | 3 | 55 |

**Table IV.1.** Abundance of meiofauna (Ind.10 cm$^{-2}$) during FORVSS Cruise 219 & 225(WM)



| St. No. | Location | Depth (n | Nemato | Foramini | Crustace | Other G | Total |
|---|---|---|---|---|---|---|---|
| **27** | **Goa** | 230 | 149 | 128 | 2 | 13 | 292 |
| **28** | **Goa** | 520 | 83 | 66 | 0 | 6 | 155 |
| **29** | **Goa** | 1050 | 63 | 10 | 0 | 2 | 76 |
| **30** | **Ratnagiri** | 210 | 186 | 186 | 1 | 3 | 376 |
| **31** | **Ratnagiri** | 470 | 519 | 278 | 3 | 13 | 813 |
| **32** | **Ratnagiri** | 950 | 68 | 56 | 24 | 32 | 181 |
| **33** | **Dhabol** | 220 | 860 | 34 | 8 | 27 | 929 |
| **34** | **Dhabol** | 558 | 357 | 12 | 2 | 9 | 381 |
| **35** | **Dhabol** | 1010 | 86 | 18 | 31 | 11 | 146 |
| **36** | **Mumbai 1** | 200 | | | | | |
| **37** | **Mumbai 1** | 520 | 0 | 0 | 0 | 0 | 0 |
| **38** | **Mumbai 1** | 1000 | 2 | 0 | 0 | 0 | 2 |
| **39** | **Mumbai 2** | 200 | 4 | 6 | 0 | 0 | 10 |
| **40** | **Mumbai 2** | 490 | 28 | 15 | 0 | 10 | 53 |
| **41** | **Mumbai 2** | 1010 | 16 | 2 | 0 | 14 | 33 |
| **42** | **Veravel** | 202 | 167 | 103 | 0 | 23 | 294 |
| **43** | **Veravel** | 530 | 86 | 82 | 0 | 4 | 171 |
| **44** | **Veravel** | 1006 | 169 | 137 | 5 | 6 | 317 |
| **45** | **Porbande** | 200 | 152 | 188 | 0 | 9 | 349 |
| **46** | **Porbande** | 500 | 100 | 16 | 0 | 6 | 122 |
| **47** | **Porbande** | 1025 | 27 | 18 | 0 | 6 | 51 |

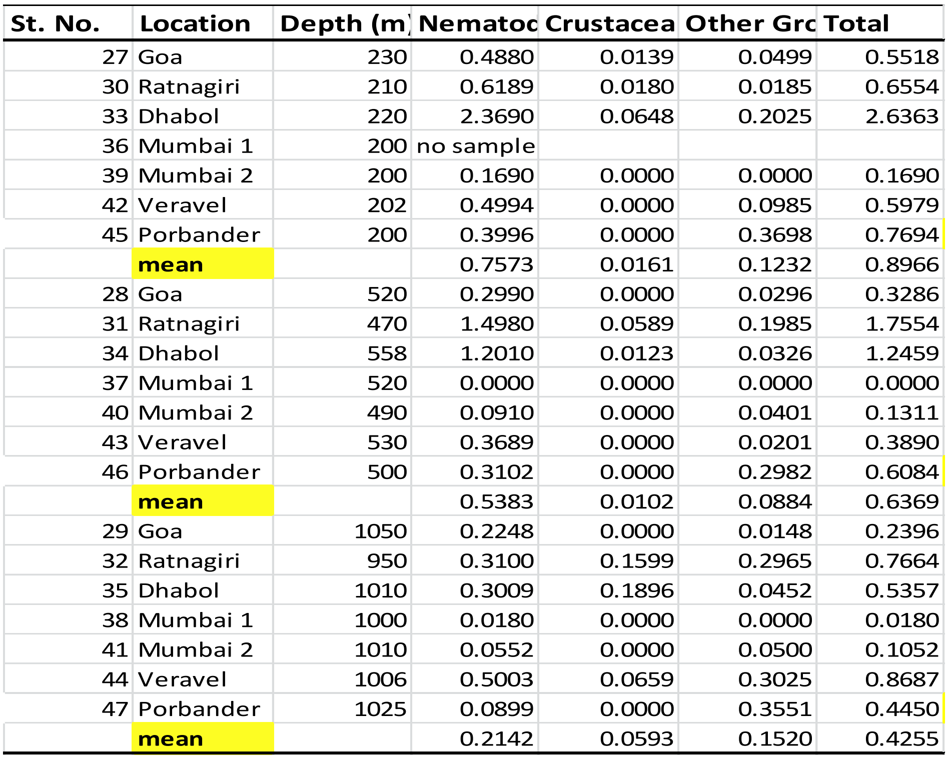
**Table IV.2.** Abundance of meiofauna (Ind.10 cm$^{-2}$) during FORVSS Cruise 228& 233 (SM)

| St. No. | Location | Depth (n | Nemato | Foramini | Crustace | Other G | Total |
|---|---|---|---|---|---|---|---|
| 27 | Goa | 203 | 18 | 15 | 0 | 0 | 34 |
| 28 | Goa | 490.9 | 9 | 10 | 2 | 2 | 23 |
| 29 | Goa | 847 | 8 | 27 | 4 | 6 | 45 |
| 30 | Ratnagiri | 200 | 26 | 83 | 0 | 12 | 120 |
| 31 | Ratnagiri | 521 | 4 | 8 | 2 | 4 | 18 |
| 32 | Ratnagiri | 860 | 44 | 9 | 2 | 2 | 57 |
| 33 | Dhabol | 218 | 0 | 2 | 0 | 0 | 2 |
| 34 | Dhabol | 503 | 2 | 35 | 5 | 1 | 43 |
| 35 | Dhabol | 817 | 4 | 20 | 2 | 1 | 28 |
| 36 | Mumbai 1 | 242 | 258 | 105 | 9 | 3 | 376 |
| 37 | Mumbai 1 | 575 | 47 | 51 | 0 | 4 | 102 |
| 38 | Mumbai 1 | 878 | 88 | 0 | 0 | 0 | 88 |
| 39 | Mumbai 2 | 213 | 194 | 54 | 12 | 0 | 260 |
| 40 | Mumbai 2 | 540 | 99 | 2 | 18 | 0 | 119 |
| 41 | Mumbai 2 | 850 | 10 | 29 | 0 | 10 | 49 |
| 42 | Veravel | 217 | 8 | 0 | 8 | 0 | 16 |
| 43 | Veravel | 534 | 9 | 9 | 0 | 0 | 18 |
| 44 | Veravel | 827 | 2 | 6 | 5 | 0 | 13 |
| 45 | Porbande | 200 | 27 | 46 | 0 | 13 | 86 |
| 46 | Porbande | 520 | 17 | 8 | 3 | 19 | 48 |
| 47 | Porbande | 933 | 5 | 3 | 1 | 7 | 16 |

**Table IV.3.** Abundance of meiofauna (Ind.10 cm$^{-2}$) during FORVSS Cruise 254 (SIM)

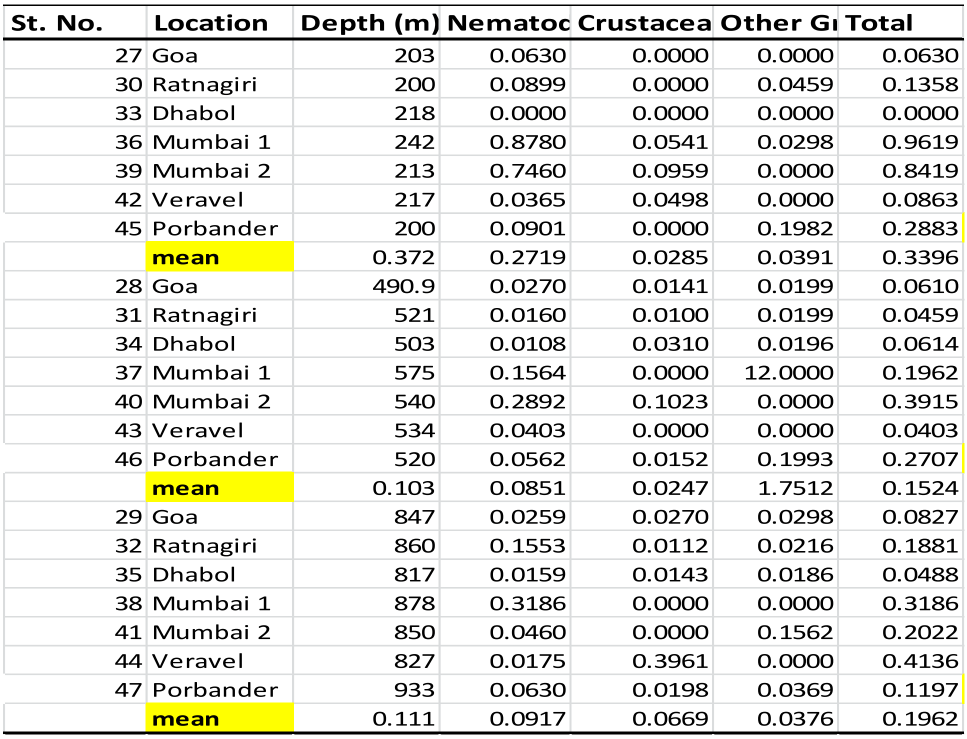
| St. No. | Location | Depth (m | Nematode | Crustacea | Other Gr | Total |
|---|---|---|---|---|---|---|
| 27 | Goa | 214 | 0.8782 | 0.5020 | 0.0199 | 1.4001 |
| 30 | Ratnagiri | 208 | 0.2751 | 0.0270 | 0.0155 | 0.3176 |
| 33 | Dhabol | 240 | 3.6024 | 0.4999 | 0.0789 | 4.1812 |
| 36 | Mumbai 1 | 211 | 0.8780 | 0.0998 | 0.0156 | 0.9934 |
| 39 | Mumbai 2 | 205 | 0.2340 | 0.2299 | 0.0169 | 0.4808 |
| 42 | Veravel | 218 | 0.0596 | 0.1000 | 0.0556 | 0.2152 |
| 45 | Porbander | 221 | 0.0100 | 0.0081 | 0.1230 | 0.1411 |
|  | **mean** |  | 0.8482 | 0.2095 | 0.0465 | 1.1042 |
| 28 | Goa | 517 | 0.5586 | 0.2190 | 0.0188 | 0.7964 |
| 31 | Ratnagiri | 496 | 0.0663 | 0.2111 | 0.0198 | 0.2972 |
| 34 | Dhabol | 489 | 0.4989 | 0.2000 | 0.0696 | 0.7685 |
| 37 | Mumbai 1 | 561 | 0.0403 | 0.2200 | 0.0198 | 0.2801 |
| 40 | Mumbai 2 | 525 | 0.0180 | 0.3600 | 0.0989 | 0.4769 |
| 43 | Veravel | 547 | 0.0109 | 0.1600 | 0.0652 | 0.2361 |
| 46 | Porbander | 490 | 0.0769 | 0.0079 | 0.0145 | 0.0993 |
|  | **mean** |  | 0.1814 | 0.1969 | 0.0438 | 0.4221 |
| 29 | Goa | 1080 | 0.1689 | 0.0540 | 0.0460 | 0.2689 |
| 32 | Ratnagiri | 991 | 0.2284 | 0.2200 | 0.0198 | 0.4682 |
| 35 | Dhabol | 1014 | 0.0269 | 0.1090 | 0.0196 | 0.1555 |
| 38 | Mumbai 1 | 902 | 0.1653 | 0.1431 | 0.0143 | 0.3227 |
| 41 | Mumbai 2 | 1031 | 0.0250 | 0.2213 | 0.0183 | 0.2646 |
| 44 | Veravel | 1010 | 0.2740 | 0.1190 | 0.0325 | 0.4255 |
| 47 | Porbander | 1030 | 0.0500 | 0.2009 | 0.0235 | 0.2744 |
|  | **mean** |  | 0.1341 | 0.1525 | 0.0249 | 0.3114 |

**Table IV. 4.** Biomass of metazoan meiofauna (mg 10cm$^{-2}$) during FORVSS Cruise 219



| St. No. | Location | Depth (m | Nematoc | Crustacea | Other Grc | Total |
|---|---|---|---|---|---|---|
| 27 | Goa | 230 | 0.4880 | 0.0139 | 0.0499 | 0.5518 |
| 30 | Ratnagiri | 210 | 0.6189 | 0.0180 | 0.0185 | 0.6554 |
| 33 | Dhabol | 220 | 2.3690 | 0.0648 | 0.2025 | 2.6363 |
| 36 | Mumbai 1 | 200 | no sample | | | |
| 39 | Mumbai 2 | 200 | 0.1690 | 0.0000 | 0.0000 | 0.1690 |
| 42 | Veravel | 202 | 0.4994 | 0.0000 | 0.0985 | 0.5979 |
| 45 | Porbander | 200 | 0.3996 | 0.0000 | 0.3698 | 0.7694 |
| | **mean** | | 0.7573 | 0.0161 | 0.1232 | 0.8966 |
| 28 | Goa | 520 | 0.2990 | 0.0000 | 0.0296 | 0.3286 |
| 31 | Ratnagiri | 470 | 1.4980 | 0.0589 | 0.1985 | 1.7554 |
| 34 | Dhabol | 558 | 1.2010 | 0.0123 | 0.0326 | 1.2459 |
| 37 | Mumbai 1 | 520 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 40 | Mumbai 2 | 490 | 0.0910 | 0.0000 | 0.0401 | 0.1311 |
| 43 | Veravel | 530 | 0.3689 | 0.0000 | 0.0201 | 0.3890 |
| 46 | Porbander | 500 | 0.3102 | 0.0000 | 0.2982 | 0.6084 |
| | **mean** | | 0.5383 | 0.0102 | 0.0884 | 0.6369 |
| 29 | Goa | 1050 | 0.2248 | 0.0000 | 0.0148 | 0.2396 |
| 32 | Ratnagiri | 950 | 0.3100 | 0.1599 | 0.2965 | 0.7664 |
| 35 | Dhabol | 1010 | 0.3009 | 0.1896 | 0.0452 | 0.5357 |
| 38 | Mumbai 1 | 1000 | 0.0180 | 0.0000 | 0.0000 | 0.0180 |
| 41 | Mumbai 2 | 1010 | 0.0552 | 0.0000 | 0.0500 | 0.1052 |
| 44 | Veravel | 1006 | 0.5003 | 0.0659 | 0.3025 | 0.8687 |
| 47 | Porbander | 1025 | 0.0899 | 0.0000 | 0.3551 | 0.4450 |
| | **mean** | | 0.2142 | 0.0593 | 0.1520 | 0.4255 |

**Table IV.5.** Biomass of metazoan meiofauna (mg $10cm^{-2}$ ) during FORVSS Cruise 228



| St. No. | Location | Depth (m) | Nematoc | Crustacea | Other G | Total |
|---|---|---|---|---|---|---|
| 27 | Goa | 203 | 0.0630 | 0.0000 | 0.0000 | 0.0630 |
| 30 | Ratnagiri | 200 | 0.0899 | 0.0000 | 0.0459 | 0.1358 |
| 33 | Dhabol | 218 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 36 | Mumbai 1 | 242 | 0.8780 | 0.0541 | 0.0298 | 0.9619 |
| 39 | Mumbai 2 | 213 | 0.7460 | 0.0959 | 0.0000 | 0.8419 |
| 42 | Veravel | 217 | 0.0365 | 0.0498 | 0.0000 | 0.0863 |
| 45 | Porbander | 200 | 0.0901 | 0.0000 | 0.1982 | 0.2883 |
|  | **mean** | 0.372 | 0.2719 | 0.0285 | 0.0391 | 0.3396 |
| 28 | Goa | 490.9 | 0.0270 | 0.0141 | 0.0199 | 0.0610 |
| 31 | Ratnagiri | 521 | 0.0160 | 0.0100 | 0.0199 | 0.0459 |
| 34 | Dhabol | 503 | 0.0108 | 0.0310 | 0.0196 | 0.0614 |
| 37 | Mumbai 1 | 575 | 0.1564 | 0.0000 | 12.0000 | 0.1962 |
| 40 | Mumbai 2 | 540 | 0.2892 | 0.1023 | 0.0000 | 0.3915 |
| 43 | Veravel | 534 | 0.0403 | 0.0000 | 0.0000 | 0.0403 |
| 46 | Porbander | 520 | 0.0562 | 0.0152 | 0.1993 | 0.2707 |
|  | **mean** | 0.103 | 0.0851 | 0.0247 | 1.7512 | 0.1524 |
| 29 | Goa | 847 | 0.0259 | 0.0270 | 0.0298 | 0.0827 |
| 32 | Ratnagiri | 860 | 0.1553 | 0.0112 | 0.0216 | 0.1881 |
| 35 | Dhabol | 817 | 0.0159 | 0.0143 | 0.0186 | 0.0488 |
| 38 | Mumbai 1 | 878 | 0.3186 | 0.0000 | 0.0000 | 0.3186 |
| 41 | Mumbai 2 | 850 | 0.0460 | 0.0000 | 0.1562 | 0.2022 |
| 44 | Veravel | 827 | 0.0175 | 0.3961 | 0.0000 | 0.4136 |
| 47 | Porbander | 933 | 0.0630 | 0.0198 | 0.0369 | 0.1197 |
|  | **mean** | 0.111 | 0.0917 | 0.0669 | 0.0376 | 0.1962 |

**Table IV.6.** Biomass of metazoan meiofauna (mg 10cm$^{-2}$ ) during FORVSS Cruise 254 (SIM)

| | FORVSS 219 | FORVSS 228 | FORVSS 254 |
|---|---|---|---|
| **200m** | 15-4823 | 10-929 | 2-376 |
| | 967±1718 | 375±301 | 128±140 |
| **500m** | 34-282 | 0-813 | 119-18 |
| | 168±103 | 242±279 | 53±41 |
| **1000m** | 48-286 | 317-2 | 88-13 |
| | 143±81 | 115±109 | 42±26 |

**Table IV.7.** Range & mean abundance (No. 10cm$^{-2}$) of meiofauna at the three depths

| | FORVSS 219 | FORVSS 228 | FORVSS 254 |
|---|---|---|---|
| **200m** | 0.14-4.18 | 0.17-2.64 | 0.00-0.96 |
| | 1.104±1.431 | 0.897±0.876 | 0.340±0.40 |
| **500m** | 0.80-0.10 | 0.00-1.76 | 0.04-0.39 |
| | 0.422±0.270 | 0.637±0.638 | 0.152±0.138 |
| **1000m** | 0.16-0.47 | 0.02-0.87 | 0.5-0.41 |
| | 0.311±0.105 | 0.426±0.324 | 0.196±0.131 |

**Table IV.8.** Range & mean biomass (mg. 10cm$^{-2}$) of metazoan meiofauna at the three depths

Chapter **V**

# DIVERSITY AND COMMUNITY STRUCTURE OF FREE LIVING NEMATODES IN THE EASTERN ARABIAN SEA MARGIN

Contents

## V. 1. INTRODUCTION

Deep-sea sediments cover more than 65 % of the Earth's surface, but its biodiversity remains woefully understudied. It is estimated that only 1 % of marine species is currently described (Snelgrove & Smith, 2002). Most studies of deep-sea benthic diversity are focused on larger forms such as mega or macro faunal organisms, nevertheless studies of the meiobenthos and nannobenthos have revealed a diverse fauna (Thiel, 1983; Baguley, 2006; Vanreusel et al., 2010). The general patterns of abundance and biomass of the metazoan meiobenthos as a whole are well documented (Thiel, 1983; Tietjen, 1992; Vincx et al., 1994), but its functional role in deep-sea food chains is limited. In deep-sea sediments, meiobenthic abundance and diversity exceed that of macrofauna and megafauna, and the biomass of the meiofauna (40 to 1000 µm) community dominates that of the larger infaunal animals with increasing water depth (Tietjen, 1992; Rex & Etter, 2010). Comparison of biomass and respiration rates also suggests that meiofauna have greater rates of carbon flow through food webs in deeper waters than the larger macrofauna and megafauna (Baguley et al., 2008; Rowe et al., 2008). Meiofauna abundance patterns generally reflect nematode abundance patterns, since nematode typically comprise more than 90 % of the total abundance of metazoan meiofauna (Rosli, 2017).

Meiofauna are the most abundant infauna in deep-sea sediments, with nematodes being the most abundant taxon (Heip et al., 1985; Vanreusel et al., 2010b). Nematodes are reported to be the dominant community of meiofauna from different regions of the Ocean of the world (Ansari et al., 2001, 2017; Riera & Hubas, 2003; Robert et al., 2005; Rex et al., 2006; Wei et al., 2010). Although our understanding of meiofaunal community structure of deep-sea habitats is growing, meiofauna are not considered in a number of biodiversity studies and are generally poorly studied compared to larger macrofauna (Zeppilli et al., 2015a). Studies of nematode biodiversity in the deep sea conducted in the Pacific and Atlantic Oceans (Shirayama, 1984; Thistle & Sherman, 1985; Tietjen et al., 1989; Vopel & Thiel, 2001; Danovaro et al., 2009a,b) reveal both latitudinal (Lambshead et al., 2002) and depth-related gradients (Soetart et al., 1991; Soltwedel, 2000; Vanhove et al., 2004). Additionally, Danovaro et al., (2008) observed a longitudinal gradient in nematode biodiversity in the Mediterranean Sea that was related to surface primary production and sediment organic matter. It appears that the spatial biodiversity and distribution of nematodes are affected by deep-sea habitat heterogeneity (Vanreusel et al., 2010), further supporting the broader contention that habitat heterogeneity plays an important role in maintaining deep-sea species diversity (Levin et al., 2001) across taxa and size classes. The eastern Arabian Sea slope region is impacted by strong oxygen minimum zone at bathyal depths (150-1500 m) causing changes in ambient oxygen availability and sediment geochemistry across the sea floor (Helly & Levin, 2004). World over, approximately 6 % of the continental margins (1.5 million $km^2$ of seafloor) experience permanent dysoxic conditions within OMZs (Helly & Levin, 2004) and this area is predicted to grow as a consequence of both anthropogenic changes in climate and ecosystem dynamics (Bakun & Weeks, 2004; Stramma et al., 2008). One of the largest and thickest OMZs occurs in the Arabian Sea, where 285,000 $km^2$ of continental margin seafloor is impacted between depths of 150–1500 m (Cowie et al., 1999; Helly & Levin, 2004; Acharya & Panigrahi, 2016). Within this region, sediments are characterised by a high organic carbon content (Cowie et al., 1999) and preservation of labile organic compounds such as amino acids, lipids and photosynthetic pigments (Smallwood et al., 1999; Vandewiele et al., 2009; Woulds & Cowie, 2009). Thus, the benthic environment in the EAS can be described as food rich and oxygen deficient.

Nematodes are ubiquitous in all deep sea regions and are characterised by potentially high species richness (Jensen, 1988; Tietjen, 1992). Being the numerically dominant meiofaunal taxon in deep sea sediments, nematodes play significant roles in marine biogeochemical cycles such as bioturbation and related processes that enhance sediment oxygenation and solute transport, thereby increasing rates of demineralization (Aller & Aller, 1992; Cullen, 1973; Pike et al., 2001). However, despite their numerical dominance, high species diversity and functional significance (Mokievsky et al., 2004; Miljutin et al., 2010), studies that encompass a description of the deep sea nematode taxonomic composition are rare and limited to a few sites. To date there is little information available on nematode distribution in the Indian Ocean, with most studies conducted in the intertidal as well as shallow subtidal region. A recent work on the free-living marine nematodes of the Indian subcontinent enlists 155 species from west coast (Sajan, 2003) and 199 species from East coast of India (Ansari et al., 2012), all of which occur in the continental shelf up to 200 m. However, nematode collections from the deep Indian Ocean have been limited to ecological studies of the meiofaunal community as a whole (Cook et al., 2000; Ingole, 2010). Due to the significant ecological as well as economic importance of the Arabian Sea margin and the inevitability of future oil and gas exploration in deep water, it is critical to understand the regional patterns of biodiversity in this region. Since free living nematodes are considered as suitable organisms for monitoring studies, this study also provides a valuable baseline dataset for free living nematodes from the continental slope of the west coast of India for comparison with potential future environmental perturbations such as the oil spillages, dredging and mining activities.

This chapter presents the first ecological study of nematode assemblages in the deep Eastern Arabian Sea (EAS), northern Indian Ocean, specifically investigating patterns of nematode community structure with latitude, depth and season, as well as in relation to environmental variables along the EAS slope. To test this we examined (1) the composition of the nematode communities along latitudinal, bathymetric and seasonal gradients, (2) the functional diversity of the nematode community as determined from the morphology of the buccal cavity.

## V. 2. RESULTS

Based on the physicochemical as well as biogeochemical process, Eastern Arabian Sea is divided in to South Eastern Arabian Sea (SEAS) and North Eastern Arabian Sea (NEAS) (Madhupratap et al., 2001; Sanjeevan et al., 2010). So the 48 survey sites along the entire eastern Arabian Sea, west coast of India (Latitude 7$^o$ 01’ N to 21$^o$ 30’ N; Longitude 67$^o$ 28’ E to 77$^o$ 15’ E) were grouped into appropriate SEAS and NEAS zone to identify region-scale similarities in species composition.

### V. 2. 1. Abundance of nematodes in the EAS margin

All together 288 core samples from 48 sites of eastern Arabian Sea are investigated here for nematode community structure. The abundance of nematodes varied among 0 (FORVSS 228, Mumbai 1 500 m; FORVSS 254, Dhabol 200 m) and 1732 Ind.10 cm$^{-2}$ (FORVSS 219, Dhabol 200 m) in the entire study.

### V. 2. 2. Nematode composition and diversity

The results of the present study showed that the free-living marine nematodes in the EAS margin are very diverse. Throughout 48 sampling sites, 385 putative species, belonging to 141 genera and 29 families represented from a total of 8887 individuals were obtained from the 288 core samples. Of the 385 species, some were new to science and >100 species were recorded for the first time from Eastern Arabian Sea. The species composition of nematodes varied among different sampling stations, depth and survey. From the 48 sites sampled, highest number of species (131) were seen at site 1 (Cape Comorin, 200 m), while the lowest (12 species) were seen in the site 48, northern most transect Porbander (1000 m). The total number of species encountered at 200 m, 500 m and 1000 m were 302, 276 and 224 species respectively. During the initial survey 194 species were reported. The number of species increased gradually to 208 and 317 in the following 2nd and 3rd surveys. The numerically dominant species from the present study were *Acantholaimus quintus* (3.7 % of total individuals) followed by *Desmodora* sp8 (3.3 %). Species such as *Daptonema oxycerca* (2.5 %), *Daptonema sp8* (2.4 %), *Aponema ninae* (2.2 %), *Microlaimus* sp2 (2.1 %), *Richtersia bathyalis* (2.1 %), *Desmodorella* spp (2 %) and *Sabatieria* spp (2 %) were also showed high abundance. The numerically dominant species varied with each survey. In the 1st survey at 2003 dominant species was *Microlaimus* sp2 (4.1 %) followed by *Acantholaimus quintus* (4 %) and *Desmodora* sp8 (3.1 %). During the 2nd survey during 2004, the dominance was found among *Desmodora* sp8 (5 %) *Acantholaimus quintus* (4.8 %) and *Aponema ninae* (4.4 %). In the 3rd survey during 2007, the dominance was shifted to *Daptonema oxycerca* (3.7 %), *Gonionchus intermedius* (3.5 %) and *Microlaimus abyssalis* (2.8 %).

The most important family in terms of percentage contribution and number of species represented from the study area was Xyalidae (21 %, 51 species). Other families with high number of species were Linhomoeidae (6 %, 41), Chromadoridae (15 %, 39), Microlaimidae (15 %, 31), Desmodoridae (11 %, 27), Comesomatide (4 %, 22), Oxystominidae (3 %, 19), Selachinematidae (16 species), Cyatholaimidae (15), Diplopeltidae (14), Desmoscolecidae (13), Trefusidae (12), Leptolaimidae (11) and Sphaerolaimidae (10).

The most species-rich genera were *Daptonema* (25 morphotypes) and *Acantholaimus* (21 morphotypes). Although there were 7 more genera with 8–15 morphotypes (*Microlaimus, Terschellingia, Desmodora, Paralinhomoeus, Theristus, Pomponema and Sphaerolaimus*). In addition, many rare genera of free living nematodes were also represented in the present study. The genera whose species are known from a few individual specimens or there are few reports on their species despite the volume of work carried out on diversity and systematics of marine free living nematodes across the world's oceans are recognised as 'rare'. Rare genera such as *Paramicrolaimus, Psammonema, Cobbianema, Scaptrella, Morlaixia, Tarvaia, Grieffiella, Bathynox,* *Boucherius, Caligocanna, Ixonema, Xenolaimus* and *Xyala* were found across the Eastern Arabian Sea margin.

### V. 2.3. Sampling sufficiency: species accumulation curve

In order to test the sufficiency of sampling, species accumulation curves were plotted for the free living nematodes from the EAS margin, west coast of India and species estimators were calculated to determine the number of species likely to be encountered in the study area with unlimited sampling. In most ecological systems, the number of species observed increases nonlinearly with the area sampled. Larger areas tend to harbour more numbers of species. Species accumulation curves gives an idea about the number of species may occured in a habitat and the number of species can obtained each time we sample. Species accumulation curves for the nematode community in the eastern Arabian Sea margin were constructed based on the 288 core samples. The species accumulation curve did not reaches the upper asymptote, signifying that the study area was sampled sufficiently (Figure V.1).

Various species estimators were used to predict the true number of species that would be found as the number of samples tend to be infinity. The total number of species estimated by different estimators for the eastern Arabian Sea margin ranged from 385 to 515 species (Figure V.1). Total number of species found (Sobs) in the samples was 385 and the maximum number of species that could have occurred in the study area based on the estimator (Jacknife2) was 515. While the minimum estimate was given by Sobs and UGE, the supreme estimate was given by Jacknife2. The number of nematode species for the entire study area estimated by Chao1, Chao2, Jacknife1, Bootstrap and MM were 494, 469, 473, 426, and 367 respectively. Based on the estimators, almost 75 % of expected species from the eastern Arabian Sea are collected across three surveys. From the south eastern Arabian Sea, the observed number of species in samples was 338 (Sobs) and maximum expected number of species for SEAS is 484 (Jacknife2). In the SEAS About 70 % of the species are encountered. Similarly, from NEAS observed number of species is 224 and expected species is 296 which signifies about 75 % of the expected species are obtained from NEAS. Based on the estimators the present study area was sampled sufficiently in terms free living nematodes.

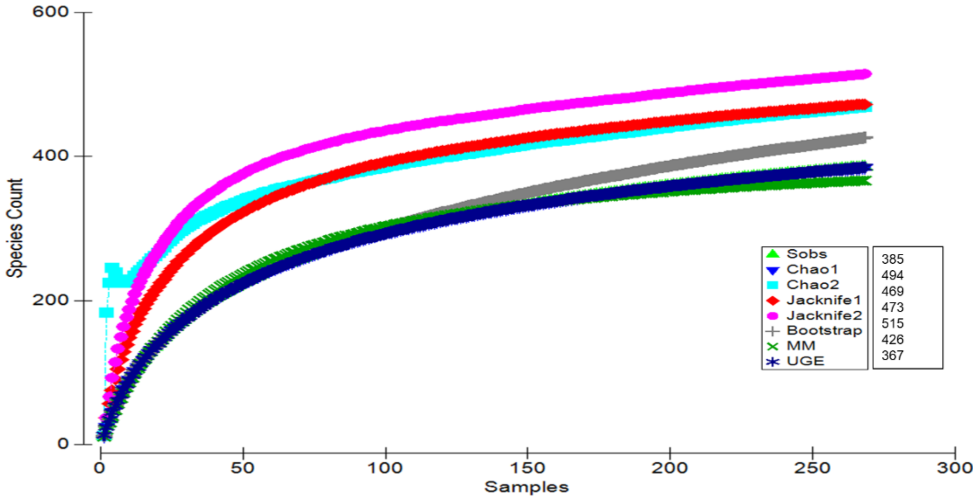


**Figure V.1.** Species accumulation curve for nematode species in the study area

### V. 2. 4. Univariate indices of nematode diversity

Nematode diversity along the 48 sites during the three surveys (Tables V.1-4) was estimated using several common ecological indices. The diversity indices such as species number (S), species richness (Margalef's index, d), species evenness (Pielou's index, J'), species diversity (Shannon index, H') and species dominance (Simpson's index, λ') were worked out for nematodes.

#### *(a) Variation in nematode diversity with survey*

During the first survey, total number of species varied between one (Mumbai 2, 500 m) and 58 (Cape, 500 m) (mean 15.96±12.14); it varied between 1 (Mumbai 1, 1000 m) and 57 (Kollam, 200 m) (mean 19.02±15.38) in the second survey and between 1 (Mangalore, 500 m; Dhabol, 500 m) and 82 (Cape, 500 m) (mean 21.87±20.36) during the third survey.

Species richness (d) in the first survey ranged from 0 (Mumbai 2, 500 m) to 10.65 (Cape, 500 m) (mean 3.90±2.11); between 0 (Mumbai 1, 1000 m) and 11.64 (Cape, 1000 m) (mean 4.26±2.63) during the second survey, and between 0 (Mangalore, 500 m; Dhabol, 500 m) and 15.98 (Cape, 500 m) (mean 5.02±3.65) during the third survey.

A relatively high evenness index was observed during the study and the mean value was 0.92±0.06 (first survey), 0.92±0.05 (second survey) and 0.92±0.07 (third survey).

The minimum value of Shannon-Wiener diversity during first survey was 0 (Mumbai 2, 500 m) and maximum was 3.44 (Coondapur, 200 m; Goa, 200) (mean 2.26±0.76), whereas in the second survey diversity value ranged between 0 (Mumbai 1, 1000 m) and 3.73 (Kollam, 200 m) (mean 2.37±0.86). During the third survey the value ranged between 1.34 (Mangalore, 500 m; Dhabol, 500 m) and 3.79 (Kollam, 200 m) (mean 2.33±0.95).

As with the analysis of data on faunal density, nematode species diversity data from the 48 sites were used to test the variability with survey. The result of ANOSIM indicated that the time of survey was not a significant factor determining nematode diversity, Species number, Shannon-Wiener diversity, Evenness and dominance (Table V. 1).

### *b)* Variation in nematode diversity with depth

Figures V.2-6 shows the numbers of species, richness, diversity, evenness and dominance indices at each site during the study. Over all the species number decreased with increase in depth (200 m, 26.72±16.13; 500 m, 16.80±18.03; 1000 m, 13.38±10.44). Number of nematode species in 200 m depth sites varied from 3 at Porbander (survey 1) to 63 at Trivandrum (Survey 3) (mean, 26.72±16.13). In the initial survey it ranged between 3 (Porbander) and 50 (Goa) (mean, 21.75±12.50), while in second survey it ranged between 2 (Mumbai 2) and 57 (Kollam) with a mean of 23.80±14.43. In the third survey observed range of species number was 7 (Veravel) and 63 (Trivandrum) (34.93±18.74).

At 500 m, number of species varied from 1 (Mumbai 2, 1st survey; Mangalore and Dhabol, 3rd survey) to 39 (mean, 16.80±18.03). Mean species number for 500 m depth sites are as follows: 1st survey, (13.33±14.38); 2nd survey, (18±15.05); 3rd survey, (18.94±23.50). At 1000 m depth sites number of species ranged from 1 (Mumbai 1, 2nd survey) to 51 (Cape, 2nd survey) with mean value 13.38±10.44. Mean species numbers for different surveys were 12.63±6.94; 15.50±13.93; 11.93±9.52 respectively for 1st, 2nd and 3rd surveys.

Species richness (d) at 200 m varied from 0.71 (Mumbai 2, 2nd survey) to 12.36 (Trivandrum, 3rd survey) with an overall mean of 5.62±2.76. During the 3rd survey species richness in 200 m depth (7.37±3.02) was very high when compared to initial (4.69±2.02) and 2nd surveys (4.85±2.49). In the following depth categories it did not showed much variation among surveys. Mean species richness for 500 m was 3.37±2.51, 4.12±2.38 and 4.39±4.47 respectively for 1st, 2nd and 3rd surveys with an overall mean of 3.97±3.25. At 1000 m depth, average richness was 3.60±1.63 (1 survey); 3.83±3.02 (2nd survey); 3.35±1.71 (3rd survey). As a whole mean richness for this depth class was 3.60±2.18.

| Univariate indices | Group | ANOSIM R Value | P Value |
|---|---|---|---|
| Species No. (S) | Depth | 0.093 | 0.20% |
| | Transect | 0.043 | 2.70% |
| | Survey | -0.027 | 79.80% |
| Species richness (d) | Depth | 0.06 | 0.30% |
| | Transect | 0.053 | 1.00% |
| | Survey | -0.027 | 77.20% |
| Species evenness (J’) | Depth | 0.004 | 32.80% |
| | Transect | -0.008 | 65.00% |
| | Survey | -0.016 | 68% |
| Species diversity (H’) | Depth | 0.061 | 0.20% |
| | Transect | 0.047 | 1.70% |
| | Survey | -0.036 | 85.10% |
| Dominance (λ’) | Depth | 0.005 | 33.60% |
| | Transect | 0.111 | 3.70% |
| | Survey | -0.038 | 87.30% |

**Table V. 1.** ANOSIM analysis of univariate indices

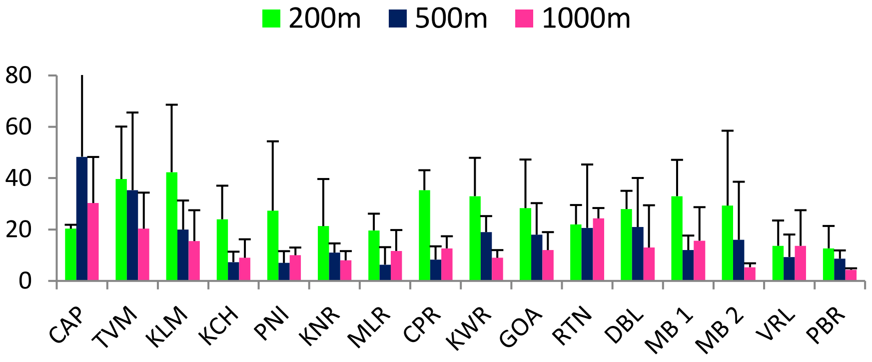


**Figure V. 2.** Species number (S) for each site in the study area

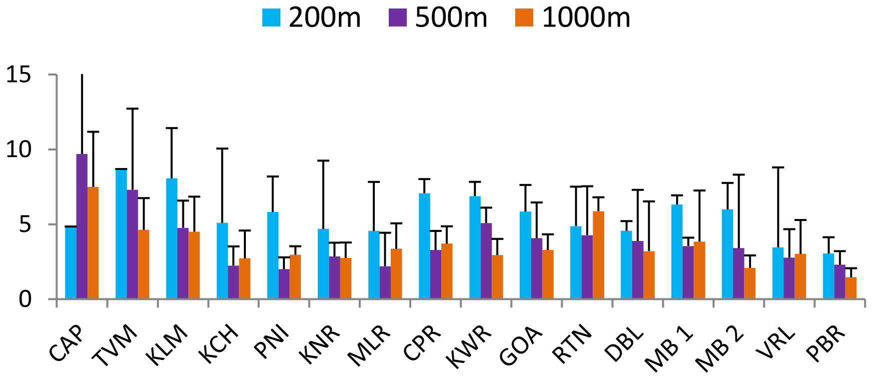


**Figure V. 3.** Species richness (d) for each site in the study area

Diversity (H') at 200 m sites was lowest at Mumbai 2 (0.56) and higher at Kollam (3.79); and the mean diversity for this depth category as a whole was 2.74±0.66. At this depth category species diversity was almost similar in all three surveys conducted (2.63±0.63; 2.65±0.76; 2.95±0.59). At 500 m, species diversity ranged from 0 (Mumbai 2, initial survey; Dhabol, 3rd survey) to 3.74 (Trivandrum, 3rd survey) (mean 2.10±0.97). Species diversity in the 500 m depth stations was more or less similar in the 2nd and 3rd survey (mean 2.34±0.81; 2.06±1.15) but showed lower value in 1st survey (1.91±0.92). At 1000 m stations the observed range was from 0 (Mumbai 1, 2nd survey) 3.71 (Cape, 2nd survey) with a mean of 2.12±0.76. In all the surveys species diversity at 1000 m, remained more or less the same (2.22±0.57; 2.14±0.97; 2.01±0.73).

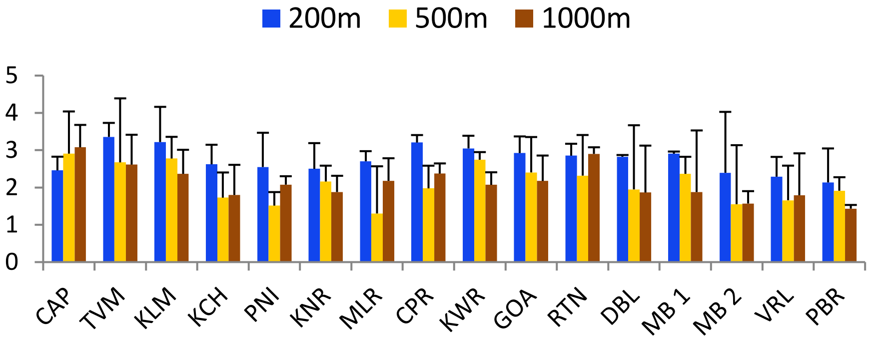


**Figure V. 4.** Species diversity (H') for each site in the study area

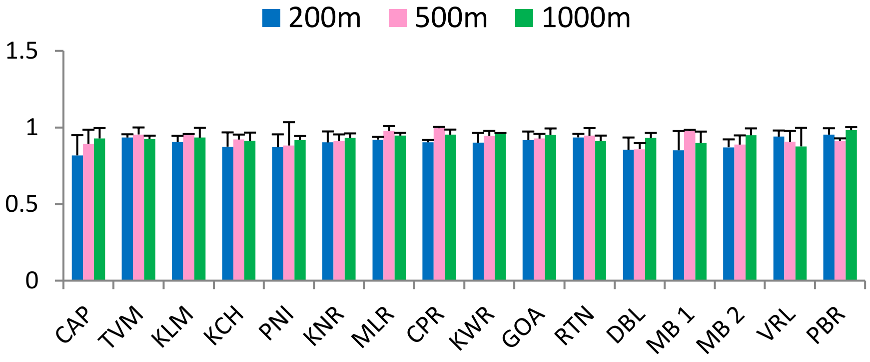


**Figure V.5.** Evenness (J') for each site in the study area

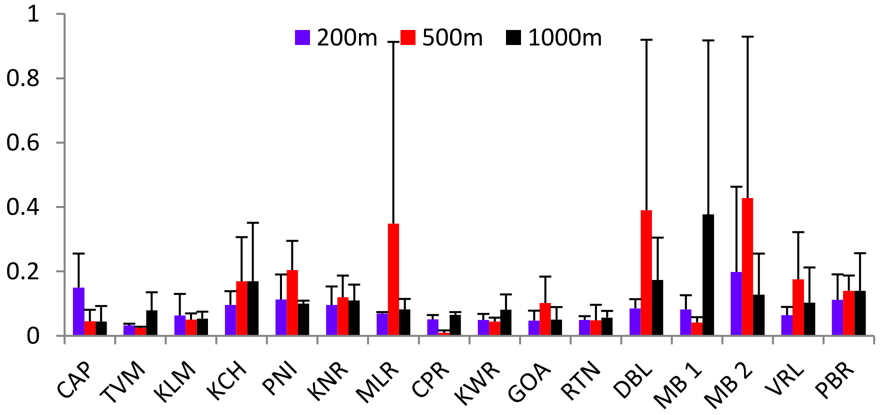


**Figure V.6.** Dominance (λ') for each site in the study area

Mean evenness index values were comparatively low in 200 m depth sites (0.90±0.07). The deeper 500 and 1000 m depth stations showed similar values 0.93±0.06. There was meagre variation in evenness between surveys, in every depth group studied.

There was no significant differences in the number of species, species richness, species diversity, evenness (J') and dominance (Table V. 1) with respect to depth, latitude and survey .

### *c) Variation in nematode diversity with latitude*

From the Eastern Arabian Sea as a whole the number of species, in 1st survey ranged from 1 (Mumbai 2, 500 m) to 58 (Cape, 500 m) with an average of 15.96±12.14. From the South Eastern part it varied from 2 (Trivandrum, 500 m) to 58 (Cape, 500 m) with an average of 16.42±12.51 while it varied from 1 (Mumbai 2, 500 m) to 50 (Goa, 200 m) in the Northern part with an average of 15.38±11.95. During the 2nd survey species number ranged from 1 (Mumbai 1, 1000 m) to 57 (Kollam, 200) (mean 19.02±14.57). In SEAS, number of species spanned from 3 (Kochi, 500 & 1000) to 57 (Kollam, 200) with mean value of 18.04±15.38 while at NEAS it ranged from 1 (Mumbai 1, 1000 m) to 49 (Ratnagiri, 500) (mean 20.42±13.62). In the 3rd survey observed range of species number was from 1 (Mangalore, 500 m; Dhabol, 500) to 82 (Cape, 500 m) (21.87±20.36). From SEAS number of species ranged from 1 (Mangalore, 500 m) to 82 (Cape, 500 m) (27.19±21.91) and from NEAS it varied from 1 (Dhabol, 500) to 60 (Mumbai 2, 200) with a mean of 14.95±16.14.

Species richness (d) in the Eastern Arabian Sea varied from 0 (Mumbai 2, 500 m) to 10.65 Cape, 500 m) (mean 3.90±2.11) in first survey and comparatively high richness was observed from SEAS (mean 4.12±2.06) with reference to NEAS (mean 3.62±2.19). From the second survey richness in Eastern Arabian Sea margin varied from 0 (Mumbai 1, 500 m) to 11.64 (Cape, 1000) (4.26±2.63). From the SEAS mean richness was 4.43±2.83 while at NEAS, observed mean richness was 4.01±2.37. In the 3rd sampling, richness varied from 0 (Mangalore, 500 m) to 15.98 (Cape, 500 m) (5.02±3.65). High richness was observed in the SEAS margin (5.93±3.95) while NEAS obtained richness value of 3.84±2.90. Comparatively high richness was observed from the third survey.

Diversity (H') of free living nematodes in the eastern Arabian Sea margin from initial survey varied from 0 (Mumbai 2, 500) to 3.44 (Coondapur, 200 m; Goa, 200 m), with a mean value of 2.26±0.76. From the southern sites average value of Shannon diversity was 2.35±0.65 whereas from the northern sites mean value was 2.15±0.89. During second survey nematode diversity along eastern Arabian Sea as a whole ranged from 0 (Mumbai 1, 1000 m) to 3.71 (Cape, 1000 m) (mean 2.37±0.86). From the average values it is clear that there is not much variation in diversity along SEAS and NEAS (2.38±0.78; 2.37±0.98). In the third survey, diversity along the entire study area stretched among 0 (Dhabol, 500 m) and 3.79 (Kollam, 200 m) (mean 2.33±0.95). Relatively low diversity is observed from the NEAS region (2.01±0.93) when compared to that of SEAS (2.58±0.91). Even though diversity as a whole did not show high variation, increased diversity values can be observed from the extreme south sites such as Cape, Trivandrum and Kollam (Table V.1-4).

Mean evenness value for various surveys and region is as follows: 0.92±0.06 (SEAS, 0.92±0.06; NEAS 0.91±0.05); 0.92±0.5 (SEAS 0.93±0.04; NEAS 0.90±0.05); 0.92±0.07 (SEAS 0.90±0.07; NEAS 0.94±0.06) (1st, 2nd and 3rd survey respectively).

Even though there was variation in the number of species, species richness, diversity, evenness and dominance none of them was statistically significant (Table V. 1).

### d) k-dominance curve for nematodes in the EAS margin

In order to get a clear picture of the dominance/evenness of nematode, k-dominance curves were built using the data of abundance of nematode species. By using k-dominance curves the level of dominance in each sample is compared. In this method the curves cumulate the number of individuals according to the rank of species in each replicate/sample. In this plot, Species are ranked in order of importance along the x axis and their percentage contribution to the total is plotted along the y axis. In the present study, k-dominance plots were constructed for all transects over depths and zones using statistical software PRIMER (Figures V.7-9). In general, high dominance and low diversity was observed across northern transects. Relatively high diversity and low dominance was observed from transects Cape, Trivandrum and Kollam.

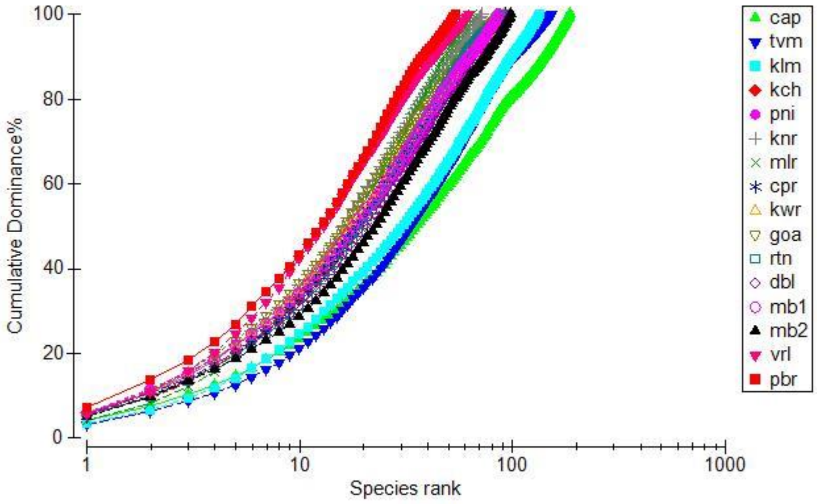


**Figure V.7.** k-dominance curve of nematode species in various transects

All the three depth category showed more or less similar distribution of species diversity. All along the eastern Arabian Sea, dominance was low in the southern part and high dominance was observed from northern part. This was mostly because of high dominance, and low abundance at many sites. The number of species found increasing with high number of individuals. So, most of the stations with high number of individuals tend to contain higher number of species hence causing low dominance and high diversity. (Figures V.7-9).

When the zones of eastern Arabian Sea (SEAS and NEAS) are compared, high dominance was observed from NEAS (Figure V.9). I Eighty percent of total organisms were represented by 11 species at NEAS and 40 species at SEAS from the initial survey. During 2nd and 3rd surveys it was 16 species, NEAS; 38 species, SEAS and 6 species, NEAS; 30 species, SEAS respectively. The present study revealed that high nematode diversity occurs along the continental margin, especially at SEAS; and that there was relatively high species dominance NEAS.

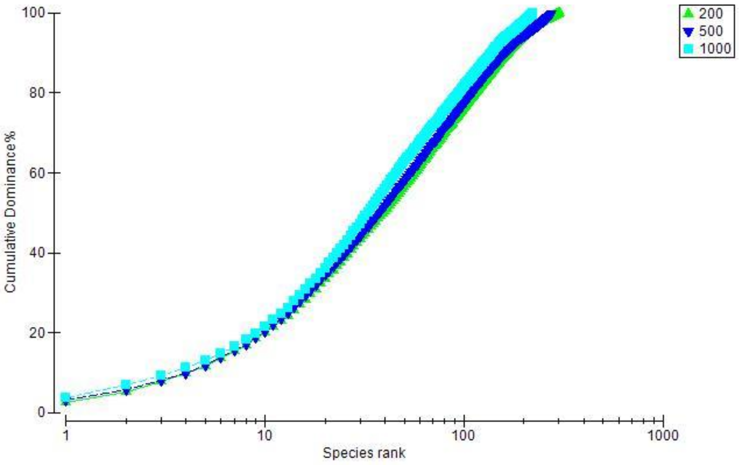


**Figure V.8**. k-dominance curve of nematode species in the 200 m, 500 m and 1000 m depth category

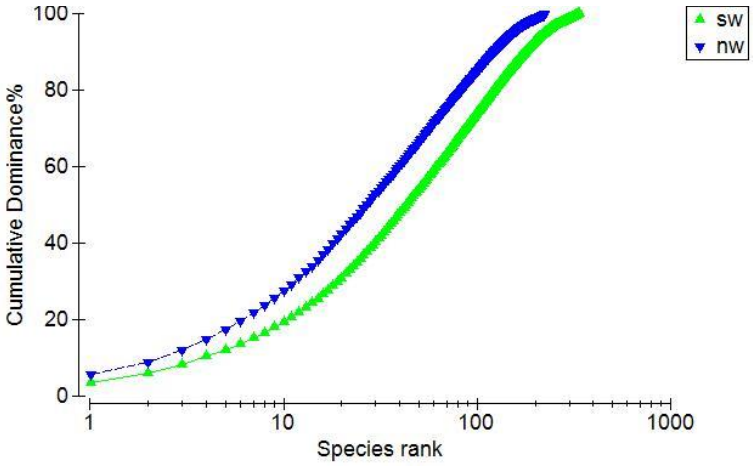


**Figure V.9**. k-dominance curve of nematode species along the SEAS (sw) and NEAS (nw)

### V. 2. 5. *Multivariate analyses of community structure*

Multivariate analysis was employed to compare nematode community structure along and across the various transects in the study area. Similarity matrices were constructed based on nematode species data from the 144 stations distributed across the eastern Arabian Sea. The whole set of data were square root transformed to reduce the impact of patchiness or heterogeneity on the assessment of the community similarities (Clark & Warwick, 2001). Based on the similarity matrix nematode community data along the entire Eastern Arabian Sea were tested with respect to season, depth and latitude. Results of ANOSIM test for variation of nematode community structure with respect to season (Global R: 0.08) and depth (Global R: 0.041) did not showed any significant variation (Figure V.10-11), but showed a significant latitudinal variation (Global R: 0.685) (Figure V.12).

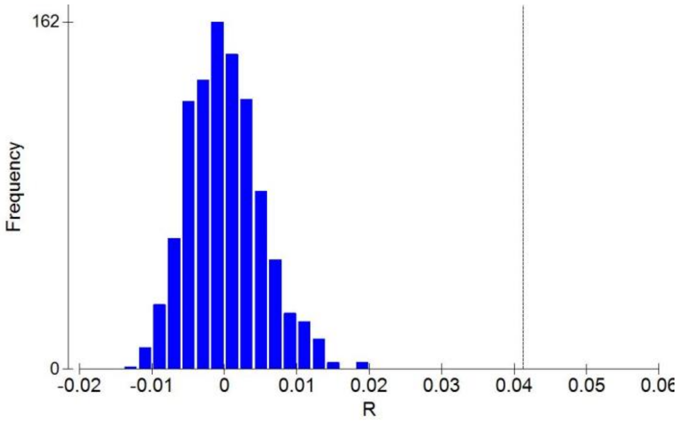


**Figure V.10.** Histogram of ANOSIM test for variation of nematode community with respect to depth

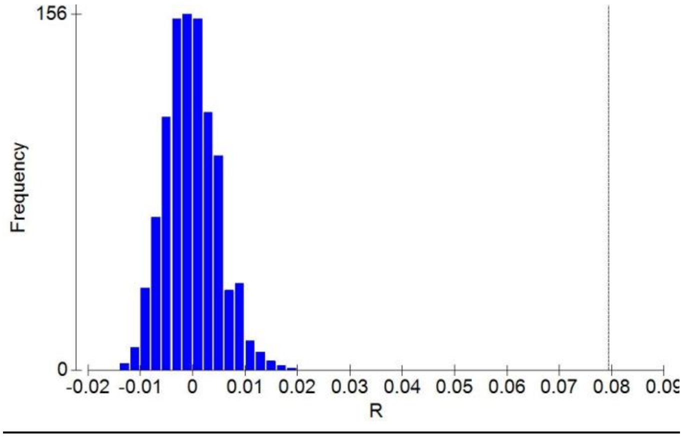


**Figure V.11.** Histogram of ANOSIM test for variation of nematode community with respect to season

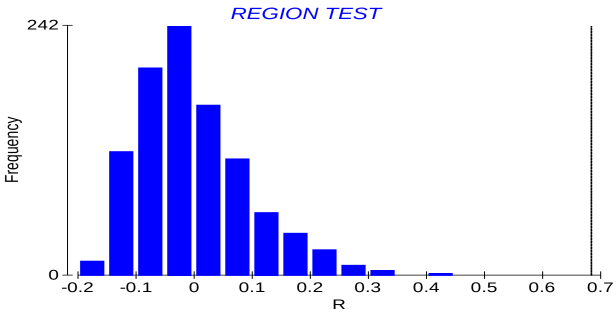


**Figure V.12.** Histogram of ANOSIM test for variation of nematode community with respect to region or latitude

To investigate the region-scale variations among the SEAS and NEAS zone (latitudinal) in species composition, hierarchical clustering analysis based on Bray-Curtis similarity was carried out. Since there was no significant difference among the different depth stations, data were averaged to get transect wise abundance in each survey. Based on cluster dendrogram and nonmetric Multidimentional scaling (nMDS) analysis, nematode community structure clearly showed regional differences between SEAS and NEAS transects. In the hierarchical cluster analysis on full set of (48 sites) transect wise data, 45 sites grouped into 5 major clusters at a similarity of 15% ($p<0.05$), of which one could be further distinguished into two sub-clusters, while three transects remained outliers (Figure V.13). The clusters are formed irrespective of surveys (seasons) forming clusters between transects in different surveys and showed a latitudinal pattern by clubbing most of SEAS transects together.

The five major clusters are designated from A to E (Figure V.13). First cluster group A is the clubbing of Veravel and Porbander of 1st survey, Mumbai 2 of 2nd survey and Dhabol of 3rd survey. The B cluster composed of Ponnani and Veravel transects of 2nd survey and Ratnagiri of 3rd survey. The larger cluster 'C' comprised of three sub clusters (C1, C2, C3) at 20 % similarity. Sub cluster C1 comprised of transects Mumbai 1 and Mumbai 2 of the 3rd survey. They were two adjacent sites separated at 1° interval.

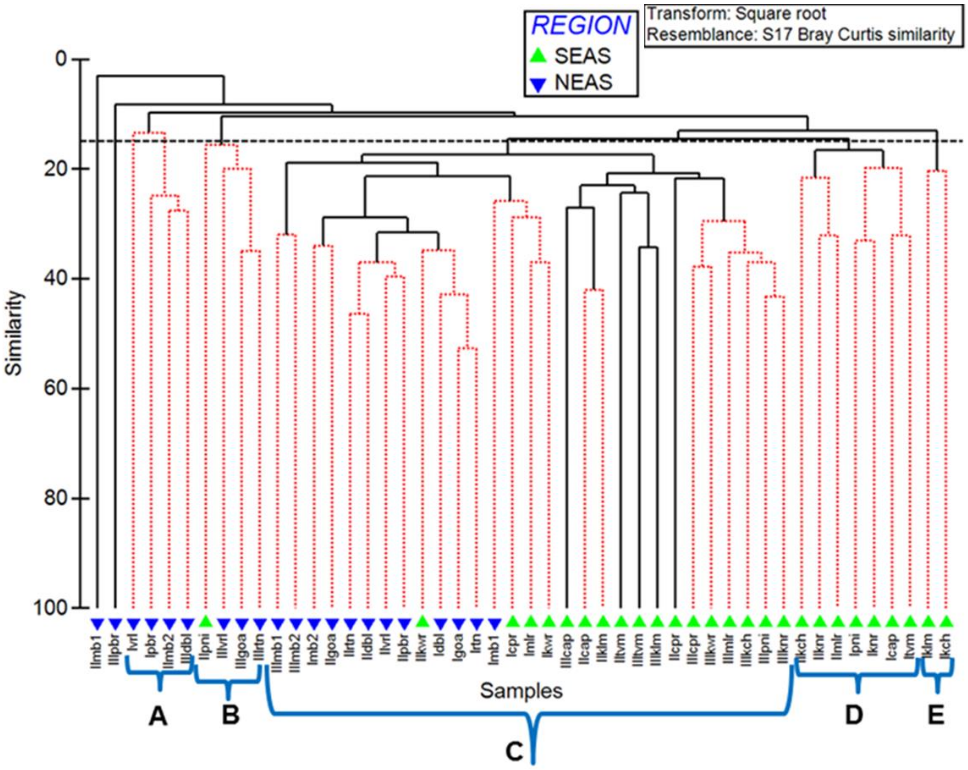


**Figure V.13.** Dendrogram of nematode species data over three surveys

Sub cluster C2 formed of two other large clusters of which again sub divided in to C2a and C2b. Cluster C2a formed by 9 NEAS transects from the 1st and second survey and one SEAS transect 2nd survey. Cluster C2b composed of one NEAS and 3 SEAS transects from the 1st survey. Cluster C3 comprises of 13 SEAS transects from 2nd and 3rd survey. It is also divided in to C3a and C3b. The southernmost transects Cape, Trivandum and Kollam from the second and third survey were grouped together to form the cluster C3a while the other SEAS transects towards NEAS latitude such as Kochi, Ponnani, Kannur, Coondapur, Karwar and Mangalore from the 2nd and 3rd collection jointed in cluster C3b. Cluster D clubbed together Kochi, Kannur and Mangalore from 2nd survey with Cape, Trivandrum, Ponnani and Kannur from 1st survey. Cluster E was the grouping of Kochi and Kollam from the 1st survey. From the cluster analysis it is revealed that the SEAS community and NEAS community are different with very low level of similarity (15 %). Clusters are formed among transects designated in two zones. The clusters A, B, C1 and C2a formed clusters by joining 18 NEAS transects with 2 SEAS transect while clusters C2b, C3, D and E formed cluster with rest of the 27 transects in the SEAS. The separate clustering of SEAS and NEAS community was irrespective of different surveys.

The variations between the two observed regions were detected in detail by using Similarity percentage analysis (SIMPER). Based on SIMPER (similarity percentage) analysis, the species responsible for the defined clustering pattern was identified. The similarities and dissimilarities between different assemblage groups were caused by presence or absences of distinct species or variation in abundance of predominant species. The SIMPER analysis carried out at the species level demonstrated that the main differences in the nematode composition between the SEAS and the NEAS stations were principally due to the species *Acantholaimus quintus* and *Sabatieria* spp. The species *Acantholaimus quitus* dominated along the NEAS contributing 26.78 % to the similarity while from the SEAS its importance decreased in to 0.99 % of total similarity. In the SEAS region the dominance of *Sabatieria* spp was high contributing 20.72 % to the similarity with meagre abundance along NEAS. The presence of certain species like *Gonionchus intermedius*, *Sphaerolaimus* sp1, *Eubostrichus hortulanus*, *Sabatieria alata*, *Perspira* sp, *Daptonema* sp2, *Hopperia* spp, *Desmodora* sp3, *Paralinhomoeus* sp1, *Daptonema hirsutum*, *Psammonema kuriani*, *Acantholaimus* sp1, *Neotonchus vitius*, *Pomponema clavicaudatum*, *Eubostrichus africanus*, *Daptonema* sp3, *Pseudochromadora unicornis*, *Laimella longicaudata*, *Neotonchus* spp, *Neotonchus cupulatus*, *Manganonema* sp2, *Dasynemoides riemanni*, *Synonchiella micramphis*, *Leptolaimus* sp4, *Pterygonema* spp, *Filoncholaimus* sp and *Molgolaimus* sp6 in the SEAS region also contributed to significant dissimilarity along two regions. From NEAS, some of the species such as *Prochaetosoma* sp1, *Desmodora* sp4, *Paralinhomoeus appendixocaudatus*, *Acantholaimus* sp2, *Microlaimus* sp2, *Microlaimus* sp3, *Aponema decremerae*, *Microlaimus africanensis*, *Paralongicyatholaimus* sp, *Daptonema* sp4 and *Pierrickia* sp were absent.

Since there was no significant variation over the three surveys (seasons) (ANOSIM Global R=0.08) data were pooled to average in 21 transects. The hierarchal cluster based on the similarity and SIMPROF test of pooled data in each site clearly depicts the latitudinal variation of nematode community along the SEAS and NEAS margin. Cluster dendrogram based on pooled species abundance data of nematode are shown in Figure V.14. The 21 transect samples are clustered into 2 main clusters (SEAS and NEAS) at about 30 % Bray-Curtis similarity. SEAS cluster included all samples of southern sites located below latitude 15ºN and all the sites between 15ºN to 21ºN clustered together to form NEAS cluster. Each main cluster was sub grouped in to two with an outlier. The subclusters of SEAS were (35 % similarity) Sa and Sb, in which Sa formed out of the southernmost three transects viz. Cape, Trivandrum and Kollam. In the Sb cluster all remaining transects (Mangalore, Kannur, Ponnani, Karwar and Coondapur) except Kochi are grouped together. NEAS clusters were named Na and Nb. The cluster ‘Na’ formed between transects Goa, Ratnagiri and Dhabol. All these adjacent transects are closer to the southern region. The cluster Nb were formed between northern most transects Mumbai 2, veravel and Porbander. The transect Mumbai 1 was located immediate middle of all the NEAS transects and remained as an outlier.

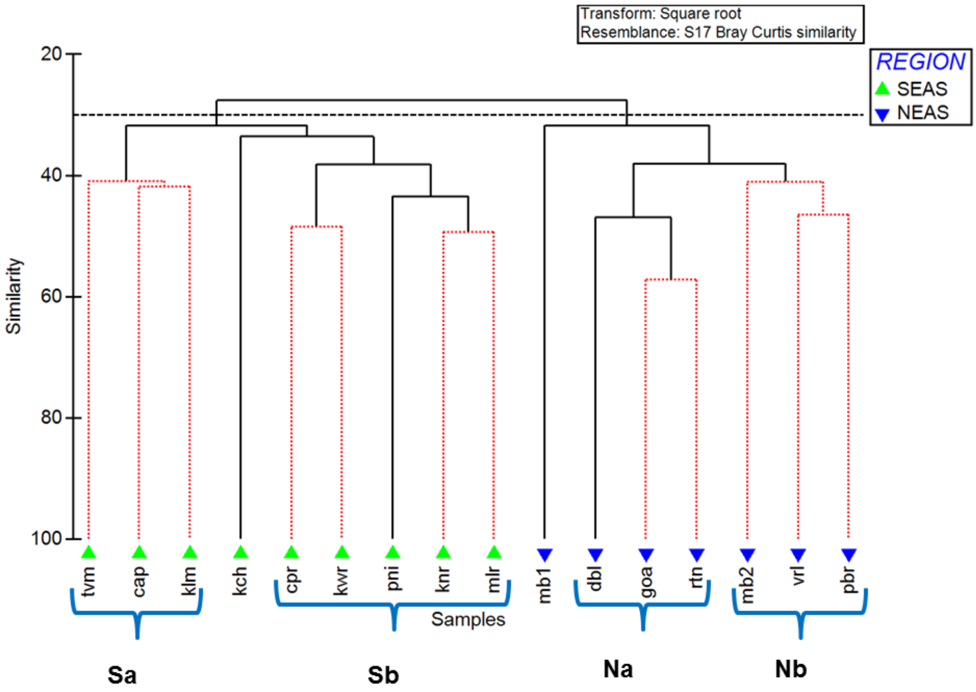


**Figure V.14.** Dendrogram of nematode species data over transects

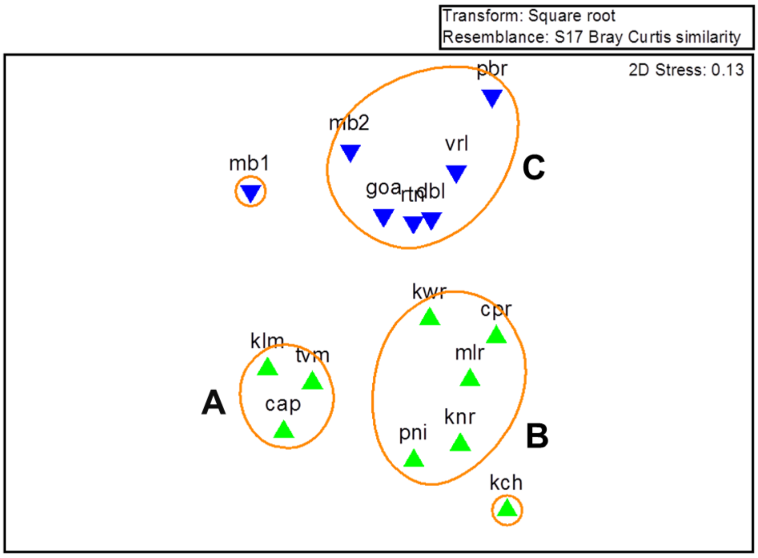


**Figure V.15.** nMDS for nematode species level data at various transects

MDS ordination of nematode taxa abundance (Figure V.15) condenses multivariate site similarities into a two-dimensional plot, where distances between sites are proportional to their similarities (Bray-Curtis similarity). MDS analysis of the pooled species abundance data shows a strong trend with latitude. In MDS ordination of sampling sites, discrimination between the two regions depicted much more clearly.

All sites at SEAS showed obvious differences from NEAS sites at 35 % similarity. Three groups can be defined, two representing stations from South Eastern Arabian Sea, a third group with stations of NEAS (Figure V.15). As observed in the cluster ‘Sa’ of the dendrogram, the southernmost transects Cape, Trivandrum and Kollam are clustered in Group A of nMDS. Similarly nMDS group B is the identical of the group ‘Sb’ of cluster analysis. In both the analysis, Kochi transect remains as an outlier. The group C of nMDS formed by all the transects from Goa to Porbander except Mumbai 1.

Similarity percentage (SIMPER) analyses were performed to show average similarities and average dissimilarities and contribution of nematode species to similarities and dissimilarities among the observed pattern of dendrogram and nMDS.

Dissimilarities among sites in the two regions observed from the dendrogram are shown in Table V.4. Between the two observed regions SEAS and NEAS, dissimilarities were higher 71 % (ANOSIM R=0.746, P=0.002). High percentage contribution along with presence or absence of certain exclusive species from the regions mainly caused observed dissimilarity pattern between NEAS and SEAS sites. A high presence of species such as *Acantholaimus quintus, Desmodorella* spp, *Daptonema* sp1, *Desmodora* sp1, *Microlaimus* sp1 and *Desmodora* sp2 were observed from NEAS sites when compared to SEAS sites. Species like *Sabatieria* spp, *Richtersia bathyalis* and *Daptonema oxycerca* were higher in the SEAS region. When the total number of species is considered a total of 338 species were observed from the SEAS sites whereas from the NEAS the observed numbers of species were 224. About 159 species are observed exclusively from the SEAS region and 48 species found exclusively in the NEAS region. Many of these species were considered rare since they encountered very rarely from the studies world-wide. Between the various subclusters observed within the SEAS and NEAS clusters also showed high percentages of dissimilarity. From the SEAS subclusters Sa and Sb the average dissimilarity percentage was 67.51 % whereas from the NEAS observed average dissimilarity percentage was 61.96 % (Table V.6).

As listed in the SIMPER results, similarities of stations within the NEAS sites (41%) were higher than stations within SEAS sites (37%). Main species contributing to similarities within NEAS sites were *Acantholaimus quintus* (10.78%), *Desmodorella* spp (6.48%), *Daptonema* sp1 (6.36%) and *Microlaimus* spp (4.02%). All these species together contributed to a cumulative percentage of 27.65%. In the SEAS sites the species contributed up to 25% of cumulative percentage contribution were *Sabatieria* spp (7.11%), *Daptonema oxycerca* (5.30), *Halalaimus* spp (4.64%), *Richtersia bathyalis* (3.26%), *Daptonema* sp5 (2.85%) and *Tricoma* spp (2.75%).

The similarity within the SEAS sub clusters Sa (41.21 %) and Sb (41.36 %) are more or less same. The major species contributing to the similarity among the Sa cluster formed between the southern most transects viz Cape, Trivandrum and Kollam are *Halalaimus spp* (4.11 %) and *Sabatieria* spp (3.47 %). In the Sb sub cluster the dominating species were *Sabatieria* spp (8.6 %) and *Daptonema oxycerca* (6.24 %). Like wise in the NEAS sub cluster, Na showed 50.35 % of similarity with species like *Acantholaimus quintus* contributing 9.61 % and *Daptonema* 152 contributing 5.1 % to percentage similarity. In the subcluster Nb (42.86 %), *Acantholaimus quitus* contributed 12.9 %, *Microlaimus* spp 8.56 % and *Desmodorella* spp contributed 7.88 % to the cumulative similarity percentage.

### V. 2. 6. Trophic composition

The trophic composition was defined according to Wieser (1953) based on the buccal morphology (size and shape of buccal cavity and its armature). Wieser (1953) distinguished nematodes into 4 trophic groups (Figure V.16), as follows: selective deposit feeders (1A): animal with no buccal cavity or a fine tubular one. These nematodes feed on dissolved organic matter, bacteria and particles in the bacterial size. Non- selective deposit feeders (1B): nematodes with large but unarmed buccal cavity. Buccal cavities are conical, cup or in cylindrical shapes. These nematodes also feed on bacteria, as well as detritus, occasionally diatom, large-sized protozoan and even other metazoan organism. Observation on some representatives of this group suggest that particle selection is largely a matter of particle size, shape and associated characteristics, such as particles that fit into the nematodes mouth are readily ingested (Nehring, 1992; Moens & Vincx, 1997). Epistratum or epigrowth (diatom) feeders (2A): animals with buccal cavity armoured with scraping teeth or similar structures. These nematodes mainly feed on diatoms and other unicellular microalgae and filamentous green and blue-green algae, but bacteria may be also equally important (Moens & Vincx, 1997). Food organisms can be pierced by a tooth or cracked after partial intake into the mouth (Jensen, 1982; Romeyn & Bouwman, 1983; Moens & Vincx, 1997). Predators/omnivores (2B): large buccal cavity with more pronounced tooth or mandibles and pronounced muscular pharynx than the epistratum feeders.

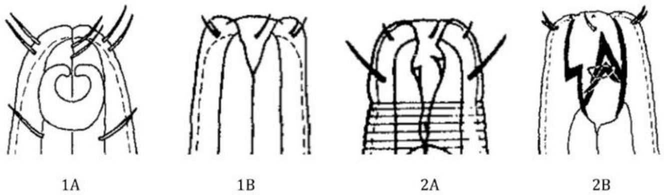


**Figure V.16.** Trophic groups of nematodes distinguished by Wieser (1953)

Jensen (1987), Moens & Vincx (1997) and Moens et al., (1999) proposed a modified feeding-type classification on the basis of live observations and ecological information viz. (1) microvores; (2) ciliate feeders; (3) deposit feeders; (4) epigrowth feeders; (5) facultative predators; and (6) predators. However, in the present study, the Wieser classification was preferred because it is still widely used and feeding type information based on Moens et al., (1999) for most of the genera encountered in deep-sea systems are lacking. Within a community of nematodes, all the feeding groups may be represented. Resource partitioning in free-living nematodes is accomplished by food size, shape and quality selection and by means of differentiated structures in the buccal cavity. The available food resources in the sediments are thereby utilized and partitioned between these four trophic guilds.

In accordance with the buccal armature of all the individuals in the present study, they were assigned to either of the feeding groups: (1A): selective deposit feeders; (1B): non- selective deposit feeders; (2A): epistrate or epigrowth feeders; (2B) predators. The relative abundance of each feeding type differed between stations, and often showed great variability between latitude, depth and season (Figure V.18-22). Generally, the nematode community in the eastern Arabian Sea slope is dominated by the epistrate feeders. As a whole in the study area (EAS margin), the percentage composition of different guilds is as follows: selective deposit feeders (1A, 18 %); non- selective deposit feeders (1B, 29 %); epistrate or epigrowth feeders (2A, 44 %); predators (2B, 9 %). The deposit feeders (1A+1B), selective and non selective collectively contribute 47 % (Figures V.17).

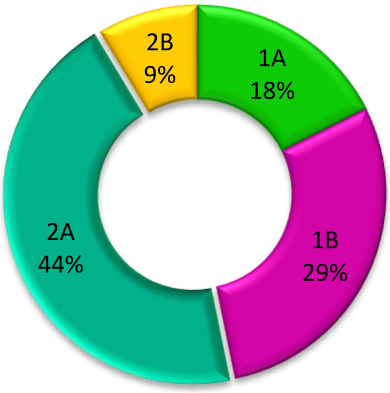


**Figure V.17.** Over all percentage contribution of nematode feeding guilds in the study area

### V.2.6.1. Temporal variation of feeding guild

In each survey the percentage contribution of different feeding guild varied considerably. During the initial sampling selective deposit feeders (1A) comprised 37 species and accounted for 18 % (at 200 m), 14 % (500 m) and 18 % (at 1000 m) of the total nematode abundance. As a whole they contributed 17 % of the total population. Non-selective deposit feeders (1B) included 59 species and accounted for 31 % (at 200 m), 21 % (500 m) and 36 % (at 1000 m). Epistrate feeders (2A, 130 species) were the dominant feeding type contributing 43 % (200 m), 43 % (500 m) and 37 % (1000 m). Predators (2B) were composed of 31 species and their relative contribution ranged from 8 % (at 200 m), 22 % (500 m) and 9 % (at 1000 m).

In the second survey the selective deposit feeders (1A) included 51 species and contributed to 15 % (at 200 m), 17 % (500 m) and 22 % (at 1000 m) of the total nematode abundance. Non-selective deposit feeders (1B) included 54 species and accounted for 28 % (at 200 m), 25 % (500 m) and 29 % (at 1000 m). Epistrate feeders (2A, 76 species) were the dominant feeding type sharing 52 % (200 m), 51 % (500 m) and 42 % (1000 m). Predators (2B) were composed of 27 species and their relative abundance ranged from 5 % (at 200 m), 7 % (500 m) and 7 % (at 1000 m).

At the time of 3rd survey the selective deposit feeders (1A) included 81 species and accounted for 13 % (at 200 m), 29 % (500 m) and 26 % (at 1000 m) of the total nematode abundance. Non-selective deposit feeders (1B) represented 85 species and accounted for 34 % (at 200 m), 25 % (500 m) and 35 % (at 1000 m). Epistrate feeders (2A, 103 species) accounted for 44 % (200 m), 37 % (500 m) and 28 % (1000 m). Predators (2B) were of 47 species and their relative abundance ranged from 9 % (at 200 m), 9 % (500 m) and 11 % (at 1000 m).

### V. 2.6.2 Bathymetric variation of nematode feeding guild

The bathymetric variation of feeding guilds are more prominent in southern transects. At 200 m, SEAS is dominated by non-selective deposit feeders contributing 63 % but it drastically dropped down to 18 % and 26 % in 500 m and 1000 m depths. The NEAS margin was characterised by the dominance of epistrate feeders (65 %) and their dominance decreased with depth gradually in to 59 % and 49 % respectively.

Overall in the study area, with increase in depth, percentage contribution of epistrate feeders found to be decreasing. The relative abundance of non-selective deposit feeders is increasing with depth and

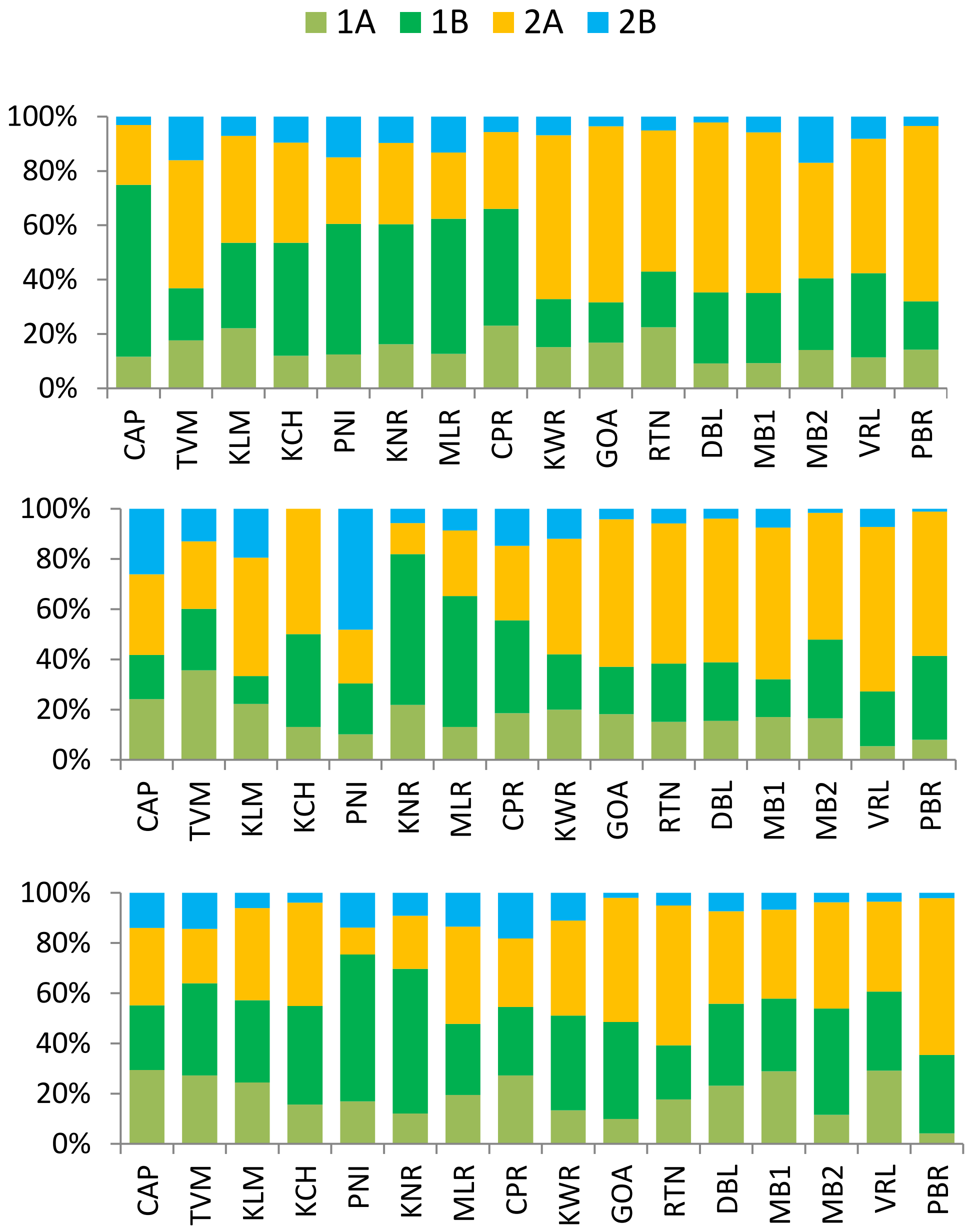


**Figure V.18.** Distribution of nematode feeding guilds in 200, 500 and 1000 m depths

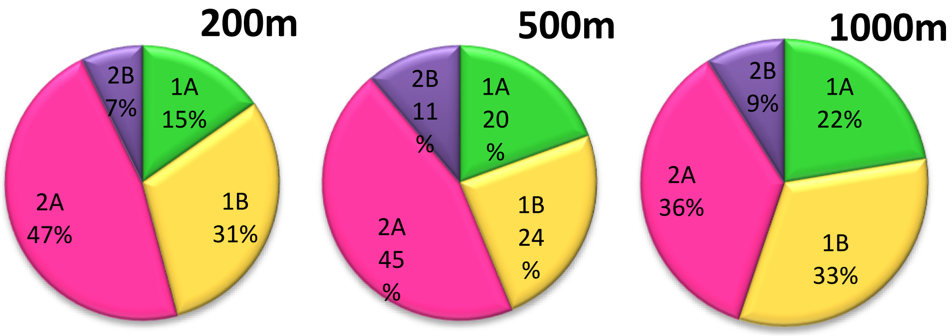


**Figure V.19.** Percentage contribution of nematode feeding guilds in various depths

comparatively high abundance of predator population is supported by 500 m depth. The trophic structure of nematode assemblages as a whole at three depth catagory is reported in Figure V.18.

Altogether, selective deposit feeders (1A) included 97 species and accounted for 15 % (at 200 m), 20 % (500 m) and 22 % (at 1000 m) of the total nematode abundance. Non-selective deposit feeders (1B) included 98 species and accounted for 31 % (at 200 m), 24 % (500 m) and 33 % (at 1000 m). Epistrate feeders (2A, 130 species) were the dominant feeding type at all the three depths in all the surveys, accounting for 47 % (200 m), 45 % (500 m) and 36 % (1000 m). Predators (2B) were composed of 59 species and their relative importance was comparatively low at each depth, ranging among 7 % (at 200 m), 11 % (500 m) and 9 % (at 1000 m) (Figure V.19).

### V.2.6.3. Latitudinal variation of nematode feeding guild

The feeding guild composition of nematodes in the eastern Arabian Sea slope showed substantial variation with its southern (SEAS) and northern (NEAS) latitudes. Relative abundance of epistrate feeders increase towards northern transects. In southern transects relative abundance of predators and non-selective deposit feeders are high (Figure V.20).

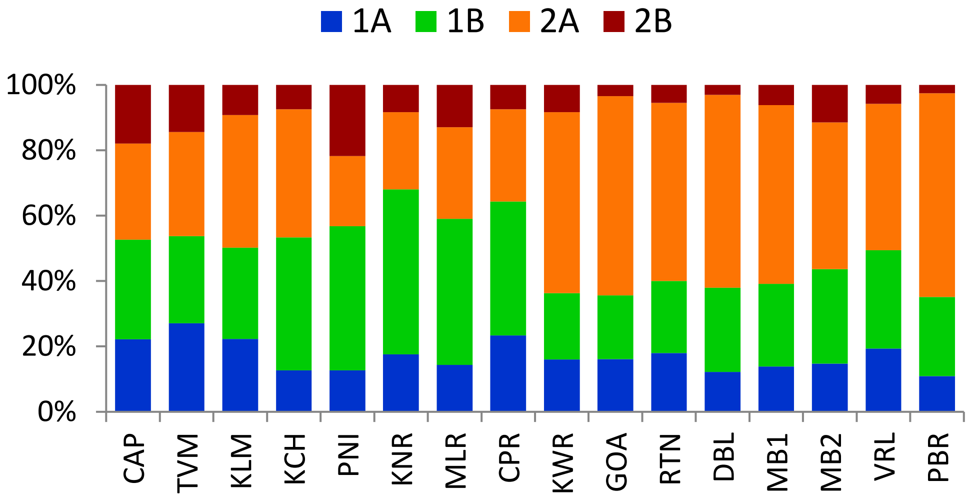


**Figure V.20.** Latitudinal distribution of nematode feeding guilds in the study area

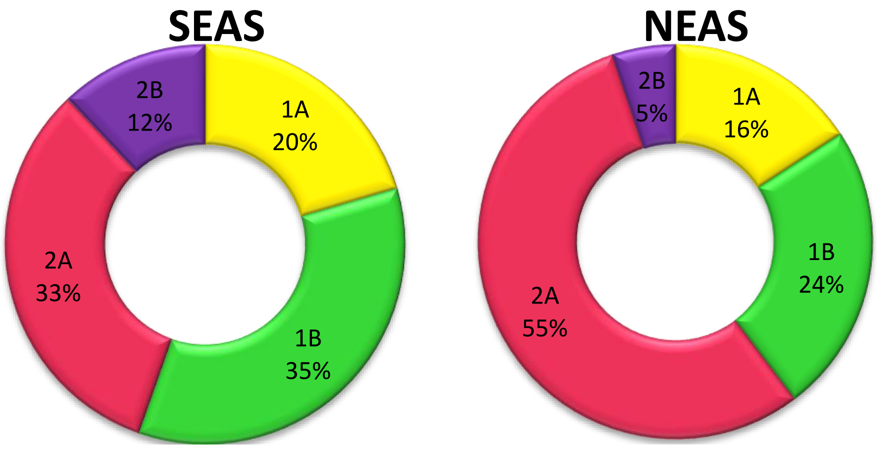


**Figure V.22.** Composition of feeding guilds at the two regions

As a whole in the SEAS, principal feeding community was non selective deposit feeders (1B), collectively contributing to 35 % of total nematode population. Non selective deposit feeders was followed by epistrate feeders (2A) and accounted for 33 % of population. Even though, non-selective deposit feeders and epistrate feeders were almost equal in percentage contribution, number of species represented in each group varied considerably. Former group represented by 86 species where later epistrate feeders represented by 110 species. Selective deposit feeders were of 20 % with a species number (85) almost that of non-selective deposit feeding group (86). Predators were comparatively low in abundance (12 %) and in species number (56). In contrary to the SEAS community, North eastern community evidently dominated by epistrate feeding group (55 %) but number of species in epistrate community was much less when compared to SEAS community (110 Vs. 77). The sub dominant non selective deposit feeding group accounted for 24 % of population and spanned among 63 species. Selective deposit feeders (16 %, 54 species) were less abundant in the NEAS margin. Predators (5 %) were meagrely distributed in the north eastern Arabian Sea with only 29 species (Figure V.22).

## V.3. DISCUSSION

The results of present study showed that the fauna of free-living nematodes in the EAS margin are very diverse. Throughout 48 sampling sites, 385 putative species, belonging to 141 genera, and 29 families were identified. World over, investigation of nematode composition in deep sea at lower taxonomic level is limited. Nematode species diversity observed in the present study are comparable with the available results from elsewhere. To date there is little information available on nematode distribution in the Indian Ocean particularly in the deep sea. The available studies from the Indian sector are fought with many problems such as sampling limited to few sites. A recent comprehensive study from the eastern Arabian Sea shelf as a whole (West coast of India) reported about 155 species of free nematodes (Sajan et al., 2010). The study covered as many as 74 sites representing various depth strata (30, 50, 75, 100 and 200 m), along 17 bathymetric transects extended from 08º 03.96’ N to 77º 21.96’ E to 21.56.99 N and 67.57.69E of the Eastern Arabian Sea continental shelf. A study conducted in the Kenyan slope, Western Indian Ocean, during the Netherlands Indian Ocean Programme (NIOP, 1990–1995), reported 224 genera from 20 stations (Muthumbi et al., 2004; 2011). While investigating the composition and distribution of nematofauna inhabiting nodule fields in the central Indian Ocean basin, Singh et al., 2014 reported 284 morphotypes from 4 locations located in 5000 m depth. Recently, Singh & Ingole, 2016 observed 110 morphotypes of free living nematodes along a bathymetric transect (30 m-2500 m) in the EAS margin. Muthumbi et al., (2004), Singh et al., (2014) and Singh & Ingole, (2015) reported many species as morphotypes only. In the present study, a majority of species were identified to morphotypes or were assigned to putative species for ecological analysis since it was not possible to ascertain the species using the available literature. Deep-sea sediments contains a surprisingly diverse community of nematodes, displaying highest evenness and α-diversity which has been found only in the tropical sublittoral zone (Boucher & Lambshead, 1995). In the deep-sea several hundreds of undescribed species can be found in a sample of 1,000 nematodes, but most of them may be represented by only a few or even one specimen making it difficult to taxonomic description (Miljutin et al., 2010). Exploration of each new deep-sea habitat has been consistently augmented by the discovery of new faunal communities. The species richness of these communities has exceeded all scientific expectations; in a sample of about 2,000 individuals there can be exist about 200 to 325 nematode morphotypes (Bussau, 1993; Lambshead et al., 2003; Miljutina et al., 2010). From the deep-sea nodule field of the Clarion-Clipperton Fracture Zone (Pacific), 246 nematode genera were found in a total sample of 18,000 individuals (Radziejewska et al., 2001). In the present study 3 new species are described and hundreds of morphototypes are anticipating descriptions.

Different deep-sea sites are frequently characterized by a high ‘α’ diversity (number of species belonging to the same genus) (Soetaert et al., 1991b; Gray, 1994; Fonseca et al., 2006a). In addition, each of these genera is often represented by more than one and some-times up to 20 different morphologically recognizable species or morphotypes at the same spot (Tietjen, 1984). The dominant genera found throughout EAS margin were *Daptonema, Acantholaimus* and *Desmodora*. All these genera observed with high number of species. Consecutively, each of the genera represented by 25, 21 and 21 species. The genus *Acantholaimus* is considered to be one of the most species-rich deep-sea nematode genera. Twelve *Acantholaimus* species were occured in the deep Tropical West Pacific (Tietjen, 1989). Twenty morphotypes of this genus were noted by Bussau (1993) in the Peru Basin (Atlantic) at a depth of about 4200 m. Muthumbi & Vincx (1997) observed 37 *Acantholaimus* morphotypes from the Indian Ocean off Kenya (depth of 500–2179m). Lambshead et al., (2003) documented 7 morphotypes of *Acantholaimus* among nematodes from the Clarion–Clipperton Fracture Zone (Pacific) and 8 morphotypes recognized in the Porcupine Abyssal Plain (Atlantic). De Mesel et al., (2006) found as many as 55 *Acantholaimus* morphotypes in samples from four areas of Antarctic Seas at a depth of 182–2009m. Thirty-three morphotypes of this species were recorded from the Clarion– Clipperton Fracture Zone (Pacific) at a depth of about 5000 m (Miljutina et al., 2010). A number of publications reported a high abundance of genus *Acantholaimus* in deep-sea nematode assemblages and this is often considered to be among the dominating genera (Bussau, 1993; Soetaert & Heip, 1995; Soetaert et al., 1995; Vanaverbeke et al., 1997a,b; Vanreusel et al., 2000; Sajan et al., 2007; Miljutina et al., 2010). Also, most deep-sea nematode genera are well known to be cosmopolitan. For instance, Vanhove et al., (1999) describes nematode communities from the deep Antarctic Sea sharing many similarities in terms of generic composition with communities identified along a Mediterranean slope transect. The apparent homogeneity of the deep-sea environment in sediment texture (Vanhove et al., 1999) and the absence of marked dispersal barriers are considered as one of the proposed explanations for such similarities (Lambshead & Boucher, 2003). Fonseca et al., (2006) reports genus A*cantholaimus*, as dominant as well as cosmopolitan genera in the deep sea. As far as nematode density in deep sea is considered, it can be more than 6000 individuals per 10 $cm^2$ in organically enriched hadal regions such as the Atacama trench (Gambi et al., 2003). Similarly a comparable peak in nematode density was observed from a NEAS site with high organic matter content (1732 Ind.10 $cm^{-2}$; FORVSS 219, Dhabol 200 m).

In the present study, Xyalidae, Chromadoridae, Microlaimidae and Desmodoridae were the dominant families. Each family occupied an average percentage of at least 10 % of the total nematodes. Comparable results were observed from studies conducted elsewhere in Indian Ocean. From the shelf region of the EAS, Sajan et al., (2010) observed 28 families. All of which, the dominant one with respect to abundance were Desmodoridae, Comesomatidae and Xyalidae, whilst the most speciose families were Xyalidae (20 species) and Desmodoridae (16 species) (Sajan et al., 2010). The common families in the nodule fields of the central Indian Ocean basin were Chromadoridae (29.6 %), Xyalidae (19.4 %), Oncholaimidae (11.2 %) and Desmoscolecidae (5.0 %) while at the genus level, *Acantholaimus* (22.3 %), *Halalaimus* (5.8 %), *Desmoscolex* (4.4 %), *Daptonema* (3.8 %) and *Theristus* (3.6 %) were dominant (Singh et al., 2014). From the Kenyan slope, northern Indian Ocean, the most important families were Xyalidae (12 %), Monhysteridae (12 %), and Comesomatidae (10 %) (Muthumbi & Vincx, 1997).

Nematodes receive less attention in deep-sea ecological studies despite of their high abundance, high diversity and high proportion of undescribed species due to labour intensive sample processing and limited taxonomic expertise (Miljutin et al., 2010, Rex & Etter, 2010). Nevertheless, nematodes often dominate benthic communities and typically constitute more than 90 % of infaunal metazoans (Grove et al., 2006; Giere, 2009). Studies on deep-sea nematode are generally restricted to a single scale, with a focus on patterns related to bathymetry (Vanreusel et al., 2000; Sevastou et al., 2013), habitats (Garcia et al., 2007; Bianchelli et al., 2010); or two scales, such as between sediment depths and sites (Van Gaever et al., 2004).

Even though horizontal patchiness in the deep sea remains poorly studied, a high degree of centimetre-scale variation has been observed both horizontally (Gallucci et al., 2009) and vertically into the sediments (Vincx et al., 1994; Leduc et al., 2010). Shallow water studies have shown that horizontal patchiness may result from the distribution of organic matter (Rice & Lambshead, 1994), which is influenced by topography and hydrodynamic regime (waves and currents), as well as with biological activities such as bioturbation and construction of biogenic structures by other benthic organisms (Reise, 2002). Vertically in the sediment, nematode diversity is generally higher in the surface sediment and decreases in subsurface sediments (Vincx et al., 1994; Ingels et al., 2011b). Vertical distribution in the sediment is mainly controlled by decreasing food and oxygen availability and the presence of toxic sulphides in subsurface sediments. In the present study, nematode community structure varies between surface and subsurface sediments, with some genera such as *Acantholaimus*, *Desmoscolex*, and *Halalaimus* showing a preference for surface sediments whereas genera tolerant of low oxygen conditions such as *Sabatieria* are generally most abundant in subsurface sediment layers (Vanaverbeke et al., 1997b; Leduc et al., 2010; Leduc et al., 2015). As with habitat preference, upper continental slopes are generally characterised by relatively high abundance of *Sabatieria*, species of which are well adapted to fine sediment environments with high organic input and low oxygen levels (Vanreusel, 1990; Schratzberger et al., 2009; Vanreusel et al., 2010b; Ingels et al., 2011a), whereas the genera *Acantholaimus* and *Thalassomonhystera* generally occur on the lower continental slope and abyssal plains, and are typically associated with low food input (De Mesel et al., 2006; Vanreusel et al., 2010b; Ingels et al., 2011a). In contradiction to the above observation high abundance of genus *Acantholaimus* was recorded from the NEAS, in association with high organic matter content.

Multivariate analysis was used to compare nematode community structure in different surveys, season and region (latitude) over EAS margin. Based on cluster dendrogram and multidimentional scaling (MDS) analysis, nematode community structure clearly showed a regional difference in the EAS margin. The differences between two identified region, SEAS and NEAS are largely determined by the dominance and presence/absence of certain species.

The study sites located along the southern region of eastern Arabian Sea (SEAS) was characterized by a high hydrodynamic activity which in turn influence the sediment nature. When the sedimentological parameters are compared, SEAS region shows five textural classes of sediments viz. sand, silty sand, sandy silt, clayey sand and a homogeneous admixture of sand, silt and clay. All these classes contains considerable quantity of sand particles. The NEAS regions were represented mostly by clayey silt sediments with increased percentages of finer particles. Also these finer sediments in the NEAS shows high organic matter content. Even though low as compared to NEAS region, SEAS also harbours moderate amount of OM. From the EAS margin as a whole, SEAS region recorded comparatively high DO (200 m, 0.395±165 ml $l^{-1}$; 500 m, 0.497±0.172 ml $l^{-1}$; 1000 m, 0.667±0.217 ml $l^{-1}$) where the NEAS region characterized by oxygen depleted conditions as low as <0.2 ml $l^{-1}$, with an increasing severity towards the north. In the present study, meiofaunal abundance shows a positive correlation with oxygen concentration. Within the group level, the dominant component nematodes shows the same trend with dissolved oxygen. As far as nematodes are considered they prefer to live in oxygenated environments. In general, their response to oxygen stress includes changes in abundance, diversity and community structure (Neira et al., 2001). Also they were characterized by varying abundance of some dominant species. In other words, responses of nematode communities to oxygen stress are species–specific and related to the duration of exposure (Neira et al., 2001). The present study reveals low nematode diversity along the NEAS when compared to SEAS where oxygen deficiency was less pronounced. Seasonal increase in oxygen concentration particularly during summer monsoon did not showed any difference in species richness and diversity.

No significant bathymetric or seasonal variation in nematode community along the EAS margin is observed. The variations between two regions were distinguished in detail by using similarity percentage analysis (SIMPER). Several genera were characterised by higher relative abundance in the SEAS than the NEAS region. The result demonstrated that the five most important typifying species at SEAS sites were *Daptonema oxycerca (3.4%), Richtersia bathyalis (3.3%), Sabatieria spp (3%), Daptonema sp5 (2.1%) and Halalaimus spp.* These species belong to non-selective deposit feeders *(Daptonema oxycerca, Daptonema sp5), epistrate feeders (Richtersia bathyalis, Sabatieria spp)* and selective deposit feeders *(Halalaimus* spp*)*. The important typifying species that of NEAS sites were *Acantholaimus quintus* (6.4 %), *Desmodora 313* (5.6 %), *Aponema ninae* (4.8 %), *Desmodorella* spp (3.9 %) and *Daptonema 152* (3.9 %). All of them except *Daptonema* were epistrate feeders. Species such as *Sabatieria* and *Daptonema* are well adapted to finer sediments with high organicmatter content (Wetzel et al., 2002; Vanreusel et al., 2010b; Ingels et al., 2011a) even though they were more abundant in the SEAS margin than NEAS region, *Acantholaimus,* which is a typical deep-sea genus, usually associated with low food input, showed the high abundance in the NEAS (De Mesel et al., 2006; Vanreusel et al., 2010b; Ingels et al., 2011a). Even though NEAS region is characterised by high organic matter content, the quality of which is questionable. Distinction among assemblages in nematode community were mainly driven by differences in the relative abundance of shared genera. Nevertheless, some genera are exclusive in certain habitats only. Genera with such restricted distributions were found in all habitats. In the present study SEAS had a higher number of exclusive genera (159) compared to NEAS along the EAS margin.

A similar study conducted on the macrobenthos of the SEAS margin also points towards a clear regional difference with respect to the polychaete community (Abdul Jaleel, 2012; Jaleel et al., 2014). This study study describes the occurrence of a highly diverse polychaete community inhabiting the southernmost sampling sites and a progressive decrease towards the northern sites which is influenced by the Arabian Sea OMZ. Such an oxygen minimum area has strong effect on the macrobenthos especially with crustaceans and polychaetes (Levin, 2003; Ingole et al., 2010; Hunter et al., 2012. Raman et al., 2014) directly influencing the distribution of macrofauna community in the EAS margin. In general, a latitudinal trend in species richness and diversity was found to be evident throughout their study at all depth categories (200 m, 500 m and 1000 m). The southern transects from Kollam to Cape showed a more consistent pattern in species distribution with a high species richness and diversity.

Generally, increasing levels of environmental stress have been considered to decrease diversity, species richness and evenness. Comparatively high species diversity in the SEAS region may attribute to current velocity and mixing, sediment granulometry and better oxygenation which allowed habitat and resource partitioning. Heip & Decraemer (1974) noted that silty environments had lower spatial heterogeneity rendering such environments fewer niches and thus supporting fewer species compared to sandy sediments. Tietjen (1976, 1984) found high species diversity in sediments with high sand content. Therefore, higher diversity is probably linked to higher sand and a lower silt fraction in the SEAS region. The north eastern Arabian Sea is characterised by high primary production and strong oxygen minimum zone causing high surface productivity and there by increased organic matter content in the sediment. Increased productivity is thought to increase the number of species that can coexist (Wright, 1983), but very high levels of POM flux to the deep-sea floor may lower diversity due to increased dominance by opportunistic species (Levin & Gage, 1998).

Nematode trophic structure can be a useful concept in exploring variation in benthic food webs across the spatial scales. The multi-scale study by Ingels & Vanreusel (2013) has revealed that greater variability in nematode functional diversity (which included trophic diversity) occurred between sediment depths, than between habitats or water depths. All major feeding groups according to Wieser (1953) were represented in our samples with the diversity of feeding groups. Deep-sea nematodes are characteristically dominated by microvores, which feed selectively on bacteria, and deposit feeders, which feed less selectively on detrital particles and associated microbiota (Moens & Vincx, 1997; Vanaverbeke et al., 1997a; Giere, 2009; Danovaro et al., 2013). Trophic group composition even varies between sediment layers, which can reflect available food sources and oxygen supply within sediment (Vanreusel et al., 1995; Neira et al., 2013). For example predators and omnivores, are usually associated with sediments with relatively large amounts of organic matter, and can be found either on surface sediment or at deeper oxygenated sediment layer with higher food availability, whereas some deposit feeders such as *Sabatieria* sp and *Theristus* sp can dominate deeper layers of sediment since they can thrive in low oxygen conditions (Steyaert et al., 2003; Neira et al., 2013). Facultative predators and predators are normally larger and longer compared to other feeding types, which make them more agile (Ingels et al., 2009). A study by Pusceddu et al., (2009) indicated that areas on seamounts with different sediment organic matter harbour different types of nematode trophic groups. Areas on seamounts characterized by high food availability were dominated by predators and omnivores, which suggest increased food availability, will favour nematode abundance and hence increase the availability of prey in the area. In areas with low food availability epigrowth feeders are more abundant. Epigrowth feeders are often prominent in deep-sea sediments where inputs of fresh and intact diatom cells is absent or limited, which suggests that they can obtain food by scraping microbes from sediment particles or mucus threads (Moens & Vincx, 1997; Vanreusel et al., 2010b; Moens et al., 2014). Although the abundance of particular feeding groups may not always necessarily reflect the abundance of their supposed food sources, different trophic groups respond to different environmental factors differently, and the presence of a trophically diverse community may allow persistence of the ecosystem function following disturbance (Walker, 1995; Naeem, 1998; De Mesel et al., 2006).

The diversity of the feeding groups illustrates that many nematode species can coexist through partitioning their food resources. In the SEAS region, all the four feeding groups were distributed wisely utilising all the available resources. A notable increase in number of predator population is characteristic to SEAS region. This may be due to the sediment textural variability generated after increased percentages of sand along with better oxygenation. Nematode diversity showed a positive correlation with the amount of fine sand and a negative correlation with the silt fraction of sediment (Muthumbi & Vincx, 1997). In the NEAS, fauna is dominated clearly by epistrate feeding group. Epistrate feeders did occur in low numbers at the SEAS that receive relatively low input of phytodetritus as compared with NEAS which is characterised by winter phytoplankton blooms (Jyotibabu et al., 2010; Lathika et al., 2013). The production and subsequent sinking of OM to the sub surface leads to the utilization of oxygen in the water column which in turn results in the formation of OMZ and the intensity of OMZ is enhanced with sluggish circulation (Levin, 2003; Hunter et al., 2012). In the NEAS, a permanent and strong OMZ located in the water column allows, almost all the phytodetritus produced in the highly productive surface to reach unutilised. The distribution pattern of nematode abundance and reproduction was influenced by organic matter quality (Gallucci et al., 2009). Deposit feeders were overall most common among nematodes in Arctic (Vanaverbeke et al., 1997a; Vanreusel et al., 2000) and other lower latitudes (van der Loeff & Lavaleye, 1986; Jensen, 1988). High quality and quantity of organic matter in turn influences the abundance of bacteria. The high proportion of deposit-feeding nematodes in the deep sea reflects the important role of bacteria in their nutrition (Danovaro et al., 2008). A strong correlation of meiobenthic densities with bacterial activity was found in the Arctic deep sea (Hoste et al., 2007) and these authors suggest that deposit feeders consume bacteria associated with detritus. Vanreusel et al., (2000) reported low abundance of epigrowth feeders (2A) in other deep-sea meiofauna. This is probably related to the scarceness of sedimentation of fresh organic matter and phytodetritus in deep-sea environment (Soltwedel, 1997), although bacteria may also be an important food for epigrowth feeders in deep Sea (Soetaert & Heip, 1995; Vanaverbeke et al., 1997a). The NEAS is also characterised by high abundance of bacterial population especially in sites with high organic matter content (Neil, 2012). In contrary to the observation of Vanreusel et al., (2000), the present study reports higher density of epistrate feeders in the slope of north eastern Arabian Sea. The strong and permanent OMZ in the water column of the continental margin exports OM without much degradation in the water column (Ittekkot et al., 1996; Cowie et al., 1999). Like with other organisms, large-sized nematodes were thought to be scarce at great water depths (Soetaert et al., 2002, 2009), which has been attributed to the quality and availability of food and sediment properties (Udalov et al., 2005).

The organic matter content in SEAS is not low enough to reduce community but the hydrodynamic activity prevailing in the region enhance the OM oxidation through churning and mixing. Abundance of deposit feeders and microvores is generally associated with organically rich sediments that occur in a high productivity region (Gallardo & Espinoza, 2007), where these two trophic groups feed on bacteria, detrital particles and associated microbiota (Moens & Vincx, 1997). SEAS is observed with modest number of predators where in the NEAS there abundance is much low. Since SEAS region is characterised by varying percentages of sand particles and greater quantity of OM content, large sized predatory nematodes can occupy the interstitial space. Higher abundance of predators and facultative predators also reflects interstitial prey population availability that help to facilitate the energy transfer within nematode communities and reaches up to the higher trophic level (Pusceddu et al., 2009). Epigrowth feeders are often prominent in low productivity deep-sea sediments despite low inputs of fresh organic matter such as diatom cells (Pusceddu et al., 2009; Vanreusel. et al., 2010b, Moens et al., 2014).

Distribution pattern of free living nematode community feeding guilds clearly depicts the regional differences, as observed in the community structure which gives an insight into the functional basis of the regional variations in community structure. The present study describes distribution pattern of nematode communities in the poorly studied OMZ impinged Arabian Sea margin of northern Indian Ocean. Also the study described many novel species from the area, with the possibility of several more from the hundreds of morphotypes observed during the ecological analysis.

| Station | Depth (m) | S | N | d | J' | H'(loge) | Lambda' |
|---|---|---|---|---|---|---|---|
| **CAP*** | 200 | 19 | 39.80 | 4.89 | 0.96 | 2.82 | 0.04 |
| **CAP*** | 500 | 58 | 211.22 | 10.65 | 0.85 | 3.43 | 0.06 |
| **CAP*** | 1000 | 21 | 24.49 | 6.25 | 0.99 | 3.01 | 0.01 |
| **TVM*** | 200 | 25 | 61.22 | 5.83 | 0.96 | 3.08 | 0.04 |
| **TVM*** | 500 | 2 | 2.04 | 1.40 | 1.00 | 0.69 | 0.02 |
| **TVM*** | 1000 | 7 | 14.29 | 2.26 | 0.90 | 1.75 | 0.14 |
| **KLM*** | 200 | 12 | 107.14 | 2.35 | 0.86 | 2.13 | 0.14 |
| **KLM*** | 1000 | 7 | 8.16 | 2.86 | 0.98 | 1.91 | 0.04 |
| **KCH** | 200 | 33 | 125.51 | 6.62 | 0.90 | 3.14 | 0.05 |
| **KCH** | 500 | 8 | 21.43 | 2.28 | 0.93 | 1.92 | 0.13 |
| **KCH** | 1000 | 7 | 9.18 | 2.71 | 0.97 | 1.89 | 0.06 |
| **PNI** | 200 | 17 | 46.94 | 4.16 | 0.78 | 2.21 | 0.20 |
| **PNI** | 500 | 12 | 65.31 | 2.63 | 0.71 | 1.77 | 0.30 |
| **PNI** | 1000 | 10 | 28.57 | 2.69 | 0.92 | 2.12 | 0.11 |
| **KNR** | 200 | 7 | 22.45 | 1.93 | 0.90 | 1.75 | 0.16 |
| **KNR** | 500 | 14 | 57.14 | 3.21 | 0.95 | 2.51 | 0.07 |
| **KNR** | 1000 | 12 | 17.35 | 3.86 | 0.95 | 2.36 | 0.05 |
| **MLR** | 200 | 20 | 56.12 | 4.72 | 0.91 | 2.74 | 0.07 |
| **MLR** | 500 | 4 | 4.08 | 2.13 | 1.00 | 1.39 | 0.01 |
| **MLR** | 1000 | 21 | 42.86 | 5.32 | 0.94 | 2.85 | 0.05 |
| **CPR** | 200 | 44 | 342.86 | 7.37 | 0.91 | 3.44 | 0.04 |
| **CPR** | 500 | 7 | 7.14 | 3.05 | 1.00 | 1.95 | 0.00 |
| **CPR** | 1000 | 18 | 31.63 | 4.92 | 0.93 | 2.69 | 0.06 |
| **KWR** | 200 | 16 | 22.45 | 4.82 | 0.97 | 2.69 | 0.03 |
| **KWR** | 500 | 14 | 19.39 | 4.39 | 0.98 | 2.58 | 0.03 |
| **KWR** | 1000 | 12 | 16.33 | 3.94 | 0.96 | 2.39 | 0.04 |
| **GOA** | 200 | 50 | 255.10 | 8.84 | 0.88 | 3.44 | 0.04 |
| **GOA** | 500 | 27 | 88.78 | 5.80 | 0.89 | 2.94 | 0.06 |
| **GOA** | 1000 | 17 | 44.90 | 4.21 | 0.92 | 2.61 | 0.07 |
| **RTN** | 200 | 21 | 79.59 | 4.57 | 0.91 | 2.77 | 0.06 |
| **RTN** | 500 | 9 | 20.41 | 2.65 | 0.94 | 2.06 | 0.10 |
| **RTN** | 1000 | 20 | 52.04 | 4.81 | 0.90 | 2.71 | 0.07 |
| **DBL** | 200 | 23 | 205.10 | 4.13 | 0.91 | 2.86 | 0.07 |
| **DBL** | 500 | 23 | 73.47 | 5.12 | 0.83 | 2.60 | 0.12 |
| **DBL** | 1000 | 4 | 6.12 | 1.66 | 0.90 | 1.24 | 0.20 |
| **MB 1** | 200 | 23 | 76.53 | 5.07 | 0.94 | 2.95 | 0.05 |
| **MB 1** | 500 | 8 | 9.18 | 3.16 | 0.98 | 2.04 | 0.03 |
| **MB 1** | 1000 | 26 | 45.92 | 6.53 | 0.95 | 3.10 | 0.03 |
| **MB 2** | 200 | 26 | 70.41 | 5.88 | 0.90 | 2.93 | 0.06 |
| **MB 2** | 500 | 1 | 2.04 | 0.00 | 0.00 | 0.00 | 1.00 |
| **MB 2** | 1000 | 5 | 6.12 | 2.21 | 0.97 | 1.56 | 0.07 |
| **VRL** | 200 | 9 | 17.35 | 2.80 | 0.94 | 2.07 | 0.09 |
| **VRL** | 500 | 2 | 3.06 | 0.89 | 0.92 | 0.64 | 0.34 |
| **VRL** | 1000 | 10 | 81.63 | 2.04 | 0.76 | 1.74 | 0.23 |
| **PBR** | 200 | 3 | 6.12 | 1.10 | 1.00 | 1.10 | 0.20 |
| **PBR** | 500 | 11 | 22.45 | 3.21 | 0.90 | 2.16 | 0.10 |
| **PBR** | 1000 | 5 | 22.45 | 1.29 | 0.96 | 1.55 | 0.19 |

**Table V.2.** Diversity indices of nematodes during FORVSS Cruise 219 & 225 **(* indicates sites sampled during Cruise 225)**

| Station | Depth (m) | S | N | d | J' | H'(loge) | Lambda' |
|---|---|---|---|---|---|---|---|
| **CAP*** | 200 | 22 | 80.61 | 4.78 | 0.80 | 2.47 | 0.15 |
| **CAP*** | 500 | 5 | 5.10 | 2.46 | 1.00 | 1.61 | 0.01 |
| **CAP*** | 1000 | 51 | 73.47 | 11.64 | 0.94 | 3.71 | 0.02 |
| **TVM*** | 200 | 31 | 48.98 | 7.71 | 0.93 | 3.21 | 0.03 |
| **TVM*** | 500 | 43 | 139.80 | 8.50 | 0.96 | 3.59 | 0.03 |
| **TVM*** | 1000 | 19 | 30.61 | 5.26 | 0.94 | 2.76 | 0.05 |
| **KLM*** | 200 | 57 | 201.02 | 10.56 | 0.92 | 3.73 | 0.03 |
| **KLM*** | 500 | 12 | 23.47 | 3.49 | 0.95 | 2.37 | 0.06 |
| **KLM*** | 1000 | 24 | 41.84 | 6.16 | 0.89 | 2.82 | 0.07 |
| **KCH*** | 200 | 9 | 29.59 | 2.36 | 0.95 | 2.10 | 0.10 |
| **KCH*** | 500 | 3 | 8.16 | 0.95 | 0.89 | 0.97 | 0.32 |
| **KCH*** | 1000 | 3 | 10.20 | 0.86 | 0.87 | 0.95 | 0.38 |
| **PNI*** | 200 | 7 | 13.27 | 2.32 | 0.95 | 1.85 | 0.10 |
| **PNI*** | 500 | 6 | 9.18 | 2.26 | 0.94 | 1.68 | 0.11 |
| **PNI*** | 1000 | 7 | 10.20 | 2.58 | 0.94 | 1.83 | 0.09 |
| **KNR*** | 200 | 15 | 38.78 | 3.83 | 0.98 | 2.64 | 0.05 |
| **KNR*** | 500 | 12 | 22.45 | 3.54 | 0.92 | 2.29 | 0.09 |
| **KNR*** | 1000 | 5 | 9.18 | 1.80 | 0.95 | 1.52 | 0.14 |
| **MLR*** | 200 | 13 | 29.59 | 3.54 | 0.94 | 2.42 | 0.07 |
| **MLR*** | 500 | 14 | 18.37 | 4.47 | 0.96 | 2.52 | 0.04 |
| **MLR*** | 1000 | 8 | 16.33 | 2.51 | 0.97 | 2.01 | 0.09 |
| **CPR** | 200 | 29 | 106.12 | 6.00 | 0.92 | 3.08 | 0.05 |
| **CPR** | 500 | 4 | 4.08 | 2.13 | 1.00 | 1.39 | 0.01 |
| **CPR** | 1000 | 9 | 21.43 | 2.61 | 0.99 | 2.18 | 0.07 |
| **KWR** | 200 | 44 | 221.43 | 7.96 | 0.89 | 3.36 | 0.05 |
| **KWR** | 500 | 26 | 54.08 | 6.27 | 0.91 | 2.97 | 0.05 |
| **KWR** | 1000 | 9 | 13.27 | 3.10 | 0.96 | 2.10 | 0.07 |
| **GOA** | 200 | 20 | 133.67 | 3.88 | 0.89 | 2.67 | 0.08 |
| **GOA** | 500 | 23 | 76.53 | 5.07 | 0.95 | 2.97 | 0.05 |
| **GOA** | 1000 | 15 | 55.10 | 3.49 | 0.93 | 2.52 | 0.08 |
| **RTN** | 200 | 30 | 174.49 | 5.62 | 0.94 | 3.21 | 0.04 |
| **RTN** | 500 | 49 | 393.88 | 8.03 | 0.90 | 3.51 | 0.04 |
| **RTN** | 1000 | 28 | 66.33 | 6.44 | 0.88 | 2.93 | 0.07 |
| **DBL** | 200 | 33 | 605.10 | 5.00 | 0.80 | 2.79 | 0.11 |
| **DBL** | 500 | 39 | 345.92 | 6.50 | 0.89 | 3.25 | 0.05 |
| **DBL** | 1000 | 32 | 82.65 | 7.02 | 0.96 | 3.31 | 0.03 |
| **MB 1** | 1000 | 1 | 2.04 | 0.00 | 0.00 | 0.00 | 1.00 |
| **MB 2** | 200 | 2 | 4.08 | 0.71 | 0.81 | 0.56 | 0.50 |
| **MB 2** | 500 | 5 | 27.55 | 1.21 | 0.93 | 1.50 | 0.22 |
| **MB 2** | 1000 | 4 | 12.25 | 1.20 | 0.90 | 1.24 | 0.27 |
| **VRL** | 200 | 25 | 162.25 | 4.72 | 0.90 | 2.90 | 0.07 |
| **VRL** | 500 | 19 | 45.92 | 4.70 | 0.83 | 2.45 | 0.13 |
| **VRL** | 1000 | 29 | 146.94 | 5.61 | 0.87 | 2.94 | 0.06 |
| **PBR** | 200 | 20 | 145.92 | 3.81 | 0.94 | 2.81 | 0.06 |
| **PBR** | 500 | 10 | 52.04 | 2.28 | 0.91 | 2.08 | 0.13 |
| **PBR** | 1000 | 4 | 22.45 | 0.96 | 0.99 | 1.37 | 0.23 |

**Table V.3.** Diversity indices of nematodes during FORVSS Cruise 228 & 233 (* indicates sites sampled during Cruise 233)

| Station | Depth (m) | S | N | d | J' | H'(loge) | Lambda' |
|---|---|---|---|---|---|---|---|
| **CAP** | 200 | 20 | 48.98 | 4.88 | 0.70 | 2.09 | 0.26 |
| **CAP** | 500 | 82 | 159.18 | 15.98 | 0.84 | 3.68 | 0.07 |
| **CAP** | 1000 | 19 | 50.00 | 4.60 | 0.85 | 2.52 | 0.10 |
| **TVM** | 200 | 63 | 151.02 | 12.36 | 0.91 | 3.78 | 0.03 |
| **TVM** | 500 | 61 | 146.94 | 12.02 | 0.91 | 3.74 | 0.03 |
| **TVM** | 1000 | 35 | 210.20 | 6.36 | 0.94 | 3.33 | 0.05 |
| **KLM** | 200 | 58 | 156.12 | 11.29 | 0.93 | 3.79 | 0.02 |
| **KLM** | 500 | 28 | 86.74 | 6.05 | 0.96 | 3.19 | 0.04 |
| **KCH** | 200 | 30 | 100.00 | 6.30 | 0.77 | 2.63 | 0.14 |
| **KCH** | 500 | 11 | 17.35 | 3.51 | 0.95 | 2.28 | 0.06 |
| **KCH** | 1000 | 17 | 32.65 | 4.59 | 0.90 | 2.56 | 0.07 |
| **PNI** | 200 | 58 | 179.59 | 10.98 | 0.88 | 3.59 | 0.04 |
| **PNI** | 500 | 3 | 6.12 | 1.10 | 1.00 | 1.10 | 0.20 |
| **PNI** | 1000 | 13 | 27.55 | 3.62 | 0.89 | 2.28 | 0.10 |
| **KNR** | 200 | 42 | 139.80 | 8.30 | 0.83 | 3.11 | 0.08 |
| **KNR** | 500 | 7 | 27.55 | 1.81 | 0.87 | 1.69 | 0.20 |
| **KNR** | 1000 | 7 | 10.20 | 2.58 | 0.90 | 1.75 | 0.14 |
| **MLR** | 200 | 26 | 101.02 | 5.42 | 0.91 | 2.96 | 0.06 |
| **MLR** | 500 | 1 | 2.04 | 0.00 |  | 0.00 | 1.00 |
| **MLR** | 1000 | 6 | 9.18 | 2.26 | 0.94 | 1.68 | 0.11 |
| **CPR** | 200 | 33 | 59.18 | 7.84 | 0.89 | 3.10 | 0.07 |
| **CPR** | 500 | 14 | 16.33 | 4.66 | 0.99 | 2.60 | 0.02 |
| **CPR** | 1000 | 11 | 16.33 | 3.58 | 0.94 | 2.25 | 0.07 |
| **KWR** | 200 | 39 | 126.53 | 7.85 | 0.84 | 3.09 | 0.07 |
| **KWR** | 500 | 17 | 32.65 | 4.59 | 0.95 | 2.68 | 0.05 |
| **KWR** | 1000 | 6 | 16.33 | 1.79 | 0.96 | 1.72 | 0.13 |
| **GOA** | 200 | 15 | 18.37 | 4.81 | 0.98 | 2.66 | 0.02 |
| **GOA** | 500 | 4 | 9.18 | 1.35 | 0.95 | 1.31 | 0.20 |
| **GOA** | 1000 | 4 | 4.08 | 2.13 | 1.00 | 1.39 | 0.01 |
| **RTN** | 200 | 15 | 23.47 | 4.44 | 0.96 | 2.59 | 0.04 |
| **RTN** | 500 | 4 | 4.08 | 2.13 | 1.00 | 1.39 | 0.01 |
| **RTN** | 1000 | 25 | 42.86 | 6.39 | 0.95 | 3.06 | 0.03 |
| **DBL** | 500 | 1 | 4.08 | 0.00 | 0.00 | 0.00 | 1.00 |
| **DBL** | 1000 | 3 | 8.16 | 0.95 | 0.95 | 1.04 | 0.29 |
| **MB 1** | 200 | 43 | 256.12 | 7.57 | 0.76 | 2.87 | 0.11 |
| **MB 1** | 500 | 16 | 44.90 | 3.94 | 0.97 | 2.69 | 0.05 |
| **MB 1** | 1000 | 20 | 44.90 | 4.99 | 0.85 | 2.54 | 0.10 |
| **MB 2** | 200 | 60 | 177.55 | 11.39 | 0.90 | 3.69 | 0.03 |
| **MB 2** | 500 | 42 | 93.88 | 9.03 | 0.85 | 3.16 | 0.07 |
| **MB 2** | 1000 | 7 | 8.16 | 2.86 | 0.98 | 1.91 | 0.04 |
| **VRL** | 200 | 7 | 8.16 | 2.86 | 0.98 | 1.91 | 0.04 |
| **VRL** | 500 | 7 | 9.18 | 2.71 | 0.97 | 1.89 | 0.06 |
| **VRL** | 1000 | 2 | 2.04 | 1.40 | 1.00 | 0.69 | 0.02 |
| **PBR** | 200 | 15 | 27.55 | 4.22 | 0.92 | 2.49 | 0.07 |
| **PBR** | 500 | 5 | 17.35 | 1.40 | 0.93 | 1.50 | 0.19 |
| **PBR** | 1000 | 4 | 4.08 | 2.13 | 1.00 | 1.39 | 0.01 |

**Table V.4.** Diversity indices of nematodes during FORVSS Cruise FORVSS 254

| | Species | Av. Ab SEAS | Av. Ab NEAS | Con. % | Cum. % |
|---|---|---|---|---|---|
| **Cluster SEAS & NEAS - ANOSIM R=0.746 P=0.002** | Average dissimilarity 71 % | | | | |
| | *Acantholaimus quintus* | 0.27 | 1.53 | 3.27 | 3.27 |
| | *Desmodorella spp* | 0.11 | 0.94 | 2.26 | 5.52 |
| | *Daptonema* sp1 | 0.29 | 0.91 | 1.95 | 7.47 |
| | *Desmodora* sp1 | 0.38 | 0.93 | 1.89 | 9.36 |
| | *Sabatieria spp* | 0.83 | 0.2 | 1.78 | 11.14 |
| | *Microlaimus* sp1 | 0.23 | 0.69 | 1.59 | 12.73 |
| | *Richtersia bathyalis* | 0.64 | 0.33 | 1.45 | 14.17 |
| | *Desmodora* sp2 | 0.1 | 0.55 | 1.28 | 15.45 |
| | *Daptonema oxycerca* | 0.73 | 0.42 | 1.15 | 17.85 |

**Table V.5.** Average dissimilarity and major nematode species contributing to dissimilarity between sites in the SEAS and NEAS regions (Av. Ab: average abundance; Con: contribution; Cum: cumulative)

| | **Species** | **Av. Ab Sa** | **Av. Ab Sb** | **Con. %** | **Cum. %** |
|---|---|---|---|---|---|
| **Cluster Sa & Sb ANOSIM R=0.85 P=0.002** | Average dissimilarity 67.51 % | | | | |
| | Total number of species | 281 | 192 | | |
| | *Eubostrichus hortulanus* | 0.76 | 0 | 1.95 | 1.95 |
| | *Perspira sp* | 0.6 | 0 | 1.54 | 3.5 |
| | *Richtersia bathyalis* | 0.49 | 0.74 | 1.45 | 4.94 |
| | *Daptonema oxycerca* | 0.9 | 0.62 | 1.42 | 6.36 |
| | *Halanonchus sp1* | 0.48 | 0 | 1.23 | 7.6 |
| | *Daptonema* sp1 | 0.51 | 0.15 | 1.22 | 8.81 |
| | *Desmodora* sp1 | 0.14 | 0.53 | 1.18 | 9.99 |
| | *Daptonema* sp6 | 0.57 | 0.25 | 1.08 | 11.07 |
| | **Species** | **Av. Ab Na** | **Av. Ab Nb** | **Con. %** | **Cum. %** |
| **Cluster Na & Nb ANOSIM R=0.86 P=0.002** | Average dissimilarity 61.96 % | | | | |
| | Total number of species | 140 | 155 | | |
| | *Desmodora* sp1 | 1.5 | 0.35 | 3.18 | 3.18 |
| | *Acantholaimus quintus* | 2 | 1.07 | 2.7 | 5.88 |
| | *Desmodora* sp2 | 0.94 | 0.16 | 2.47 | 8.35 |
| | *Microlaimus* sp1 | 1.03 | 0.34 | 2.04 | 10.38 |
| | *Desmoscolex spp* | 0.75 | 0.22 | 1.77 | 12.15 |
| | *Richtersia bathyalis* | 0.61 | 0.05 | 1.73 | 13.88 |
| | *Pselionema spp* | 0.75 | 0.18 | 1.72 | 15.6 |
| | *Desmodorella spp* | 1.13 | 0.74 | 1.66 | 17.26 |

**Table V.6.** Average dissimilarity and major nematode species contributing to dissimilarity between subclusters in the SEAS and NEAS regions (Av. Ab: average abundance; Con: contribution; Cum: cumulative**)**

# Chapter VI

# SYSTEMATICS AND TAXONOMY OF FREE LIVING NEMATODES IN THE EASTERN ARABIAN SEA (EAS) MARGIN

Contents

## VI. 1. INTRODUCTION

Nematodes, which constitute the predominant meiofaunal phylum, are the most abundant, speciose and ubiquitous metazoan organisms residing in deep-sea sediments. Because of their numerical dominance, high metabolic rates, and short generation times, nematodes are presumed to be important in the benthic carbon cycle (Giere, 2009). Nematode communities in deep sea sediments show high species and genus diversity (Soetaert et al., 1991a; Lambshead and Boucher, 2003). In the biodiversity point of view, despite their numerical dominance, high species diversity and functional significance (Mokievsky et al., 2004; Miljutin et al., 2010), studies that encompass a description of the deep sea nematode taxonomic composition are rare and limited to a few sites for several reasons. A considerable fraction of this high local genus diversity is attributable to the presence of many rare genera. Even though the deep-sea bottom contains a surprisingly diverse community of nematodes, the true extent of their species diversity is impossible to evaluate (Miljutin et al., 2010) and most of the species is still remain to be described (Fonseca et al., 2006a). In a recent review of the published literature on nematode, 638 valid species belonging to 175 genera and 44 families are described from deep-sea (Miljutin et al., 2010). The major impediment in describing new species from deep sea is the small size, difficulty to get enough specimens of the same species for descriptions and the low proportion of males present in samples. Even if several hundred unknown species can be found in a sample of 1000 nematodes, most of them may be represented by only a few or even single specimen (Miljutin et al., 2010).

The free-living marine nematode fauna has been studied in many regions of the world. The ecology and taxonomy of free-living marine nematodes cover a huge amount of information mainly related to temperate ecosystems. Vast areas of the deep sea floor have not been studied due to logistical difficulties associated with deep-sea sampling and the scarcity of taxonomic expertise. Indian Ocean is one among the geographical regions which has not been studied extensively. The deep-sea nematode fauna in the Indian Ocean region, in particular, is very poorly known, with only descriptions from the coast of Kenya covered during the Netherlands Indian Ocean Programme (Muthumbi & Vincx, 1996, 1997, 1998, 1999). No species have been described from the northern region of deep Indian Ocean till date.

Nevertheless, in both the coasts of India, the studies in terms of nematode systematics are inadequate and scanty (Sulthan Ali et al., 1998) with most studies conducted in the intertidal as well as shallow subtidal region, possibly due to lack of expertise and the financial resources for its exploration. Apart from some preliminary studies, (Timm, 1956; Govindankutty, 1967; Rao and Ganapati, 1968) no other work was carried out on this aspect. In the present investigation on meiofauna, they occurred regularly from all stations and often represented 49% of the total meiofauna recorded.

## VI. 2. RESULTS

### VI. 2. 1. Systematic list of free·living marine nematodes, West Coast of India, EAS margin

Nematodes are a highly diverse and very important group of multicellular animals, but their systematics have always been unstable and are restructured from time to time. There are some nematode systematics used in the past such as an early phylogeny by Micolezky (1922), the system of Filipjev (1934), Chitwood's Adenophorea/Secernentea system (Chitwood &

Chitwood 1933, Chitwood 1937), the systems of De Coninck (1965), Maggenti (1963, 1983), Andrássy (1974, 1976), the system of Lorenzen (1981, 1994) and the system of Malakhov (1994). Currently nematode systematics is entering a new phase of turbulence with the system of De Ley & Blaxter (2002) which is a new system based on morphology as well as molecular methods to classify nematodes. Despite or as result of the long standing debate existing about advantages and disadvantages of molecular and morphological approach to taxonomy (Hebert et al., 2003; Will and Rubinoff, 2004; Hebert and Gregory, 2005) a combined approach is emerging in nematode taxonomy. Global estimates of number of known and described species of free-living marine nematodes are so far in the range of 4000 – 5000 species (Eyualem-Abebe et al., 2008); while global estimated total (unknown + described) species numbers vary between 10000 to 20000 species (Mokievsky and Azovsky, 2002), and up to more than 1 x 106 species (Lambshead, 1993; Snelgrove et al., 1997).

Number of free-living marine nematode taxa in EAS margin is very high and its species composition is very abundant. A total of 385 species were found during the current intensive ecological studies of the free living nematodes from continental margin of eastern Arabian Sea. However, here we only mention and discuss the descriptions of 100 species which are taxonomically resolved. Rest all species are identified to morphotypes or were assigned to putative species for ecological analysis. Many of them are found to be novel species and formal taxonomic descriptions of some novel species belonging to rare genera are also presented here. More emphasis was given on the detailed morphology of the specimen than on absolute or relative measurements, since variations in body size is prominent in nematodes from place to place (Platt and Warwick, 1998). The sketches of mostly male or else female are given unless otherwise mentioned. The classified list of free-living nematodes and their systematics and taxonomy is given below.

**Class Enoplea**

**Order Enoplida Filipjev, 1929**

**Family Anticomidae Filipjev, 1918**

**Genus *Cephalanticoma* Platonova, 1976**

*Cephalanticoma* sp

**Family Ironoidae de Man 1876**

**Genus *Dolicholaimus* De Man, 1888**

*Dolicholaimus* sp

**Genus *Syringolaimus* de Man, 1888**

*Syringolaimus annae* Coelho Lima, Lins, Da Silva & Esteves, 2009

*Syringolaimus filicaudatus* Vitiello, 1970

*Syringolaimus magdae* Coelho Lima, Lins, Da Silva & Esteves, 2009

**Family Oncholaimidae Filipjev, 1916**

**Genus *Filoncholaimus* Filipjev, 1927**

*Filoncholaimus* sp

**Genus *Pontonema* Leidy, 1855**

*Pontonema* sp

**Genus *Viscosia* De Man, 1890**

*Viscosia carnleyensis* Ditlevsen, 1921

*Viscosia dubiosa* Kreis, 1932

*Viscosia elegans* Kreis, 1924

*Viscosia franzii* Boucher, 1977

**Family Oxystominidae Micoletzky, 1924**

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

*Halalaimus longamphidus* Huang & Zhang, 2005

*Halalaimus longicaudatus* (Filipjev, 1927) Schneider, 1939

**Genus *Litinium* Cobb, 1920**

*Litinium bananum* Gerlach, 1956

**Genus *Oxystomina* Filipjev, 1921**

*Oxystomina affinis* Gerlach, 1956

*Oxystomina alpha* Chitwood, 1937

*Oxystomina asetosa* Southern, 1914

*Oxystomina elongata* Butschli, 1874

**Genus *Thalassoalaimus* de Man, 1893**

*Thalassoalaimus brevicaudatus* Vitiello, 1970

*Thalassoalaimus egregius* Steiner, 1916

*Thalassolaimus mediterraneus* Vitiello, 1970

*Thalassoalaimus paramontemari* Vitiello, 1970

**Genus *Weiseria* Gerlach 1956**

*Weiseria hispida* Vitiello, 1972

*Wieseria leptura* Vitiello, 1972

*Wieseria scotlandica* Zhang, 1983

**Family Tripyloididae de Coninck & Stekhoven, 1933**

**Genus *Gairleanema* Warwick and Platt, 1973**

*Gairleanema* sp

**Genus *Halanonchus* Cobb, 1920**

*Halanonchus* sp

**Genus *Tripyloides* De Man, 1886**

*Tripyloides* sp

**Family Trefusiidae Gerlach, 1966**

**Genus *Rhabdocoma* Cobb, 1920**

*Rhabdocoma Americana* Cobb, 1920

**Genus *Trefusia* De Man, 1893**

*Trefusia* sp

**Genus *Trefusialaimus* Riemann, 1974**

*Trefusialaimus* sp

**Family Enchelidiidae Filipjev, 1918**

**Genus *Bathyeurystomina* Lambshead & Platt, 1979**

*Bathyeurystomina* sp

**Genus *Calyptronema* Marion, 1870**

*Calyptronema* sp

**Genus *Eurystomina* Filipjev, 1918**

*Eurystomina* sp

**Genus *Pareurystomina* Filipjev, 1921**

*Pareurystomina* sp

**Genus *Polygastrophora* de Man, 1922**

*Polygastrophora* sp

**Class Chromadorea**

**Order Araeolaimida**

**Family Comesomatidae Filipjev, 1918**

**Genus *Cervonema* Wieser, 1954**

*Cervonema gourbaulti* Muthumbi, Soetaert & Vincx, 1997

**Genus *Comesoma* Bastian, 1865**

*Comesoma* sp

**Genus *Dorylaimopsis* Ditlevsen, 1918**

*Dorylaimopsis coomansi* Muthumbi, Soetaert & Vincx, 1997

*Dorylaimopsis variabilis* Muthumbi, Soetaert & Vincx, 1997

**Genus *Hopperia* Vitiello, 1969**

*Hopperia* sp

**Genus *Kenyanema* Muthumbi, Soetaert & Vincx, 1997**

*Kenyanema monorchis* Muthumbi, Soetaert & Vincx, 1997

**Genus *Laimella* Cobb, 1920**

*Laimella longicaudata* Cobb, 1920

**Genus *Metacomesoma* Wieser, 1954**

*Metacomesoma sp*

**Genus *Minolaimus* Vitiello, 1970**

*Minolaimus* sp

**Genus *Paracomesoma* Hope & Murphy, 1972**

*Paracomesoma longispiculum* Timm, 1961;

**Genus *Paramesonchium* Hopper, 1967**

*Paramesonchium mombasi* Muthumbi, Soetaert&Vincx, 1997

**Genus *Pierrickia* Vitiello, 1970**

*Pierrickia* sp

**Genus *Sabatieria* Rouville, 1903**

*Sabatieria alata* Warwick, 1973

*Sabatieria exilis* Botelho, Da Silva,
Sobral & Fonseca-Genevois, 2009

*Sabatieria paracupida* Wieser & Hopper, 1967

**Genus *Setosabatieria* Platt, 1985**

*Setosabatieria* sp

**Family Axonolaimidae Filipjev 1918**

**Genus *Odontophora* Bütschli, 1874**

*Odontophora falcifera* Ott, 1972

**Genus *Parodontophora* Timm, 1963**

*Parodontophora brevamphida* Timm 1952

*Parodontophora danka* Belogurov & Kartavtseva, 1975

*Parodontophora xenotricha* Boucher, 1973

**Family Diplopeltidae Filipjev, 1918**

**Genus *Campylaimus* Cobb, 1920**

*Campylaimus gerlachi* Timm, 1961

*Campylaimus rimatus* Vitiello, 1974

**Genus *Diplopeltis* Cobb, 1905**

*Diplopeltis ornatus* Gerlach, 1950

**Genus *Diplopeltula* Gerlach, 1950**

*Diplopeltula asetosa* Juario, 1974

*Diplopeltula incisa* Gerlach, 1962

**Genus *Diplopeltoides* Gerlach, 1962**

*Diplopeltoides linkei* Jensen, 1991

**Genus *Morlaxia* Vincx & Gourbault, 1988**

*Morlaixia contusa* Vincx & Gourbault, 1988

*Morlaixia obscura* Vincx & Gourbault, 1988

**Genus *Pararaeolaimus* Timm, 1961**

*Pararaeolaimus rumohri*

**Genus *Southerniella* Allgén, 1932**

*Southerniella conicauda* Schuurmans Stekhoven, 1950

*Southerniella nojii* Jensen, 1991

*Southerniella simplex* Allgen, 1932

**Order Desmoscolecida**

**Family Desmoscolecidae Shipley, 1896**

**Genus *Desmoscolex* Claparède 1863**

*Desmoscolex abyssorum* Decraemer, 1984

*Desmoscolex fennicus* Lorenzen, 1969

*Desmoscolex noctuabundus* Bussau, 1993

*Desmoscolex pedunculus* Rho, Kim & Chang, 2007

*Desmoscolex segonzaci* Decraemer, 1983

**Genus *Greeffiella* Cobb, 1922**

*Greeffiella pierri* Schrage & Gerlach, 1975

**Genus *Pareudesmoscolex* Weischer 1962**

*Pareudesmoscolex laciniosus* Lorenzen, 1969

**Genus *Tricoma* Cobb, 1894**

*Tricoma brevirostris* Southern, 1914

*Tricoma filipjevi* Chitwood, 1951

*Tricoma polydesma* Southern, 1914

**Family Meyliidae de Coninck, 1965**

**Genus *Boucherius* Decraemer & Jensen, 1982**

*Boucherius spinosus* Gerlach, 1956

**Family Cyartonematidae Tchesunov, 1990**

**Genus *Cyartonema* Cobb 1920**

*Cyartonema elegans* Jayasree & Warwick, 1977

*Cyartonema flexile* Cobb, 1920

*Cyartonema germanicum* Juario, 1972

*Cyartonema zosterae* Allgén, 1929

**Order Chromadorida**

**Family Selachinematidae Cobb, 1915**

**Genus *Cheironchus* Cobb, 1917**

*Cheironchus vorax* Cobb, 1917

**Genus *Cobbionema* Filipjev, 1922**

*Cobbionema* sp

**Genus *Demonema* Cobb, 1894**

*Demonema* sp

**Genus *Gammanema* Cobb, 1920**

*Gammanema polydonta* Murphy, 1965

**Genus *Halichoanolaimus* De Man, 1886**

*Halichoanolaimus consimilis* Allgen, 1933

*Halichoanolaimus dolichurus* Ssaweljev, 1912

**Genus *Latronema* Wieser, 1954**

*Latronema orcina* Gerlach 1952

*Latronema piratica* Wieser 1954

**Genus *Richtersia* Steiner, 1916**

*Richtersia bathyalis* Soetaert & Vincx, 1987

**Genus *Synonchiella* Cobb, 1933**

*Synonchiella micramphis* Schuurmans Stekhoven, 1950

*Synonchiella riemanni*, Warwick 1970

**Family Chromadoridae Filipjev, 1917**

**Genus *Acantholaimus* Allgén, 1933**

*Acantholaimus ewensis* Platt and Zhang, 1982
*Acantholaimus formosus* Miljutina, Miljutin & Tchesunov, 2013
*Acantholaimus geraerti* Muthumbi & Vincx, 1997
*Acantholaimus invaginatum* Muthumbi & Vincx, 1997
*Acantholaimus quintus* Gerlach, Schrage & Riemann, 1979
*Acantholaimus vermeuleni* Muthumbi & Vincx, 1997

**Genus *Chromadorella* Filipjev, 1918**

*Chromadorella ariminiensis* (Gerlach, 1953) Lorenzen, 1972
*Chromadorella circumflexa* Wieser, 1954
*Chromadorella cobbiana* Johnston, 1938
*Chromadorella filiformis* (Bastian, 1865) Filipjev, 1918
*Chromadorella salicaniensis* Boucher, 1976

**Genus *Chromadorina* Filipjev, 1929**

*Chromadorina* sp

**Genus *Endeolophos* Boucher, 1976**

*Endeolophos* sp

**Genus *Harpagonchus* Platonova & Potin, 1972**

*Harpagonchus* sp

**Genus *Innocuonema* Inglis, 1969**

*Innocuonema* sp

**Genus *Neochromadora* Micoletzky, 1924**

*Neochromadora* sp

**Genus *Nygmatonchus* Cobb, 1933**

*Nygmatonchus* sp

**Genus *Prochromadorella* Micoletzky, 1924**

*Prochromadorella* sp

**Genus *Rhips* Cobb, 1920**

*Rhips* spp

**Genus *Spilophorella* Filipjev, 1917**

*Spilophorella* sp

**Genus *Trochamus* Boucher & de Bovée, 1971**

*Trochamus* sp

**Family Neotonchidae Wieser & Hopper, 1966**

**Genus *Comesa* Gerlach, 1956**

*Comesa* sp

**Genus *Neotonchus* Cobb, 1933**

*Neotonchus corcundus* Gerlach, 1956

*Neotonchus cupulatus* Vitiello, 1970

*Neotonchus meeki* Warwick, 1971

*Neotonchus vitius* Warwick, 1971

*Neotonchus votadinii* Warwick, 1971

**Genus *Nannolaimus* Cobb, 1920**

*Nannolaimus volutus* Gerlach, 1956

**Family Cyatholaimidae Filipjev, 1918**

**Genus *Longicyatholaimus* Micoletzky, 1924**

*Longicyatholaimus capsulatus* Vitiello, 1971

**Genus *Nannolaimoides* Ott, 1972**

*Nannolaimoides decoratus* Ott, 1972

**Genus *Paracyatholaimus* Micoletzky, 1922**

*Paracyatholaimus* sp Micoletzky, 1922

**Genus *Paralongicyatholaimus* Stekhoven, 1950**

*Paralongicyatholaimus* sp

**Genus *Pomponema* Cobb, 1917**

*Pomponema clavicaudatum* Schuurmans Stekhoven, 1935

*Pomponema corniculata* Gourbault, 1980

*Pomponema elegans* Lorenzen, 1972

*Pomponema multipappillatum* Filipjev, 1922

*Pomponema polydonta* Murphy, 1963

*Pomponema proximamphidum* Tchesunov, 2008

*Pomponema segregatum* Wieser 1959

**Order Desmodorida**

**Family Desmodoridae Filipjev, 1922**

**Genus *Catanema* Cobb, 1920**

*Catanema macintyri* Platt and Zhang, 1982

**Genus *Eubostrichus* Certes, 1899**

*Eubostrichus africanus* Muthumbi,
Verschelde & Vincx, 1995

*Eubostrichus hortulanus* Leduc, 2013

**Genus *Desmodora* de Man, 1889**

*Desmodora masira* Warwick, 1973

*Desmodora pilosa* Ditlevsen, 1926

**Genus *Desmodorella* Cobb, 1933**

*Desmodorella tenuispiculum* Allgen 1928

**Genus *Leptonemella* Cobb, 1920**

*Leptonemella juliae* Hoschitz, Buchholz & Ott, 1999

**Genus *Metachromadora* Filipjev, 1918**

*Metachromadora pulvinata* Wieser & Hopper, 1967

**Genus *Onyx* Cobb, 1891**

*Onyx perfectus* Cobb, 1891

**Genus *Parabostrichus* Tchesunov, Ingels & Popova, 2012**

*Parabostrichus bathyalis* Tchesunov, Ingels & Popova, 2012

**Genus *Perspira* Wieser & Hopper, 1967**

*Perspira* sp

**Genus *Polysigma* Cobb, 1920**

*Polysigma* sp

**Genus *Pseudochromadora* Daday, 1899**

*Pseudochromadora* sp

**Genus *Psammonema* Verschelde & Vincx, 1995**

*Psammonema kuriani* Jacob, Anilkumar,
Philip and Damodaran, 2015

**Genus *Robbea* Gerlach, 1956**

*Robbea* sp

**Genus *Spirinia* Gerlach, 1963**

*Spirinia parasitifera* Bastain, 1865

**Family Draconematidae Filipjev, 1918**

**Genus *Draconema* Cobb, 1913**

*Draconema japonicum* Kito, 1976

*Draconema longicapitatum* Allgén, 1932

**Genus *Prochaetosoma* Micoletzky, 1922**

*Prochaetosoma dokdoense* Rho, Min, Decreamer and Kim, 2010

**Family Microlaimidae Micoletzky, 1922**

**Genus Aponema Jensen, 1978**

*Aponema abyssalis* (Miljutin & Miljutina, 2009) Tchesunov, 2014
*Aponema decremerae* Muthumbi & Vincx, 1999
*Aponema ninae* Portnova, 2009
*Aponema nympha* Bussau & Vopel, 1999

**Genus *Bathynox* Bussau & Vopel, 1999**

*Bathynox clavata* Bussau & Vopel, 1999

**Genus *Caligocanna* Bussau & Vopel, 1999**

*Caligocanna mirabilis* Bussau & Vopel, 1999

**Genus *Calomicrolaimus* Lorenzen, 1976**

*Calomicrolaimus microseta (*Gerlach, 1953) Jensen, 1978

**Genus *Ixonema* Lorenzen, 1971**

*Ixonema sordidum* Lorenzen, 1971

**Genus *Microlaimus* de Man, 1880**

*Microlaimus aequisetosus* Blome, 1982
*Microlaimus africanensis* Furstenberg & Vincx, 1992
*Microlaimus discolensis* Bussau & Vopel, 1999
*Microlaimus parviporosus* Miljutin & Miljutina, 2009
*Microlaimus tenuispiculum* de Man, 1922
*Microlaimus ostracion* Schuurmans Stekhoven, 1935
*Microlaimus zosterae* Allgén, 1930

**Genus *Molgolaimus* Ditlevsen, 1921**

*Molgolaimus abyssorum* Muthumbi & Vincx, 1996

**Genus *Spirobolbolaimus* Soetaert & Vincx, 1988**

*Spirobolbolaimus bathyalis* Soetaert & Vincx, 1988

**Order Plectida**

**Family Camacolaimidae Micoletzky, 1924**

**Genus *Alaimella* Cobb, 1920**

*Alaimella macramphis* Tchesunov & Miljutina, 2007

**Genus *Dagda* Southern, 1914**

*Dagda* sp

**Genus *Diodontolaimus* Southern, 1914**

*Diodontolaimus* sp

**Genus *Procamacolaimus* Gerlach, 1954**

*Procamacolaimus bipapillata* Southern, 1914

**Genus *Stephanolaimus* Ditlevsen, 1918**

*Stephanolaimus elegans* Ditlevsen, 1918

**Family Tarvaiidae Lorenzen, 1981**

**Genus *Tarvaia* Allgén, 1934**

*Tarvaia angusta* Gerlach, 1953

*Tarvaia heegeri* Jensen, 1991

*Tarvaia peruvensis* Nichols & Musselman, 1979

**Family Leptolaimidae Örley, 1880**

**Genus *Antomicron* Cobb, 1920**

*Antomicron* sp

**Genus *Leptolaimus* de Man, 1876**

*Leptolaimus* sp

**Family Ceramonematidae Cobb, 1933**

**Genus *Ceramonema* Cobb, 1929**

*Ceramonema carinatum* Wieser, 1959

*Ceramonema filipjevi* de Coninck, 1942

**Genus Dasynemoides Chitwood, 1936**

*Dasynemoides riemanni* Haspeslagh, 1973

**Genus *Pselionema* Cobb, 1933a**

*Pselionema* sp

*Pselionema annulatum* Filipjev, 1922

**Genus Pterygonema Gerlach, 1954**

*Pterygonema ornatum* Timm, 1961

**Family Paramicrolaimidae Lorenzen, 1981**

**Genus Paramicrolaimus Wieser, 1954**

*Pramicrolaimus damodarani* Jacob, Jaleel & Vijayan, 2015

*Paramicrolaimus spirulifer* Wieser, 1959

**Order Monhysterida**

**Family Xyalidae Chitwood 1951**

**Genus *Ammotheristus* Lorenzen, 1977**

*Ammotheristus* sp

**Genus *Amphimonhystera* Allgen, 1929**

*Amphimonhystera anechma* Southern, 1914

**Genus *Cobbia* De Man, 1907**

*Cobbia* sp

**Genus *Daptonema* Cobb 1920**

*Daptonema hyalocella* Kito and Aryuthaka, 2012
*Daptonema balatum* Nguyen Dinh Tu et al., 2014
*Daptonema hirsutum* Vitiello, 1967
*Daptonema oxycerc*a DeMa, 1888
*Daptonema setihyalocella* Aryuthaka and Kito, 2012
*Daptonema williamsi* Vinx and Coomans, 1983

**Genus *Gonionchus* Cobb, 1920**

*Gonionchus intermedius* Jensen, 1986
*Gonionchus africanus* Vincx & Furstenberg, 1988
*Gonionchus cumbraensis* Benwell, 1981

**Genus *Manganonema* Bussau, 1993**

*Manganonema* sp

**Genus *Metadesmolaimus* Schuurmans Stekhoven, 1935**

*Metadesmolaimus aversivulva* Gerlach, 1953
*Metadesmolaimus heteroclitus* Lorenzen, 1972
*Metadesmolaimus tersus* Gerlach, 1956

**Genus *Paramonhystera* Steiner, 1916**

*Paramonhystera albigensis* Riemann, 1966

**Genus *Promonhystera* Wieser, 1956**

*Promonhystera* sp

**Genus *Rhinema* Cobb, 1917**

*Rhinema* sp

**Genus *Retrotheristus* Lorenzen, 1977**

*Retrotheristus* sp

**Genus *Scaptrella* Cobb, 1917**

*Scaptrella filicaudata* Jacob Anilkumar, Philip and Damodaran, 2015

**Genus *Theristus* Bastian,** 1865

*Theristus altenbachi* Jensen, 1991

*Theristus anoxybioticus* Jensen, 1995

*Theristus balticus* Lorenzen, 1973

*Theristus bastiani* Gerlach & Riemann, 1973

*Theristus denticulatus* Warwick, 1970

*Theristus fistulatus* Wieser & Hopper, 1967

*Theristus heterospiculum* Allgén, 1932

*Theristus otoplanobius* Gerlach, 1951

**Genus *Valvaelaimus* Lorenzen, 1977**

*Valvaelaimus* sp

**Genus *Xenolaimus* Cobb, 1920**

*Xenolaimus striatus* Cobb 1920

**Genus *Xyala* Cobb, 1920**

*Xyala* sp

**Family Sphaerolaimidae Filipjev 1918**

**Genus *Metasphaerolaimus* Gourbault & Boucher, 1981**

*Metasphaerolaimus cancellatus* Gourbault & Boucher, 1981

*Metasphaerolaimus inglisi* Gourbault & Boucher, 1981

**Genus *Sphaerolaimus* Bastian 1865**

*Sphaerolaimus crenellatus* Warwick, 1973

*Sphaerolaimus dispar* Filipjev, 1918

*Sphaerolaimus glaphyrus* Vitiello, 1971

*Sphaerolaimus gracilis* de Man, 1876

*Sphaerolaimus macrocirculus* Filipjev, 1918

**Family Siphonolaimidae Filipjev 1918**

**Genus *Siphonolaimus* De Man, 1893**

*Siphonolaimus ewensis* Warwick & Platt, 1973

*Siphonolaimus elongatus* (Schuurmans Stekhoven, 1950) Vitiello, 1971

*Siphonolaimus obscurus* Boucher & Helléouët, 1977

*Siphonolaimus profundus* Warwick, 1973

**Family Linhomoeidae Filipjev 1922**

- **Genus *Desmolaimus* De Man, 1880**
    - *Desmolaimus greenpatchi* Allgén, 1959
    - *Desmolaimus zosterae* Allgén, 1933
- **Genus *Didelta* Cobb, 1920**
    - *Didelta scutata* Wieser, 1954
- **Genus *Disconema* Filipjev, 1918**
    - *Disconema sp*
- **Genus *Eleutherolaimus* Filipjev 1922**
    - *Eleutherolaimus hopperi* Timm, 1967
    - *Eleutherolaimus nutus* Gerlach, 1964
- **Genus *Linhomoeus* Bastian, 1865**
    - *Linhomoeus filaris* Lorenzen, 1973
- **Genus *Megadesmolaimus* Wieser, 1954**
    - *Megadesmolaimus contortus* Timm, 1962
    - *Megadesmolaimus falcatus* Gerlach, 1963
    - *Megadesmolaimus uncinatus* Gerlach, 1963
- **Genus *Metalinhomoeus* De Man, 1907**
    - *Metalihomoeus gracilis* (Kreis, 1929) Wieser, 1956
    - *Metalinhomoeus biformis* Juario, 1974
    - *Metalinhomoeus effilatus* Schuurmans Stekhoven, 1942
- **Genus *Paralinhomoeus* De Man 1907b**
    - *Paralinhomoeus anteporus* Vitiello, 1969
    - *Paralinhomoeus appendixocaudatus* Allgén, 1959
    - *Paralinhomoeus brevicaudatus* Schuurmans Stekhoven, 1950
    - *Paralinhomoeus conspicuus* Gerlach, 1957
    - *Paralinhomoeus fuscacephalus* (Cobb, 1920) Gerlach, 1963
    - *Paralinhomoeus longisetosus* Schuurmans Stekhoven, 1950
    - *Paralihomoeus meridionalis* (Cobb, 1930) Wieser, 1956
    - *Paralinhomoeus lepturus* DeMan, 1907
- **Genus *Terschellingia* Man, 1888**
    - *Terschellingia baylisi* Allgén, 1959
    - *Terschellingia brevicauda* Ott, 1972

*Terschellingia claviger* Wieser, 1956
*Terschellingia communis* De Man 1888
*Terschellingia distalamphida* Juario, 1974
*Terschellingia filicaudata* Wang, Ligou
An and Huang, 2017
*Terschellingia lissa* Timm, 1962
*Terschellingia longicaudata* DeMan 1907
*Terschellingia mora* Gerlach, 1956
*Terschellingia parva* Vitiello, 1969
*Terschellingia viridis* Timm, 1961

## VI. 2. 2. Systematic account of marine free living nematodes of the eastern Arabian Sea continental margin, West Coast of India

### Class Enoplea
### Order Enoplida Filipjev, 1929
### Family Anticomidae Filipjev, 1918
### Genus *Cephalanticoma* Platonova, 1976

*Cephalanticoma* sp

**Plate 1 (A)**

***Collection locations:*** Cape Comorin 200 m; Kollam 500m; Mumbai 2 1000 m; Veravel 500 m and 1000 m.

***Diagnosis:*** Smooth or resembling no more than weakly striated cuticle. Labial sensilla are papilli like and setiform. The labial region with three lips. Amphids are hardly visible and pocket-like in shape. Cephalic capsule is strong and pharyngeal musculature inserts into it. Buccal cavity small and conical bearing three teeth at the anterior of oesophagus. Excretory pore opens posterior to cervical setae. Cervical setae 3 to 5 in numbers, tail long.

### Family Ironoidae de Man 1876
### Genus *Dolicholaimus* De Man, 1888

*Dolicholaimus* sp

**Plate 1 (B)**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 1000 m

***Diagnosis:*** Smooth cuticle. Cephalic sensilla the 6 + 4 and papilliform, of the 4, third sensilla circle are usually predominant. Buccal cavity armed with three or four movable teeth. One is situated dorsally and two subventrally, and all three teeth are more or less equal in length. Females with two antidromously reflexed ovaries. Tail clavate.

### Genus *Syringolaimus* de Man, 1888

*Syringolaimus annae* Coelho Lima, Lins, Da Silva & Esteves, 2009

**Plate 1 (C)**

***Collection locations:*** Trivandrum 200 m; Cape Comorin 500 m

***Diagnosis:*** Body 1.8 mm and elongated**,** maximum diameter 30.8 µm. Cuticle almost smooth with faint striations on tail region only. Six small, outer labial papillae and four cephalic papillae both are arranged in two different sat of circles. Buccal cavity strong, cylindrical, sclerotized and deep. Three arrow-shaped asymmetrical bifid teeth of equal size, one dorsal and two subventral. Pharynx with strong musculature with an elongated basal bulb, 50 µm long and 27µm in diameter. Testis lying on right side of intestine.Vas deferens short with developing sperm cells. Fusiform spermatozoids. Spicule with lateral punctuations like appearance and with strong sclerotization. Velum barely visible. Gubernaculum blade like. Tail conicocylindrical without spinneret and filiform in terminal region. Filiform portion comprising 75% of total tail length. Three caudal glands present.

*Syringolaimus filicaudatus* Vitiello, 1970

**Plate 1 (D)**

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Body 1.7 mm long, maximum diameter 31 µm. Cuticle faintly striated, visibly striated at anterior and posterior end of body. Labial sensilla very small and papilli form. Cephalic sensilla barely seen. Buccal cavity strong, cylindrical, deep and armed with arrow-shaped three asymmetrical odontia of equal size. Teeths are divided at their ends and are placed one dorsally and two subventralyl. Oesophagus weakly dialated near the posterior end of stoma, basal dialations of oesophagus with wavy outline and with consrictions. Tail elongated with filiform end. Spicules arched with weak head. Pre anal papillae are absent.

*Syringolaimus magdae* Coelho Lima, Lins, Da Silva & Esteves, 2009

### Plate 1 (E)

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Body 16 mm long, maximum diameter 32 µm. Cuticular striations weak and hard to see. Outer labial papillae present. Head diameter 11.4 µm. Amphid pocket-like. Buccal cavity cylindrical, sclerotized and deep, 50 µm. Three bifid asymmetrical teeth of equal size, one dorsal and two subventral. Pharynx muscular, dilated in base of buccal cavity and with an elongated basal bulb of 47 µm long. Testis lying on right side of intestine. Short vas deference with fusiform sperm cells. Spicule 31.5 µm long, arch shaped, with dorsal region hook-shaped and containing strongly sclerotized punctuations. Gubernaculum slender blade like. Tail conicocylindrical, with spinneret; the cylindrical portion comprises 70% of tail length. Spinneret long and sharp. Three caudal glands present.

### Family Oncholaimidae Filipjev, 1916

### Genus *Filoncholaimus* Filipjev, 1927

*Filoncholaimus* sp

### Plate 2 (A)

***Collection locations:*** Cape Comorin 500 m; Karwar 1000 m

***Diagnosis:*** Cuticle thick and smooth without any ornamentation. Cephalic sensilla the 6 + 4. Cervical setae arranged in rows. Amphid hardly visible, pocket like. Buccal cavity large and deep, armed with three or four movable teeth. The males with two testes facing in opposite directions. Tail long and filiform.

### Genus *Pontonema* Leidy, 1855

*Pontonema* sp

### Plate 2 (B)

***Collection locations:*** Kochi 200m; Kollam 20m, 1000m; Mumbai 2 200m; Veravel 1000m

***Diagnosis:*** Thick body is of fairly even in thickness, pale in the middle region, but otherwise of a dark-brown tinge. Cuticle thick and smooth without any ornamentation. The barely visible cephalic papillae. The buccal cavity is large, at least twice as deep as wide, and thoughened by strongly sclerotised walls. Buccal cavity is armed with large two subventral teeth which are evenly developed, strongly chitinized.

### Genus *Viscosia* De Man, 1890

*Viscosia carnleyensis* Ditlevsen, 1921

**Plate 2 (C)**

***Collection locations:*** Trivandrum 200 m, 500 m

***Diagnosis:*** Long, slender body. Cuticle smooth. Body 1.12 mm long. Lip region demarcated. Cephalic papillae absent or reduced. Buccal cavity large and deep, dimensions are 22 x 11µm. Buccal cavity armed with teeth of 22 µm and 16 µm long from the base of the buccal cavity. Pharynx cylindrical. Spicules simple, arched and cephalate proximally. Tail is long with a swollen tip.

*Viscosia dubiosa* Kreis, 1932

**Plate 2 (D)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Cuticle smooth. Body length 2.50 mm. Lip region demarcated. Six labial papillae. Lateral cervical setae are placed at the base of the buccal cavity. Buccal cavity deep and wide, armed with teeth. Large right and smaller double tipped left sub ventral teeth; prominent dorsal tooth. Pharynx cylindrical. Tail is conicocylindrical with a bulbous tip. Spicules slightly curved and cephalate proximally.

*Viscosia elegans* Kreis, 1924

**Plate 2 (E)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Long, slender body. Total body length 2.3 mm. Lip region demarcated. Six labial papillae. Lateral cervical setae are positioned at the base of the buccal cavity. Buccal cavity deep long, 14 µm wide. Large right and smaller double tipped left sub ventral teeth; dorsal tooth slight ridge only. Pharynx cylindrical and slightly broadened at base. Tail is tapering, with a bulbous tip. Sub dorsal terminal setae absent. Spicules slightly curved and cephalate proximally. No cloacal setae.

*Viscosia franzii* Boucher, 1977

**Plate 3 (A)**

***Collection locations:*** Cape Comorin 500 m, 1000 m; Kollam 200 m; Mumbai 2 200 m

***Diagnosis:*** Long, slender but only slightly tapering towards anterior end. Cuticle smooth, lacking markings or ornamentation. Lip region somewhat demarcated. Lips with 6 internal labial papillae and a circle of 6 external labial setae (6 µm) + 4 cephalic setae (5 µm). Amphideal cup-shaped. Buccal cavity 25 µm long, 14 µm wide. Prominent sublateral tooth on right side; dorsal teeth small, reaching halfway of the buccal cavity. Pharynx cylindrical and slightly broadened at base. Cardia distinct, muscular, 7 µm. Reproductive system with two opposed, outstretched testes, on right side of intestine. Vas deferens separated from the muscular ejaculatory duct by a sphincter. Spicules straight, 28 µm long with small capitulum. 12 adanal setae. Three caudal gland cells. Tail short in appearance, tip demarcated; lateral setae on each side.

### Family Oxystominidae Micoletzky, 1924

### Genus *Halalaimus* De Man, 1888

*Halalaimus longamphidus* Huang & Zhang, 2005

**Plate 3 (B)**

***Collection locations:*** Trivandrum 1000 m

***Diagnosis:*** Long slender body of 2.3mm. Cuticle thick and smooth. Head part attenuating. Cephalic setae in 6+4 arrangement. Amphid long slit like. Spicule 17 long, slightly arched. Proximal cephalisation present. Gubernaculum with strange pieces. Tail cylindrical, posterior end long and filiform.

*Halalaimus longicaudatus* (Filipjev, 1927) Schneider, 1939

**Plate 3 (C)**

***Collection locations:*** Trivandrum 500 m

***Diagnosis:*** Body slender and elongated. Total length of the animal 1.9mm. Cuticle thick and smooth. Head attenuating. Cephalic setae in 6+4 arrangement. First Amphid long slit like. Spicule 17 long, slightly arched. Proximal cephalisation present. Gubernaculum with strange pieces. Tail cylindrical, posterior end long and filiform.

### Genus *Litinium* Cobb, 1920

*Litinium bananum* Gerlach, 1956

**Plate 3 (E)**

***Collection locations:*** Ratnagiri 500 m and 1000 m

***Diagnosis:*** Body slender and elongated, 2.7mm in total length. Cuticle smooth and thick. Sexual dimorphism of the amphideal fovea is more evident. In the female, the aperture is situated within the frame of the amphideal fovea but more close to its anterior edge while in the male the aperture breaks the anterior edge of the fovea thus making the latter crescent-shaped. Spicule arched and strongly sclerotised with proximal cephalisation. Gubernaculum simple lies parallel to spicule. Single pre anal setae. Tail short and blunt.

### Genus *Oxystomina* Filipjev, 1921

*Oxystomina affinis* Gerlach, 1956

**Plate 3 (F)**

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Long slender body of 2.1mm. Smooth and thick cuticle. Amphid typical of the genus. There is no buccal cavity. 6 cephalic setae and 4 cervical setae. Spicule 26 long, strongly cuticularised. Gubernaculum not observed. Pre anal setae preset. Tail is clavate.

*Oxystomina alpha* Chitwood, 1937

**Plate 4 (A)**

***Collection locations:*** Trivandrum 200 m, 500 m; Mumbai 1 200 m; Mumbai 2 200 m

***Diagnosis:*** Slender body of 3.7 mm length. Cuticle smooth and thick. Buccal cavity minute.Cephalic setae 6 in number 15 long and cervical setae 4 in number 20 long. Amphid oval shaped. Spicule 42 long, large, heavily cuticularised with proximal cephalisation. Gubernaculum absent. Cylindrical tail with swollen tip.

*Oxystomina asetosa* Southern, 1914

**Plate 4 (B)**

***Collection locations:*** Kollam 200m

***Diagnosis:*** Cuticle is smooth and buccal cavity absent. Total length of the body 900 µm. Characteristic oval shaped amphid, with curved structure round the anterior margin extending backwards as two projections. Cephalic and cervical setae are scarcely visible. Tail is long and clavate.

*Oxystomina elongata* Butschli, 1874

**Plate 4 (C)**

***Collection locations:*** Kollam 500m

***Diagnosis:*** Body length is 1.230mm. Cuticle is smooth. Six cephalic setae are 2.21µm long. Four cervical setae having the same length as cephalic setae. Buccal cavity is absent or reduced. Amphids typical of genus. Oesophagus is slender with a small posterior bulb. Tail is long and clavate. Spicules are 34µm long with a straight bump ventrally just before the proximal tip.

### Genus *Thalassoalaimus* de Man, 1893

*Thalassoalaimus brevicaudatus* Vitiello, 1970

**Plate 4 (D)**

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Slender boby of 1.8 mm length. Cuticle smooth. Cephalic setae 10 in numbers and cervical setae four in number. Amphids typical of the genus. Narrow cylindrical buccal cavity. Spicule 33 µm long, strongly sclerotised, slightly curved, composed of two plates which are seperated by a list. Gubernaculum simple plate like. Tail short and conical.

*Thalassoalaimus egregius* Steiner, 1916

**Plate 4 (E)**

***Collection locations:*** Cape Comorin 500 m; Goa 200, 500m; Veravel 200m

***Diagnosis:*** Long slender transparent body of 3 mm long. Cuticle smooth. Cephalic setae 10 in numbers and cervical setae four in number. Amphids typical of the genus. Narrow cylindrical buccal cavity. Spicule 37 µm long, slightly curved, composed of two plates which are seperated by a list. Prominent proximal cephalisation. Gubernaculum 12 µm long, simple plate like. Tail short and conical. Two pre anal papillae of 5 long.

*Thalassolaimus mediterraneus* Vitiello, 1970

**Plate 4 (F)**

***Collection locations:*** Trivandrum 1000 m; Karwar 200 m

***Diagnosis:*** Long narrow body with attenuating anterior end. Cephalic capsule weak. Cephalic setae 10 numbers, each of 2 long. 4 cervical setae. Cuticle smooth. Amphid pouch like with circular orifice. Buccul cavity small and cylindrical. Spicule 19 µm long, slightly curved, composed of two plates which are seperated by a list. Gubernaculum 6 µm long, simple plate like. Tail short and conical with highly sclerotized tail tip. A pair of pre anal papillae.

*Thalassoalaimus paramontemari* Vitiello, 1970

**Plate 5 (A)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Long slender transparent body. Total length of the animal is 2.4mm. Anterior end attenuating. 12 cephalic setae of 2.5 µm long. Amphid formed as a pouch. 4 cervical setae. Narrow cylindrical buccal cavity. Spicule 22 µm long with prominent proximal cephalisation. Gubernaculum 9 µm long, simple plate like. Tail short and blunt. Two pre anal papillae.

### Genus *Weiseria* Gerlach 1956

*Weiseria hispida* Vitiello, 1972

**Plate 5 (B)**

***Collection locations:*** Trivandrum 200 m and 500 m

***Diagnosis:*** Head conical with thick cuticle. Twelve cephalic setae into two circles (6+6); first circle, 13 µm; second circle, 7 µm long. Amphid a slightly elongated loop, 9.5 µm in length and 6.5 µm in width. Four sublateral cervical setae anterior to amphids and two lateral cervical setae about 30 µm posterior to amphid. Buccal cavity only a small narrow funnel. The posterior end of oesophagus is slightly enlarged. Cardia present between oesophagus and intestine. Tail 123 µm long, anterior two-thirds conical, then filiform with bifurcated tip. Caudal setae few and scattered. Spicule 20.5 µm long and curved with both proximal and distal end distinctively bent.

*Wieseria leptura* Vitiello, 1972

**Plate 5 (C)**

***Collection locations:*** Veravel 1000 m

***Diagnosis:*** Long slender body of 1.2 mm length. Anterior end attenuating. Cuticle smooth, 1.8- 2 µm in thickness. Somatic setae scattered, Head conical with thick cuticle. Labial organs not distinguished. Twelve cephalic setae into two circles. Amphid a slightly elongated loop, 9.5 long µm and 28.5 µm away from anterior. Four 10.5 µm long sublateral cervical setae anterior to amphids and two 10 µm long lateral cervical setae about 30 µm posterior to amphid. Buccal cavity only a small narrow funnel. The posterior end of oesophagus is slightly enlarged. Cardia present between oesophagus and intestine. Spicule 21µm arched with both proximal and distal end distinctively bent. Gubernaculum 9µm long. Precloacal ventral setae 2.5 µm long. Two testes, apparently reflexed. Tail 130 µm long, anterior two-thirds conical, then filiform; tip bifurcate. Caudal setae few and scattered.

*Wieseria scotlandica* Zhang, 1983

**Plate 28 (A)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body elongated thread like 2.7mm, anteriorly attenuating. Cuticle smooth, 2 µm in thickness. Somatic setae 6 long, scattered, less numerous and shorter elsewhere except cephalic region. Head conical with thick cuticle. Twelve cephalic setae into two circles (6+6); first circle, 14 µm; second circle, 7 µm long. Amphid a slightly elongated loop, 9 long. Buccal cavity only a small narrow funnel. The posterior end of oesophagus is slightly bulged. Cardia present between oesophagus and intestine. Tail long anterior two-thirds conical, then filiform; tip bifurcate. Caudal setae few and scattered. Spicule 20 µm long, curved with both proximal and distal end distinctively bent. Gubernaculum 7.5 µm long. Precloacal ventral setae 2.5 µm long.

### Family Tripyloididae de Coninck & Stekhoven, 1933

### Genus *Gairleanema* Warwick and Platt, 1973

*Gairleanema* sp

**Plate 5 (D)**

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Cuticle with indistinct transverse striation. Mouth surrounded by three high lips each with a pair of 28-30 µm long labial setae. The labial setae have bulbous swelling about half way along their length. Buccal cavity with a pointed heavily cuticularised dorsal onchium.Two subventral teeth less strongly cuticularised. Amphids situated just behind lateral cephalic setae. Spicules long, L-shaped, cephalate proximally and with broad ventral alae. Gubernaculum paired, with hooked dorsal apophyses. There is a ventral precloacal seta 11.5-13 µm long, a small ventral papilla 12.5-13 µm in front of the cloaca and two large rounded mammilate protuberances.

### Genus *Halanonchus* Cobb, 1920

*Halanonchus* sp

**Plate 5 (G)**

***Collection locations:*** Cape Comorin 200 m, 500 m, 1000 m; Trivandrum 200 m; Kollam 200 m, 500 m; Kochi 1000 m; Ponnani 200; Coondapur 500, 1000 m; Karwar 500 m; Mangalore 1000 m; Mumbai 2 500 m; Veravel 500m

***Diagnosis:*** Smooth cuticle. Body long and slender. Three large, deeply cut lips, on each lip 2 thin labial setae and, shortly behind, 2 larger, two-jointed cephalic setae. The amphids pocket-shaped with a distinctly circular orifice. In the cervical region 5-6 ventral bumps. Buccal cavity with strong walls. Oesophagus weakly dilated posteriorly, no bulb. A small triangular cardia is present. Spicula slender, gubernaculum either absent or consisting of a thin lamella, lying parallel to the spicula. There are about 12 preanal supplements, the posterior six being more distinct than the more anterior ones. Tail long.

### Genus *Tripyloides* De Man, 1886

*Tripyloides* sp

**Plate 5 (E)**

***Collection locations:*** Kollam 1000 m

***Diagnosis:*** Body length is 1.6 mm. Cuticle is smooth. Six longer cephalic setae 7 µm long and jointed; shorter four are 4.5 µm long and unjointed. Buccal cavity is in four separate sections, cuticularised, and posterior most cavities with two sub ventral teeth. Amphids circular, 4.7 µm in diameter, placed level with the base of buccal cavity. Spicules are 25 µm long. Tail short.

### Family Trefusiidae Gerlach, 1966

### Genus *Rhabdocoma* Cobb, 1920

*Rhabdocoma Americana* **Cobb, 1920**

**Plate 5 (F)**

***Collection locations:*** Cape Comorin 500 m, 1000 m; Kollam 500m

***Diagnosis:*** Body slender, attenuating on posterior end. Head slightly round and not set off. Cuticle smooth. Amphids inconspicuous. Buccal cavity conical and small without noticeable teeth. Inner labial setae lacking. Outer labial setae in papilla. Jointed 6 cephalic and situated at the median part of the head. Subcephalic setae 9 µm long, located at 29 µm from anterior end. Pharynx slender and cylindrical. Ventral gland and nerve ring not seen. Tail long, slender and cylindrical with round tail tip. Caudal setae absent. Spinneret developed.

### Genus *Trefusia* De Man, 1893

*Trefusia* sp

**Plate 6 (A)**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 1000 m; Kollam 200 m, 1000 m

***Diagnosis:*** Cuticle is smooth. Labial sensilla are papilliform or setiform. The 6+4 cephahc setae are usually arranged in two rows. Jointed cephalic setae. Amphlds are non-spiral. Labial region is generally divided into three lips. Buccal cavity is conical or barrel-shaped without teeth. The males posses two testes which face in opposite and females with two ovaries. Males with pre-anal and post anal supplements.

### Genus *Trefusialaimus* Riemann, 1974

*Trefusialaimus* sp

**Plate 6 (B)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Cuticle smooth, thin. Head rounded, slightly set-off with three lips, each bearing two small, conical inner labial papillae. Six outer labial setae and jointed four cephalic setae in one circle. Amphid pocket-shaped with oval aperture. Buccal cavity funnel-shaped, without teeth. Pharynx cylindrical, slightly swollen at posterior extremity. Single outstretched testis, paired, equal spicules, slightly bent, with broad proximal end and narrow pointed distal end; velum present. Gubernaculum with two pairs of narrow, pointed lateral crurae. Four pairs of small, conical cloacal papillae. Tail elongated.

### Family Enchelidiidae Filipjev, 1918

### Genus *Bathyeurystomina* Lambshead & Platt, 1979

*Bathyeurystomina* sp

**Plate 6 (C)**

***Collection locations:*** Kollam 200 m; Kochi 200 m

***Diagnosis:*** Body elongated (2mm). Anterior region attenuated with flap like lips. Cuticle smooth. Somatic setae short. Amphids cresent shaped with notched ends. Six setae 16-20 µm long and four setae about 5 µm. Buccal cavity appears as strong, large and ornamented with denticles and tooth. Testes opposite, outstretched and left of intestine. Spicules very narrow, slightly curved; gubernaculum with dorso caudal apophyses. Suppliments and accessory body are present.

### Genus *Calyptronema* Marion, 1870

*Calyptronema* sp

**Plate 6 (D)**

***Collection locations:*** Cape Comorin 1000 m; Kollam 1000 m

***Diagnosis:*** Body slender with a narrow neck region. Cuticle smooth and strongly expanded around head and neck. Rows of somatic setae arranged two sublaterally and two submedially on each side of body. Amphids transversally oval. Six small labial papillae and one circle of ten cephalic setae. Mouth opening very narrow; buccal cavity appears as a narrow duct through head capsule; two opposite gland cells opening close to mouth. Oesophagus very diffuse. Testes opposite, outstretched and left of intestine. Spicules very narrow, slightly curved; gubernaculum as a weakly cuticularized plate. Three small ventral papillae in front of cloaca and a single seta. Tail tip curved to ventral side.

### Genus *Eurystomina* Filipjev, 1918

*Eurystomina* sp

**Plate 6 (E)**

***Collection locations:*** Kochi 200; Porbandar 500m; Mumbai 1 200 m

***Diagnosis:*** Very long animal (3.5mm) with deep buccal cavity separated into two chambers by three rows of denticles. Smooth cuticle. Amphid aperture transversely oval, displaced dorsally. Excretory pore on level of amphids terminal excretory duct short. Three pairs of preanal setae present, one subventral and longer that the two submedian pairs; Tail long.

### Genus *Pareurystomina* Filipjev, 1921

*Pareurystomina* sp

**Plate 6 (G)**

***Collection locations:*** Kochi 200

***Diagnosis:*** Elongated body of length 6 mm. Maximum diameter 71. Cuticle smooth. Six small labial papillae, rounded. Cephalic setae 6.5 µm.Buccal cavity with single right subventral slender pointed tooth, two complete circles of large denticles and an incomplete circle of very fine denticles. Amphids 12 µm wide, dorsolateraly flatened. Flattened cervical setae extend posteriorly. Spicules arcuate, hooked distally, 72 µm long. Gubernaculum dorsally directed, 37 µm. Male with a pair of subventral double-pointed papillae. Two supplements with small and symmetrical wings. A pair of short setae immediately anterior to cloaca. Tail tapering to a fine point.

### Genus *Polygastrophora* de Man, 1922

*Polygastrophora* sp

**Plate 6 (F)**

***Collection locations:*** Cape Comorin 500m

***Diagnosis:*** Elongated body of 4 mm. Cuticle smooth. Genus possessing seven esophageal bulbs. Buccal cavity portioned into chambers and are armed with onchium. Sexual dimorphism present in the shape of buccal cavity. Males with two ventrally situated pre-anal supplements.

### Class Chromadorea

### Order Araeolaimida

### Family Comesomatidae Filipjev, 1918

### Genus *Cervonema* Wieser, 1954

*Cervonema gourbaulti* Muthumbi, Soetaert & Vincx, 1997

**Plate 7 (A)**

***Collection locations:*** Cape Comorin 500 m, 1000 m; Trivandrum 1000 m; Kollam 200 m, 1000 m; Kochi 200 m; Ponnani200 m, 500 m, 1000m; Goa 1000 m; Dhabol 1000 m; Mumbai 2 200 m, 1000 m; Coondapur 200 m; Porbandar 200m

***Diagnosis:*** Body length is 1.10mm. Cuticle finely striated. Anterior region narrow to elongated. Cylindrical body, tapering towards extremities with cervical elongated region .Outer labial and cephalic setae are equal in length and slender. Amphids with narrow spiral of 4.25 turns and situated far behind the anterior end. Buccal cavity minute. Weakly sclerotized spicules. Spicule is 30 µm long. The tail is conico-cylindrical, with a slightly swollen tip. Anterior most 50% of tail is conical, posterior cylindrical portion slender. Tail tip enlarged with 3 terminal setae and prominent spinneret.

### Genus *Comesoma* Bastian, 1865

*Comesoma* sp

**Plate 7 (B)**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 500 m; Karwar 200 m, 500 m, 1000 m; Goa 1000 m; Porbandar 1000 m

***Diagnosis:*** Cephalic sensilla in three distinctly separated crowns, outer labial lateral setae longer than the other four outer labial setae. Subcephalic setae in one or more crowns, each with four setae. Posterior portion of the buccal cavity weakly sclerotized and with three small blunt projections at the border to anterior portion. Spicules long and slender. Apophyses plate-like or indistinct.

### Genus *Dorylaimopsis* Ditlevsen, 1918

*Dorylaimopsis coomansi* Muthumbi, Soetaert & Vincx, 1997

**Plate 7 (C)**

***Collection locations:*** Cape Comorin 500 m; Kochi 200 m

***Diagnosis:*** The body is cylindrical anteriorly with blunt end. The cuticle is punctated with lateral differentiation. Laterally, the punctations are larger and more widely spaced on the pharyngeal and the tail region and are irregularly arranged on rest of the body. Eight rows of long (7 µm) somatic setae which may be more conspicuous at the pharyngeal region. Amphids are spiral with 2.5 turns. Stoma is tubular with three large teeth in the anterior part and highly sclerotized walls in the posterior part. The pharynx is long with an expanded base to form the terminal bulb. The reproductive system is diorchic, with opposed and outstretched testes. The spicules are curved with a capitulum and their proximal tip is sharp and hooked. There are 16 fine precloacal supplements. Gubernaculum with dorso-caudal apophysis. Tail is long, conicocylindrical with numerous setae at the ventral and subventral region. Three long terminal setae. Caudal glands open through a prominent spinneret.

*Dorylaimopsis variabilis* Muthumbi, Soetaert & Vincx, 1997

**Plate 7 (D)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** The cuticle is punctated on the median layer. Punctations begin at the level of the anterior border of the amphids and with lateral differentiation. Eight rows of somatic setae. Anterior sensilla are all distinct; inner and outer labial sensilla are tiny and the cephalic ones are long, amphids are spiral with 3 turns and situated immediately posterior to cephalic setae. Stoma has an anterior conical part with three teeth and a posterior tubular part with highly sclerotised walls. The pharynx is cylindrical, slightly expanded at the base. Cardia is small but distinct. The reproductive system is diorchic. The spicules are long arcuate and with a capitulum. The gubernaculum with long caudal apophysis. There are 12-26 pre-cloacal supplements with very fine ducts. The tail is conico-cylindrical with a swollen tip.

### Genus *Hopperia* Vitiello, 1969

*Hopperia* sp

**Plate 7 (E)**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 200 m; Kollam 200 m; Kochi 200 m; Karwar 500 m

***Diagnosis:*** Cuticle punctuated laterally with transverse rows of coarse dots. Posterior portion of buccal cavity cylindrical with three thorn-like projections. Reflexed ovaries. Spicules arcuate. Apophyses directed caudally or dorsocaudally.

### Genus *Kenyanema* Muthumbi, Soetaert & Vincx, 1997

*Kenyanema monorchis* Muthumbi, Soetaert & Vincx, 1997

**Plate 7 (F)**

***Collection locations:*** Trivandrum 500 m

***Diagnosis:*** Body cylindrical, with narrowing anterior part and conical tail with swollen tip. Cuticle annulated and punctated on the median layer. Laterall differentiation present. Somatic setae are scarce and short. Amphids are spiral with two turns. The stoma is tubular, 6–8 µm long. The reproductive system is monorchic with a short, outstretched anterior testis located to the left of the intestine. The spicules are strongly curved; Gubernaculum is strong and it has a long caudal apophysis. Tail is conical with a short cylindrical part and a swollen tip with three terminal setae.

### Genus *Laimella* Cobb, 1920

*Laimella longicaudata* Cobb, 1920

**Plate 7 (E)**

***Collection locations:*** Trivandrum 500 m; Coondapur 200 m, Karwar 200 m; Mangalore 200 m

***Diagnosis:*** Body length is 1.25mm. Cuticle is provided with fine punctuations in regular transverse rows. Dots are so close that the appearance like of transverse striations. Four circles of setae are present in the oesophageal region and numerous somatic setae in the region of anus and tail. Amphids spiral with 3.25 turns. Buccal cavity is narrow, cylindrical and weakly cuticularised. Oesophageal bulb is present. Tail is filiform. Spicules are 34 µm long, arcuate. Papillate precloacal supplements 5 numbers.

### Genus *Metacomesoma* Wieser, 1954

### *Metacomesoma* sp

### Plate 8 (A)

***Collection locations:*** Kochi 200 m

***Diagnosis:*** Two crowns of anterior sensilla. Outer labial setae as long as the cephalic setae. Buccal cavity rather weakly sclerotized. Spicules long. Gubernaculum surrounding the distal part of the spicules. Apophyses usually lacking.

### Genus *Minolaimus* Vitiello, 1970

*Minolaimus* sp

### Plate 14 (C)

***Collection locations:*** Mumbai 2 200 m, 500 m; Porbandar 5000 m

***Diagnosis:*** Anterior body end conically narrowed. Lateral differentiation as three longitudinal rows of enlarged dots. Amphideal fovea large, multispiral. Buccal cavity very small and unarmed. Tail filiform.

### Genus *Paracomesoma* Hope & Murphy, 1972

*Paracomesoma longispiculum* Timm, 1961;

### Plate 8 (B)

***Collection locations:*** Kannur 500 m

***Diagnosis:*** Body length is 1.475mm. Cuticle with transverse rows of striations regularly arranged in almost all body length except caudally. Lateral differentiation absent. Somatic setae are 6µm in length, arranged in six longitudinal rows. Lips cushion like. Cephalic sensilla are arranged in 3 crowns. Amphids spiral, 2.5 turns. Buccal cavity with anterior dilated portion. Oesophagus gradually enlarges posteriorly with a small cardia. Tail conico-cylindrical. Two terminal setae are present. Spicules are with a slight dorsal curve, gubernaculum is with a pair of minute lateral guiding pieces running parallel to spicules. One of the spicule is slightly smaller than other. Anteriorly placed 6 preanal supplements are present.

### Genus *Paramesonchium* Hopper, 1967

*Paramesonchium mombasi* Muthumbi, Soetaert & Vincx, 1997

### Plate 8 (C)

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body is cylindrical and slender,with a blunt head end. The head region shows a kind of a constriction just behind the cephalic setae. Cuticle is annulated and punctated. Punctations are with lateral differentiation. Somatic setae were observed only at the cylindrical part of the tail. Inner labial sensilla are indistinct, the outer labial sensilla are 5 µm and cephalic sensilla are 21 µm long. Amphids are spiral with 2.75 turns, 9–11 µm in diameter. Stoma is large, cup-shaped, 7–9 µm long with sclerotised walls. The reproductive system is diorchic, with opposed and outstretched testes. Spicules are arcuate, 17 µm long, gubernaculum is short with a dorso-caudally curved apophysis. Six to seven ventral pre-cloacal supplements. Three subventral setae at the conical part of the tail. The tail is conico-cylindrical, with swollen tip. There are two long setae at the tip.

### Genus *Pierrickia* Vitiello, 1970

*Pierrickia* sp

**Plate 8 (D)**

***Collection locations:*** Goa 1000 m

***Diagnosis:*** Cuticle punctuate. Amphids with more than four spirals, situated close to the front end. Outer labial setae and cephalic setae equal in length. Buccal cavity very minute. Reproductive system is diorchic, with opposed and outstretched testes. Spicules are arcuate. Gubernaculum with dorsocaudally directed apophyses.

### Genus *Sabatieria* Rouville, 1903

*Sabatieria alata* Warwick, 1973

**Plate 8 (E)**

***Collection locations:*** Cape Comorin 500 m, 1000 m; Trivandrum 200m, 500 m, 1000 m; Kollam 200; Ponnani 200 m, 1000 m; Kannur 500 m, 1000 m; Mangalorre 1000m

***Diagnosis:*** The cuticle is transversed with fine punctuation. Laterally the puntuations are larger, wider spaced and more irregularly arranged. Mouth is surrounded by six rounded lips each bearing small conical papilla. Anteriorly there are six short conical cephalic setae and more poateriorly four longer ones. Cervical setae short and scattered. Amphid large, spiral of 3.2turns. Spicules paired, equal and arcuate. Spicules bears medial list and ventral alae. Gubernaculum with dorsal apophyses. There are 21 small precloacal suppliments. The tail long with distal half filiform.

*Sabatieria exilis* Botelho, Da Silva, Sobral & Fonseca-Genevois, 2009

**Plate 8 (F)**

***Collection locations:*** Trivandrum 500 m, 1000 m; Ponnani 1000 m; Kochi 500 m

***Diagnosis:*** Body cylindrical, attenuated at both ends. Cuticle with transverse rows of small dots, lateral differentiation of larger, equally spaced dots. Short somatic setae. Rounded head with anterior sensilla arranged in three crowns: six minute internal labial papillae, six minute external labial papillae and four cephalic setae. Amphids spiral, with 1.5 turns. Buccal cavity minute. Pharynx without distinct bulb. Male reproductive system diorchic, with opposed and outstretched short testes. Slender cuticularized spicules of equal lengths and widths with alae. Small gubernaculum with apophysis. Six pre-cloacal supplements with a pre-cloacal setae. Tail conico-cylindrical with swollen tip. Three caudal glands present in postanal region, ending in a spinneret. Two caudal setae.

*Sabatieria paracupida* Wieser & Hopper, 1967

**Plate 9 (A)**

***Collection locations:*** Karwar 200 m; Trivandrum 1000 m

***Diagnosis:*** Total length is 1.070mm. Amphid 2.25 turns. Buccal cavity small and cup shaped, without teeth. Cuticle dotted with lateral differentiation. Spicules are 55µm long, curved, tapering proximally with a list. Gubernaculum is with lateral guiding pieces and caudally directed apophyses. Tail is long, 19 preanal supplements.

### Genus *Setosabatieria* Platt, 1985

*Setosabatieria* sp

**Plate 9 (B)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 500 m; Kochi 200 m; Ponnani 200 m; Mumbai 1 1000 m; Kollam 200

***Diagnosis:*** Body length 1.1 mm.Buccal cavity very small and unarmed. Anterior body end conically narrowed. Cuticle with faint transverse striations, more widely spaced posterior to the oesophageal region and are discontinuous in the lateral fields. Four cephalic setae 14-15 µm. Four longitudinal groups of closely spaced long cervical setae, 14 per grops. Other somatic setae shorter and more scattered. Amphideal multispiral 3.5 turns. Tail conico-cylindrical with three long terminal setae. Spicules 65-75 µm. Gubernaculum with straight dorsocaudal apophyses. 15 minute precloacal supplements.

### Family Axonolaimidae Filipjev 1918

### Genus *Odontophora* Bütschli, 1874

*Odontophora falcifera* Ott, 1972

**Plate 26 (I)**

***Collection locations:*** Cape Comorin 1000 m; Kollam 200

***Diagnosis:*** Body slender 1.14 mm long. Cuticle smooth. Head with four cephalic setae. Amphid loop shaped and large. At the level of amphid, one circle of 8 subcephalic stae. No somatic seta. Stoma with six odontia with blunt tips each bearing two forward directed apophyses. Well developed stoma with longitudinal muscle. Males with two testes. Spicules strongly curved, slightly cephalate proximally.Gubernaculum lies parallel to spicula, consisting of an approximately square median piece and dorsal apophyses. Tail conical, long, bearing several sub lateral bristles. Three caudal glands opens in to a spinneret terminally.

### Genus *Parodontophora* Timm, 1963

*Parodontophora brevamphida* Timm 1952

**Plate 26 (J)**

***Collection locations:*** Kollam 200

***Diagnosis:*** Body length is 1.2mm. Four rows of somatic setae. Cuticle is striated except in the anterior most part. Amphid is short and shepherd's crook like with the ventral arm longer than the dorsal. Dorsal arm is 9.6 µm long and ventral arm 14 µm long. Head rounded with six lips, six labial papillae, and four 71-lm long, cephalic setae. Oesophagus diameter is increasing posteriorly, without a buccal bulb. Spicules are arcuate, 52 µm long. Gubernaculum 18.9 µm long, arcuate. Tail is elongate-conoid. Male is with a short preanal seta and two subventra1 rows of 7 setae. Spinneret is present.

*Parodontophora danka* Belogurov & Kartavtseva, 1975

**Plate 27 (A)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Long stout body of 1.4mm length. Cuticle finely striated. Amphid large and long, shepherds crook shape, ventral arm extend beyond buccal cavity. Head rounded with six lips, six labial papillae, and four cephalic setae. Oesophagus diameter is increasing posteriorly, without a buccal bulb. Spicules are arcuate stongly sclerotised, 52 µm long. Proximal cephalisation characteristic with deep depression in the capitulum. Gubernaculum long, with apophyses. Tail is elongate-conoid. Male is with a short preanal seta and two subventra1 rows of 7 setae. Spinneret is present.

### *Parodontophora xenotricha* Boucher, 1973

**Plate 27 (B)**

***Collection locations:*** Kollam 1000 m

***Diagnosis:*** Long stout body of 1.3 mm length. Head rounded with six lips, six labial papillae, and four cephalic setae. Four rows of somatic setae are present, two on either side of each lateral chord. Cuticle finely striated. Amphid large, shepherds crook shape, both the arms are almost equal in size. Spicules are arcuate and stongly sclerotised, 49 µm long. Proximal cephalisation rounded with middle list starting from a deep depression in the capitulum. Gubernaculum triangle plate like, with apophyses. Tail is elongated conoid.

## Family Diplopeltidae Filipjev, 1918

## Genus *Campylaimus* Cobb, 1920

### *Campylaimus gerlachi* Timm, 1961

**Plate 27 (C)**

***Collection locations:*** Trivandrum 200 m, 500 m, 1000 m; Kollam 200 m; Ponnani 200 m; Mangalore 200 m; Dhabol 200 m, 500 m, 1000 m; Veravel 1000 m

***Diagnosis:*** Short stout body of 800 µm length. Cuticle striated. Buccal cavity subterminal on the ventral side. Head narrow with a clear cap at the anterior. Four cephalic setae at the level of the oral opening. Amphids with 2 parallel arms situated behind the cephalic setae and the mouth, the long arm continuous with broad lateral alae extending the length of the body almost to the tail tip; alae 3.2 µm wide. Oesophagus terminates in a small bulb-like expansion. Spicules 16.5 µm long, arcuate, distinctly cephalated. Gubernaculum with posterior apophysis.Tail conico cylindrical with a swollen tip.

*Campylaimus rimatus* Vitiello, 1974

**Plate 27 (D)**

***Collection locations:*** Mumbai 2 500 m; Ponnani 200 m; Kollam 200 m; Kochi 200 m, 1000 m; Goa 1000 m; Dhabol 1000 m; Veravel 1000 m

***Diagnosis:*** Total length of the animal 686 µm. Cuticle uniformly striated. Buccal cavity subterminal opening ventrally. Head narrow, with a clear cap at the anterior. Four cephalic setae posterior to the oral opening. Amphids consisting of 2 parallel arms situated behind the cephalic setae and the mouth, the long arm continuous with broad lateral alae extending the length of the body to the tail tip. Spicules 33µm long, arcuate, distinctly cephalated. Gubernaculum plate like. Tail conicocylindrical with a swollen tip.

### Genus *Diplopeltis* Cobb, 1905

*Diplopeltis ornatus* Gerlach, 1950

**Plate 27 (E)**

***Collection locations:*** Cape Comorin 500 m; Ratnagiri 500 m

***Diagnosis:*** Short stout body of 750 µm length. Cuticle finely striated. Amphids lying on a well-developed cuticular plate that has a double border, large, crook shaped. Four longitudinal rows of cervical setae. Ocelli present. Buccal cavity minute and terminal. Pharynx narrow. Spicules 23 µm long, thin and ventrally curved. Tail conical.

### Genus *Diplopeltula* Gerlach, 1950

Diplopeltula asetosa Juario, 1974

**Plate 27 (F)**

***Collection locations:*** Karwar 200 m, 500 m

***Diagnosis:*** Body length is 750 µm. Cuticle is coarsely annulated. Four 6 µm cephalic setae are present. Somatic setae are absent except for a few on the male tail. Amphids are 7.3 µm wide, 16.2 µm long and loop shaped with non-contiguous limbs. Buccal cavity is absent. Oesophagus is with a slight posterior bulb. Tail is conical. Spicules are 18 µm long. Gubernaculum is with small dorsal apophyses.

*Diplopeltula incisa* Gerlach, 1962

**Plate 27 (G)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m, 500m, 1000 m; Dhabol 200 m, 500 m; Mumbai 2 200 m, 500 m; Ponnani 200 m; Mangalore 1000 m; Coondapur 200m; Veravel 200m, 500 m, 1000 m

***Diagnosis:*** The body length 720 µm, the maximum diameter 52-70 µm.Buccal cavity small, mouth terminal or subterminal. Amphid wide and long, loop-shaped. Spicules curved with a short central lamella in the proximal portion, 19 µm long. Gubernaculum with a pair of tapering dorsal apophyses. Tail is conical-blunt.

### Genus *Diplopeltoides* Gerlach, 1962

*Diplopeltoides linkei* Jensen, 1991

**Plate 19 (K)**

***Collection locations:*** Trivandrum 500m, 1000 m; Kannur 500 m; Ratnagiri 500 m, 1000 m; Dhabol 1000 m

***Diagnosis:*** Body stout and slightly attenuating towards the ends. In lateral view head with a compact sclerotization at ventral and dorsal borders 10 µm behind front end. Cuticle annulated, each annule about 2.5 µm wide along the body, but 4 µm wide on posteriormost part of tail; each annule with a longitudinal striation from cephalic sclerotization to tail tip; tail tip surrounded by a weakly sclerotized cap. Four cephalic setae, 2-3 µm long. Amphids ventrally wound loop, 14-17 µm long. Pharynx differentiated into a cylindrical muscular portion 50-56 µm long continuing in an extremely narrow 44-50 µm long portion and terminating in to abulb. Spicules bent, 28 µm; gubernaculum distinctly sclerotized appearing as a rod with a narrow notch.

### Genus *Morlaxia* Vincx & Gourbault, 1988

*Morlaixia contusa* Vincx & Gourbault, 1988

**Plate 27 (H)**

***Collection locations:*** Kochi 200 m; Ponnani 200 m; Dhabol 500 m, 1000 m; Mumbai 2 200 m, 500 m; Porbandar 500m

***Diagnosis:*** Body long 1420 µm long and slender with assymetrical head located on ventral side. Cuticle with very fine annulations. Internal labial setae papilli form, 6 in numbers; located on the ventral side. Cephalic setae 9 µm long located at anterior end of amphid. Somatic setae scarce. Amphid ventrally spiralled loop. Diorchic with opposed testis. Spicules curved with highly sclerotized shaft. Gubernaculum with two dorso caudal apophyses. Tail conical.

*Morlaixia obscura* Vincx & Gourbault, 1988

**Plate 27 (I)**

***Collection locations:*** Dhabol 500 m

***Diagnosis:*** Body long 1355 µm long and slender with assymetrical head located on ventral side. Cuticle with very fine annulations. Four cephalic setae 10µm long. Amphid loop shaped. Buccal cavity un armed, narrow cylindrical. Males diorchic. Spicule simple and slightly bent with capitulum. Gubernaculum weakly sclerotized with hardly visible apophyses. Tail elongated; conico cylindrical.

### Genus *Pararaeolaimus* Timm, 1961

*Pararaeolaimus rumohri* Timm, 1961

**Plate 27 (J)**

***Collection locations:*** Trivandrum 500 m; Coondapur 200 m; Goa 200 m; Ratnagiri 500 m; Mumbai 2 200 m, 500 m; Veravel 1000 m; Porbandar 200 m.

***Diagnosis:*** Body stout. Cuticle smooth. Four cephalic setae of 1-2 µm long. Amphids ventrally wound loop with a circular outline, 17 µm in diameter. Amphids shifted slightly to the ventral body. Buccal cavity shallow. Pharynx cylindrical, slightly expanded at both ends. Spicules bent, proximally with a cephalated cap, 27 µm; gubernaculum and lateral sclerotization present. Two opposite and outstretched testes. Three caudal glands. Slender tail.

### Genus *Southerniella* Allgén, 1932

*Southerniella conicauda* Schuurmans Stekhoven, 1950

**Plate 27 (K)**

***Collection locations:*** Coondapur 200m

***Diagnosis:*** Body thick and stout and attenuating towards the ends. 996 µm in total length. Head bluntly round and surrounded by a weakly sclerotized cap. No distinct labial papillae. Cephalic stae 4 in number. Amphids large, circular in outline, but are spiral. Buccal cavity armed with rhabdions and are partitioned in to prostome and mesostome. Tail conical with three caudal gland in tandem position.

*Southerniella nojii* Jensen, 1991

**Plate 27 (L)**

***Collection locations:*** Coondapur 200m

***Diagnosis:*** Body slender and attenuating towards the ends. Head surrounded by a weakly sclerotized cap. Cuticle finely striated anterior to amphids and on posterior part of tail. Six small labial setae and four cephalic setae, 4-6 μm long. Amphids spiralized ventrally 8-9 μm in diameter with marginal border distinctly sclerotized and describing a circle. Buccal cavity narrow, deep and unarmed 4-5 μm long. Spicules sigmoidal, 36 μm; gubernaculum distinctly sclerotized with a caudal differentiation appearing as the basis of an apophysis, weakly sclerotized dorsal apophysis present. Testes opposite and outstretched. Two small precloacal papillae present. Caudal gland cells present within tail. Tail tip surrounded by a weakly sclerotized cap at a subterminal constriction.

*Southerniella simplex* Allgen, 1932

**Plate 27 (M)**

***Collection locations:*** Porbandar 200m

***Diagnosis:*** Body slender and attenuating towards the ends. 1.55mm long with faint cross striations. Head with a clear cap. Stoma deep, narrow and cylindrical. Amphids spiral of single turn.Spicule large 45 long, curved with median list. Gubernaculum with long apophyses. Tail conical tapering into a blunt tip.

### Order Desmoscolecida

### Family Desmoscolecidae Shipley, 1896

### Genus *Desmoscolex* Claparède 1863

*Desmoscolex abyssorum* Decraemer, 1984

**Plate 10 (F)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m; Kannur 200m; Coondapur 200m; Ratnagiri 1000 m

***Diagnosis:*** Cuticle annulated with 17 small main rings with foreign bodies and secretions. Anteriorly in the region of the buccal cavity cuticle is sclerotised. The extreme anterior of the head is seen as a circular projection with fine obscure pegs. The main rings are separated by wider interzones of 2 to 4 annules. Cephalic setae on peduncles 4 nos; Amphids vesiculate with a vesicular corpus gelatum. Buccal cavity small, un armed. Somatic setae arranged in alternating pairs of subdorsal and sub ventral spines. Single anterior testis; ovaries paired, outstretched. Terminal main ring conical slightly bent towards ventral side, 28 µm long with 4 µm long narrow spinneret.

*Desmoscolex fennicus* Lorenzen, 1969

**Plate 10 (G)**

***Collection locations:*** Trivandrum 200m; Karwar 200m

***Diagnosis:*** Total length of the animal 265 µm, maximum body diameter 33. Cuticle annulated with 37 to 38 main rings instead of typical 36 rings. Cuticle is sclerotised anteriorly in the region of the buccal cavity. The main rings are separated from each other by wider interzones. Single anterior testis. Spicules small slightly curved and 26 long. Small gubernaculam encircling spicule. Terminal main ring conical slightly bent towards ventral side, 21 µm long with 4 µm long narrow spinneret.

*Desmoscolex noctuabundus Bussau*, 1993

**Plate 10 (H)**

***Collection locations:*** Kannur 500 m

***Diagnosis:*** Short stout body of 300 µm. Cuticle with 17 small main rings seperated by wider interzones of 2 to 4 annules. Amphid vesiculate. Cephalic tubercles situated between labial sensilla. Buccal opening with minute un armed buccal cavity. Spicules 25 mm long, nearly straight; blade tapering caudally to a pointed tip, proximally provided with capitulum. Gubernaculum thin, trough shaped, 5 mm long. Terminal main ring conical bent towards ventral side, 22 µm long with 4 µm long narrow spinneret.

*Desmoscolex pedunculus* Rho, Kim & Chang, 2007

**Plate 10 (I)**

***Collection locations:*** Dhabol 200 m

***Diagnosis:*** Body small, ventrally curved, slightly tapered anteriorly and posteriorly; cuticle with 17 broad desmens covered with secretions and finely granular foreign material. Head wider globular. Circle of six minute, papilliform labial sensilla. Specialized cephalic tubercles situated near labial sensilla. Buccal opening with minute buccal cavity. Oesophagus 60 µm long, posteriorly extending to level of posterior margin of desmen. Single outstretched testis. Spicules short (28 µm long), straight or slightly blunt; blade tapering caudally to pointed tip, proximally provided with well-developed offset capitulum. Gubernaculum thin, trough shaped, 6 µm long. Tail with two desmens.

*Desmoscolex segonzaci* Decraemer, 1983

**Plate 10 (J)**

***Collection locations:*** Cape Comorin 200m

***Diagnosis:*** Body small 285 µm long with 17 desmens. Interzones with 3 annules. Head with narrow labial region. Amphids bipartite. Circle of six minute, papilliform labial sensilla. 8 pairs of subventral and 9 pairs of sub dorsal setae. Single testes. Spicule 32 µm long, tapered to a pointed tip with proximal capitulum. Gubernaculum thin rather obscure rod like, lies parallel to spicule.Tail with two main rings. Minute spinneret.

### Genus *Greeffiella* Cobb, 1922

*Greeffiella pierri* Schrage & Gerlach, 1975

**Plate 10 (K)**

***Collection locations:*** Mumbai 1 200 m

***Diagnosis:*** Short stout body of 350 µm composed of 62-64 annules. Narrow cuticular rings. Each annule bears row of fine setae in center, increasing in length from anterior to posterior. Head broadly rounded, narrower than first annule. Amphids large, elliptical, thick-rimmed, much broader than head. Large dark yellow pigment spots about 6 µm in diameter, located at level of annules. Stoma hardly seen. Esophageal corpus broad, slightly swollen at base. Intestine packed with large pale yellowish globules. Single short outstretched testis. Spicules distinctly cephalate 32 µm long, with distally narrow blade. Tail composed of 10 annules. Tail conical 46 µm long, consisting of a narrowly triangular anterior portion and a posterior spike opening at the tip.

### Genus *Pareudesmoscolex* Weischer 1962

*Pareudesmoscolex laciniosus* Lorenzen, 1969

**Plate 10 (L)**

***Collection locations:*** Trivandrum 500 m

***Diagnosis:*** Body small, tapered towards the extremities. Cuticle with 70 narrow homogeneous rings, bearing small spines usually surrounded by secretion and foreign material, the conical end-part of the terminal ring, however, is surrounded by a complete concretion ring of fine material. Head broadly rounded. Cuticle, except in the stomatal region and the central amphidial zones, covered by a relatively thick layer of secretion and fine foreign material. Cephalic setae on short peduncles about halfway the head-length. Setae jointed, composed of a broader basal part with fine central canal continuing into a fine distal part with open tip. Amphids thin-walled, rounded, largely covering the head laterally. Stoma small. Oesophagus short cylindrical. Reproductive system with single testis. Spicules nearly straight and slender with capitulum. Gubernaculum a thin rod-like structure. Tail consisting of about seven narrow annules including a longer end-ring.

### Genus *Tricoma* Cobb, 1894

*Tricoma brevirostris* Southern, 1914

**Plate 11 (A)**

***Collection locations:*** Cape Comorin 500m; Trivandrum 200 m; Dhabol 200 m

***Diagnosis:*** Body length is 600 µm. Body composed of 78 closely spaced desmens. Cephalic setae are 0.8 h.d long. Head is triangular with thickened cuticular walls.

*Tricoma filipjevi* Chitwood, 1951

**Plate 11 (B)**

***Collection locations:*** Cape Comorin 500m

***Diagnosis:*** Male is 360 µm long. Body marked with 37 opaque concretion annules. Spicules are 40 µm long and slightly cephalated. Gubernaculum is with a proximal arch. Tube setae consist of subdorsal pairs on annules 3, 7, 11, 16, 20, 25, 30 and 34. Tail consists of six annules.

*Tricoma polydesma* Southern, 1914

**Plate 11 (C)**

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Male is 469 µm long. Body marked with 45 opaque concretion annules. Spicules long 35 µm and slightly cephalated. Gubernaculum simple. Tail consists of six annules.

### Family Meyliidae de Coninck, 1965

### Genus *Boucherius* Decraemer & Jensen, 1982

*Boucherius spinosus* Gerlach, 1956

**Plate 20 (F)**

***Collection locations:*** Ratnagiri 200 m; Mumbai 2 500 m

***Diagnosis:*** Body relatively broad with tapering ends. Cuticle with fine annulations. Number of ring-shaped coverings or desmen is identical to the number of body rings. Each ring bears transverse rows of spine. Long somatic setae 6 µm. Somatic setae in tail is longer than the rest. More body setae on the ventral half of the body than on the dorsal part. Head truncated and triangular in shape, as long as wide. Cephalic setae slender, long (18 µm) and tapering, situated on peduncles. Amphid large vesicular. Short stoma, deep and un armed. Males diorchic. Spicules 37long, arched, gradually widening posteriorly to a capitulum. Gubernaculum lies parallel to spicule with dorsal apophyses.

### Family Cyartonematidae Tchesunov, 1990

### Genus *Cyartonema* Cobb 1920

*Cyartonema elegans* Jayasree & Warwick, 1977

**Plate 19 (G)**

***Collection locations:*** Cape Comorin 500m

***Diagnosis:*** Body long and slender. Cuticle faintly striated. Buccal cavity absent, mouth opening leads directly into the oesophagus. Four sublateral cephalic setae 6-7 µm long. Amphids circular, 7-8 µm diameter. Oesophagus 102-108 µm long, distinctly divided into anterior corpus, middle isthmus and posterior bulb.The corpus 52 µm long, the anterior half being 3 µm wide, broadening to 7 µm wide posteriorly. The isthmus is 40 µm long, very narrow (2-3 µm) throughout. The bulb is 24 µm long and 8 µm wide in the middle. There are two pairs of lateral cervical setae 5 µm long, the anterior pair 25 µm behind anterior end and the posterior pair 48 µm behind anterior end. Spicules paired, equal, slender, very arcuate and proximally cephalated. Each bears a faint ventral ala. The gubernaculum is a square piece bearing a pair of dorso-caudally directed apophyses. Tail conical.

*Cyartonema flexile* Cobb, 1920

**Plate 19 (H)**

***Collection locations:*** Cape Comorin 500m

***Diagnosis:*** Except for the cephalic setae cuticle is smooth, length of the body 1.1mm. Circlet of 6 minute labial papillae and four long cephalic setae. Amphid circular, large almost as wide as head. Spicules arcuate with proximal cephalisation. Gubernaculum with dorsocaudally directed apophyses. Tail long and conicocylindrical.

*Cyartonema germanicum* Juario, 1972

**Plate 19 (I)**

***Collection locations:*** Trivandrum 500 m; Mumbai 1 200 m; Mumbai 2 500 m; Coondapur 200 m

***Diagnosis:*** Body length is 865 µm, Maximum diameter 21 µm. Cuticle is faintly striated. Four cephalic setae are 6 µm long; two pairs of cervical setae absent. Oesophageal bulb is short and broad; 12 µm long and 16 µm wide. Spicules without ventral alae. Tail is conical.

*Cyartonema zosterae* Allgén, 1929

**Plate 19 (J)**

***Collection locations:*** Trivandrum 200 m; 500 m

***Diagnosis:*** Body length 1.1 mm. Maximum diameter 31 µm. Cuticle faintly striated. Four 7 µm cephalic setae. Amphids 12 µm wide, rounded but somewhat squared posteriorly, walls strongly cuticularised, with rounded central fleck. Oesophagus with an elongate posterior bulb. Spicules 35 µm arcuate, proximally cephalate and distally open-ended. Gubernaculum with a pair of dorso-caudally directed apophyses. Male tail with two Subventral files of setae, female tail with only a few small setae near the tip; somatic setae otherwise absent. Tail cylindrical with a rounded end.

## Order Chromadorida

## Family Selachinematidae Cobb, 1915

### Genus *Cheironchus* Cobb, 1917

*Cheironchus vorax* Cobb, 1917

**Plate 9 (C)**

***Collection locations:*** Trivandrum 500 m; Ponnani 200 m, 500 m; Mumbai 2 200 m

***Diagnosis:*** Body cylindrical, stout. Cuticle annulated and punctated. Lateral punctations larger in pharyngeal and tail regions. Mouth opening wide with six lips, each bearing a conical inner labial papilla. Six outer labial sensilla, conical; Four cephalic sensilla, short, inserted in small oval pits. Amphid coiled in five turns. Cervical and somatic sensilla conical, papilliform. Cheilostom small, cup-shaped, with rugae. Pharyngostom with three mandibles and crest of transverse incisions along inner side of anterior arm. Male diorchic with opposed testes. Spicules equal, slightly arcuate, distally pointed, proximally narrowed into handle and slightly ventrally turned knob. Gubernaculum weakly developed, paired. 20 cup-shaped precloacal supplements decreasing in size posteriorly. Tail bluntly conical with terminally thickened cuticle.

### Genus *Cobbionema* Filipjev, 1922

*Cobbionema* sp

**Plate 9 (D)**

***Collection locations:*** Cape Comorin 500 m, 1000 m; Trivandrum 200 m; Kochi 200 m; Karwar 200 m, 500 m; Coondapur 200m; Mumbai 1 200 m; Mumbai 2 200 m, 1000 m; Veravel 1000 m

***Diagnosis:*** Body cylindrical, stout. Cuticle annulated and punctated. Outer labial sensilla as long setae, cephalic sensilla as short setae. Amphid spirally coiled in three turns. Stoma consists of anterior cup-shaped and posterior cylindrical chambers with denticles between them. Apophyses projected from anterior rhabdions into the pharyngeal tissue. Pharynx with strong anterior bulb and weaker posterior thickening. Tail consists of anterior conical and posterior slender cylindrical portions.

### Genus *Demonema* Cobb, 1894

*Demonema* sp

**Plate 28 (B)**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 500 m, 1000 m; Kollam 200 m; Goa 200 m; Ratnagiri 20 m, 500 m, 1000 m; Dhabol 500 m; Mumbai 1 200 m, 1000 m; Mumbai 2 500 m, 1000 m; Veravel 200 m, 1000 m

***Diagnosis:*** Thick plump body of 1.3 mm. Maximum body diameter 35 µm. Cuticle thick and punctuated with lateral differentiation of dots. Stoma armed with rhabdions. All sensillae papilliform. Males diorchis with thick stout spicule. Simple gubernaculum encircling the spicule. Tail long, conicocylindrial with swollen tip and spinneret.

### Genus *Gammanema* Cobb, 1920

*Gammanema polydonta* Murphy, 1965

**Plate 9 (E)**

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Body broad and cylindrical. Only 2 circlet of cephalic setae. Anterior and cephalic sensilla setose. Four cervical setae. Cuticle striated with numerous fine punctuations and no lateral differentiation of the cuticle. Stoma very large. Cuticular rhabdions of the anterior cup-shaped stoma chamber often with fine longitudinal striation; the anterior rhabdions posteriorly terminate in teeth like projections but no denticles on bottom of the anterior stoma chamber. Oesophagus short. Spicules slender with lateral pieces. Gubernaculam small. Tail conical with numerous papillae.

### Genus *Halichoanolaimus* De Man, 1886

*Halichoanolaimus consimilis* Allgen, 1933

**Plate 9 (F)**

***Collection locations:*** Trivandrum 1000 m

***Diagnosis:*** Body length is 1.4 mm. Labial setae are very small. Cephalic setae are 5 µm long. All anterior sensilla are papilloid. Cervical setae not evident. Amphids 4.5 turns. Cuticular ornamentation in the form of fine dots to the level of cephalic setae; lateral differentiation present, lateral dots bigger and more widely separated. Anterior portion of buccal cavity is 19 µm long and posterior portion 16 µm deep. There are three sets of denticles between the anterior and posterior stoma chambers. Spiculs 55 µm long with accessory piece. Preanal supplements are setose. Tail elongated with a distal cylindrical and two third of filiform.

*Halichoanolaimus dolichurus* Ssaweljev, 1912

**Plate 28 (C)**

***Collection locations:*** Trivandrum 500 m

***Diagnosis:*** Body length is 1.5 mm. Head bears 10 small cephalic sensilla which are conical and papilliform. Amphids are transversal oval of 3.75 turns and 12 µm wide. Spicules are 91 µm long and proximally rounded and a ventral swelling near distal tip. Gubernaculum are as a pair of doubly curved rods. Precloacal papillae are present. Cuticular dots appear coarser and widely spaced at the junction of conical and cylindrical section of tail. Tail long and filiform, posterior portion finely striated, not punctuated.

### Genus *Latronema* Wieser, 1954

*Latronema orcina* Gerlach 1952

**Plate 10 (A)**

***Collection locations:*** Trivandrum 200 m, 1000 m; Ratnagiri 500m, 1000 m

***Diagnosis:*** Body very short, cylindrical with distinct annulations and with longitudinal ridges. Body length is 1 mm. Anterior end with 12 flap like appendages. 6 long labial setae and 10 cephalic setae in one circle. Cephalic setae simple. Amphids spiral. Cuticular annulations are like dots. Buccal cavity consists of two portions with weakly developed posterior portion and an anterior portion consisting of 12 broad apophyses which are arranged in 3 groups to 4 each; the posterior end of each apophysis is formed in to 2 acute teeth. Cuticle punctuates with longitudinal differentiations; spicula simple, strongly curved with ventral cusp; accessory piece small. 13 pre cloacal supplements observed.

*Latronema piratica* Wieser 1954a

**Plate 10 (B)**

***Collection locations:*** Trivandrum 500m; Mumbai2 200 m; Porbandar 200m

***Diagnosis:*** Body is of 1.5 mm length. Head is 65 µm wide, bearing labial setae 12 µm long and cephalic setae 18 µm long. Amphids single turn and about 11 µm wide. Cervical setae are long 22 µm. Buccal cavity is 19 µm wide, anterior and posterior portion 15 µm deep. Cuticle with fine punctuations to a level of cephalic setae, longitudinal rows beginning in the anterior cervical region each accompanied by two rows of additional punctuations. Spicula are 50 µm long, plate like accessory piece 17 µm long. Cup shaped supplements 20 nos. Tail short conical with terminal setae.

### Genus *Richtersia* Steiner, 1916

*Richtersia bathyalis* Soetaert & Vincx, 1987

**Plate 10 (C)**

***Collection locations:*** Trivandrum 200 m, 500 m, 1000 m; Kollam 200 m, 500 m; Ponnani 200 m; Kannur 200 m; Mangalore 1000 m, Coondapur 200 m, 500 m, 1000 m; Karwar 200 m, 500 m, 1000 m; Goa 200 m, 500 m, 1000 m; Ratnagiri 200 m, 500 m, 1000 m; Dhabol 200 m, 500 m, 1000 m; Veravel 200 m

***Diagnosis:*** Body short, clumsy. Cuticle annulated with spines arrange in 10 longitudinal rows. No lateral differentiation in cuticle. No distinct head capsule. Buccal cavity unarmed. Somatic setae located in between longitudinal rows of spine. Head seperated by a collar. Amphid located on the collar, ventrally wound, flattened spiral. Stoma funnel shaped. Males monarchic. Spicules, long and slightly bent with capitullum and velum. Gubernaculam without apophyses. Tail conical.

### Genus *Synonchiella* Cobb, 1933

*Synonchiella micramphis* Schuurmans Stekhoven, 1950

**Plate 10 (D)**

***Collection locations:*** Kochi 200 m; Ponnani 200 m, 500 m

***Diagnosis:*** Males 1.7 mm long. Head bluntly conical, without prominent lips. Short labial papillae. Cuticle with transverse rows of dots. Buccal cavity with anterior cylindrical portion and uniformly cuticularised walls. Amphids multispiral. Spicules paired and arcuate, 46µm measured as curve, terminating proximally in dorsally directed openings and hook like structure present on edge. Gubernaculum encircling the spicule. Tail conical and its 50% filiform.

*Synonchiella riemanni*, Warwick 1970

**Plate 10 (E)**

***Collection locations:*** Cape Comorin 200 m

***Diagnosis:*** Body length 1.2 mm. Cuticle with transverse rows of dots arranged transversally or longitudinally; lateral differentiation of the cuticle weakly or not at all developed. Two lateral files of short setae down body length, more numerous in the anterior and tail regions. Six small conical labial papillae are present. Four short 3µm and six longer 8 µm cephalic setae. Anterior stoma chamber nonsclerotized and inconspicuous, 3 mandibles in buccal cavity with two long anterio teeth. The anterior two thirds of tail is conical and the remainder cylindrical. Spicules 42 µm measured as curve, arcuate, terminating proximally in dorsally directed openings and prominent hook like structure on the dorsal edge. Gubernaculum is large and rounded at its distal end encircling spicule. Cup-shaped precloacal supplements are present.

### Family Chromadoridae Filipjev, 1917

### Genus *Acantholaimus* Allgén, 1933

### *Acantholaimus ewensis* Platt and Zhang, 1982

**Plate 11 (E)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m, 500 m; Kollam 200 m, 1000 m; Kochi 200 m, 500 m, 1000 m; Kannur 200m; Ponnani 200 m; Karwar 200m; Mangalore 200 m; Goa 200 m, 500 m; Porbandar 200 m, 500 m, 1000 m; Mumbai 2 200 m, 500 m; Dhabol 500 m

***Diagnosis:*** Body length 1.2 mm. Maximum diameter 32 µm. Cuticle punctated with lateral differentiation. In anterior region lateral punctations irregular, further posteriorly they become smaller and arranged in transverse rows. Lateral differentiation of two longitudinal rows of larger punctations. Four sublateral rows of hypodermal pores, larger ones anteriorly. Long somatic setae arranged in four sublateral rows. Six 3 µm stout cephalic papillae and four 33 µm cephalic setae which sometimes appear jointed at about two-thirds of their length. Amphids 9.5 µm wide, circular with a well-cuticularised border. Buccal cavity conical with one dorsal and two subventral teeth. Oesophagus with plasmatic interruptions. Tail elongated gradually tapering with a slightly swollen tip and pointed spinneret. Spicules paired, 28 µm long, with ventral apophysis. Gubernaculum small, lateral to spicules. Stout ventral 6 µm precloacal seta.

### *Acantholaimus formosus* Miljutina, Miljutin & Tchesunov, 2013

**Plate 11 (F)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body spindle-shaped, with strongly narrowed anterior end and filiform posterior tail. Cuticle dotted densely with lateral differentiationof more or less regular transversal rows. Somatic setae sparse, 9 µm long at preanal body region and 10–13 µm long at caudal region. Numerous pores between somatic setae in rows. There are 6 triangle shaped lips. 6 outer labial setae and 4 submedian cephalic setae locating close to each other and lying at same level. Amphid round, very weakly visible. Stoma consisting of cup-shaped cheilostoma and narrow, funnel-shaped esophagostoma. Cheilostoma possessing 6 pairs of teeth-like jointed cuticular rugae. Esophagostoma with 2 massive sclerotized onchia. Rugae and onchia situated at same level. Pharynx with large plasmatic intruptions. Tail consisting of proximal conical part and a long terminal filiform cylindrical part. Single testis, outstretched, right of intestine. Curved funnel shaped paired spicules with thickened cuticular areas in shape of ridges. Gubernaculum in shape of wide plate with edged distal end and toothed proximal end.

*Acantholaimus geraerti* Muthumbi & Vincx, 1997

**Plate 11 (G)**

***Collection locations:*** Mumbai 1 200 m

***Diagnosis:*** The body is cylindrical, tapers slightly to the anterior end. Cuticle is punctated from anterior level of the amphids and are arranged in transverse rows with lateral differentiation. The stoma is 17 µm long and it has three teeth. Pharynx is cylindrical (114 µm), and anteriorly surrounds the stoma; posteriorly it is expanded to form the terminal bulb. The cardia is small and prominent. Reproductive system is monorchic with outstretched testis. The spicules are curved proximally and rounded distally. There is a pair of pre-cloacal setae at 6 µm from the cloaca. Conical and a filiform tail.

*Acantholaimus invaginatum* Muthumbi & Vincx, 1997

**Plate 11 (H)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m, 500 m, 1000 m; Kollam 200 m; Ratnagiri 200 m, 500 m, 1000 m; Mangalore 1000 m; Goa 200m, 500 m, 1000 m; Dhabol 200m; Mumbai 1 200 m, 500 m; Mumbai 2 200 m, 500 m, Coondapur 200 m; ***Diagnosis:*** Body is cylindrical, anterior end is blunt. Cuticle is punctated from the anterior level of the amphids. Punctations are in regular transverse rows. Laterall larger than on the dorsal and on ventral sides. Somatic setae 6µm long at pharyngeal and 9 µm at tail region. Amphids are circular, 5 µm in diameter. Cephalic setae are long 16 µm. Stoma has 3 to 4 invaginated teeth. Pharynx is cylindrical with posterior bulb. The reproductive system is monorchic. The spicules are curved. Tail is short conical with long posterior filiform part.

*Acantholaimus quintus* Gerlach, Schrage & Riemann, 1979

**Plate 11 (I)**

***Collection locations:*** Cape Comorin 200 m; Trivandrum 200 m, 500 m; Kollam 200 m; Kochi 500m; Ponnani 200 m; Kannur 200m; Karwar 200 m, 500 m, 1000 m; Coondapur 200 m***;*** Goa 200m, 500 m, 1000 m; Ratnagiri 200 m, 500 m, 1000 m; Dhabol 200m, 500m, 1000 m; Mumbai 1 200 m, 500 m, 1000 m; Mumbai 2 200 m, 500 m, 1000 m; Veravel 1000 m; Porbandar 200 m, 500 m, 1000 m

***Diagnosis:*** Body slightly spindle shaped with narrowed anterior end. Somatic setae cylindrical, 10 mm long, situated along entire body in 4 submedian rows and very numerous at pharyngeal region. Cuticular pores possessing distinct rim and indicating places of lost setae. Cuticle densely dotted with lateral fields. Three rings of head sensilla: 6 short and thick inner labial setae; 6 outer labial setae; and 4 longer submedian cephalic setae long. Amphid ventrally coiled, single-spiral, 10 µm in diameter. Two triplets of cervical setae. Cheilostoma cup-shaped, 8–9 mm long with 12 rugae. Pharyngostoma with thick cuticular walls and 5 sclerotized onchia. Pharynx muscular, with plasmatic inclusions. Tail consisting of proximal conical part and long terminal filiform cylindrical part. Male reproductive system monarchic. Funnel-shaped spicules. Gubernaculum with edged proximal end and bifurcated distal end.

*Acantholaimus vermeuleni* Muthumbi & Vincx, 1997

**Plate 11 (J)**

***Collection locations:*** Cape Comorin 200 m, 500 m; Trivandrum 200 m, 500 m; Mumbai 2 200 m; Ratnagiri 1000 m; Goa 200 m; Karwar 200 m, 500 m; Coondapur 200 m; Kannur 200 m, 500 m; Kochi 500 m; Ponnani 200 m, 500m; Porbandar 500 m

***Diagnosis:*** Body is cylindrical with tapering end. The head region is rather small. Cuticle with very fine punctations and four rows of somatic setae. The amphids are a simple spiral, 6 µm in diameter. Inner labial setae are indistinct, outer labial are half as long as the cephalic sensilla which are 4 µm and located at the same level. The stoma is narrow, without distinct teeth. The pharynx is cylindrical with a slightly swollen bulb. The reproductive system is monorchic with outstretched testis; Spicules are flat on the distal end and blunt on the proximal end. The tail is conical anteriorly.

### Genus *Chromadorella* Filipjev, 1918

*Chromadorella ariminiensis* (Gerlach, 1953) Lorenzen, 1972

**Plate 12 (A)**

***Collection locations:*** Cape Comorin 200 m; Kochi 200 m; Karwar 1000 m; Goa 200 m; Ratnagiri 200 m

***Diagnosis:*** Short stout body of 890 µm long. Cuticle ornamented with dots. Heterogeneous punctated body cuticle with lateral differentiation in longitudinal rows of larger dots. Amphideal fovea transverse oval in shape and slightly bent. Cephalic papillae setose. Buccal cavity with 3 solid teeths of which dorsal one is bigger. Spicule paired, 25 µm long with proximal cephalisation. Gubernaculum plate shaped with diatal tooth. 5 numbers of pre cloacal suppliments. Tail long and conical.

*Chromadorella circumflexa* Wieser, 1954

**Plate 12 (B)**

***Collection locations:*** Trivandrum 500 m; Goa 200m, 500m; Coondapur 200 m

***Diagnosis:*** Cuticle ornamented with dots and rod like structures. Amphids slit like. Cephalic papillae setose. Cephalic setae 7 µm long. Buccal cavity with one dorsal solid tooth and two smaller sub ventral teeth. Oesophageal bulb not well developed. Spicule paired, 35 µm long wide and arcuate. Gubernaculum plate shaped with diatal tooth. 5 numbers of pre loacal suppliments.Tail conical.

*Chromadorella cobbiana* Johnston, 1938

**Plate 12 (C)**

***Collection locations:*** Kollam 500 m

***Diagnosis:*** Cuticle traversed by transverse striae, all alike. The contour of the body is slightly crenate. There are no subcephalic or cervical setae. There are twelve minute lips, distinct at their acute tips. The small, typical, pharynx is as long as the radius of the head. There is one dorsal and two ventrally submedian teeth, the three make a very compact group when the mouth is closed. Inconspicuous, outer amphids, are elongate transversely, symmetrical to two linea with closed peripheries. The conoid, bulbless oesophagus is very slightly swollen anteriorly and again posteriorly. Conoid tail which finally becomes tapers to an unswollen, acute spinneret which is not striated. Caudal glands lie in the anterior fourth of the tail. No caudal setae. Spicules are compound at their distal ends and are not cephalated. There is a faintly visible chord extending across the inner arc and they may be therefore wider than they appear to be. The arcuate, slender accessory piece, with rather strong frame. Ten equidistant, preanal ventral supplementary organs.

*Chromadorella filiformis* (Bastian, 1865) Filipjev, 1918

**Plate 12 (D)**

***Collection locations:*** Kollam 200 m

***Diagnosis:***

Length of the animal 1.1 mm. Head diameter 15 µm. Lips distinct. Six short cephalic setae and 4 long ones, measuring 10 µm. Cuticle annulated, with transverse rows of dots between annules which become elongated in the posterior cervical region. Lateral differentiation through larger dots which arrange themselves into distinct longitudinal rows. Buccal cavity with three solid, subequal teeth. Esophageal bulb elongated. Spicula wide, strongly curved, 27 µm. Gubernaculum 19 µm long, consisting of a piece between the two spicula and a caudal plate which distally ends in a three projection. There are 5 large preanal supplements. Tail long.

*Chromadorella salicaniensis* Boucher, 1976

**Plate 12 (E)**

***Collection locations:*** Cape Comorin 500 m; Mangalore 200m

***Diagnosis:***

Long body of 1.13mm. Head attenuated slightly, globose with 6 Labial papillae and 4 cephalic setae. Amphid elliptical in shape. Buccal cavity bears large teeths protruding outside. Cuticular ornamentation of dots with lateral differentiation. Spicules 32 µm long, arcuate with proximal cephalisation. Gubernaculum with lateral pieces. Three precloacal suppliments. Tail long and conical.

### Genus *Chromadorina* Filipjev, 1929

*Chromadorina* sp

**Plate 12 (F)**

***Collection locations:*** Dhabol 1000 m

***Diagnosis:*** Total length of organism 900 µm. Homogeneous cuticle with transverse rows of dots but without obvious lateral differentiation. Amphideal fovea transverse slit-like. Pharyngostoma with three nearly equal solid teeth. Ocelli may be present. Cup-shaped precloacal supplements present. Tail long and conical.

### Genus *Endeolophos* Boucher, 1976

*Endeolophos* sp

**Plate 12 (G)**

***Collection locations:*** Trivandrum 200 m, 1000m; Kollam 2000, 500m

***Diagnosis:*** Long body of 895 µm length. Cuticle heterogeneous, ornamented with longitudinal stick-like elements, with lateral differentiation but not as a ridge. Six outer labial and four cephalic sensilla arranged in two separate crowns of setae. Amphideal fovea as a transversal slit at the level of cephalic setae. Buccal cavity with dorsal tooth and two tiny subventral teeth. No posterior pharyngeal bulb developed. Copulatory apparatus without telamons. Tail long and conical.

### Genus *Harpagonchus* Platonova & Potin, 1972

*Harpagonchus* sp

**Plate 11 (D)**

***Collection locations:*** Trivandrum 500 m

***Diagnosis:*** Body cuticle smooth or with faint punctuation. A circle of six setae within anterior sensilla pattern. Buccal cavity with three movable triangular-shaped mandibles and with anterior solid hooks. Pharynx enlarged anteriorly around the mandibular apparatus and posteriorly widened. Cup-shaped precloacal supplements present. Marine, ectosymbionts of Polychaeta.

### Genus *Innocuonema* Inglis, 1969

*Innocuonema* sp

**Plate 12 (H)**

***Collection locations:*** Goa 200 m, 1000 m

***Diagnosis:*** Long body of 900 µm. Head attenuated slightly. Body cuticle with complex and obvious punctations, no lateral differentiation. Buccal cavity with large hollow dorsal tooth and associated slight dorsal swelling of the pharynx in this region. Posterior bulb definite, single. Precloacal supplements absent.

### Genus *Neochromadora* Micoletzky, 1924

*Neochromadora* sp

**Plate 12 (I)**

***Collection locations:*** Cape Comorin 1000 m; Goa 200 m, 500 m, 1000 m; Ratnagiri 1000 m

***Diagnosis:*** Body 960 µm long, cuticle ornamentation complex with lateral differentiation visible as two or three longitudinal rows of large dots. Buccal cavity with a hollow dorsal tooth and two ventrosublateral teeth. Pharynx anteriorly enlarged, especially in association with the dorsal tooth and posteriorly with a developed endbulb. Male usually with numerous cup-shaped precloacal supplements.

### Genus *Nygmatonchus* Cobb, 1933

*Nygmatonchus* sp

**Plate 13 (A)**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 500 m, 1000 m;

***Diagnosis:*** Body striated, cuticlular striations protruding with a crenate contour, about 600 in numbers. No distinct pharyngeal dorsal tooth but armed with smaller ventral teeth. Pharyngeal bulb bipartite. Spicula arched with tapering end. Cephalisation as a constriction. Gubernaculam with accessory pieces. Tail conoid with a spinneret.

### Genus *Prochromadorella* Micoletzky, 1924

*Prochromadorella* sp

**Plate 13 (B)**

***Collection locations:*** Cape Comorin 200 m, 500m; Kollam 200m; Mumbai 2 200 m, 500 m; Porbander 500

***Diagnosis:*** Heterogeneous punctated body cuticle through out the body, lateral dots may be enlarged but not arranged in longitudinal rows. Amphideal fovea transversely oval, obscure, located between the four cephalic setae. Buccal cavity with three solid teeth of about equal size or the two ventrosublateral teeth smaller. Ocelli may be present. Males with cup-shaped precloacal supplements.

### Genus *Rhips* Cobb, 1920

*Rhips* spp

**Plate 13 (C)**

***Collection locations:*** Cape Comorin 200m, 500 m; Trivandrum 200 m, 500 m, 1000 m; Kollam 200m, 500m; Kochi 200 m; Kannur 200 m, 500m, 1000 m; Karwar 200m, Mangalore 200 m, 1000 m; Mumbai 1 200m, 1000m; Dhabol 1000m

***Diagnosis:*** Cuticle heterogeneous with lateral differentiation as a narrow ridge beginning at the end of pharynx. Six outer labial and four cephalic setae organized in a common circle. Amphideal fovea noticeably transversally oval with a double contour. Pharynx gradually enlarged posteriorly. Spicules double jointed. Gubernaculum with lateral pieces.

### Genus *Spilophorella* Filipjev, 1917

*Spilophorella* sp

### Plate 13 (D)

***Collection locations:*** Kochi 200 m; Goa 200 m

***Diagnosis:*** Cuticle with multifaceted heterogeneous punctated ornamentation with lateral differentiation. Deep buccal cavity with a long single hollow dorsal tooth. Peribuccal pharyngeal tissue swollen slightly and nearly symmetrical. Pharynx with elongated double posterior bulb.Tail terminated with a long pointed caudal spinneret.

### Genus *Trochamus* Boucher & de Bovée, 1971

*Trochamus* sp

### Plate 13 (E)

***Collection locations:*** Kollam 500m; Kochi 200, 1000m

***Diagnosis:*** Body cuticle heterogeneous, with a crest-like lateral differentiation. Six outer labial and four cephalic setae arranged in one crown. Amphideal fovea as poorly visible transversal slit. Buccal cavity armed with one dorsal tooth and two small subventral denticles. No lateral pieces at spicular apparatus.

## Family Neotonchidae Wieser & Hopper, 1966

### Genus *Comesa* Gerlach, 1956

*Comesa* sp

### Plate 13 (F)

***Collection locations:*** Cape Comorin 500 m; Kollam 200 m; Karwar 200 m, 500 m

***Diagnosis:*** Cuticle is always striated and punctated. Amphids are multi-spiral and situated posterior to the cephalic sensilla. Buccal cavity with a distinct forwardly pointing tooth and ventral ridges but no subventral teeth. Posterior pharyngeal bulb small but distinct. Ventrally situated cup shaped, pre cloacal suppliments.

### Genus *Neotonchus* Cobb, 1933

*Neotonchus corcundus* Gerlach, 1956

### Plate 13 (G)

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Slender body of total length 965 µm, filiform and attenuating at both ends. Cuticle striated, punctuation with lateral differentiation. Cephalic paipillae minute and 6 in numbers. Cephalic setae 4.5 µm long. Amphid spiral. Buccal cavity with small teeths. Oesophagus cylindrical with end bulb.

Spicules short 15 µm long, slightly curved with proximal cephalisation. Gubernaculum simple and lies parallel to spicules. 13 cup shaped precloacal suppliments. Tail conical, 3 caudal gland which opens to a spinneret.

*Neotonchus cupulatus* Vitiello, 1970

**Plate 13 (H)**

***Collection locations:*** Cape Comorin 200, 1000 m; Trivandrum 200 m, 500 m, 1000 m; Kollam 200 m

***Diagnosis:*** Thin boby of 700 µm long, attenuating at both ends. Cuticle ornamented with fine punctuation. Lateral differentiation present of dots. Amphid spiral composed of 5 turns. Buccal cavity with small teeths. Oesophagus cylindrical with end bulb. Spicules short 18 µm long, slightly curved with proximal cephalisation. Gubernaculum 9 µm long, simple and lies parallel to spicules. Single pre anal setae and 9 cup shaped precloacal suppliments. Tail conical with 3 caudal gland which opens to a spinneret.

*Neotonchus meeki* Warwick, 1971

**Plate 13 (I)**

***Collection locations:*** Trivandrum 1000 m

***Diagnosis:*** Cuticle ornamented with punctuations showing lateral differentiation. Total length of the animal 750 µm with maximum diameter 28 µm. Head diameter12.5 µm. Labial setae minute. 6 anterior cephalic sete of 2.5 µm and 4 posterrior cephalic setae of 7 µm Long. Buccal cavity bears dorsal tooth. Amphids 4.2 turns. Spicules 21 µm long, equal, straight. A single precloacal setae and 8 cup shaped supplement. Tail conical.

*Neotonchus vitius* Warwick, 1971

**Plate 13 (J)**

***Collection locations:*** Cape Comorin 500; Trivandrum 1000 m; Kollam 200 m; Ponnani 200 m; Mangalore 200 m, 1000 m

***Diagnosis:*** Body length of the animal is 780 µm with maximum diameter 30 µm. Cuticle with lateral differentiation of dots. Mouth bears 6 lips and minute papilla. Buccal cavity is deep and with hollow dorsal tooth and sub ventral teeth. Amphid 3.25 turns. Spicule 19 µm long, weakly cephalate proximally. With ventral kink. Gubernaculum plate like. Single precloacal seta and 11 large cup shaped precloacal suppliments.Tail conical.

*Neotonchus votadinii* Warwick, 1971

**Plate 14 (A)**

***Collection locations:*** Kollam 200m; Kochi 200 m; Ponnani 200

***Diagnosis:*** Body length of the animal is 965 µm with maximum diameter 25 µm, cuticle ornamented with transverse cuticular punctuation. Cephalic setae in two rows. Buccal cavity collapsed. Amphids 4.25 turns. Spicule equal, 30 µm long, arcuate with ventral undulations and weak cephalisation. Gubernaculum long lube like encircling spicule in distal third. One precloacal seta and 14 closely spaced cup shaped suppliments. Tail conical.

### Genus *Nannolaimus* Cobb, 1920

*Nannolaimus volutus* Gerlach, 1956

**Plate 14 (E)**

***Collection locations:*** Cape Comorin 200 m

***Diagnosis:*** Long slender body of 1.55 mm long. Cuticle thick, 1 µm, punctuated. Cephalic setae long 15 µm and 13 µm long, in 6+4 arrangement. Amphid multy spiral of 5 turns. Males diorchic with outstretched testes. Spicules 29 µm long, strongly cuticularised and arched. Gubernaculum 20 µm long with median piece and weak lateral flanges. One pre anal setae and 16 cup shaped precloacal suppliments. Tail conical.

### Family Cyatholaimidae Filipjev, 1918

### Genus *Longicyatholaimus* Micoletzky, 1924

*Longicyatholaimus capsulatus* Vitiello, 1971

**Plate 14 (B)**

***Collection locations:*** Kollam 200m; Mumbai 2 200 m

***Diagnosis:*** Body elongated with 1.5 mm in total length except for the filiform tail. Cuticle punctuated with large dots. Lateral differentiation of larger and more wide-spaced dots. Cuticular pore present. Six setiform labial papillae. Cephalic setae in usuall 6+4 arrangement. Amphid circular. Buccal cavity small, with a dorsal tooth and without subventral teeth. No posterior pharyngeal bulb. Spicule thin and narrow with velum. Gubernaculum simple, distally dentate, paired and lies parallel to spicule. 22 precloacal supplements. Tail with elongate slender flagellum.

### Genus *Nannolaimoides* Ott, 1972

*Nannolaimoides decoratus* Ott, 1972

### Plate 14 (D)

***Collection locations:*** Kollam 200m

***Diagnosis:*** Body slender, tapering towards anterior end and 1.6 mm long. Maximum body diameter 44 µm. Cuticle with transverse rows of dots. One median longitudinal row of fused dots look like bars. Amphids multispiral with 5.25 turns. Stoma shallow cup shaped with poorly developed cheilorhabdions. Males diorchic with outstretched testes. Spicules strongly cuticularised, arched and 50 µm long. Gubernaculum with median piece and weak lateral flanges.18 precloacal suppliments. Tail conical.

## Genus *Paracyatholaimus* Micoletzky, 1922

*Paracyatholaimus* sp Micoletzky, 1922

### Plate 14 (F)

***Collection locations:*** Cape Comorin 200 m, 500 m, 1000m; Trivandrum 200 m, 500 m, 1000m ; Kollam 200m , 500m, 1000 m; Kochi 500 m; Ponnani 200 m;Kannur 1000 m; Mangalore 200 m, 500 m, 1000 m; Coondapur 200 m; Karwar 200 m, 500m; Goa 200 m; Mumbai 1 200 m, 1000 m; Mumbai 2 200 m

***Diagnosis:*** Body cylindrical, filiform. Inner and outer labial sensilla setose. Lateral differentiation poorly developed. Amphidial fovea multispiral. Pharyngostoma armoured with one distinct dorsal tooth, often supplemented with smaller subventral teeth and occasionally other denticles in the stegostoma. Precloacal supplements as setae-like organs, half inserted into the body. Gubernaculum hardly dilated at the distal end and distally devoid of denticles or serrations. Tail conical or with a more or less slender cylindrical distal portion.

## Genus *Paralongicyatholaimus* Stekhoven, 1950

*Paralongicyatholaimus* sp

### Plate 14 (G)

***Collection locations:*** Mumbai 1 200 m, 1000m; Mumbai 2 200 m, 1000m

***Diagnosis:*** Body cylindrical, filiform. Inner and outer labial sensilla setose. No lateral differentiation. Teeth in the buccal cavity reduced or absent. Spicules and gubernaculum simple. No precloacal supplements. Tail filiform.

## Genus *Pomponema* Cobb, 1917

*Pomponema clavicaudatum* Schuurmans Stekhoven, 1935

**Plate 14 (H)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 500 m; Kollam 200 m, 500 m; Ponnani 200 m, 500 m

***Diagnosis:*** Total length of the animal is 968 µm. Body elongated, gradually tapering towards ends. Cuticle transversely stiated, rings are marked by dots with lateral differentiation. Amphids sprial. Head with distinct lips. Buccal cavity with single large dorsal tooth. Stout spicule with longitudinal list with distally pointed tip. Gubernaculum is encircling the spicule. Tail clavate. Proximal half conical and distalhalf filiform.

*Pomponema corniculata* Gourbault, 1980

**Plate 14 (I)**

***Collection locations:*** Cape Comorin 200m, 500 m

***Diagnosis:*** Total length of the animal is 1.04mm. Cuticle heterogeneously punctuate. 6 labial setae and 6 cephalic setae. Amphid multispiral, apical in position. Buccal cavity with large dorsal teeth and sub ventral teeth. Oesophagus cylindrical. Spicules arcuate with median list and proximal cephalisation. Gubernaculum simple. Precloacal suppliments cup shaped and 20 in numbers. Tail conical.

*Pomponema elegans* Lorenzen, 1972

**Plate 14 (J)**

***Collection locations:*** Trivandrum 1000 m

***Diagnosis:*** Body 1.2 mm long, gradually tapering towards ends. Cuticle transversely stiated, rings are marked by punctuations with lateral differentiation. Amphids multi sprial. Head with distinct lips. Buccal cavity with single large dorsal tooth. Stout spicule with longitudinal list with distally pointed tip. Gubernaculum simple and encircling the spicule. Precloacal suppliments complicated and 20 in numbers.Tail conicocylindrical.

*Pomponema multipappillatum* Filipjev, 1922

**Plate 14 (K)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body length 1.3 mm. Cuticle with transverse rows of dots, lateral differentiation after a short distance from anterior end, four longitudinal rows of dots with the inner pair larger, further apart and united by a transverse bar. Six short labial setae and ten cephalic setae all about equal in length, 8 µm.

Amphids multispiral with 5 turns, positioned relatively far forward compared with other species. Buccal cavity with a large dorsal tooth, one indistinct ventral tooth, two Subventral teeth and single lateral rows of fine denticles. Oesophagus broadens markedly towards the posterior end but has no definite bulb. Tail with distal third cylindrical. Spicules 35 µm. Gubernaculum variable with lateral flanges 18 typical precloacal supplements.

*Pomponema polydonta* Murphy, 1963

**Plate 15 (A)**

***Collection locations:*** Cape Comorin 500 m, 1000 m; Goa 1000 m; Mumbai 1 1000 m

***Diagnosis:*** Large truncated body of 2 mm length. Cuticle prominently annulated with coarse punctuation. Labial papillae 12; 6 setose cephalic papillae. Cephalic setae arranged in circlet of 6 and 4. Buccal cavity with single large dorsal tooth and a set of subventral teetha and rows of denticles. Amphid large multispiral of 4.25 turns. Males with heavily cuticularised spicule 50 long, gubernaculum with thin lateral extensions. Equally spaced 24 suppliments. Tail elongated conical.

*Pomponema proximamphidum* Tchesunov, 2008

**Plate 15 (B)**

***Collection locations:*** Kollam 200m

***Diagnosis:*** Body cylindrical, slender. Cuticle annulated and punctated with dots. Anterior end characterized by large, distinct dots arranged in regular transversal rows becoming smaller towards the mid pharynx and fusing thereafter into transversal lines. Amphid very large multispiral, ventrally coiled, with 4.25 turns. Buccal cavity differentiated into two compartments. Inner labial sensilla as conical papillae. Six outer labial sensilla. Four cephalic setae. Males diorchic, posterior testis reflexed. Spicules short, arched, distally pointed and proximally widened. Gubernaculum as paired curved plate with a small funnel-like structure with an indented sclerotized rim at each lateral side of the spicule distal tip. Thirteen midventral preanal organs. Tail long.

*Pomponema segregatum* Wieser 1959

**Plate 15 (C)**

***Collection locations:*** Kochi 200 m

***Diagnosis:*** Body length is 1 mm. Cuticle is with horizontal and vertical differentiation all along the body. Cuticular dots are very large in the anterior cervical region. Lateral differentiations beginning irregularly on a level with the amphids; Amphids with 4 turns. Tail long with a row of setae on its ventral surface.

### Order Desmodorida

### Family Desmodoridae Filipjev, 1922

### Genus *Catanema* Cobb, 1920

*Catanema macintyri* Platt and Zhang, 1982

**Plate 15 (D)**

***Collection locations:*** Kollam 200m

***Diagnosis:*** Long thread like body of length 2.2mm. Cuticle very finely annulated. Cephalic cuticle not thickened. Six small and four 18 µm cephalic setae present at anterior head. The rest of the setae are not visible. Amphids are 91 µm wide, loop shaped or spiral (2.5 turns). Minute onchia-like structures in the small stoma. Oesophagus is with a rounded posterior bulb and without cuticularised lining. Tail conical. Spicules 45 µm, arcuate, proximally squarely cephalate. Gubernaculum is with a well cuticularised dorso-caudally directed apophysis. Several pairs of sub ventral tubular setae on the tail.

### Genus *Eubostrichus* Certes, 1899

*Eubostrichus africanus* Muthumbi, Verschelde & Vincx, 1995

**Plate 15 (H)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 500 m, 1000m; Kochi 200m; Karwar 500 m

***Diagnosis:*** Body slender, cylindrical, thread-like. Cuticle fine but distinctly annulated with about 17-23 annules in 10 µm. Cephalic cuticle smooth and slightly thickened from the labial region. Tiny outer labial sensilla around the mouth. Four cephalic setae are followed by two subsequent circles of subcephalic setae. Amphid round, large. Posterior to the cardia, fourteen minute midventral papillae present gradually decreasing in size. Buccal cavity very small but distinct with weakly sclerotized walls, toothless. Pharynx consist of anterior wide radially striated procorpus gradually transforming into long slender middle region, isthmus, which in its turn widens posteriorly into small terminal bulb without radial striation. Single testis situated to the right of the intestine. Spicules small, arcuate, distally pointed and proximally cephalated. Gubernaculum as a slightly curved bar parallel to spicule; no apophysis. Tail conical, rounded at the tip.

*Eubostrichus hortulanus* Leduc, 2013

**Plate 15 (I)**

***Collection locations:*** Cape Comorin 200 m, 500 m, 1000m; Trivandrum 500 m; Kollam 200m

***Diagnosis:*** Body long, slender, tapering slightly towards both extremities. Cuticle thin, six minute outer labial papillae and four long cephalic setae. Eight short sub-cephalic setae. Amphid spiral, 3.5 turns, with faint outline. Buccal cavity small, pharynx cylindrical, with small rounded posterior bulb. Male monorchic with one anterior outstretched testis. Spicules short long, arcuate, strongly cuticularised, pointed distally, with swollen capitulum and velum. Gubernaculum short, with lateral crurae and broad, cuticularised dorso-caudal apophyses. One pair of sub-ventral thick conical setae in pre-cloacal region. Tail conical, with three sub-ventral and three sub-dorsal pairs of setae.

### Genus *Desmodora* de Man, 1889

*Desmodora masira* Warwick, 1973

**Plate 15 (E)**

***Collection locations:*** Mumbai 1 500 m

***Diagnosis:*** Cuticle marked with distinct striations between posterior edge of the cephalic capsule and a short distance from the tail tip. Head bluntly rounded, six very short conical cephalic setae anterior to cephalic capsule and four longer cephalic setae at the anterior border of the capsule. Cuticle of cephalic capsule very thick and ornamented with conspicuous pores. Amphids are small spiral of two turns. Spicules paired, equal and arcuate. They are stongly cephalated proximally and pointed distally with ventral alae. Gubernaculam small and plate like. Tail long and evenly tapered throughout its length.

*Desmodora pilosa* Ditlevsen, 1926

**Plate 15 (F)**

***Collection locations:*** Kochi 200 m; Mumbai 2 200 m

***Diagnosis:*** Body slender and attenuating. Cuticle annulated from basis of decorated cephalic capsule to tail tip and cuticle up to 5 μm thick. Somatic setae in four submedian rows, a ventral row and a dorsal row; setae varying between 5 µm and 14 µm in length. Cephalic sense organs setose and in three separate crowns: six internal labial stout setae, six stout external labial setae 9 µm long, and four slender cephalic setae 9 µm long. Amphids slightly elongated spiral, 21 µm long and 20 µm wide, buccal cavity with one dorsal tooth, small subventral teeth and a large area of denticles. Pharynx expanded around the buccal cavity, elsewhere cylindrical, posteriorly slightly enlarged. Spicules slender and curved, proximally cephalated, 85 µm along the arc, gubernaculum rod-shaped 36 µm long. Tail conicocylindrical.

### Genus *Desmodorella* Cobb, 1933

*Desmodorella tenuispiculum* Allgen 1928

**Plate 15 (G)**

***Collection locations:*** Goa 200 m; Cape Comorin 500 m

***Diagnosis:*** Body length is 1.2 mm. Head capsule blunt or rounded. Cuticle is with coarse transverse striations and longitudinal files of ridges. Posterior part of cephalic capsule is with rounded punctuations. Amphid multispiral of 2.5 turns. Six slender labial setae present. Cephalic setae arranged in 6+4 patterns. Lateral alae absent. Oesophagus is with a distinct posterior bulb.Spicules long, slender and indistinct with proximal cephalisation. Gubernaculam plate like, encircling spicule. Tail is conical, with unstriated tip.

### Genus *Leptonemella* Cobb, 1920

*Leptonemella juliae* Hoschitz, Buchholz & Ott, 1999

**Plate 15 (J)**

***Collection locations:*** Cape Comorin 200 m; Kollam 200m; Kochi 200 m; Goa 200 m; Ratnagiri 200 m; Mumbai 2 500m, 1000m;

***Diagnosis:*** Filiform nematodes with multilayered coat of symbiotic bacteria. Solid non annulated cephalic capsule slightly rounded and heavily cuticularised. Body cuticle finely annulated. The transition from the body cuticle to the head cuticle characterised by fusion of the anterior annuli with the posterior region of the cephalic capsule. Large amphids (20 µm long) with sexual dimorphism: spiral in females with 1.5 turns, shepherd's crook-shaped in males. Head with a circle of six very small labial papillae. A circle of four long cephalic setae (32 µm), followed by two circles of eight subcephalic setae. Somatic setae 13 µm long, arranged in six rows. Males with a single row of 5-6 small setae anterior to the cloaca. Three caudal glands present. Buccal cavity small and tubular, tri-partite pharynx consisting of a corpus (35 µm long), narrow isthmus (45 µm long) and a terminal bulb. Males monorchic, with outstreched testis. Spicule weakly cephalate proximally, arcuate, length 48 µm, no velum visible. Gubernaculum consisting of two strongly cuticularised pieces.

### Genus *Metachromadora* Filipjev, 1918

*Metachromadora pulvinata* Wieser & Hopper, 1967

**Plate 15 (K)**

***Collection locations:*** Cape Comorin 200 m; Trivandrum 200 m

***Diagnosis:*** Length of the animal 1.8 mm with maximum diameter 95 µm. Lips thick and fleshy demarcated from the head by distinct groove. Head cuticle longitudinally striated. Conical labial papillae. Stout cephalic setae of 8 long. Short cervical setae also observable. Amphids on cuticularised plates, ring shaped. Small closely arranged distinct cuticular striation reaches up to lip region. Strongly cuticularised buccal cavity. Large dorsal tooth and subventral tooth. Spicules long 55 µm. Gubernaculum 25 µm long. Preanaly the ventral side cuticle inflated. Spine like pre anal setae. Many long spines in the anal region. Tail conical with two wart like projection.

### Genus *Onyx* Cobb, 1891

*Onyx perfectus* Cobb, 1891

**Plate 16 (A)**

***Collection locations:*** Cape Comorin 200 m; Ponnani 200 m; Ratnagiri 500 m

***Diagnosis:*** Body length 1.8 mm. Six shorter 6-7 µm and four longer 27 µm cephalic setae. Anterior circle of eight cervical setae. Somatic setae short and sparse but more numerous in male than female. Amphids well forward in position in specimens examined, 8 µm wide, a single loop. Amphids not surrounded by cuticle striations. Buccal cavity with a long spear-like dorsal tooth. Dorsal buccal tooth 52 µm long. Posterior oesophageal bulb 83 µm long and 32 µm wide, without any constrictions. Spicules 52 µm as curve, cephalate proximally. Gubernaculum 24 µm, slightly hooked proximally. Thirteen large precloacal supplements and thirteen pairs of conical cuticular projections subventrally on tail.

### Genus *Parabostrichus* Tchesunov, Ingels & Popova, 2012

*Parabostrichus bathyalis* Tchesunov, Ingels & Popova, 2012

**Plate 16 (B)**

***Collection locations:*** Trivandrum 500 m; Kollam 200m; Kochi 200 m; Ponnani 200 m

***Diagnosis:*** Cuticle thin with annulation throughout the body. The anterior head cuticle seems to be smooth. Mouth opening small. Four thin and relatively long cephalic setae inserted around the apex edge. Large round amphid situated close to the cephalic apex; ventral spiralization not evident but very fine circular discontinuous striation visible. Pharynx relatively very short, wide in the cephalic region, then gradually narrowing towards the longer, slim median region, terminating in a small spherical posterior bulb. Interior cuticular lining well discernible along the entire pharynx; transversal muscular striation well pronounced in the bulb. Male gonad single, anterior. Spicules strongly arched, with rounded knob at anterior end and sharp posterior tip. Gubernaculum with paired, wide, weakly sclerotized, dorso-caudal apophyses. Three subventral pairs of conical papillae on the posterior body, one pair preanal and two pairs postanal. In males, tail elongate and conical.

### Genus *Perspira* Wieser & Hopper, 1967

*Perspira* sp

**Plate 16 (C)**

***Collection locations:*** Cape Comorin 200 m, 500 m, 1000m; Trivandrum 200 m, 1000m; Kollam 200m, 1000m;

***Diagnosis:*** Cuticle faintly striated on the body and prominently striated on the tail. Three minute teeth in buccal cavity or no teeth discernible. Terminal bulb of the pharynx round to pyriform. Male supplementary organs small pore-like, tubiform or lacking. Tail filiform.

### Genus *Polysigma* Cobb, 1920

*Polysigma* sp

**Plate 16 (D)**

***Collection locations:*** Cape Comorin 200 m, 1000 m

***Diagnosis:*** Amphids not surrounded by striations. Buccal cavity with a dorsal S-shaped tooth. Spicules short. Precloacal supplementary organs as cuticularized S-shaped tubes.

### Genus *Pseudochromadora* Daday, 1899

*Pseudochromadora* sp

**Plate 16 (E)**

***Collection locations:*** Cape Comorin 500 m, 1000m; Trivandrum 200 m; Kollam 200m, 500 m; Ponnani 200 m

***Diagnosis:*** Cylindrical body with short head capsule and short conical tail. Body annuli with distinct interannual spaces. Lateral alae extending from posterior to the pharynx as far as the tail. Short somatic setae arranged in six longitudinal rows.

### Genus *Psammonema* Verschelde & Vincx, 1995

*Psammonema kuriani* Jacob, Anilkumar, Philip and Damodaran, 2015

**Figure 6**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 500 m; Kollam 200 m; Kochi 200 m; Ponnani 200 m; Kannur 200 m; Karwar 200 m; Coondapur 200 m, 500 m, 1000 m

***Diagnosis:*** Large, thick cylindrical body with rounded triangle cephalic capsule ornamented with small vacuoles. Amphids 1.25 turns. Buccal cavity equipped with 12 longitudinal rugae, one strong dorsal tooth, two latero-ventral teeth and a circle of denticles. Lateral alae present. Spicules long (63 mm), with short ventral beak-like projection in capitulum. Ten precloacal supplements and a precloacal seta. Tail long, conoid with rows of thick and thin somatic setae.

### Genus *Robbea* Gerlach, 1956

*Robbea* sp

**Plate 16 (F)**

***Collection locations:*** Kochi 200 m

***Diagnosis:*** Cuticle finely striated. Cephalic capsule annulated or smooth, notlearly separated for the most part. Four cephalic setae. Amphid spirally coiled in 1.5 – 2.5 turns. Pharynx tripartite, with anterior swollen muscular region clearly separated from the long slim median region, and small posterior swelling. Gubernaculum with dorso caudal apophyses.

### Genus *Spirinia* Gerlach, 1963

*Spirinia parasitifera* Bastain, 1865

**Plate 16 (G)**

***Collection locations:*** Cape Comorin 500 m, 1000m; Trivandrum 200 m

***Diagnosis:*** Body length is 1.6 mm. Cuticle finely striated. Somatic setae arranged in eight longitudinal rows. Six papilliform anterior cephalic sensilla are followed by four 5 µm cephalic setae. Several somatic setae are present and are short. Amphids is a single loop, 6 µm wide. Buccal cavity is narrow, small dorsal tooth and posteriorly placed two minute subventral teeth. Oesophagus is short and round with well-developed posterior bulb. Tail is conical with an unstriated tip. Spicules are 53 µm long, conspicuously round and cephalated proximally with a terminal internal cuticularised knob. Gubernaculum long and arcuate.

### Family Draconematidae Filipjev, 1918

### Genus *Draconema* Cobb, 1913

*Draconema japonicum* Kito, 1976

**Plate 16 (H)**

***Collection locations:*** Kollam 500m; Trivandrum 500 m; Coondapur 1000 m; Karwar 200 m; Ratnagiri 200 m; Dhabol 200 m, 500m

***Diagnosis:*** Body characteristic S or Z shaped. First anterior 7 – 14 annules of the head cuticle enlarged.Width of anterior part is greater than that of mid body in males and vulvular region is wider in females. Cuticle finely annulated except for anterior and posterior ends. 8 rows of somatic setae enlarged and arranged longitudinally. Long and short setae densely distributed to anterior region. Amphids at posterior half of head, shaped as sheperds crook. Testes single and out stretched. Spicules long 73 µm, thin and arcuate with proximal cephalisation and the distal end pointed. Gubernaculum short 24 µm, less than one third of the spicule. Posterior ambulatory setae arranged in four rows, four sublateral rows each bearing 9 setae. Four rows of pre anal setae.

*Draconema longicapitatum* Allgén, 1932

**Plate 16 (I)**

***Collection locations:*** Cape Comorin 500 m; Kollam 500m; Mumbai 2 200 m

***Diagnosis:*** Body characteristic of Draconema in general. Cuticle finely annulated except for anterior and posterior ends. 8 rows os somatic setae enlarged and arranged longitudinally. Long and short setae densely distributed to anterior region. Amphids at posterior half of head, shaped as sheperds crook. Testes single and out stretched. Spicules long 43, thin and arcuate with proximal cephalisation and the distal end pointed. Gubernaculum short, simple. Tail conical with perforated non annulated tail tip.

### Genus *Prochaetosoma* Micoletzky, 1922

*Prochaetosoma dokdoense* Rho, Min, Decreamer and Kim, 2010

**Plate 16 (J)**

***Collection locations:*** Trivandrum 500 m; Veravel 1000 m

***Diagnosis:*** Longer slendr body. Body cuticle finely annulated except for head region and tail terminus. Head 21 µm long with slightly granulated ornamentation. Elongated loop shaped amphid, eight cephalic adheshion tubes just anterior to swollen pharyngeal region. Pharyngeal body region slightly or not swollen. Rostrum rounded. Four to 14 CAT located posterior to rostrum. Buccal cavity moderately developed, with conspicuous dorsal tooth. Spicule long 86 µm, long cylidro conoid tail.

### Family Microlaimidae Micoletzky, 1922

### Genus Aponema Jensen, 1978

*Aponema abyssalis* (Miljutin & Miljutina, 2009) Tchesunov, 2014

**Plate 17 (H)**

***Collection locations:*** Mangalore 500 m, 1000 m; Mumbai 1 200 m

***Diagnosis:*** Body cylindrical, with slightly narrowed anterior end and conical tail. Cuticle annulated along whole body except cephalic capsule. Amphid monospiral with cuticular edging. Buccal cavity present, its cuticular walls thicker. Three small sclerotized teeth. Pharynx consisting of slender cylindrical anterior part with well developed muscular elements and posterior terminal bulb with plasmatic interruptions. Reproductive system diorchic.Spicules rather large, curved, with feebly developed capitulum at its distal end and thin velum. Gubernaculum in shape of a curved, thick rod. Thick prominent bent, hook-like apophysis present which liyng perpendicularly to gubernaculum to caudal direction in its basal part and than changing to be dorsal. Tail conical.

*Aponema decremerae* Muthumbi & Vincx, 1999

**Plate 17 (A)**

***Collection locations:*** Mumbai 2 200 m; Porbandar 200 m

***Diagnosis:*** Cylindrical body attenuating on both ends.The head is slightly set off by a fine constriction. The cuticle has fine annuli starting from the level of the constriction. The amphids are simple spiral and the spiral origin is obvious on the ventral side. The inner and outer labial sensilla are inconspicuous, while the four cephalic ones are very short. The stoma is rather small with one small dorsal tooth and two sub-ventral one. The pharynx has a well developed pyriform terminal bulb. The reproductive system is diorchic with outstretched testes located anterior to the right or the left of the intestine and posterior one on the opposite side.The spicules are long, slightly curved and with a poorly developed capitulum. The gubernaculum is sclerotized and has a dorsal-caudal apophysis. The tail conical and cylindrical on the posterior half and has a pointed tip.

*Aponema ninae* Portnova, 2009

**Plate 17 (B)**

***Collection locations:*** Kollam 200m; Kochi 200 m; Ponnani 200 m; Goa 200 m; Ratnagiri 500 m, 1000 m; Dhabol 200 m; Mumbai 1 200 m

***Diagnosis:*** Body short, slender. Cuticle thin and finely striated. Amphidial fovea distinctly sclerotized and circular, with interruption in the posterior part 4–5 µm, in diameter. Head small, offset by a slight constriction, with four cephalic setae, 2.5–3 µm long. Somatic setae 2–4 µm long, scattered along the body. Stoma small, narrow and weakly sclerotized. Oesophagus cylindrical and muscular along its entire length. Posteriorly it is enlarged into spherical bulb 18 µm by width and 20 µm by length. Single anterior testis to the left side of intestine. Spicules are short, curved, slightly widened and cephalated proximally. Gubernaculum strongly sclerotized. The female reproductive system didelphic, posterior and anterior ovaries of equal length, outstretched. Tail long, slender, narrowed, with drop–shaped tip.

*Aponema nympha* Bussau & Vopel, 1999

**Plate 17 (C)**

***Collection locations:*** Ponnani 200 m, 500 m; Mumbai 1 200 m

***Diagnosis:*** Body short, slender. Cuticle thin and finely striated. Cuticle 0.5 µm thick at mid-body. Numerous sublateral somatic setae. Six small cephalic papillae at anterior tip of head. The four cephalic setae of the third circle). Amphids 6 µm wide. Small, unarmed, funnel-shaped buccal cavity. Pharynx posteriorly enlarged to a muscular bulb with sclerotised internal lining.

Curved spicules 20 µm long. Gubernaculum with two dorsally oriented apophyses. Tail length five times body diameter at anus. Caudal glands open to exterior through a common duct.

### Genus *Bathynox* Bussau & Vopel, 1999

*Bathynox clavata* Bussau & Vopel, 1999

**Plate 17 (D)**

***Collection locations:*** Cape Comorin 500 m; Kochi 200 m, 500 m; Goa 500 m; Veravel 500m, 1000m

***Diagnosis:*** Faintly annulated cuticle 1 µm thick at the mid-body regionand rings 0.3 µm wide. Somatic setae of the cervical region derive from pores, those of the remaining body from peduncles. Head 8 µm long and not annulated. The six cephalic setae positioned 2 µm behind anterior end. The four cephalic setae of the third circlet positioned 8 µm behind anterior end. Club-shaped corpus gelatum (26µm long, up to 7 µm thick) projects behind anterior end and possesses a solid outer wall. Buccal cavity funnel-shaped, slightly cuticularised and armed with a small dorsal tooth and one or two small subventral teeth. Pharynx posterior enlarged to a muscular bulb. Spicula 22 µm long. Gubernaculum measured 10 µm. Tail length 3.7 times body diameter at anus. Caudal glands open to exterior through a common duct.

### Genus *Caligocanna* Bussau & Vopel, 1999

*Caligocanna mirabilis* Bussau & Vopel, 1999

**Plate 17 (E)**

***Collection locations:*** Trivandrum 200 m, 500 m; Karwar 200 m; Mangalore 200 m;; Coondapur 200 m; Dhabol 500 m; Mumbai 1 200m, 1000 m; Mumbai 2 200 m; Porbandar 500 m; Veravel 200 m

***Diagnosis:*** Body cylindrical with elongated cervical region. Cuticle annulated along whole body except at anterior most cephalic capsule. Cephalic capsule short, its length less than its width. Cuticular annuli 1.7 µm in width, with very close and fine longitudinal bars. There are distinctly bordered deep furrows between annuli. Amphid monospiral round. Two long dorsal teeth and two short ventral teeth visible in anterior part of stegostoma. Pharynx cylindrical but having a terminal oval bulb. Both testes lying ventrally from intestine. Spicules strongly curved, thick, with proximal knob and velum. Gubernaculum in shape of a curved rod. Tail conical.

### Genus *Calomicrolaimus* Lorenzen, 1976

*Calomicrolaimus microseta (*Gerlach, 1953) Jensen, 1978

**Plate 17 (F)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body cylindrical, attenuating at both ends, 980 µm long. Cuticle annulated. Cervical region elongated. Specialized thick spine-like setae present in cervical region. Amphideal fovea at a distance from the anterior end with corpus gelatum protruding from the amphideal aperture. Papilloid precloacal supplements and precloacal cuticular thickenings present. Buccal cavity narrow with weakly sclerotized walls. Dorsal and sub ventral teeths are hardly visible. Males diorchic with short testis and elongated sperm cells. Spicules equal, 23 µm with capitulum. Tail with spinneret and caudal glands.

### Genus *Ixonema* Lorenzen, 1971

*Ixonema sordidum* Lorenzen, 1971

**Plate 17 (G)**

***Collection locations:*** Trivandrum 200 m; Kollam 500m; Mumbai 2 1000 m; Veravel 1000 m

***Diagnosis:*** Spindle shaped body both ends are narrow. Cuticle appears as smooth or with fine striations. Total length 530 µm. Elongated anterior end resembling neck. Amphid located in the neck region with protruding corpus gelatum. Single testes. Spicules narrow and arcuated. Simple plate like gubernaculum.

### Genus *Microlaimus* de Man, 1880

*Microlaimus aequisetosus* Blome, 1982

**Plate 17 (I)**

***Collection locations:*** Ratnagiri 200 m, 500 m; Mumbai 2 500 m

***Diagnosis:*** Small animal 621 µm. Cuticle with fine annulations. Labial setae short; 6+4 cephalic setae in separate rows. Amphid round. Buccal cavity with single dorsal and two sub ventral tooth. Pharynx muscular with end bulb. Males diorchic. short slender spicule, 35 µm long, gubernaculam simple rod like. Tail short and conical.

*Microlaimus africanensis* Furstenberg & Vincx, 1992

**Plate 17 (J)**

***Collection locations:*** Ratnagiri 200 m, 500 m, 1000m; Dhabol 1000 m

***Diagnosis:*** Body slender, cylindrical and attenuating at both extremities. Cuticle with fine annulations. Labial setae short; 6+4 cephalic setae always in separate rows. Amphid round. Buccal cavity with single dorsal and two sub ventral tooth. Pharynx muscular with end bulb. Males diorchic. Short slender spicule, 44 µm long with prominent capitulum, gubernaculam simple rod like. Tail short and conical without terminal setae.

*Microlaimus discolensis* Bussau & Vopel, 1999

**Plate 17 (K)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m, 1000m; Kochi 1000 m; Karwar 200 m; Mangalore 1000 m; Coondapur 200 m; Goa 200 m, 500 m, 1000 m; Ratnagiri 200 m, 500 m, 1000 m; Dhabol 200 m; Mumbai 2 200 m; Porbandar 200 m, 500m

***Diagnosis:*** Body cylindrical with slightly narrowed anterior end and conical tail. Cuticle annulated. Annulation beginning posterior to cephalic capsule. Four somatic setae of 3 µm length visible at caudal region. No other somatic setae found. Head sensilla arranged in three circles: 6 inner labial papillae 2 µm long of first circle; 6 thick outer labial setae 5 µm long of second one; 4 cephalic setae 6 µm long of third circle situated near posterior border of cephalic capsule. Amphidial fovea round. One big dorsal sclerotized tooth. Pharynx thick, muscular. Well-developed terminal bulb. Reproductive system diorchic, with opposite outstretched testes. Spicules rather large and curved. Gubernaculum rod like. Tail conical.

*Microlaimus parviporosus* Miljutin & Miljutina, 2009

**Plate 18 (B)**

***Collection locations:*** Dhabol 200 m

***Diagnosis:*** Body cylindrical with slightly narrowed anterior end and conical tail. Cuticle with strong annuli, which beginning at posterior of cephalic capsule. Sensilla of cephalic end arranged in 2 circles: 6 short, outer, labial setae 2 µm long at level of cephalic tip and there are 4 submedian cephalic setae. Amphidial fovea, round. Small dorsal tooth. Pharynx with terminal bulb. Reproductive system diorchic, with outstretched anterior testis and reflected posterior one. Spicules rather large, curved, 6 µm, with delicately marked knob at its distal end. Gubernaculum rod-like, slightly bent anteriorly.

*Microlaimus tenuispiculum* de Man, 1922

**Plate 18 (C)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Cuticle with delicate annulations. Labial setae short; 6+4 cephalic setae always in separate rows. Amphid round. Buccal cavity with single dorsal and two sub ventral tooth. Pharynx muscular with end bulb. Males diorchic. Long slender spicule, 165µm long, gubernaculam simple rod like. Two tiny papillae in the caudal region.

*Microlaimus ostracion* Schuurmans Stekhoven, 1935

**Plate 18 (A)**

***Collection locations:*** Ratnagiri 1000 m; Dhabol 500 m,

***Diagnosis:*** Cuticle with annulatins, each annuli ornamented with vertical bars. Labial setae short; 6+4 cephalic setae always in separate rows. Amphid round open. Cephalic papillae setiform. Buccal cavity deep with subrerminal teeth. Spicule short and thick with a small gubernaculam. Tail tapering.

*Microlaimus zosterae* Allgén, 1930

**Plate 18 (D)**

***Collection locations:*** Dhabol 1000 m

***Diagnosis:*** Cuticle almost smooth to weakly striated. Six inner labial papillae. Amphid round, monospiral. Pharynx with muscular posterior bulb. Males diorchic. Spicules 28 µm long, arcuate with capitulum. Gubernaculam without apophyses 14 µm long, curved, tapering at both ends. 5 thin suppliments. Tail, short, conical, tapering to the tip with terminal spinneret.

### Genus *Molgolaimus* Ditlevsen, 1921

*Molgolaimus abyssorum* Muthumbi & Vincx, 1996

**Plate 18 (E)**

***Collection locations:*** Kollam 200m; Coondapur 200 m, 1000 m; Mumbai 1 500 m

***Diagnosis:*** Body cylindrical 342 µm long, narrower in cephalic region. Cuticle faintly striated, or barely visible. Somatic setae not seen. Small circular amphid. Stoma tubular. Reproductive system monarchic with outstretched testes. Spicules narrow and arcuate 23 µm. Gubernaculum simple, surrounds the proximal end of spicule. Tail conico cylindrical with pointed tail tip.

### Genus *Spirobolbolaimus* Soetaert & Vincx, 1988

*Spirobolbolaimus bathyalis* Soetaert & Vincx, 1988

### Plate 18 (F)

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 200 m, 500 m; Kollam 200m; Karwar 200 m

***Diagnosis:*** Body cylindrical, slightly narrowing anteriorly, tapering posteriorly. Cuticle annulated each annule is convex, making its margins well pronounced, a prominent interannular region is present. Somatic sensilla papilliform, in four submedian rows. Head rounded; anterior part not annulated and broader than long. Amphideal fovea distinctly sclerotized, multispiral, ventrally wound, 4.5 turns, 10-11 µm wide; Six rows of 2-6 setae present posterior to the amphideal fovea: two ventro sublateral, two dorso sublateral rows, one medio dorsal and one medioventral row. Buccal cavity with one dorsal tooth; a pair of ventrosublateral teeth is situated posterior to the dorsal tooth. Male diorchic; testes outstretched and opposite. Two equal spicules, strongly sclerotized; capitulum narrow, weakly sclerotized lamella present. Gubernaculum 10-11 µm long, plate-like. No precloacal supplements observed. Female didelphic, amphidelphic. Tail gradually tapering; three caudal glands emptying together.

### Order Plectida

### Family Camacolaimidae Micoletzky, 1924

### Genus *Alaimella* Cobb, 1920

*Alaimella macramphis* Tchesunov & Miljutina, 2007

### Plate 18 (G)

***Collection locations:*** Goa 200 m; Coondapur 200 m; Ratnagiri 200 m, 500 m, 1000 m; Porbandar 200 m

***Diagnosis:*** The body is slender, filiform and transparent. 2.3 mm, maximum diameter of the body 25.0 µm respectively. The cuticle is thick, with simple sharp and rough annulation. Cuticular rings show fine longitudinal ribbing. There is no lateral differentiation of the cuticle. The mouth opening is small and the lips are not obviously developed. Around the mouth there are two rings of anterior sensilla; the first ring consists of six papillae; the second ring comprises four long lateromedian cephalic setae. The amphid is very large, occupies the entire lateral surface of the body, rounded in shape,looks like a comma with a very short rudimentary “tail.” The width of the amphid is 12.5µm. The cheilostome is minute and narrow. The esophastome is not pronounced and does not differ from the lumen of esophagus. The anterior part of the esophagus is cylindrical, with a distinct granulation in the neck of dorsal gland. In its middle portion, the esophagus is narrowed, while toward the posterior extremity it makes up an elongated-conical glandular expansion. Spicules are slender, arcuate, pointed distally, with bent capitulums proximally. The gubernaculum is in the shape of a weakly sclerotized lobe, the length of spicules is 36.5 µm along the chord, gubernaculum is 10.5 µm long. The tail is conical. In the beginning of the posterior third of the tail there is a subventral 2.5 µm seta. On the end of tail there is a spinneret.

### Genus *Dagda* Southern, 1914

*Dagda* sp

**Plate 18 (I)**

***Collection locations:*** Cape Comorin 200 m; Coondapur 200 m; Mumbai 2 200 m

***Diagnosis:*** Body long 3 mm. Maximum diameter 50 µm. Cuticle with finely transversely striated. Rounded lips with globular papillae. Four long cephalic setae. Somatic setae absent. Amphids small transversely oval. Buccal cavity armed with one dorsal and two subventral triangular teeth. Tail conical. Spicules 40 µm, arcuate with proximal cephalisation and ventral alae. Gubernaculum with rounded dorsal apophysis Eleven 23 µm long cuticularised tubular precloacal supplements with the proximal ends bent, slightly expanded and a thickened cuticular ring around the tip.

### Genus *Diodontolaimus* Southern, 1914

*Diodontolaimus* sp

**Plate 19 (A)**

***Collection locations:*** Cape Comorin 200 m; Trivandrum 200 m, 500 m; Kollam 200m ; Ratnagiri 200 m, 500 m; Dhabol 200 m, 500m; Mumbai 2 200 m; Porbandar 200 m

***Diagnosis:*** Body long 2mm. Maximum diameter 46 µm. Cuticle with widely spaced transverse striations. Lips with pointed papillae. Four long cephalic setae. Amphids small inconspicuous. Oesophagus gradually expands towards the base. Spicules 40 µm, strongly arcuate, cephalate proximally with a ventral ala. Gubernaculum with pointed, caudally directed dorsal apophysis. Nine cuticularised tubular precloacal supplements, expanded and bent at the proximal ends with a ring of cuticle surrounding the distal tip. Tail conoid with cuticularised spinneret.

### Genus *Procamacolaimus* Gerlach, 1954

*Procamacolaimus bipapillata* Southern, 1914

**Plate 19 (C)**

***Collection locations:*** Mumbai 2 200 m

***Diagnosis:*** Body slender and elongate. Cuticle with marked coarse tansverse striation. Mouth surrounded by 6 lips each bearing short, outwardly curving papilla. Long cephalic setae. Buccal cavity short and conical and contains a solid dorsal tooth opposed by a pair of hollow sub ventral teeth. Amphid small, circular which is brocken posteriorly. Spicules paired, equal and arcuate. Flattened in width gradually towards the proximal end at which a rounded cephalisation is set off by neck like constriction. Gubernaculam with strong rounded dorsal apophyses. There is a stout pre cloacal seta and nine srongly cuticularised suppliments. The pre cloacal suppliments are tubular, pointed distally and with their cephalate proximal ends set by a constriction.

### Genus *Stephanolaimus* Ditlevsen, 1918

*Stephanolaimus elegans* Ditlevsen, 1918

**Plate 19 (D)**

***Collection locations:*** Trivandrum 500 m

***Diagnosis:*** Body length 3.0 mm. Maximum diameter 55 µm. Cuticle coarsely annulated, without lateral differentiation. Anterior six cephalic sensilla small and pointed. Four longer cephalic setae 27 µm. A few long cervical setae, about 15 µm, remainder of body devoid of setae except for two subventral files on the male tail. Amphids 4 µm wide, reniform. Buccal cavity small and funnel shaped with six small pointed teeth at its anterior end. Oesophagus broadens posteriorly but has no definite bulb. Tail with an unstriated tip of dense cuticle forming a caudal capsule. Spicules 70 µm measured as a curve, with round proximal cephalisation. Gubernaculum 30 µm with prominent dorsocaudal apophysis. 45 more or less equally spaced tubular cuticularised 20 µm long precloacal supplements extending almost to base of oesophagus, cephalate proximally with a sharp flexure near the distal tip; those in the posterior region lie at right angles to the body surface but the anterior ones are directed slightly backwards. A small stout precloacal spine.

## Family Tarvaiidae Lorenzen, 1981

### Genus *Tarvaia* Allgén, 1934

*Tarvaia angusta* Gerlach, 1953

**Plate 28 (D)**

***Collection locations:*** Cape Comorin 500 m; Mumbai 2 200 m

***Diagnosis:*** Body slender and elongated 1 mm. Maximum diameter 15 µm. Four 13 µm cephalic setae. Small papillae irregularly distributed throughout body length and several short setae on the male tail. Amphids 4.5 µm long, 12 µm wide, a large elongated loop of 1.25 turns, not supported on a cuticular shield or plaque. Spicules 31 µm, curved, arcuate with proximal cephalisation. Gubernaculumn with paired dorso-caudally directed apophyses. Tail conicocylindrical.

*Tarvaia heegeri* Jensen, 1991

**Plate 19 (E)**

***Collection locations:*** Karwar 200 m

***Diagnosis:*** Body slender and attenuating towards the ends. Cuticle annulated from base of amphids to tail tip; head and tail tip smooth. Cephalic capsule about 20 µm long. Cephalic setae 9 µm long, each inserted in a groove at the front end. Somatic setae scarce. Amphids elongated as a ventrally wound spiral, 25 µm long and 10 µm wide; anterior border situated 9 µm behind front end. Buccal cavity indistinct. Pharyngeal musculature proximally enlarged. Tail tip narrow and cut-off. Spicules slender and curved, 28 µm along the arc; gubernaculum with a sclerotized caudal apophysis.

*Tarvaia peruvensis* Nichols & Musselman, 1979

**Plate 19 (F)**

***Collection locations:*** Kochi 200 m

***Diagnosis:*** Species with sexual dimorphism in the shape of amphids. Cuticle weakly annulated. No cervical or somatic setae. Head significantly narrower than body. Amphid spiral located on the plate in the neck region, 14.2 µm wide in males and 22.6 µm wide in females.neck diameter of male at the base of amphid is 28.5 µm and 53 µm in females. Four long cephalic setae. Tail conical.

## Family Leptolaimidae Örley, 1880

### Genus *Antomicron* Cobb, 1920

*Antomicron* sp

### Plate 18 (H)

***Collection locations:*** Cape Comorin 500 m; Coondapur 200 m; Goa 200 m, 500 m; Dhabol 200 m, 500 m; Mumbai 1 1000 m; Mumbai 2 200 m; Porbandar 200 m, 500m, 1000m

***Diagnosis:*** Cuticule annulated, annulation smooth. Lateral field present. First annules appear posterior to cephalic setae bases, at level of or posterior to amphids. Sclerotized cephalic capsule absent. Amphidial fovea loop-shaped derived from ventrally unispiral. Male reproductive system diorchic.

### Genus *Leptolaimus* de Man, 1876

*Leptolaimus* sp

### Plate 19 (B)

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 200 m; Kollam 200m; Ponnani 200 m; Karwar 200 m, 500m, 1000m; Mangalore 200 m; Goa 200 m, 500 m; Ratnagiri 500 m; Dhabol 200 m; Mumbai 2 200 m, 500m

***Diagnosis:*** Body slender and attenuating towards the ends with a sclerotized. Cuticle annulated from head to tail tip, each annule about 1 µm wide, but slightly wider on posterior most portion of tail. A 1.5 µm wide lateral field raised above the cuticle from midpharyngeal region to anterior most half of tail. Four cephalic setae, 2 µm long. Amphids ventrally wounded and circular in outline, 5 µm in diameter. Buccal cavity narrow and tubular continuing in a 23 µm long tubular pharyngeal region. Spicules bent, proximally cephalated, 22 µm along the arc, 18 µm from tip to tip; gubernaculum with a 8 µm long dorso-caudal apophyses, lateral sclerotization present. One testis present. Nine almost equi-distant precoacal supplements present appearing as sclerotized tubes, proximally cephalated, distally dentated and surrounded by a sickle-shaped sclerotization. Conical tail tip.

### Family Ceramonematidae Cobb, 1933

### Genus *Ceramonema* Cobb, 1929

*Ceramonema carinatum* Wieser, 1959

### Plate 20 (A)

***Collection locations:*** Kollam 500m; Goa 1000 m; Ratnagiri 200 m, 500 m; Dhabol 500m, 1000m;

***Diagnosis:*** Species are with about 280 numbers of transversely undulating cuticle annules. Body length is 2.3 mm. Cuticle is tiled, eight longitudianal cuticle ridges or crests. Crests that are arranged in rows along the body interrupt tiles. The longitudinal rows extend up to the head as rows of dots. Head is 33 µm long. Lips are indistinct. Cephalic setae are in two circles of 6 and 4. Amphids are placed in posterior half of head, 14.9 µm long and 8.2 µm wide. Tail, distal cone 12.7 µm long, anal diameter is 16.3 µm.

*Ceramonema filipjevi* de Coninck, 1942

**Plate 28 (E)**

***Collection locations:*** Cape Comorin 500 m; Kollam 500m , 1000m, Dhabol 500m, 1000m

***Diagnosis:*** Body short, 527 µm. Cephalic setae in 6+4 pattern. Cuticle ornamented with plates. Longitudinal rows of plates are interrupted with crests. Spicules short and arcuate 21 µm in length. Gubernaculum simple. Three anal setae. Tail conical.

### Genus Dasynemoides Chitwood, 1936

*Dasynemoides riemanni* Haspeslagh, 1973

**Plate 20 (B)**

***Collection locations:*** Cape Comorin 500 m; Kollam 500m, 1000 m

***Diagnosis:*** Body length is 1.45mm, over 500 cuticle annules. Cuticle is with 8 longitudinal ridges in the anterior and posterior region, 10 in the middle region and six near the tail tip. Cephalic capsule particularly elongated, 28 µm long and 16 µm wide, with 8 cuticular ribs extending forwards from its base. Cephalic seta is in 6+4 pattern, 8 µm and 12 µm long. Somatic setae are absent. Amphids is a closed loop, 4.6 µm wide. Buccal cavity is absent. Spicules are 21 µm long and arcuate. Tail is with 30 µm end cone.

### Genus *Pselionema* Cobb, 1933

*Pselionema* sp

***Collection locations:*** Cape Comorin 200 m, 500 m, 1000m; Trivandrum 200 m, 500 m, 1000m;Kollam200 m, 500m; Kochi 200 m, 500 m, 1000m; Ponnani 200 m; Kannur 200 m, 500 m; Coondapur 200 m; Karwar 200 m, 500m; Mangalore 200 m; Goa 200 m, 500 m, 1000 m; Ratnagiri 200 m, 500 m, 1000 m; Dhabol 200 m, 500m, 1000m; Mumbai 1 200 m ,500 m, 1000 m; Mumbai 2 500 m; Veravel 1000 m

***Diagnosis:*** Cuticle thick, annulated, each body ring overlaps onto the neighbouring body ring; 360 cuticular annulations; cuticle ridges are not markedly enlarged. Cephalic capsule ornamented with hexagonal plates; amphids inverted U-shape and ventrally spiral. Labial sensilla minute; 4 cephalic setae as long as cephalic diameter; buccal cavity minute or absent; Oesophagus reaching to the anterior end and surrounds the narrow oral slit.Tail conical, unstriated slender with swollen spinneret tip.

*Pselionema annulatum* Filipjev, 1922

**Plate 20 (C)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Cuticle thick, coarsely annulated, each body ring overlaps onto the neighbouring body ring; 350 cuticle annules; cuticle ridges are not markedly enlarged. Cephalic capsule unstriated on which amphids are situated; amphids are usually an inverted U-shape and ventrally spiral. Labial sensilla not discernible; 4 cephalic setae as long as cephalic diameter; buccal cavity minute or absent; Oesophagus reaching to the anterior end and surrounds the narrow oral slit.Tail conical, unstriated slender with swollen spinneret tip.

### Genus Pterygonema Gerlach, 1954

*Pterygonema ornatum* Timm, 1961

**Plate 20 (D)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body elongated and conspicuously annulated. Cuticle annules approximately 1.5 µm wide and spaced at intervals of 0.5 µm. Total number of body annules 250. Each annule composed of 8 cuticular plates, the ends of which are prolonged into conspicuous perpendicular ridges, together forming eight longitudinal alae running the length of the body. Somatic setae very rare about 5µm long. Cephalic capsule heavily cuticularized. Head diameter 8.5 µm. Four cephalic setae 18µm long. Amphids large, loop-shaped on plaque which looks like a shield-shaped cuticular plate. Buccal cavity absent. Oesophagus narrow but widens slightly at the posterior end. Tail elongated. Spicules paired, curved, 17 µm long. Gubernaculum with apophyses 6.5 µm long. A single preanal seta, 3.5 µm long. Two testes.

### Family Paramicrolaimidae Lorenzen, 1981

### Genus Paramicrolaimus Wieser, 1954

*Pramicrolaimus damodarani* Jacob, Jaleel & Vijayan, 2015

Figure 1-3

***Collection locations:*** Cape Comorin 200 m, 1000 m; Kollam 200m , 1000 m; Kochi 200 m; Karwar 200 m; Goa 200 m; Ratnagiri 1000 m; Mumbai 1 1000 m

***Diagnosis:*** Cuticle with a very thin cortical layer and with fine transverse striations. Numerous hypodermal gland cells distributed all over especially in the cephalic region. Amphids transversely oval. Buccal cavity irregular with a deep vestibulum and weakly sclerotized walls. Curved thick spicules. Gubernaculum weakly sclerotized and apparently surrounding distal parts of the spicules. Seven preanal supplements present as cuticular dilations of the ventral margin and accompanied by caudally directed thornlike structures at their orifice.

*Paramicrolaimus spirulifer* Wieser, 1959

**Plate 20 (E)**

***Collection locations:*** Cape Comorin 1000 m; Kollam 200m

***Diagnosis:*** Body 5.17 mm long and slender. Hypodermal gland cells present. Cuticle with a very thin cortical layer and with fine transverse striations. Somatic setae 10 pm long, sparsely and irregularly distributed in four longitudinal rows beginning at level of center of amphids. Amphids transversely oval. Cephalic sense organs in three crowns as six internal labial papillae, six slender external labial setae 17 µm long inserting 10 µm behind front end, and four slender cephalic setae 18 µm long. A transparent cuticular cap surrounds that part of the head anterior to the external labial setae. Buccal cavity irregular with a 5 µm deep vestibulum and a 6 µm deep and narrow anterior part with weakly sclerotized walls without dentation, however, a small thornlike projection is present at the outermost dorsal margin. No bulb present posteriorly. Curved spicules, 39 µm long around the arc, 30 µm long. Gubernaculum weakly sclerotized. Ten preanal supplements. Tail conical.

## Order Monhysterida

### Family Xyalidae Chitwood 1951

### Genus *Ammotheristus* Lorenzen, 1977

*Ammotheristus* sp

### Plate 20 (G)

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m; Kannur 200 m; Karwar 200 m

***Diagnosis:*** Cuticle finely striated. Long somatic setae along the body. Anterior sensilla in two circles with the second circle with additional subcephalic setae. Amphids blistered without a cuticularized rim. Pharynx weakly muscular; thickening at the posterior end forming glandular bulb. Tail conical without terminal setae.

### Genus *Amphimonhystera* Allgen, 1929

*Amphimonhystera anechma* Southern, 1914

### Plate 20 (H)

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m, 500m; Goa 200 m; Ratnagiri 200 m, 1000m

***Diagnosis:*** Body length is 1.8mm. Cuticle striated. Outer labial and cephalic setae in one circle together with additional subcephalic setae. Distinct hyaline lips with six thin labial setae are present. Cephalic setae are 26 μm long. Scattered somatic setae are very thin up to 18 μm. Amphids large longitudinally oval in shape and with a cuticularized opening and a distinct spot near the center. Buccal cavity is small. Spicules small, strongly bent, proximally cephalated and 47 μm long. Gubernaculum is a complex structure surrounding the distal end of the spicule and consisting of several elements. Three caudal glands opening at separate pores. Tail elongated conical.

### Genus *Cobbia* De Man, 1907

*Cobbia* sp

### Plate 21 (C)

***Collection locations:*** Karwar 200 m; Mumbai 1 200 m, 1000 m; Porbandar 500 m

***Diagnosis:*** Cuticle finely striated. Anterior sensilla arranged in two circles of six + ten or six + twelve. Inner labial sensilla setiform, outer labial setae longer than the cephalic setae and, when present, adjacent lateral setae. Buccal cavity conical, partially surrounded by pharyngeal musculature and equipped with one or three teeth. Amphids circular. Two testes.Tail conical or conical cylindrical without terminal setae.

### Genus *Daptonema* Cobb 1920

*Daptonema hyalocella* Kito and Aryuthaka, 2012

**Plate 20 (K)**

***Collection locations:*** Cape Comorin 200 m, 500 m; Trivandrum 200 m, 1000m; Kochi 200 m, 500 m, 500 m; Ponnani 200 m, 500 m, 1000 m; Kannur 200 m; Coondapur 200 m, 1000m; Karwar 200 m; Ratnagiri 200 m; Dhabol 200 m; Mumbai 1 200 m

***Diagnosis:*** Body short, about 0.7 mm long. Cuticle weakly striated, annules about 1.5 µm apart. Short somatic setae sparsely distributed throughout body. Head blunt, clearly set off; labial region low, about 7 µm. Head equipped with 6 tiny papillae and 12 short cephalic setae. Amphids circular about 6 µm in diameter. Buccal cavity cup-shaped, posterior half surrounded by pharynx. Pharynx muscular, almost cylindrical but gradually enlarging toward posterior portion. Reproductive system diorchic. Spicules weakly cuticularized, remarkably thin and short. Gubernaculum indistinct, small lateral pieces located near distal end of spicules.

*Daptonema balatum* Nguyen Dinh Tu et al., 2014

**Plate 20 (I)**

***Collection locations:*** Ratnagiri 500 m

***Diagnosis:*** Anterior body end strongly narrowed. Inner labial sensillae papilliform hardly visible. Six labial sensillae and four cephalic sensillae shaped like thin and short setae. Cephalic sensillae 3µm long. Outer labial setae shorter. Cervical setae not found. Cheilostoma narrow weakly cuticulized. Esophastoma in the shape of funnel, its walls strongly cuticulized. Amphid circle shaped. Esophagus thin, muscular, slightly widening to its base. Gonads paired, opposed. Spicules paired, curved weakly ventrally, with bifid tip. Apical end of spicules curved. Gubernaculum consists of the main body and long caudal apothysis strongly curved ventrally.Tail elongate conical, gradually narrowing. Caudal setae not found. Tail has 3 short subtermal setae.

*Daptonema hirsutum* Vitiello, 1967

**Plate 20 (J)**

***Collection locations:*** Kannur 500 m, 1000 m

***Diagnosis:*** Cylindrical body attenuating on anterior and posterior ends. Head slightly round. Cuticle annulated and quite conspicuous. Somatic setae present along the body surface. Amphids simple and round. Buccal cavity conical and without teeth. Inner labial sensilla 3µm long. Pharynx slender and cylindrical. Reproductive system is diorchic with two opposed testes. Spicules are curved and with a poorly developed capitulum. The gubernaculum with a dorsocaudally directed apophyses. Precloacal setae situated at 11 µm from the cloaca and 10 µm long. Tail cylindrical and filiform posteriorly with swollen tip at the posterior end. Caudal setae are 38 µm long. Spinneret developed.

*Daptonema oxycerc*a DeMan, 1888

**Plate 20 (L)**

***Collection locations:*** Cape Comorin 200 m, 500 m, 1000m; Trivandrum 200 m, 500 m, 1000m; Kollam 200m; Kochi 200 m, 500 m; Ponnani 200 m, 1000 m; Kannur 200 m, 500 m, 1000 m; Coondapur 200 m, 1000 m; Karwar 200 m, 500m, 1000m; Goa 200 m; Mangalore 200 m, 500 m; Goa 200 m, 500 m; Ratnagiri 200 m, 1000 m; Dhabol 200 m, 500m; Mumbai 1 200 m; Mumbai 2 500m, 1000m; Veravel 200 m

***Diagnosis:*** Body length is 1.7mm. Cephalic setae are in 6+6 pattern, six, 10 µm long and six 7.2 µm long. Somatic setae are scarce and short. Amphids are 9 µm in diameter. Spicules are 60 µm long, proximally cephalate, distally with fine small teeth. Gubernaculum surrounds distal ends of spicules, apophyses absent. Tail long; posterior third is cylindrical with terminal setae short.

*Daptonema setihyalocella* Aryuthaka and Kito, 2012

**Plate 21 (A)**

***Collection locations:*** Cape Comorin 200 m; Kannur 200 m, 500 m, 1000 m; Ratnagiri 1000 m; Mumbai 1 200 m, 500 m

***Diagnosis:*** Body short, about 1 mm long, almost uniform diameter except pharyngeal and tail regions; posterior portion bent dorsally. Amphids are circular small. Cuticle weakly striated. Spicules are 30 µm, L-shaped and having proximal cephalation, a distinct gubernaculum with dorsal apophysis and lateral piece, and four terminal setae.

*Daptonema williamsi* Vinx and Coomans, 1983

**Plate 21 (B)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body length is 1.4 mm. Cuticle strongly annulated. Amphids are circular small. Spicules are 45 µm long, arcuate. Gubernaculum simple plate like. Tail cylindrical with swollen tip at the posterior end. Caudal setae are located at 4 µm from the posterior end. Spinneret developed.

### Genus *Gonionchus* Cobb, 1920

*Gonionchus intermedius* Jensen, 1986

**Plate 21 (F)**

***Collection locations:*** Trivandrum 200 m; Kochi 200 m; Ponnani 200 m; Kannur 200 m; Mangalore 200 m, 500 m; Coondapur 200 m, 500 m

***Diagnosis:*** Body attenuating towards ends. Cuticle annulated. Somatic setae in four submedian rows. Amphids very weakly cuticularized, circular in outline with an inner spiralization. Six labial setae and a circle of six cephalic setae 15 µm lon. Buccal cavity rectangular to conical with strongly cuticularization; two blunt projections in subventral sectors, about 8 µm long. Testes opposite and outstretched, anterior testis left, posterior right of intestine. Spicules 46 µm, strongly cuticularized, distal tip bent to left. Gubernaeulum strongly cuticularized and with a weakly cuticularized apophysis.

*Gonionchus africanus* Vincx & Furstenberg, 1988

**Plate 21 (D)**

***Collection locations:*** Cape Comorin 200 m, 500 m; Coondapur 200 m

***Diagnosis:*** Body cylindrical, tapering towards end. Cuticle clearly annulated. Longitudinal ornamentation absent. 6 internal labial setae, 6 external labial setae at the same level with cephalic setae and numerous cervical setae. Somatic setae thin and arranged in 8 rows. Amphid circular with a central spot. Buccal cavity conical with 6 thin lips. Males diorchic, spicules equal in size, curved with rounded capitulum. Gubrnaculum with two lateral pieces. Tail conical provided with ventral setae. No terminal setae.

*Gonionchus cumbraensis* Benwell, 1981

**Plate 21 (E)**

***Collection locations:*** Cape Comorin 200 m, 1000 m; Kollam 200m; Kannur 200 m; Mumbai 1 200 m

***Diagnosis:*** Cuticle clearly annulated. Annulations 2.5 µm wide. 6 high lips each with longitudinal striations. Labial setae short. Cervical setae arranged in sets of 3 or 4. Males diorchic. Spicules paired, equal, proximally cephalate with walls thickened distally. Gubernaculam with weak apophyses. Tail long, cylindrical posteriorly.

### Genus *Manganonema* Bussau, 1993

*Manganonema* sp

### Plate 21 (G)

***Collection locations:*** Cape Comorin 500 m, 1000m; Trivandrum 200 m, 500 m; Kollam 200m, 1000m; Kochi 200m; Karwar 200 m; Coondapur 200 m

***Diagnosis:*** Body cuticle transversely striated; somatic setae short, more or less papilliform and difficult to recognize, arranged in four longitudinal rows. Conspicuous narrow anterior end, head diameter at least one-third smaller than the body diameter at the level of amphids, and marked or set-off from the rest of the body by a narrowing of the region. Anterior sensilla arranged in two crowns. Amphids circular, and relatively large. Buccal cavity minute, surrounded by pharyngeal musculature. Male reproductive system monarchic. Two small straight spicules and a weak gubernaculum without apophysis. Tail pointed, curved dorsally upon fixation.

### Genus *Metadesmolaimus* Schuurmans Stekhoven, 1935

*Metadesmolaimus aversivulva* Gerlach, 1953

### Plate 21 (H)

***Collection locations:*** Goa 200 m; Cape Comorin 500 m; Mumbai 2 500 m

***Diagnosis:*** Body long 1.3mm. Cuticle finely striated. Buccal cavity large and partitioned with a ring. 6 labial papillae. Numerous somatic setae. Amphid circular. Buccal cavity extended, divided into two parts by a ring. Spicule 27 µm in length, sclerotized, arched with a proximal capitulum. Gubernaculum simple sheathing distal part of spicule. Apophyses absent. Three caudal glands opening at separate pores. Tail conico-cylindrical.

*Metadesmolaimus heteroclitus* Lorenzen, 1972

### Plate 21 (I)

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Body elongated 850 µm in length. Cuticle finely striated. Somatic setae scattered along the body. Inner labial sensilla setiform. Outer labial setae in two parts. Cephalic setae at the same level as the outer labial setae. Amphids circular. Buccal cavity portioned with wide ring. Spicules paired and un equal in size. Spicule stongly arcuate with proximal cephalization. Gubernaculum small and simple. Body bears so many long setae. Tail conical.

*Metadesmolaimus tersus* Gerlach, 1956

### Plate 21 (J)

***Collection locations:*** Coondapur 200 m; Karwar 200 m; Ratnagiri 1000 m

***Diagnosis:*** Body long 1.2 mm. Cuticle with large striations. Buccal cavity moderate. Amphid circular with a faint notch. Spicule 45 μm long, arcuate with proximal cephalisation. Gubernaculum small and simple. Tail conical.

### Genus *Paramonhystera* Steiner, 1916

*Paramonhystera albigensis* Riemann, 1966

**Plate 21 (K)**

***Collection locations:*** Cape Comorin 200 m; Dhabol 500 m; Ponnani 200 m; Kannur 500 m; Mangalore 200 m; Goa 200 m; Veravel 200 m, 500m

***Diagnosis:*** Cuticle striated. Long stout body 1.14 mm. Head rounded at anterior end with cuticular inflation at labial region. Six prominent labial setae, 10 cephalic setae. Amphid elliptical with thin wall. Spicules 28 μm long, cephalated. Gubernaculum simple, triangle shaped without apophyses. Tail conicocylindrical.

### Genus *Promonhystera* Wieser, 1956

*Promonhystera* sp

**Plate 21 (L)**

***Collection locations:*** Cape Comorin 500 m; Ponnani 500 m; Kannur 200 m; Coondapur 200 m, 1000 m; Karwar 200 m, 1000 m; Goa 1000 m; Ratnagiri 200 m, 500 m, 1000 m; Dhabol 1000 m; Porbandar 500 m

***Diagnosis:*** Cuticle striated. Anterior sensilla in two circles. Inner labial sensilla setiform, very long. Second circle composed of ten setae. Amphids vesicular, circular in shape. Buccal cavity conical. Spicules elongated. Gubernaculum a small plate at the distal end of the spicula. Tail conical or conico-cylindrical with terminal setae.

### Genus *Rhinema* Cobb, 1917

*Rhinema* sp

**Plate 22 (B)**

***Collection locations:*** Kochi 1000 m

***Diagnosis:*** Cuticle thick, interrupted at twelve places so as to form exceedingly distinct longitudinal wings, which when brought in to focus give a somewhat "fishbone"-like effect. The annules and their modifications give a retrorse appearance to the entire cuticle, but in reality the striae are retrorse in the posterior part of the body, and the reverse in the anterior part. There are submedian longitudinal striâtions extending to the middle of the tail. Neck for the most part cylindroid. Opposite the dorsal tooth there is a distinct junction with the cuticle of the lip-region indicated by an almost imperceptible constriction encircling the head. In front of this constriction there are two others, close together, connected with the lip-region.

### Genus *Retrotheristus* Lorenzen, 1977

*Retrotheristus* sp

**Plate 22 (A)**

***Collection locations:*** Cape Comorin 500 m; Karwar 200 m; Coondapur 200 m
***Diagnosis:*** Cuticle weakly cuticularized. Only four cephalic setae visible. Amphids absent. Buccal cavity conical and completely surrounded by pharyngeal muscles. Cardia relatively long and strongly vacuolate. Tail conico-cylindrical with three terminal setae.

### Genus *Scaptrella* Cobb, 1917

*Scaptrella filicaudata* Jacob Anilkumar, Philip and Damodaran, 2015

**Figure 4**

***Collection locations:*** Cape Comorin 500 m, 1000m;
***Diagnosis:*** Cuticle striated. Anterior sensilla in two circles (six + ten) with the anterior-most setiform and the posterior with the outer labial setae longer than the cephalic setae. Amphids circular, placed at the base of the buccal cavity. Buccal cavity deep, conical and sclerotized, equipped with six eversible odontia. Gubernaculum apophyses absent. Tail long filiform.

### Genus *Theristus* Bastian, 1865

*Theristus altenbachi* Jensen, 1991

**Plate 22 (C)**

***Collection locations:*** Coondapur 200 m, 500 m, 1000 m; Mumbai 1 200 m
***Diagnosis:*** Body slender and attenuating towards the ends. Cuticle weakly annulated. Cephalic sense organs in two circles as six internal labial setae, 1 µm long and a circle of six external labial setae and four cephalic setae, 5 µm long. Amphids a circle, 12-14 µm in diameter. Buccal cavity shallow and unarmed. Pharyngeal musculature weakly developed, pharynx cylindrical and posteriorly slightly enlarged with three gland cells. Spicules slender and curved, 49 µm. Testes opposite and outstretched, anterior branch to the left of

intestine, posterior branch to the right; posterior branch with packets of sperm cells.

*Theristus anoxybioticus* Jensen, 1995

**Plate 22 (D)**

***Collection locations:*** Kannur 200 m; Coondapur 500 m, 200 m; Karwar 200 m; Ratnagiri 200 m; Mumbai 1 200 m,

***Diagnosis:*** Body cylindrical, tapering at both ends with slightly clavate tail tip. Cuticle annulated except on head and tail tip. Amphid circular, 6 µm in diameter. Buccal cavity funnel-shaped, widest at lip base, walls weakly sclerotized, without teeth. Testes opposed, outstretched, anterior testis to left and posterior testis to right of intestine. Spicules strongly sclerotized, proximally cephalated. Gubernaculum weakly sclerotized, surrounding spicules distally. Three prominent caudal gland cells with separate outlets. No subterminal or terminal setae.

*Theristus balticus* Lorenzen, 1973

**Plate 22 (E)**

***Collection locations:*** Coondapur 200 m; Goa 200 m; Dhabol 200 m; Mumbai 1 200 m,

***Diagnosis:*** Body long, thin and striated. 900 µm in length. Buccal cavity moderate and sclerotized. 6 cephalic setae. Amphid faintly visible. Thin somatic setae. Spicule 23 µm long, arcuate with proximal cephalisation. Gubernaculum lies parallel to spicule.Tail conical. Three caudal gland.

*Theristus bastiani* Gerlach & Riemann, 1973

**Plate 22 (F)**

***Collection locations:*** Ponnani 200 m; Mumbai 1 200 m, 1000 m; Dhabol 200 m; Veravel 200 m

***Diagnosis:*** Body small 520 µm long. Cuticle heavily striated, broader striae. Buccal cavity small and deep. Amphid circular. Spicule 22 µm long, strongly arcuate with cephalisation. Gubernaculum with small apophyses. Single preanal papillae. Tail conical with three caudal glands.

*Theristus denticulatus* Warwick, 1970

**Plate 22 (G)**

***Collection locations:*** Mumbai 1 200 m

***Diagnosis:*** Head end is attenuatedc onsiderably. Ten cephalic setae. Structure of buccal cavity typical as of the genus. Amphids slightly subcircular and elongated longitudinally. Spicules paired, unequal in size and structure. The right one is shorter and is sharply bent in the middle with a narrow rounded slightly cephalate proximal tip and a pointed distal tip. The left spicule is not sharply bent. Gubernaculam complex array of structures. Distally there are two lateral pieces and covered ventrally with minute denticles. Proximally it with dorsal apophyses.

*Theristus fistulatus* Wieser & Hopper, 1967

**Plate 22 (H)**

***Collection locations:*** Cape Comorin 200 m; Kollam 1000m; Kannur 200m, 500 m ; Mangalore 500 m; Goa 200 m; Ratnagiri 200 m; Dhabol 500 m; Mumbai 1 200 m, 500 m; umbai 2 200 m, 1000m; Porbandar 200 m

***Diagnosis:*** Body length is 0.937 mm. Head diameter is 14 µm. Lips are round, bears short setose papilla. Cephalic setae are 10, 11 µm long. Scattered cervical and somatic setae present in the body. Amphids are 5.3 µm. Spicula are 24 µm long, cephalate proximally, outwardly curved in its distal sixth. Gubernaculum sleeve- like" without apophysis. Distally with curved tubular piece. Tail is long.

*Theristus heterospiculum* Allgén, 1932

**Plate 22 (I)**

***Collection locations:*** Ponnani 200 m; Dhabol 500 m; Mumbai 1 1000 m,

***Diagnosis:*** Body length 985 µm, maximum body diameter 55 µm. Cuticle striated with long somatic setae. Small circular amphid. Spicules paired, strongly arcuate and with distal capitulum. Both spicules vary in size. Tail conical with three caudal glands.

*Theristus otoplanobius* Gerlach, 1951

**Plate 22 (J)**

***Collection locations:*** Cape Comorin 200 m; Trivandrum 200 m; Kollam 200m, 1000 m; Ponnani 1000 m; Kannur 200 m, 500 m, 1000 m; Coondapur 200 m; Mangalore 200 m, 500 m; Goa 200 m; Dhabol 1000 m; Mumbai 2 200 m, 500m; Porbandar 200 m, 500 m

***Diagnosis:*** Long slender body with annulated cuticle. Amphids large, circular in shape. Spicules 23 long, paired, arcuate and strongly sclerotised. Gubernaculum with apophyses. Tail conical.

### Genus *Valvaelaimus* Lorenzen, 1977

*Valvaelaimus* sp

**Plate 22 (K)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Cuticle striated. Anterior sensilla in two crowns; six papilla, ten setae with six outer labial longer than four cephalic setae and two extra lateral setae. Amphids circular with a round opening at the middle and slightly placed to the dorsal side. Lip region relatively flat. Buccal cavity equipped with three relatively large tooth-like structures. Two gonads in each sex. Anterior gonad to the left of intestine; posterior gonad to the right. Three caudal glands opening into separate pores. Tail conical without terminal setae.

### Genus *Xenolaimus* Cobb, 1920

*Xenolaimus striatus* Cobb 1920

**Plate 22 (L)**

***Collection locations:*** Cape Comorin 1000m; Trivandrum 1000 m; Kollam 500m ***Diagnosis:*** Body length is 2.5 mm. Cuticle coarsely striated ornamented with the first cuticular annule being wider than the rest; ornamentation consisting longitudinal rows of V-shape structures. Head set-off, protusible, diameter is 26 µm. Lips 7 µm high flap like. Labial setae are 6 µm long. Ten cephalic setae, the longer ones measuring more than 17 µm. Buccal cavity is wide and deep with two weakly cuticularised teeth. Amphids placed in enlarged portion of the fifth cuticular annule. Spicula are symmetrical, 30 µm long. Apophyses of gubernaculums are also asymmetrical, 19 µm long. Tail is long, conical.

### Genus *Xyala* Cobb, 1920

*Xyala* sp

**Plate 22 (M)**

***Collection locations:*** Cape Comorin 200 m

***Diagnosis:*** Body slender, attenuating towards ends. **C**uticle coarsely striated with rectangular projections aligned in longitudinal rows to form ridges; each annule with 28 ridges. More ridges around region of amphids there are, whereas on tail there are 8 ridges only. Lips high, hyaline without protusions and jointed; buccal cavity rectangular to conical with cuticularized walls and surrounded by oesophageal musculature. Somatic setae very slender, 20-30 μm long. Amphids circular in outline. Six labial setae 8 μm long and a circle of twelve cephalic setae where six setae are 23 μm long and six setae 17 μm long; six subcephalic setae 13 μm long. Spicules slightly bent, proximally cephalated, 38 μm; gubernaculum with a weakly cuticularized dorso-caudal apophysis. No preanal supplements. Three caudal gland cells with a granular secretion; tail tip with three separate outlets.

### Family Sphaerolaimidae Filipjev 1918

### Genus *Metasphaerolaimus* Gourbault & Boucher, 1981

*Metasphaerolaimus cancellatus* Gourbault & Boucher, 1981

**Plate 22 (N)**

***Collection locations:*** Ratnagiri 500 m, 1000 m

***Diagnosis:*** Large stout body of 1.5 mm. Body relatively wide, finely annulated, each ring with transverse rows of spines. Somatic setae long 11 μm. Head truncated triangular. Cephalic setae 18 μm long inserted on short peduncles. Amphids large vesicular. Buccal cavity large and armed with cheilorhabdions. Spicules slightly bent, thick and strongly sclerotized. Gubernaculum simple, plate like. Tail conicocylindrical with 3 terminal setae.

*Metasphaerolaimus inglisi* Gourbault & Boucher, 1981

**Plate 23 (A)**

***Collection locations:*** Mangalore 200m; Karwar 500 m; Mumbai 1 1000 m,

***Diagnosis:*** Total length of the body 1.3 mm. Body relatively thick and wide. Cuticle finely striated. Buccal cavity large. Amphid small and circular. Six inner labial papillae; six outer labial setae at the same level of four longer cephalic setae; eight groups of several subcephalic setae. Few cervical setae. Amphids circular, placed posterior to the buccal cavity. Buccal cavity strongly cuticularized with six H-shaped mandibles, hooked anteriorly and articulating on solid base plates posteriorly. Pharynx cylindrical with sclerotized lumen. Ovary single and anteriorly outstretched. Tail conicocylindrical with 3 terminal setae.

### Genus *Sphaerolaimus* Bastian 1865

*Sphaerolaimus crenellatus* Warwick, 1973

**Plate 23 (B)**

***Collection locations:*** Ponnani 1000 m; Coondapur 1000 m

***Diagnosis:*** Cuticle with fine tansverse striations without lateral differentiation. Mouth is surrounded by 6 triangular lip flaps. At the base of each lip flap are 6 minute conical labial papillae. More posteriorly there are 10 cephalic papillae. Sub cephalic setae are arranged in 8 groups with between two and four setae in each group. 10 groups of cervical setae, eight triplets correspond in position with the cephalic setae and are unequal in length. Eight groups of longer setae extend backward from the head. Mouth open in to small globular vestibule which leads by a conical passage boardered crown of 40 cheilorhabdions to a heavily cuticularised buccal cavity. Amphids circular. Sextual dimorphism in the shape of amphid. Spicules paired and equal. They are divided in the middle by a suture with distal projection which is laterally curved. Gubernaculum with poorly cuticularised dorsal apophyses.

*Sphaerolaimus dispar* Filipjev, 1918

**Plate 23 (C)**

***Collection locations:*** Coondapur 200 m; Ponnani 200 m; Karwar 200 m

***Diagnosis:*** Total length of the animal 1.3 mm. Body finely annulated. Two sets of labial setae crown. Buccal cavity large and armed and supported by longitudinal bars. Amphids circular and small. Spicule, short, slender, bluntly pointed at both extremities. Gubernaculum complicated with apophyses. Tail elongate conical.

*Sphaerolaimus glaphyrus* Vitiello, 1971

**Plate 23 (D)**

***Collection locations:*** Kannur 200 m; Coondapur 200 m; Karwar 200 m, 500m; Ratnagiri 500 m, 1000 m

***Diagnosis:*** Large stout body of 1.6 mm. Anterior end attenuated. Cephalic setae arranged in groups. Buccl cavity typical of the genus with armature. Amphid posterior to buccal cavity, small and round. Spicule 70 µm long, arcuate and strongly sclerotized with a proximal capitulum. Gubernaculum small, triangular with dorsal apophyses.

*Sphaerolaimus gracilis* de Man, 1876

**Plate 23 (E)**

***Collection locations:*** Dhabol 500 m

***Diagnosis:*** Total length of the body 1 mm. Head conical with crown of labial setae. Amphid lower to buccal cavity, circular in shape. Spicules thick and arcuate. Proximal capitulum not developed or open. Gubernaculum with long apophyses. Tail cylindrical with swollen tip and three caudal setae.

*Sphaerolaimus macrocirculus* Filipjev, 1918

**Plate 23 (F)**

***Collection locations:*** Kochi 200 m; Ratnagiri 200 m, 500 m; Dhabol 500 m; Mumbai 1 1000 m; Veravel 1000 m; Porbandar 200 m

***Diagnosis:*** Body length is 1.2 mm. Cephalic setae are 5.2 µm long. Amphids are round, 17 µm long situated level with the base of the cephalic capsule. Spicules are 140 µm long and slender. Gubernaculum is with a strongly curved apophysis. Pre cloacal supplements consisting of raised pores. Tail long, anterior two thirds conical, remainder is cylindrical. Longer terminal setae are also present.

### Family: Siphonolaimidae Filipjev 1918

### Genus *Siphonolaimus* De Man, 1893

*Siphonolaimus ewensis* Warwick & Platt, 1973

**Plate 23 (H)**

***Collection locations:*** Cape Comorin 200 m, 500 m, 1000m; Trivandrum 200 m, 500 m, 1000m; Coondapur 200 m; Dhabol 1000 m; Mumbai 2 200 m

***Diagnosis:*** Long slender body 3.5 mm. Cuticle transversely striated. Ten cephalic setae; submedian pairs 22 µm. Circle of 6 subcephalic setae level with anterior border of amphids, 16 µm long. Amphids thick walled, circular, 17 µm diameter. Buccal cavity with axial spear 63 µm long. Posterior half of oesophagus dilated. Intestine full of opaque granules. Setae sparse on mid-body region, becoming more numerous on tail. Spicules long, arcuate, cephalate proximally and with weakly cuticularised ventral alae. The dorso-caudal apophysis of the gubernaculum is 30 µm long. On either side of the gubernaculum there is a well cuticularised lateral swelling with a cup-shaped distal end. There are six prominent setose pre-cloacal supplements. Tail conical.

*Siphonolaimus elongatus* (Schuurmans Stekhoven, 1950) Vitiello, 1971

**Plate 23 (G)**

***Collection locations:*** Cape Comorin 500 m; Trivandrum 200 m; Dhabol 200 m, 500m; Mumbai 2 200 m; Porbandar 200 m

***Diagnosis:*** Body elongated 3.2 mm. Head truncate with distinct lips and four cephalic setae. Cuticle striated. Buccal cavity containing an axial cuticularized spear-like structure. 6+ 4 cephalic setae situated more or less at the same level, the six always shorter than the four. Amphids circular. Single anterior testis. Tail elongate and tapering with a long spinneret.

### *Siphonolaimus obscurus* Boucher & Helléouët, 1977

**Plate 23 (I)**

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Total body length of the animal 3.6 mm. Cuticle faintly striated difficult to distinguish. Amphid, large, circular in shape. Spicule arcuate with proximal cephalisation. Gubernaculum with triangular apophyses. Tail conical.

### *Siphonolaimus profundus* Warwick, 1973

**Plate 23 (J)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Cuticle is marked with fine transverse striations. The head bears circle of 10 cephalic setae of which four larger and stouter than the remaining six. Two sets of four short setaeare positioned just just anterior and to and posterior to amphids. Amphids circular in outline but its margin is expanded along the posterior edge. Buccal cavity typical of the genus with long cuticularised axial spear. Oesophagus is expanded posteriorly in to an elongated bulb. Spicules paired, equal and arcuate with a central list which occupies their proximal two thirds. Gubernaculam with strong apophyses. Tail conical.

## Family Linhomoeidae Filipjev 1922

## Genus *Desmolaimus* De Man, 1880

### *Desmolaimus greenpatchi* Allgén, 1959

**Plate 23 (K)**

***Collection locations:*** Cape Comorin 500m, 1000 m; Trivandrum 1000 m; Kollam 200 m, 1000 m; Kochi 200 m, 500 m, 1000 m; Ponnani 200 m, 1000 m; Coondapur 200 m; Karwar 200 m, 1000m; Goa 1000 m; Ratnagiri 1000 m; Dhabol 200 m, 500m; Veravel 200 m, 1000m

***Diagnosis:*** Cuticle finely annulated. Head rounded, at the front end truncate. Cephalic setae situated far anteriorly, consisting of 4 pairs of submedian setae, the posterior setae of each pair much smaller than the anterior setae. Buccal cavity broad. Oesophagus short, with a large but weakly demarcated bulb. Spicules short, clumsy, at the middle strongly and irregularly curved kneelike. Gubernaculum with an apophysis directed dorsally and posteriorly. Tail ventrally curved, tapering gradually. In males, the tail weakly swollen with rounded end tip.

### *Desmolaimus zosterae* Allgén, 1933

**Plate 24 (A)**

***Collection locations:*** Kollam 1000m; Kannur 1000 m

***Diagnosis:*** Body cylindrical, tapering slightly towards both extremities. Cuticle annulated from posterior of mouth cavity. Head almost flat. Buccal cavity relatively large, 5-7 µm deep with cuticularised base and two cuticularised transverse rings. The two transverse rings touch each other, with posterior ring wider than anterior ring. Four 15 µm long cephalic setae. Eight 4-6 µm long sub-cephalic setae. Amphideal fovea circular. Pharynx slightly dilated in front, lumen cuticularised, ovoid oesophageal bulb. Cardia long, with slightly cuticularised lumen. Single anterior outstretched testis. Spicules equal, curved, 27 µm, more thickly cuticularised on dorsal side. Gubernaculum with paired dorso-caudal apophyses of 10-12 µm length. Tail conical with two sub-ventral rows of short setae and 2-4 short setae on dorsal side.

## Genus *Didelta* Cobb, 1920

### *Didelta scutata* Wieser, 1954

**Plate 24 (B)**

***Collection locations:*** Trivandrum 500 m; Kannur 1000 m; Ponnani 1000 m; Mumbai 2 200 m, 500m

***Diagnosis:*** Body length is 1.6 mm. Cuticle finely striated. Head diameter is 21 µm. Labial papillae are indistinct. Ten cephalic setae are present. Longer setae 7.2 µm and shorter ones 3.6 µm long. Cervical setae 4, at the level with anterior, 4 on level with posterior portion of oval amphids. Cuticle is striated. Amphids 24.9 µm long on a cuticularized triangular basal plate. Oesophagus dilated posteriorly without bulb. Two outstretched ovaries. Spicules short arcuate. Apophysess oriented caudally.Tail filiform.

## Genus *Disconema* Filipjev, 1918

### *Disconema sp*

**Plate 24 (C)**

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 500 m, 1000m; Kollam 200m; Kochi 200 m, 1000 m; Coondapur 200 m; Goa 200 m; Mumbai 1 1000 m; Mumbai 2 200 m; Veravel 200 m; Porbandar 200 m

***Diagnosis:*** Cuticle striated. Outer labial and cephalic sensilla in one crown at the anterior-most end. Sensilla setiform, the outer labial setae longer than cephalic setae. Additional four subcephalic setae or papilla at the level of amphids. Amphids mostly oval with an inner oval lining. Buccal cavity minute. Pharynx weakly muscular enlarging at the posterior end. Cardia large and usually elongated.Two outstretched ovaries. Spicules short and arcuate. Apophyses oriented caudally. Tail conicocylindrical.

### Genus *Eleutherolaimus* Filipjev 1922

*Eleutherolaimus hopperi* Timm, 1967

**Plate 24 (D)**

***Collection locations:*** Kannur 200 m

***Diagnosis:*** Head truncated and not offset from the body. Cephalic setae arranged in two separate circles. Amphids circular. No somatic setae posterior to the posterior cephalic crown. Male gonads paired; anterior testis straight and posterior testis reflexed. Spicules short, arcuate, distally acute and proximally widened with slightly developed knobs. Gubernaculum with dorso-caudal apophysis. No preanal supplementary organs. Tail cylindro-conical to cylindrical with rounded tip.

*Eleutherolaimus nutus* Gerlach, 1964

**Plate 24 (E)**

***Collection locations:*** Cape Comorin 500 m, 1000 m

***Diagnosis:*** Filiform body 2.3 mm long and head truncated and not offset from the body. Cephalic setae arranged in two separate circles. Amphids circular with fine but distinct rim broken at posterior side. No somatic setae posterior to the posterior cephalic crown. Spicules thick, short, arcuate and proximally widened with slightly developed knobs. Gubernaculum with a caudal apophysis. No preanal supplementary organs. Tail elongate, cylindro-conical to cylindrical, with rounded tip.

### Genus *Linhomoeus* Bastian, 1865

*Linhomoeus filaris* Lorenzen, 1973

### Plate 24 (F)

***Collection locations:*** Cape Comorin 200 m, 1000m; Ponnani 200 m; Veravel 200 m

***Diagnosis:*** Body very long 3.5 mm and filiform. Cuticle finely striated. Head bluntly rounded, furnished with a circle of eight setae. Amphids circular in outline, cryptospiral, usually with a broken shape and inner circular lining. Buccal cavity cup-shaped, more or less sclerotized, sometimes divided by a cuticular ring, having three thin horny laminae continued backwards with rounded and minutely serrated edges. Spicules of moderate length 25 µm, curved, accessory pieces thin, flat, blade-like.

## Genus *Megadesmolaimus* Wieser, 1954

*Megadesmolaimus contortus* Timm, 1962

### Plate 24 (G)

***Collection locations:*** Kollam 200m

***Diagnosis:*** Length of the animal 2.8 mm, body usually coiled, faintly striated. Head not set off. Four cephalic setae and two groups of four cervical setae. Amphid crypto spiral in outline with thickly sclerotized walls. Buccal cavity sclerotized, asymmetrical and ventral side more deep. Spicules arcuate, 35 µm long with ventrally inclined capitulum. Gubernaculum broad, encircling with a dorsal apophyses. Tail conico cylindrical with out swollen tip.

*Megadesmolaimus falcatus* Gerlach, 1963

### Plate 24 (H)

***Collection locations:*** Mumbai 1 200 m

***Diagnosis:*** Body 1.7 mm long and coiled, faintly striated. Head not set off. Four cephalic setae. Amphid large, circular in outline with thickly sclerotized walls. Buccal cavity heavily sclerotized, asymmetrical. Spicules arcuate, small, 30 µm long with proximal cephalisation. Gubernaculum broad with a dorsocaudally directed apophyses. Tail conico cylindrical with out swollen tip.

*Megadesmolaimus uncinatus* Gerlach, 1963

### Plate 24 (I)

***Collection locations:*** Trivandrum 200 m

***Diagnosis:*** Body long 3.4 mm. Cuticle faintly striated. Spicules thick 45 µm heavily sclerotized with faint cephalisation. Gubernaculum broad with a dorsocaudally directed apophyses. Tail conico cylindrical with out swollen tip.

### Genus *Metalinhomoeus* De Man, 1907

*Metalihomoeus gracilis* (Kreis, 1929) Wieser, 1956

**Plate 24 (J)**

***Collection locations:*** Mangalore 200 m; Mumbai 1 200 m; Goa 200 m

***Diagnosis:*** Body very long 2.7 mm, slender and evenly thick. Cuticle with fine annulations. Head rounded with 2 lateral and 4 submedian setae. Amphids broken circular shaped. Buccul cavity typical of the genus. Oesophagus with intermediate bulb. Tail tapering. Spicules short 16 µm, clumsy thickest at proximal end without cephalisation and tapering distally. Gubernaculum with dorsocaudal apophyses.

*Metalinhomoeus biformis* Juario, 1974

**Plate 24 (K)**

***Collection locations:*** Cape Comorin 200 m; Veravel 200 m; Mumbai 1 1000 m

***Diagnosis:*** Long slender body of 2.4 mm. Oesophagus with intermediate bulb. Spicules short 13 µm, clumsy thickest at proximal end without cephalisation and tapering distally. Gubernaculum triangular plate like with dorsocaudal apophyses. Tail tapering.

*Metalinhomoeus effilatus* Schuurmans Stekhoven, 1942

**Plate 24 (L)**

***Collection locations:*** Ratnagiri 1000 m

***Diagnosis:*** Body long, thin 2.5 mm in length. Head flattened anteriorly with four long setae. Amphids cryptospiral. Buccal cavity long cylindrical. Tail filiform with long flagellum. Short thick, curved spicula. Gubernaculum simple with dorsal apophyses.

### Genus *Paralinhomoeus* De Man 1907b

*Paralinhomoeus anteporus* Vitiello, 1969

**Plate 25 (A)**

***Collection locations:*** Dhabol 1000 m; Porbandar 200 m

***Diagnosis:*** Long thin body faintly striated 1.7 mm.Attenuating both ends. 6 Labial papillae. Amphid circular with interruption posteriorly and plaque in the centre. Buccal cavity assymetrical with sclerotisation. Spicule 22 µm long curved, proximal end more thicker with pointing distal end. Gubernaculum with 17 µm long dorsocaudal apophyses.

### *Paralinhomoeus appendixocaudatus* Allgén, 1959

### Plate 25 (B)

***Collection locations:*** Mumbai 1 500 m; Veravel 200 m, 500m

***Diagnosis:*** Body moderately slender long thin body faintly striated 3.4 mm. Cuticle thin, smooth. Head truncate torounded with rather short and slender submedian bristles. Buccal cavity bordered by thick walls, in structure typical. Oesophagus short and thick, posteriorly strongly bulb-like swollen. Very characteristic of this species is its tail, being cylindrical in its proximal part, but in its distal part, very remarkably shaped, strongly thinned, evenly thick, posteriorly rounded, on the whole similar to a mammal coecum with its appendix. In the tail, the thinned part makes 2/3 of the anterior cylindrical part. Immediately behind the rectum there are 3 caudal glands.

### *Paralinhomoeus brevicaudatus* Schuurmans Stekhoven, 1950

### Plate 25 (C)

***Collection locations:*** Cape Comorin 200 m; Dhabol 200 m; Veravel 200 m

***Diagnosis:*** Body 2.1 mm long. Head rounded anteriorly and slightly swollen. Cephalic setae long 20 in number arranged in a single crown. Amphid large and circular. Buccal cavity divided in to three parts vestibulum formed of long ridges, mesosome with cuticularised walls leading to oesophagus. Tail short and blunt rounded posteriorly.

### *Paralinhomoeus conspicuus* Gerlach, 1957

### Plate 25 (D)

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Long slender body. Anterior end rounded. Long labial as well as cephalic setae. Buccal cavity small. Amphid large almost as the corresponding body diameter. Spicule short, thin with poorly formed capitulum. Gubernaculum simple triangle shaped apophyses. Tail short cylindrical.

### *Paralinhomoeus fuscacephalus* (Cobb, 1920) Gerlach, 1963

### Plate 25 (E)

***Collection locations:*** Cape Comorin 1000 m; Trivandrum 500 m; Kollam 200m; Ponnani 1000 m; Dhabol 200 m, 500m; Coondapur 200 m, 1000 m

***Diagnosis:*** Body elongated 2.5 mm in total length. Jointed longer cephalic setae. Numerous cervical setae. Amphid small with cuticularised wall. Spicule arcuate with simple plate like gubernaculum. Tail conococylindrical.

### *Paralinhomoeus longisetosus* Schuurmans Stekhoven, 1950

### Plate 25 (G)

***Collection locations:*** Cape Comorin 200 m, 1000m; Trivandrum 500 m; Kollam 200m; Ponnani 500 m; Dhabol 500 m; Karwar 200 m; Coondapur 500 m, 1000 m; Mumbai 2 500 m

***Diagnosis:*** Long slender body of 2.4 mm with fine annulations. Head rounded with distinct labial papillae. Cephalic setae 12 in number of which the dorsal and ventral are long. Amphids circular. Buccal cavity wide composed of two cylindrical portions with cuticularisation. Tail elongate conical.

*Paralihomoeus meridionalis* (Cobb, 1930) Wieser, 1956

### Plate 25 (H)

***Collection locations:*** Dhabol 200 m

***Diagnosis:*** Transparent cuticle with fine transverse striae, very hard to discern. Ten cephalic setae, at least the longer submedian ones are jointed, no subcephalic or cervical setae. Simple wide pharynx. When seen dorso-ventrally, the amphids appear as depressions with a well-cutinized lining, the bottom part of which is somewhat rounded up in the center. Two equal straight spicule. Rather slender but strong with simple accessory pieces joined behind and surrounding the spicula near the anus. The very inconspicuous, equidistant, preanal, ventral supplementary organs extend to opposite the proximal part of the spicula.

*Paralinhomoeus lepturus* DeMan, 1907

### Plate 25 (F)

***Collection locations:*** Coondapur 200 m, 1000 m; Goa 500 m; Veravel 200 m

***Diagnosis:*** Body length is 4 mm. Cuticle is faintly striated. Labial papillae are not clear. 10 Cephalic setae are arranged in six groups; four longer sub median 14 µm; lateral setae slightly shorter than the shorter sub median ones. Amphids are 9 µm long with central dots. Buccal cavity is cup shaped with dorsal tooth like structure. Oesophagus widens in the posterior third. Tail is conicocylindrical.

### Genus *Terschellingia* Man, 1888

*Terschellingia baylisi* Allgén, 1959

### Plate 25 (I)

***Collection locations:*** Kollam 200m; Kochi 200 m

***Diagnosis:*** Body evenly thick throughout 3 mm long. Cuticle finely annulated. Head rounded, with 4 short, slender submedial bristles. Buccal cavity small. Oesophagus very short and thick with a very large, strongly muscular bulb. Spicules short, slender, strongly curved posteriorly pointed. Accessory piece partly in the shape of an elongated arch like formation, partly as an apophysis. Tail short, cylindro-conical, posteriorly rounded.

*Terschellingia brevicauda* Ott, 1972

**Plate 25 (J)**

***Collection locations:*** Goa 200 m, 1000 m

***Diagnosis:*** Body stout fusy form, 1.4 mm. Cuticle smooth. Cephalic setae 6+4 and eight cervical setae. No somatic setae found. Amphids circular. Stoma small and cylindrical. Male with single out stretched testis. Spicula 44 µm long strongly cephalate. Gubernaculum with apophyses. Tail conical.

*Terschellingia claviger* Wieser, 1956

**Plate 26 (A)**

***Collection locations:*** Kollam 200m; Kochi 200 m

***Diagnosis:*** Body long 1.6 mm. Cuticle finely striaed. Labial papillae small. Cephalic setae 3 µm long. One circle of cervical setae arranged posterior to amphid. Large circular amphid with thick walls. Buccal cavity absent, only vestibulum present. Oesophagus without true bulb. Spicule 75 µm long, arcuate with a short central list. Cephalisation present proximally. Gubernaculum with 26 µm long dorsal apophyses. Tail long filiform.

*Terschellingia communis* De Man 1888

**Plate 26 (B)**

***Collection locations:*** Trivandrum 500 m; Kollam 200m, 1000 m; Kannur 200 m, 1000 m; Mumbai 2 200 m

***Diagnosis:*** Body length is 1.7 mm. Cuticle is transversely striated, six conical cephalic papillae. Four 3 µm cephalic setae are placed at level with the amphids. Four 2.5 µm are sub cephalic setae are present posterior to the amphids. Somatic setae are absent apart from the tail. Amphids are 7 µm in diameter. Buccal cavity absent. Oesophagus is with a prominent rounded posterior rounded bulb and long cardia projecting in to the lumen of the oesophagus. Anterior half of tail is conical and posterior half filiform.

*Terschellingia distalamphida* Juario, 1974

**Plate 26 (C)**

***Collection locations:*** Trivandrum 200 m, 500 m; Kollam 200m , 1000 m; Goa 200 m;  Mumbai 1 200 m; Mumbai 2 200 m; Ratnagiri 200 m

***Diagnosis:*** Body 1.8 mm elongate, slender and fusiform. The anterior end oblique and slightly narrowed. Cuticle optically not striated and smooth. Four cephalic setae, 4 µm in length. Amphid circular and distinctly sclerotized. No cervical setae. Spicules paired, equal, arcuate, with proximally cephalization and tapered distally. Gubernaculum short, with caudal apophysis. Tail elongate, with three caudal glands.

*Terschellingia filicaudata* Wang, Ligou An and Huang, 2017

**Plate 28 (F)**

***Collection locations:*** Cape Comorin 500 m

***Diagnosis:*** Large body with short cephalic setae. Cup-shaped small buccal cavity. Pharyngeal posterior end bulb is absent. Spicules slender with hooked cephalisation proximally. Tail elongated with long filiform portion.

*Terschellingia lissa* Timm, 1962

**Plate 26 (D)**

***Collection locations:*** Mumbai 1 1000 m

***Diagnosis:*** Body long, tapering at anal end. No prominent striation on cuticle is seen. Head not set off. Six labial papillae. Cervical setae not found. Circular amphid placed anteriorly with thin walls. Spicules with broad expanded capitulum 35 µm long. Gubernaculum with a short conical piece and dorsal apophyses. Tail cylindrical, slightly swollen with rounded tip.

*Terschellingia longicaudata* DeMan 1907

**Plate 26 (E)**

***Collection locations:*** Cape Comorin 1000 m; Kollam 200m , 500m; Kochi 1000 m; Ponnani 200 m; Kannur 200 m, 500 m, 1000 m; Coondapur 200 m; Mumbai 1 200 m, 1000 m; Mumbai 2 200 m; Veravel 200 m

***Diagnosis:*** Cuticle is striated. Four 3 µm long cephalic setae. Four 4 µm sub cephalic setae are situated either side of the amphid. A pair of cervical setae are placed behind each amphid. Somatic setae absent, except in the tail. Amphids are 7 µm diameter. Buccal cavity is absent. Oesophagus is with a prominent round bulb. Long cardia is projecting in to the intestine. Spicules are 39 µm with a short central lamella in the broad proximal portion. Gubernaculum is with a pair of 21 µm, dorsal apophyses. Tail is long filiform tip consisting 75% of total tail length.

*Terschellingia mora* Gerlach, 1956

**Plate 26 (F)**

***Collection locations:*** Cape Comorin 500 m; Karwar 200 m; Porbandar 200 m

***Diagnosis:*** Total length of the body 1.15 mm. Very fine cuticular striation. Truncated head with fused lips. Inner circle of tiny 6 labial setae. Cervical setae absent. Amphid circular in shape. Stoma shallow. Spicules 40 µm long. With a ventrally inclined capitulum. Gubernaculum with short piece around spicule and a dorsal apophyses. Tail conicocylindrical.

*Terschellingia parva* Vitiello, 1969

**Plate 26 (G)**

***Collection locations:*** Cape Comorin 500 m; Ponnani 200 m; Kannur 200 m; Dhabol 200 m, 500m; Mumbai 2 200 m, 500m

***Diagnosis:*** Body fusy form of 873 µm long with filiform tail. Cuticle finely striated. 6 labial setae. Anteriorly placed large circular amphid. Buccal cavity absent instead a small vestibulum present. Spicules 24 µm long, strongly sclerotised with proximal cephalisation. Gubernaculum simple, triangular apophyses pointing dorsocaudal. Tail conicocylindrical without swollen tip.

*Terschellingia viridis* Timm, 1961

**Plate 26 (H)**

***Collection locations:*** Cape Comorin 500 m; Coondapur 200 m, 1000 m

***Diagnosis:*** Body elongated 963 µm long. Cuticle smooth. Head truncate. 6 labial setae and 4 cephalic setae. No cervical setae. Amphid circular in shape and thin walled. Stoma absent instad a shallow vestibulum present. Spicules 30 µm long with proximal capitulum. Gubernaculum with short pieces. Tail conicocylindrical.

PLATE 1

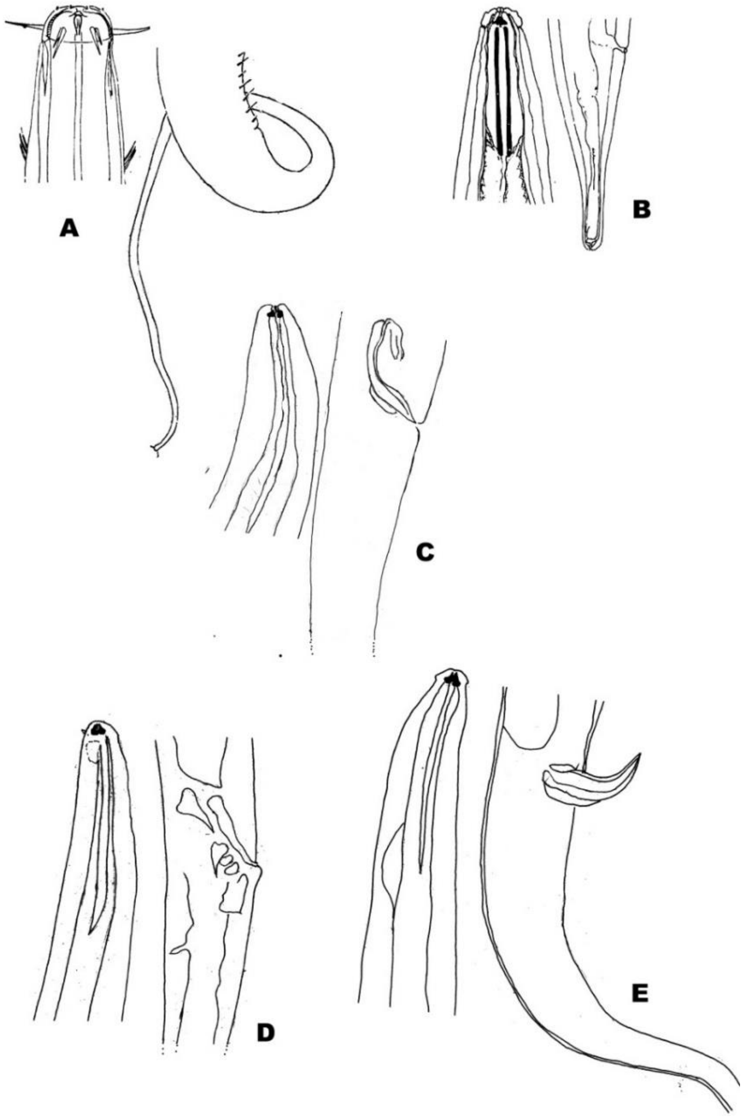


**Plate 1 (A)** *Cephanticoma* sp Platonova, 1976, **(B)** *Dolicholaimus* sp de Man, 1888, **(C)** *Syringolaimus annae* Coelho Lima, Lins, Da Silva & Esteves, 2009, **(D)** *Syringolaimus filicaudatus* Vitiello, 1970**, (E)** *Syringolaimus magdae* Coelho Lima, Lins, Da Silva & Esteves, 2009

## PLATE 2

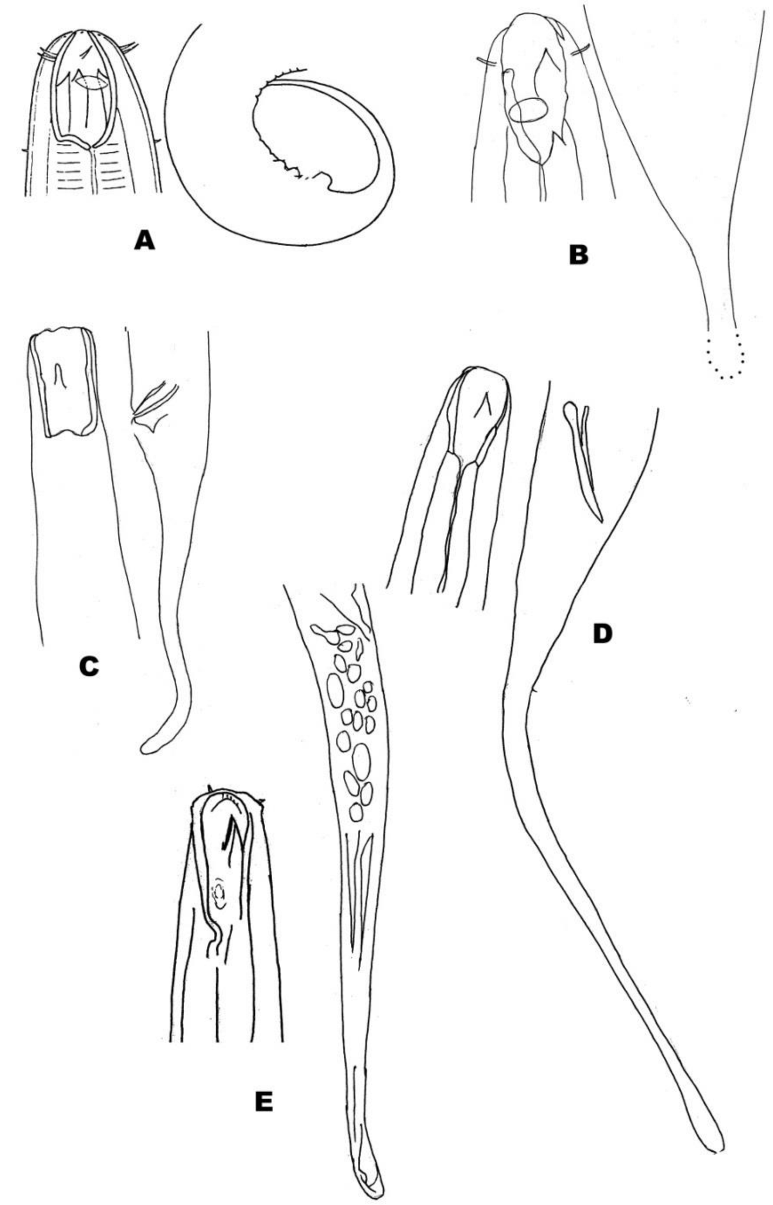


**Plate 2 (A)** *Filoncholaimus* sp Filipjev, 1927, **(B)** *Pontonema* sp Leidy, 1855, **(C)** *Viscosia carnleyensis* Ditlevsen, 1921, **(D)** *Viscosia dubiosa* Kreis, 1932, **(E)** *Viscosia elegans* Kreis, 1924

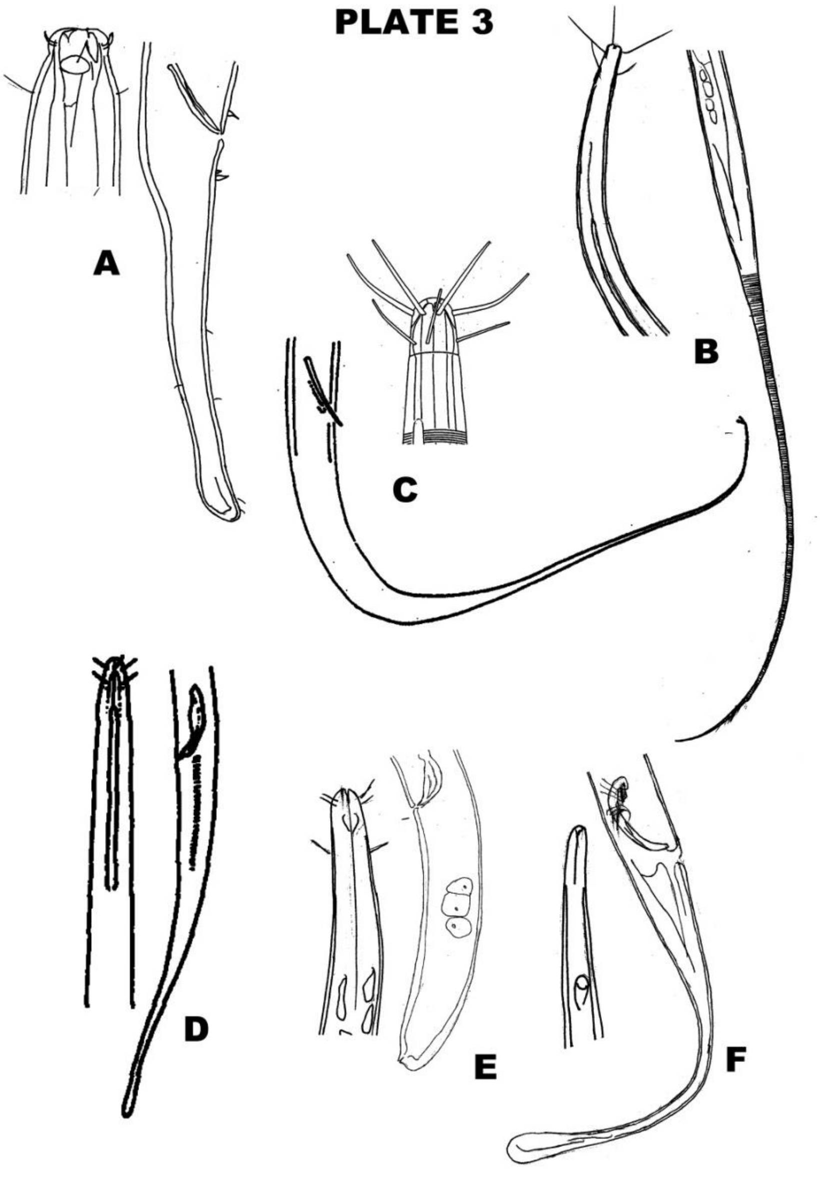


**Plate 3 (A)** *Viscosia franzii* Boucher, 1977, **(B)** *Halalaimus longamphidus* Huang & Zhang, 2005, **(C)** *Halalaimus longicaudatus* (Filipjev, 1927) Schneider, 1939, **(D)** *Halalaimus isaitshikovi* Filipjev, 1927, **(E)** *Litinium bananum* Gerlach, 1956, **(F)** *Oxystomina affinis* Gerlach, 1956

## PLATE 4

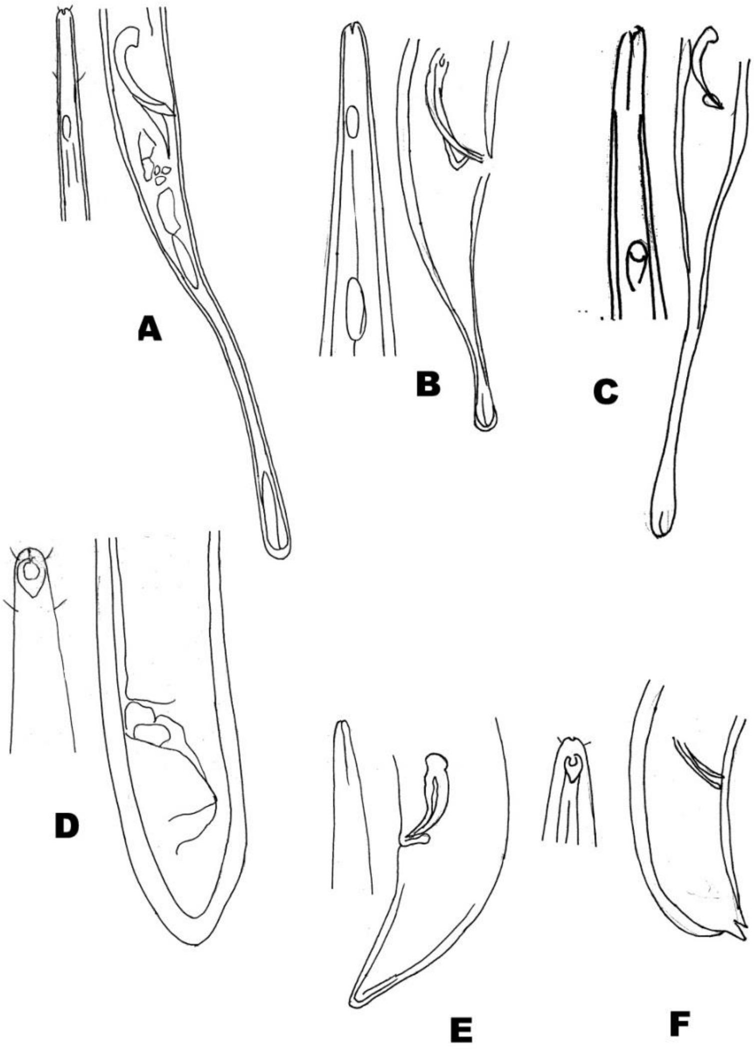


**Plate 4 (A)** *Oxystomina alpha* Chitwood, 1937, **(B)** *Oxystomina asetosa* Southern, 1914, **(C)** *Oxystomina elongata* Butschli, 1874, **(D)** *Thalassoalaimus brevicaudatus* Vitiello, 1970, **(E)** *Thalassoalaimus egregius* Steiner, 1916, **(F)** *Thalassolaimus mediterraneus* Vitiello, 1970

**PLATE 5**

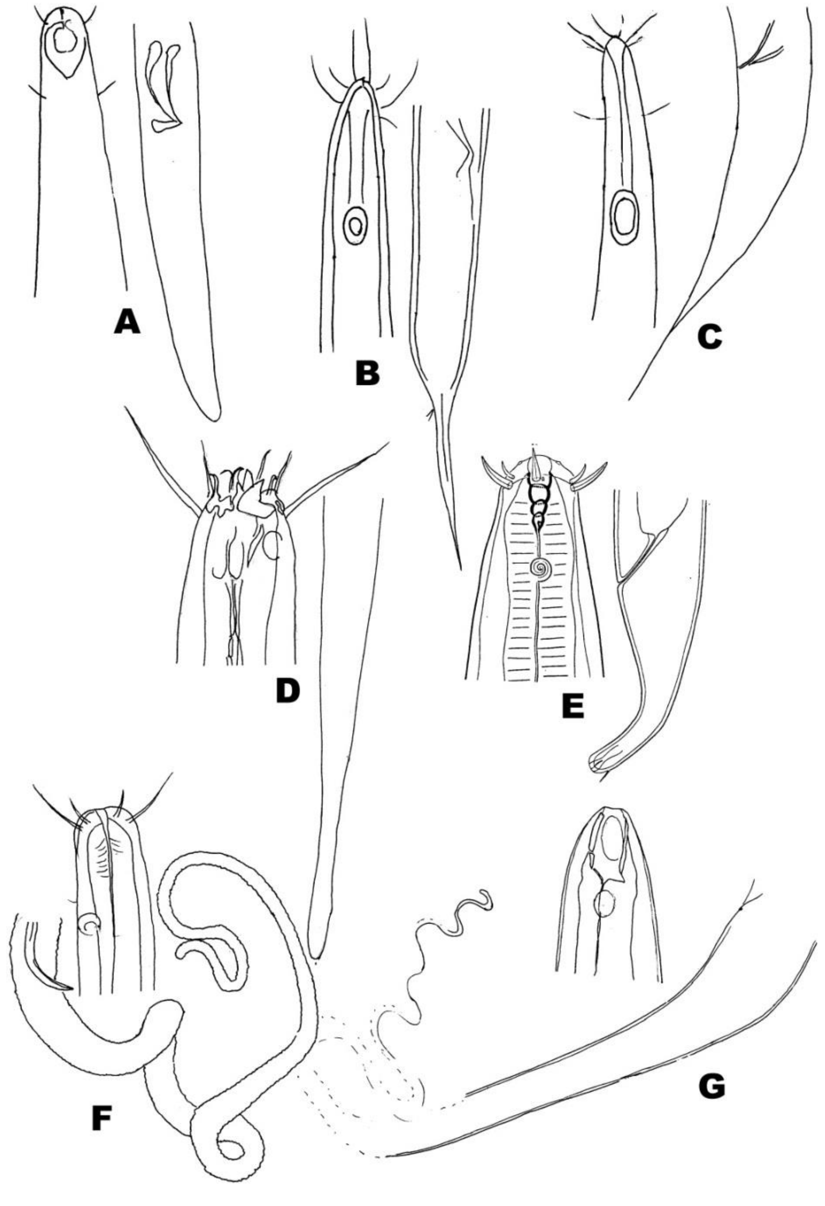


**Plate 5 (A)** *Thalassoalaimus paramontemari* Vitiello, 1970, **(B)** *Weiseria hispida* Vitiello, 1972, **(C)** *Wieseria leptura* Vitiello, 1972, **(D)** *Gairleanema* sp Warwick & Platt, 1973, **(E)** *Tripyloides* sp, **(F)** *Rhabdocoma americana* Cobb, 1920, **(G)** *Halanonchus* sp Cobb, 1920

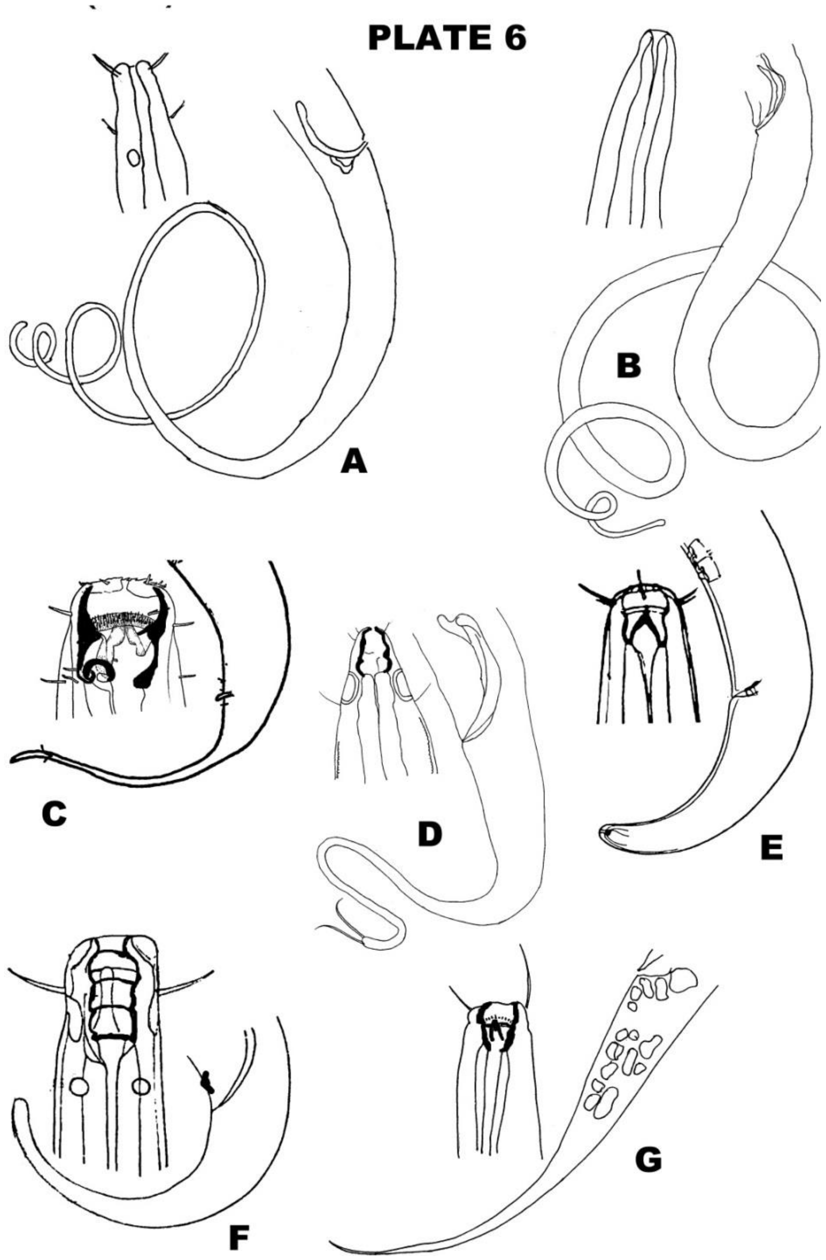


**Plate 6 (A)** *Trefusia* sp De Man, 1893, **(B)** *Trefusialaimus* sp Riemann, 1974, **(C)** *Bathyeurystomina* sp Lambshead & Platt, 1979, **(D)** *Calyptronema* sp Marion, 1870, **(E)** *Eurystomina* sp Filipjev, 1918, **(F)** *Polygastrophora* sp de Man, 1922, **(G)** *Pareurystomina* sp Filipjev, 1921

# PLATE 7

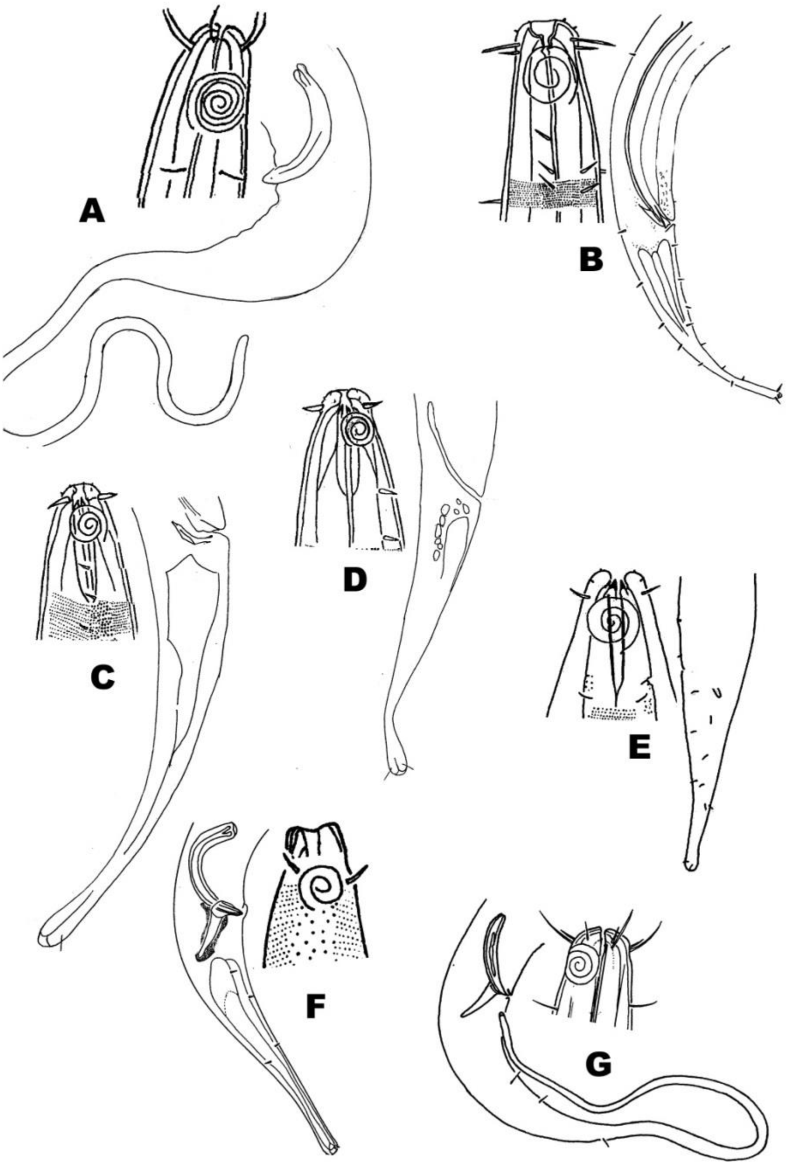


**Plate 7 (A)** *Cervonema gourbaulti* Muthumbi et al., 1997, **(B)** *Comesoma* sp Bastian, 1865, **(C)** *Dorylaimopsis coomansi* Muthumbi et al., 1997, **(D)** *Dorylaimopsis variabilis* Muthumbi et al., 1997, **(E)** *Hopperia* sp Vitiello, 1969, **(F)** *Kenyanema monorchis* Muthumbi et al., 1997, **(G)** *Laimella longicaudata* Cobb, 1920

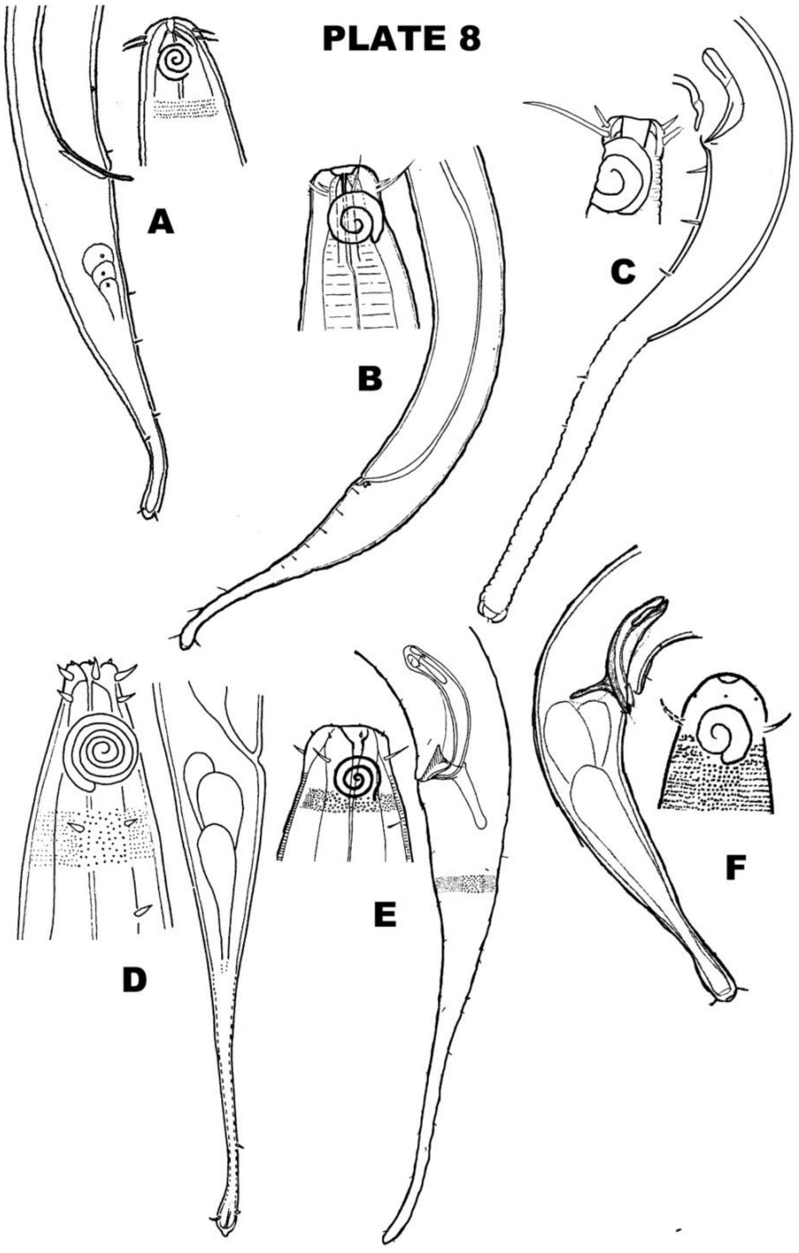


**Plate 8 (A)** *Metacomesoma* sp Wieser, 1954, **(B)** *Paracomesoma longispiculum* Timm 1961 & Hopper, 1967, **(C)** *Paramesonchium mombasi* Muthumbi Soetaert & Vincx, 1997, **(D)** *Pierrickia* sp Vitiello,1970, **(E)** *Sabatieria alata* Warwick, 1973, **(F)** *Sabatieria exilis* Botelho et al., 2009

PLATE 9

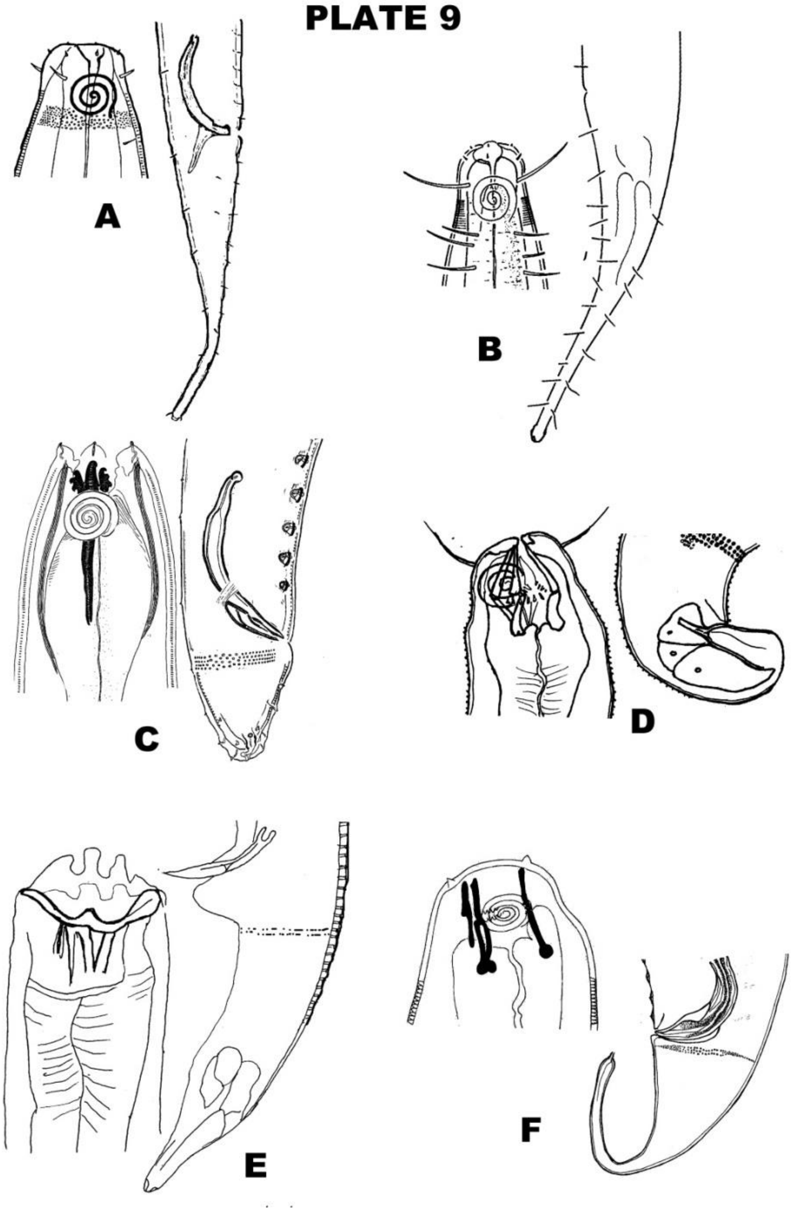


**Plate 9 (A)** *Sabatieria paracupida* Filipjev et al., 1967, **(B)** *Setosabatieria* sp Platt, 1985, **(C)** *Cheironchus vorax* Cobb, 1917, **(D)** *Cobbionema* sp Filipjev, 1922, **(E)** *Gammanema polydonta* Murphy, 1965, **(F)** *Halichoanolaimus consimilis* AlIgen, 1933

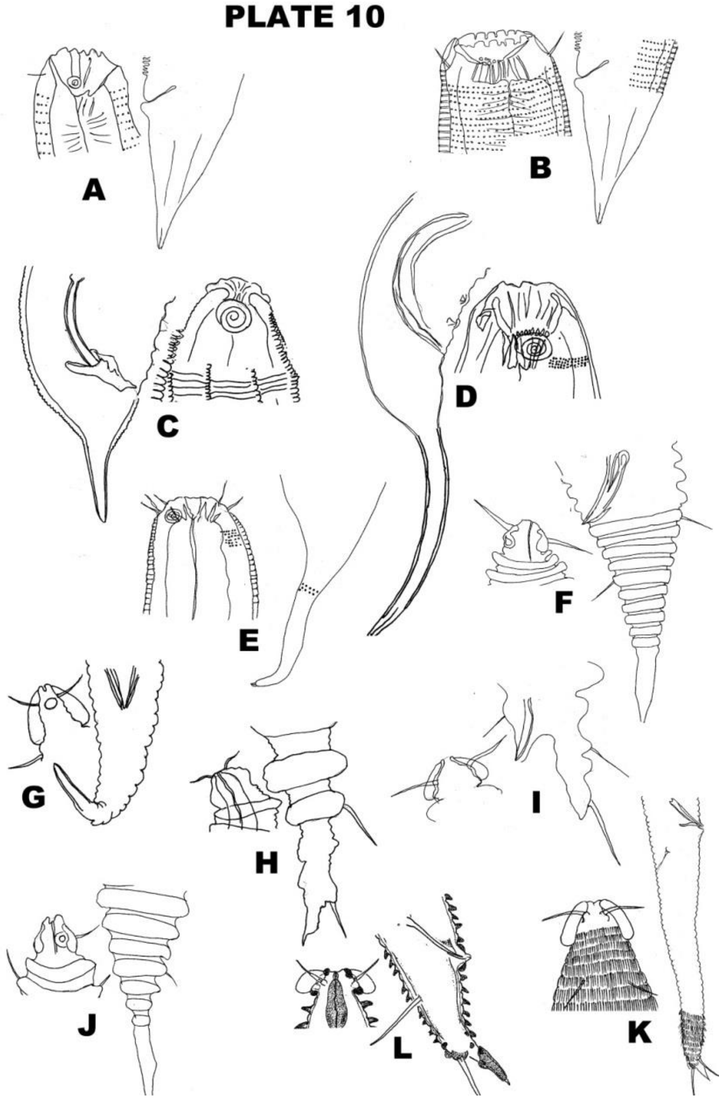


**Plate 10 (A)** *Latronema orcina* Gerlach, 1952, **(B)** *Latronema piratica* Wieser, 1954, **(C)** *Richtersia bathyalis* Soetaert & Vincx, 1987, **(D)** *Synonchiella micramphis* Schuurmans Stekhoven, 1950, **(E)** *Synonchiella riemanni* Warwick, 1970, **(F)** *Desmoscolex abyssorum* Decraemer, 1984, **(G)** *Desmoscolex fennicus* Lorenzen, 1969, **(H)** *Desmoscolex noctuabundus* Bussau, 1993, **(I)** *Desmoscolex pedunculus* Rho et al., 2007, **(J)** *Desmoscolex segonzaci* Decraemer, 1983 **(K)** *Greeffiella pierri* Schrage & Gerlach, 1975, **(L)** *Pareudesmoscolex laciniosus* Lorenzen, 1969

PLATE 11

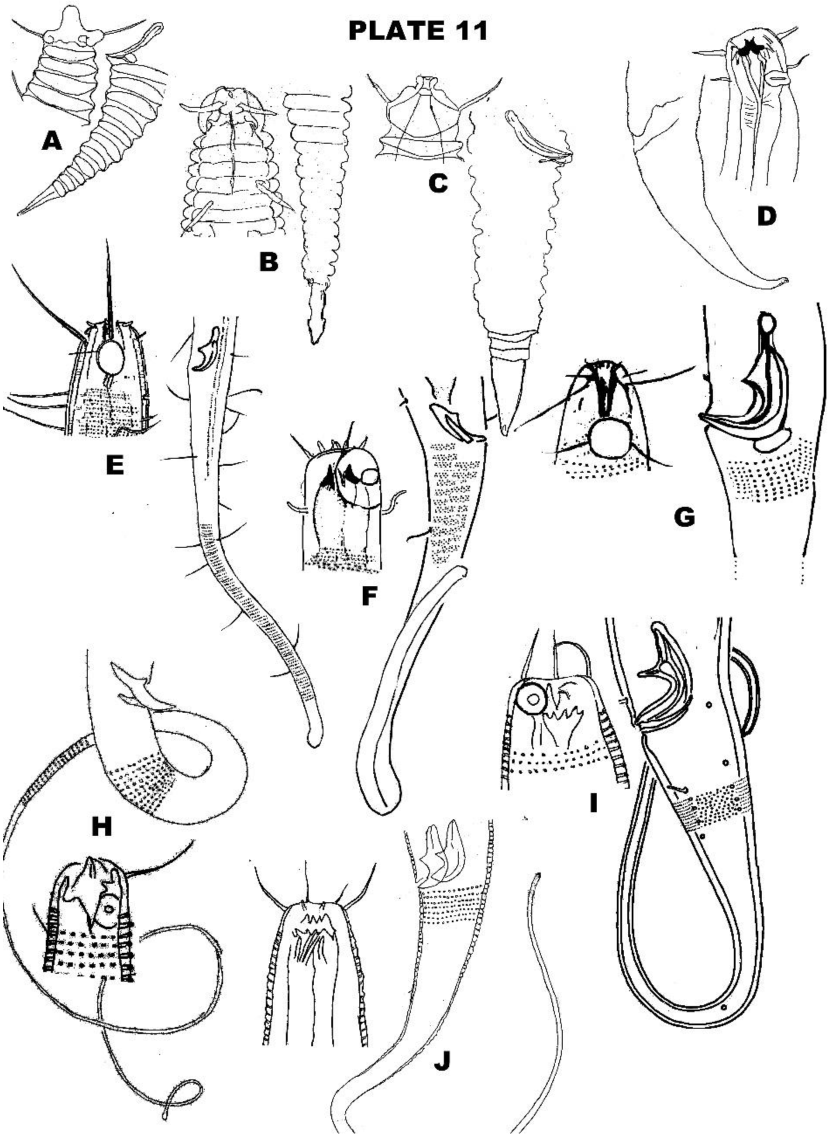


**Plate 11 (A)** *Tricoma brevirostris* Southern, 1914, **(B)** *Tricoma filipjevi* Chitwood, 1951, **(C)** *Tricoma polydesma* Southern, 1914, **(D)** *Harpagonchus* sp Platanova & Potin, 1972, **(E)** *Acantholaimus ewensis* Platt & Zhang, 1982, **(F)** *Acantholaimus formosus* Miljutina et al., 2013, **(G)** *Acantholaimus geraerti* Muthumbi & Vincx, 1997, **(H)** *Acantholaimus invaginatum* Muthumbi & Vincx, 1997, **(I)** *Acantholaimus quintus* Gerlach et al., 1979, **(J)** *Acantholaimus ermeuleni* Muthumbi & Vincx, 1997

PLATE 12

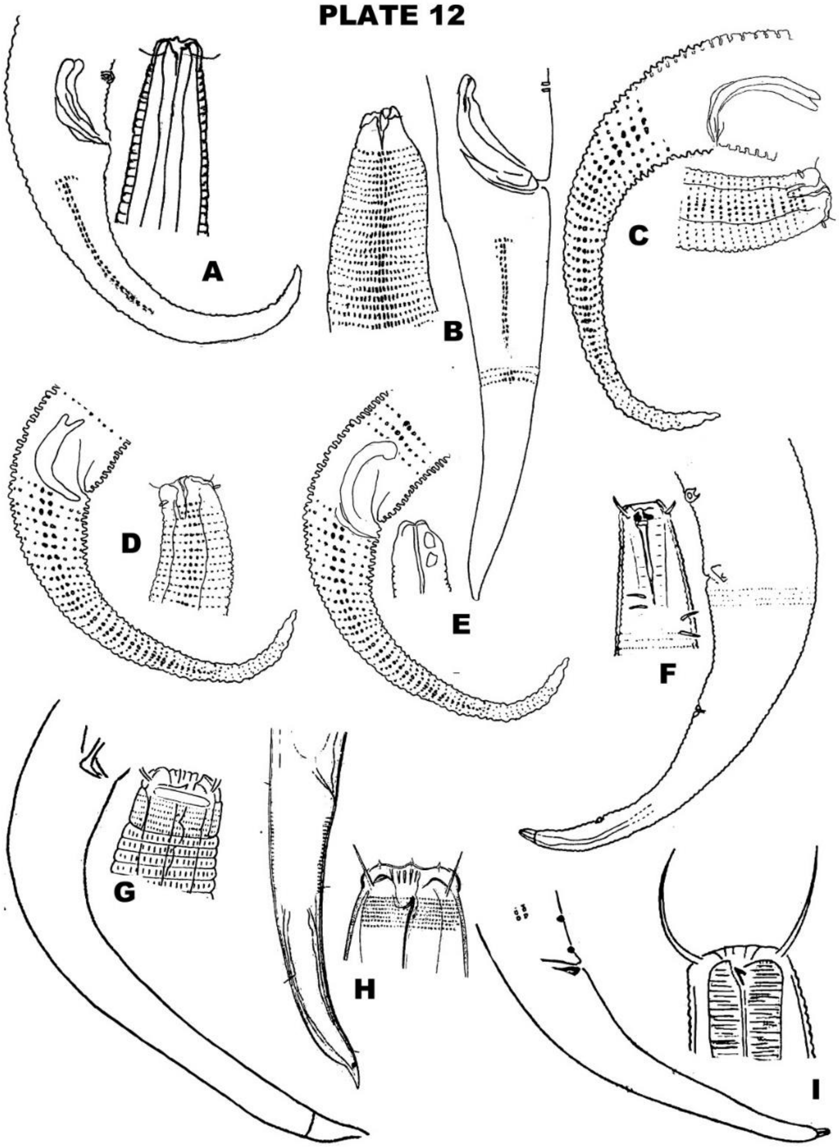


**Plate 12 (A)** *Chromadorella ariminiensis* (Gerlach, 1953) Lorenzen, 1972, **(B)** *Chromadorella circumflexa* Wieser, 1954, **(C)** *Chromadorella cobbiana* Johnston, 1938, **(D)** *Chromadorella filiformis* (Bastian, 1865) Filipjev, 1918, **(E)** *Chromadorella salicaniensis* Boucher, 1976, **(F)** *Chromadorina* sp Filipjev, 1918, **(G)** *Endeolophos* sp Boucher, 1976, **(H)** *Innocuonema* sp Inglis, 1969, **(I)** *Neochromadora* sp Micoletzky, 1924

PLATE 13

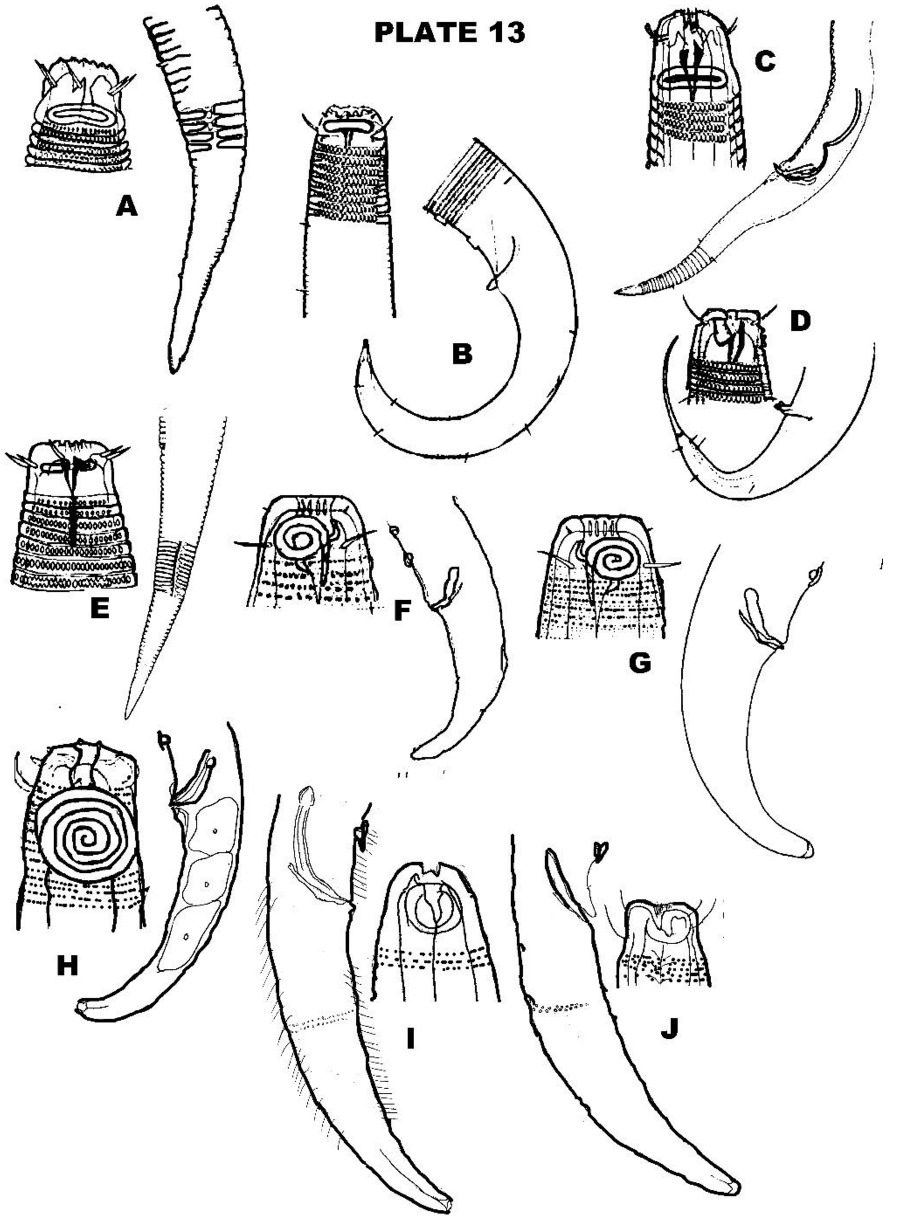


**Plate 13 (A)** *Nygmatonchus* sp Cobb, 1933, **(B)** *Prochromadorella* sp Micoletzky, 1924, **(C)** *Rhips* sp Cobb, 1920, **(D)** *Spilophorella* sp Filipjev, 1917, **(E)** *Trochamus* sp Boucher & Bovee, 1972, **(F)** *Comesa* sp Gerlach, 1956, **(G)** *Neotonchus corcundus* Gerlach, 1956, **(H)** *Neotonchus cupulatus* Vitiello, 1970, **(I)** *Neotonchus meeki* Warwick, 1971, **(J)** *Neotonchus vitius* Warwick, 1971

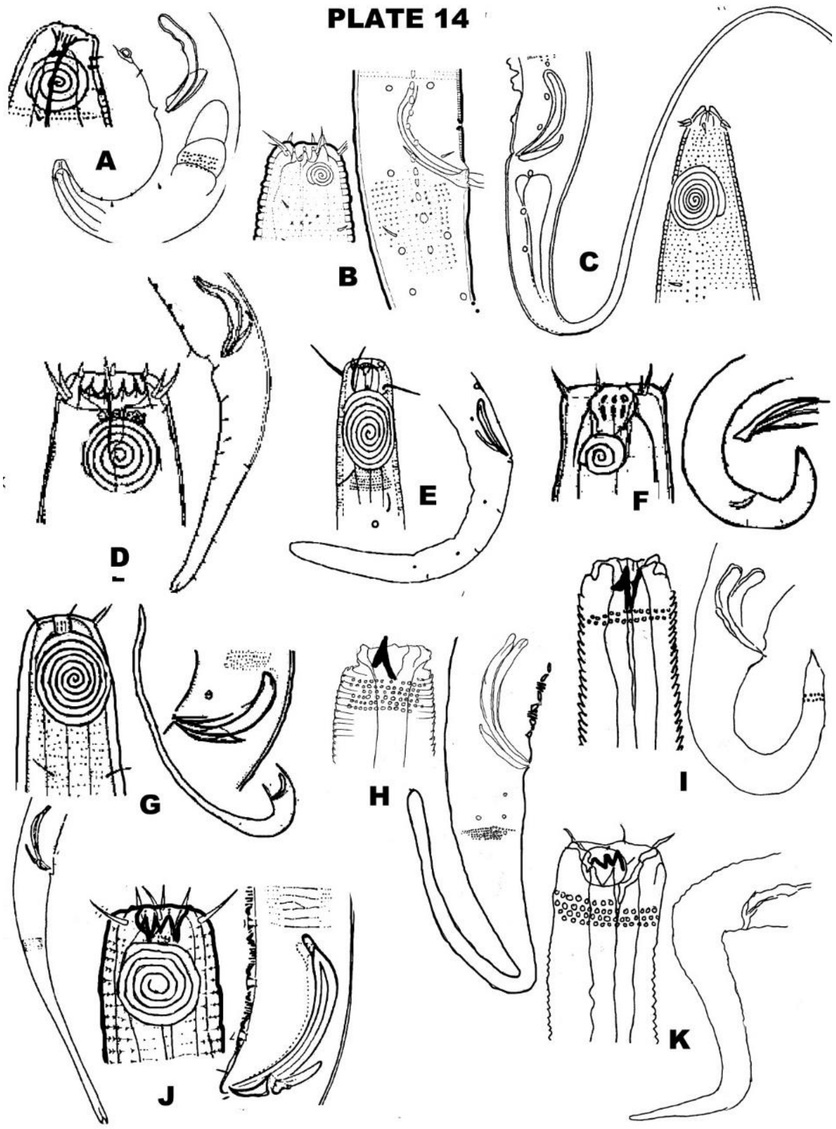


**Plate 14 (A)** *Neotonchus votadinii* Warwick, 1971, **(B)** *Longicyatholaimus capsulatus* Vitiello, 1971, **(C)** *Minolaimus* sp Vitiello, 1970, **(D)** *Nannolaimoides decoratus* Ott, 1972, **(E)** *Nannolaimus volutus* Gerlach, 1956, **(F)** *Paracyatholaimus* sp Micoletzky, 1922, **(G)** *Paralongicyatholaimus* sp Stekhoven, 1950, **(H)** *Pomponema clavicaudatum* Schuurmans Stekhoven, 1935, **(I)** *Pomponema corniculata* Gourbault, 1980, **(J)** *Pomponema elegans* Lorenzen, 1972, **(K)** *Pomponema multipappillatum* Filipjev, 1922

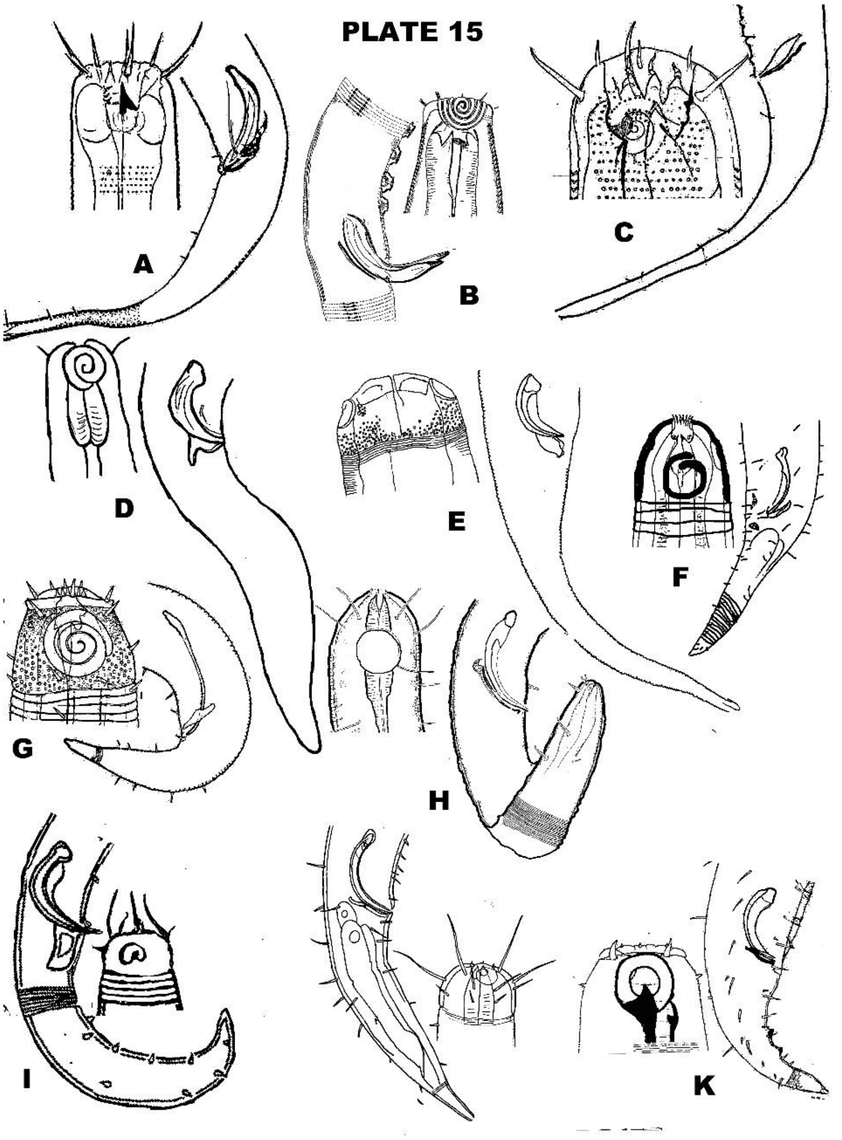


**Plate 15 (A)** *Pomponema polydonta* Murphy, 1963 , **(B)** *Pomponema proximamphidium* Tchesunov, 2008, **(C)** *Pomponema segregatum* Wieser, 1959, **(D)** *Catanema macintyrei* Platt & Zhang, 1982, **(E)** *Desmodora masira* Warwick, 1973, **(F)** *Desmodora pilosa* Ditlevsen, 1926, **(G)** *Desmodorella tenuispiculum* Allgén, 1928, **(H)** *Eubostrichus africanus* Muthumbi et al., 1995, **(I)** *Eubostrichus hortulanus* Leduc, 2013, **(J)** *Leptonemella juliae* Hoschitzbi et al., 1999, **(K)** *Metachromadora pulvinata* Wieser & Hopper, 1967

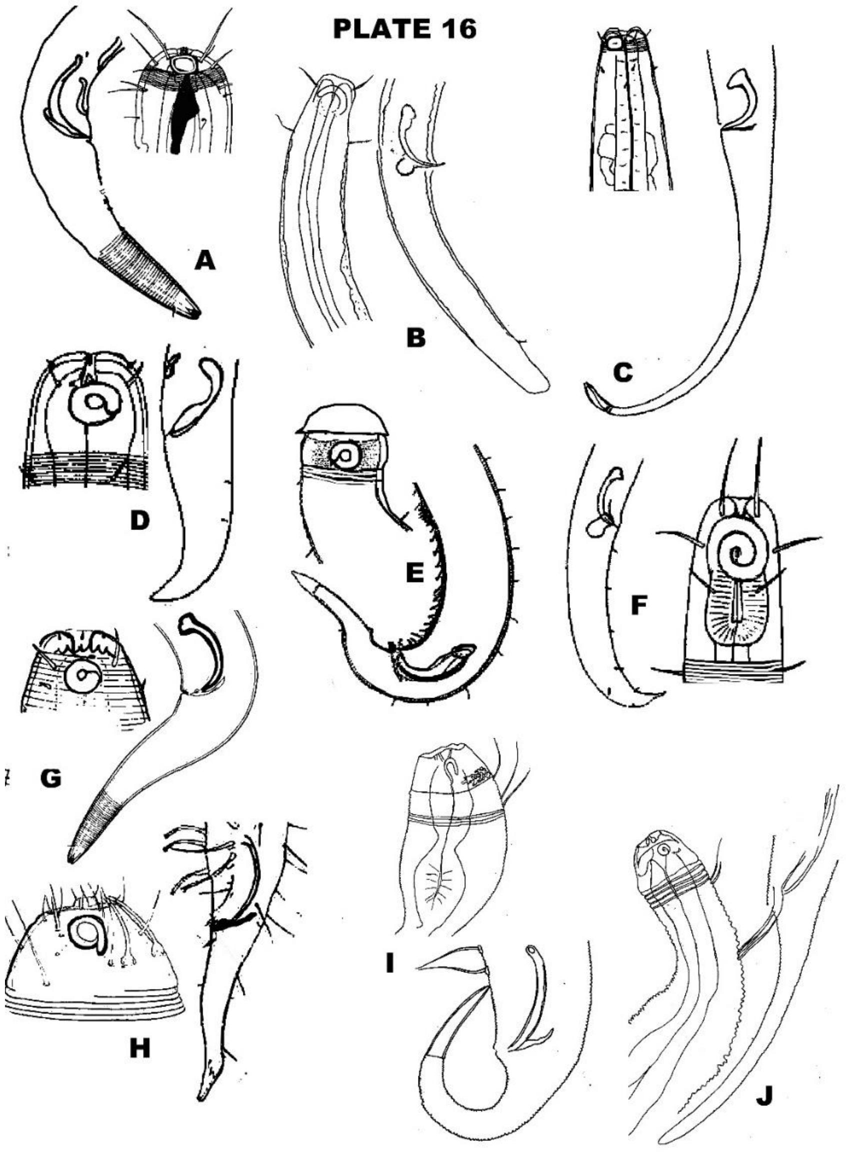


**Plate 16 (A)** *Onyx perfectus* Cobb, 1891 , **(B)** *Parabostrichus bathyalis* Tchesunov et al., 2012, **(C)** *Perspira* sp Wieser & Hopper, 1967, **(D)** *Polysigma* sp Cobb, 1920, **(E)** *Pseudochromadora* sp Daday, 1899, **(F)** *Robbea* sp Gerlach, 1956, **(G)** *Spirinia parasitifera* Bastian, 1865, **(H)** *Draconema japonicum* Kito, 1976, **(I)** *Draconema longicapitatum* Allgén, 1932, **(J)** *Prochaetosoma dokdoensis* Rho et al., 2010

PLATE 17

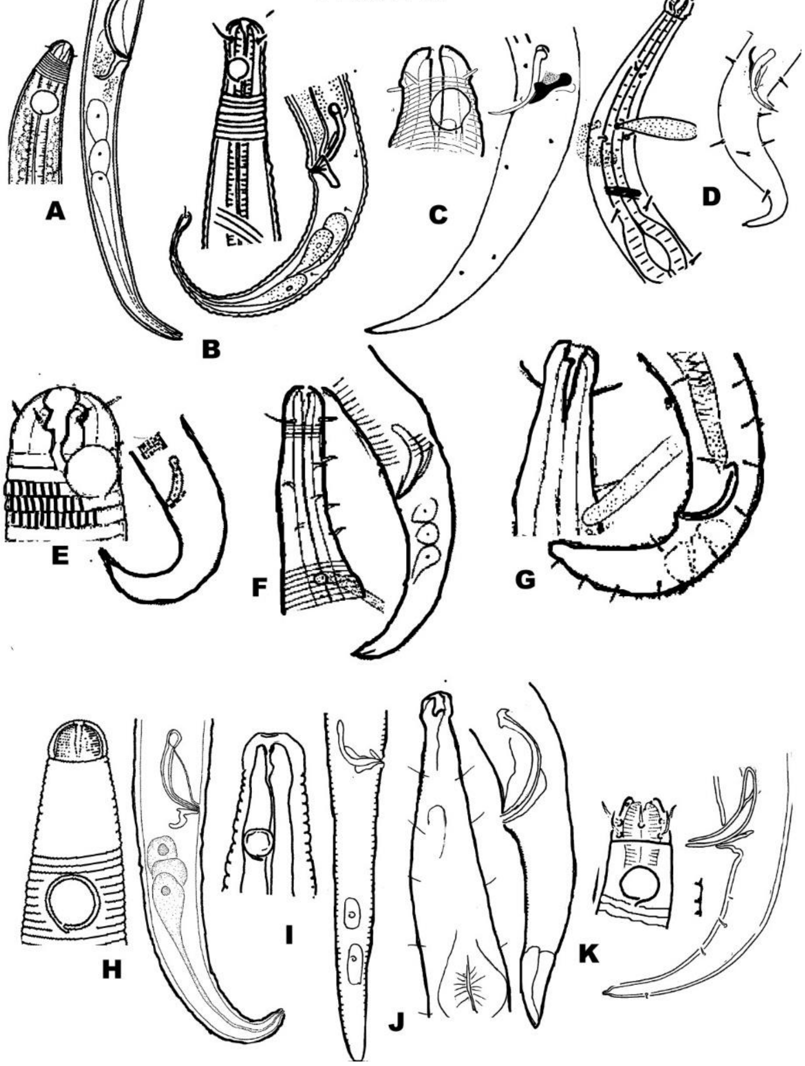


**Plate 17 (A)** *Aponema decremerae* Muthumbi & Vincx, 1999, **(B)** *Aponema ninae* Portnova, 2009, **(C)** *Aponema nympha* Bussau & Vopel, 1999, **(D)** *Bathynox clavata* Bussau & Vopel, 1999, **(E)** *Caligocanna mirabilis* Bussau & Vopel, 1999, **(F)** *Calomicrolaimus microseta* Gerlach, 1953, **(G)** *Ixonema sordidum* Lorenzen, 1971 , **(H)** *Aponema abyssalis* (Miljutin & Miljutina, 2009) Tchesunov, 2014, **(I)** *Microlaimus aequisetosus* Blome, 1982, **(J)** *Microlaimus africanensis* Furstenberg & Vincx, 1992, **(K)** *Microlaimus discolensis* Bussau & Vopel, 1999

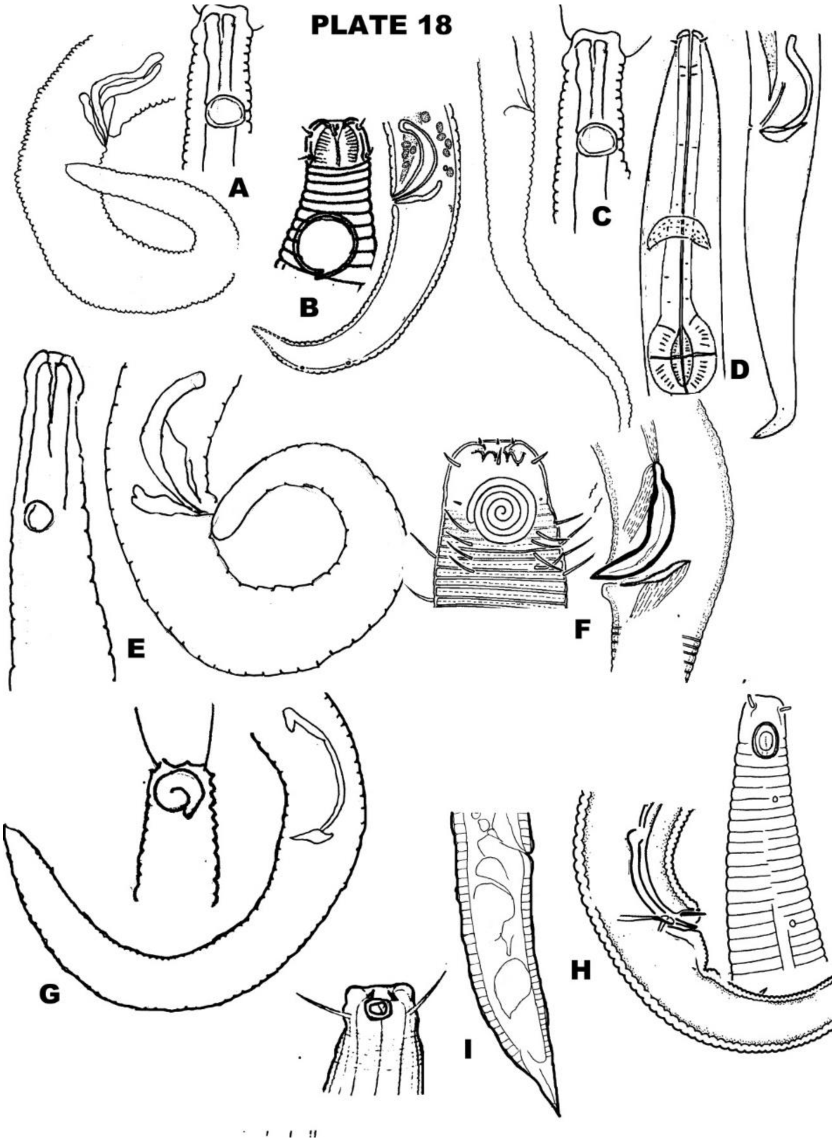


**Plate 18 (A)** *Microlaimus ostracion* Schuurmans Stekhoven, 1935, **(B)** *Microlaimus parviporosus* Miljutin & Miljutina, 2009, **(C)** *Microlaimus tenuispiculum* de Man, 1922, **(D)** *Microlaimus zosterae* Allgén, 1930, **(E)** *Molgolaimus abyssorum* Muthumbi & Vincx, 1996, **(F)** *Spirobolbolaimus bathyalis* Soetaert & Vincx, 1988, **(G)** *Alaimella macramphis* Tchesunov & Miljutina, 2007, **(H)** *Antomicron* sp Cobb, 1920, **(I)** *Dagda* sp Southern, 1914

PLATE 19

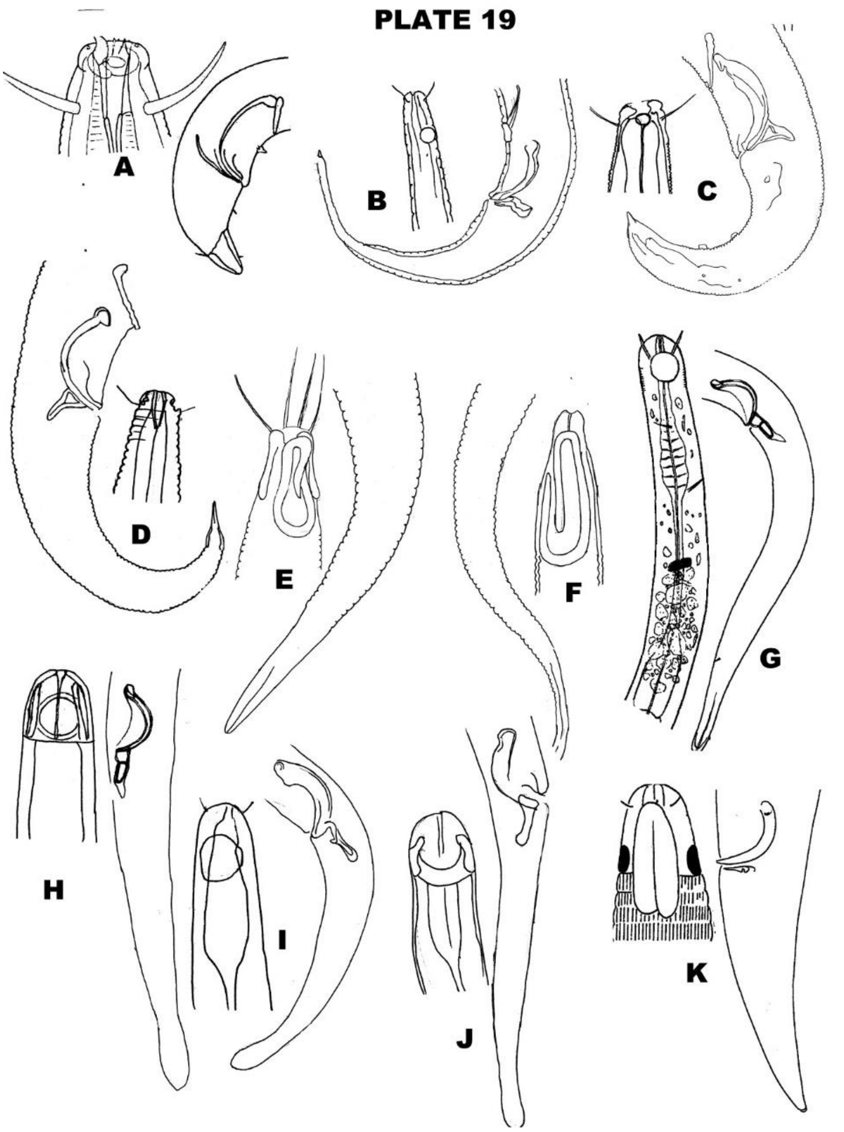


**Plate 19 (A)** *Diodontolaimus* sp Southern, 1914, **(B)** *Leptolaimus* sp de Man, 1876, **(C)** *Procamacolaimus bipapillata* Southern, 1914, **(D)** *Stephanolaimus elegans* Ditlevsen, 1918, , **(E)** *Tarvaia heegeri* Jensen, 1991 , **(F)** *Tarvaia peruvensis* Nichols & Musselman, 1979 , **(G)** *Cyartonema elegans* Jayasree & Warwick, 1977, **(H)** *Cyartonema flexile* Cobb, 1920, **(I)** *Cyartonema germanicum* Juario, 1972, **(J)** *Cyartonema zosterae* Allgén, 1929, **(K)** *Diplopeltoides linkei* Jensen, 1991

PLATE 20

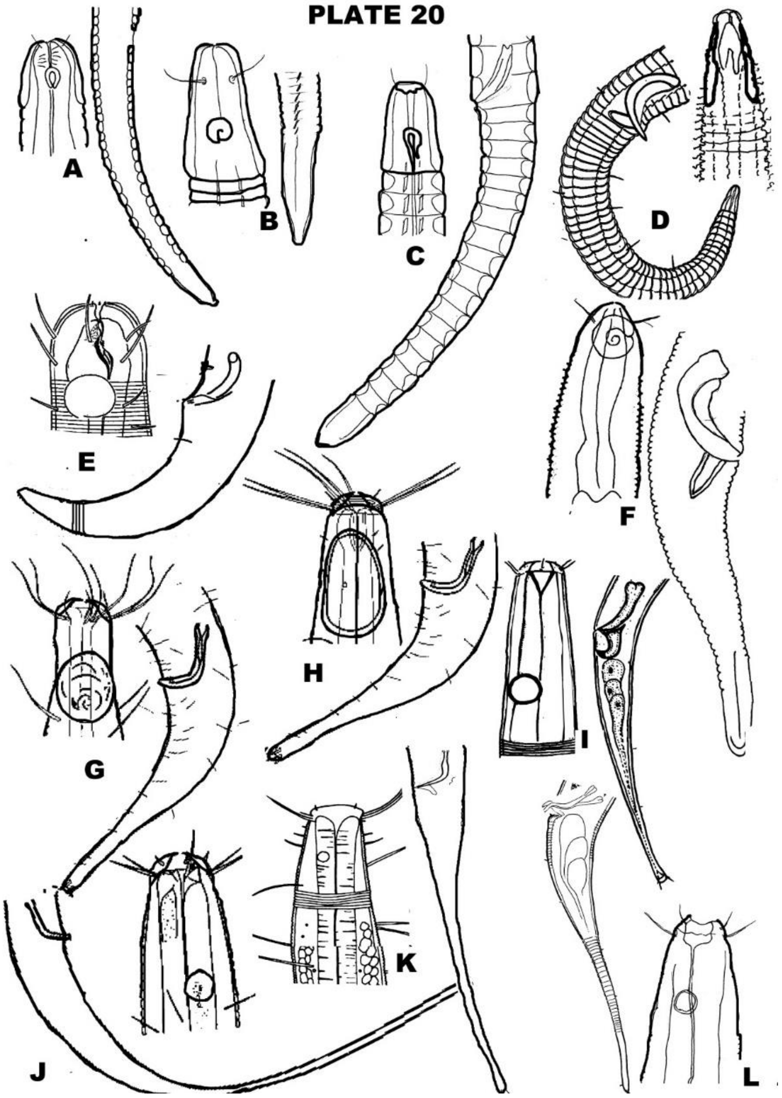


**Plate 20 (A)** *Ceramonema carinatum* Wieser, 1959, **(B)** *Dasynemoides riemanni* Haspeslagh, 1973, **(C)** *Pselionema annulatum* Filipjev, 1922, **(D)** *Pterygonema ornatum* Timm, 1961, **(E)** *Paramicrolaimus spirulifer* Wieser, 1954, **(F)** *Boucherius spinosus* Gerlach, 1956, **(G)** *Ammotherisus* sp Lorenzen, 1977, **(H)** *Amphymonhystera anchima* (Southern, 1914) Lorenzen, 1977, **(I)** *Daptonema balatum* Dinhh Tu et al., 2014, **(J)** *Daptonema hirsutum* Vitiello, 1967, **(K)** *Daptonema hyalocella* Aryuthaka and Kito, 2012, **(L)** *Daptonema oxycerca* de Man, 1888

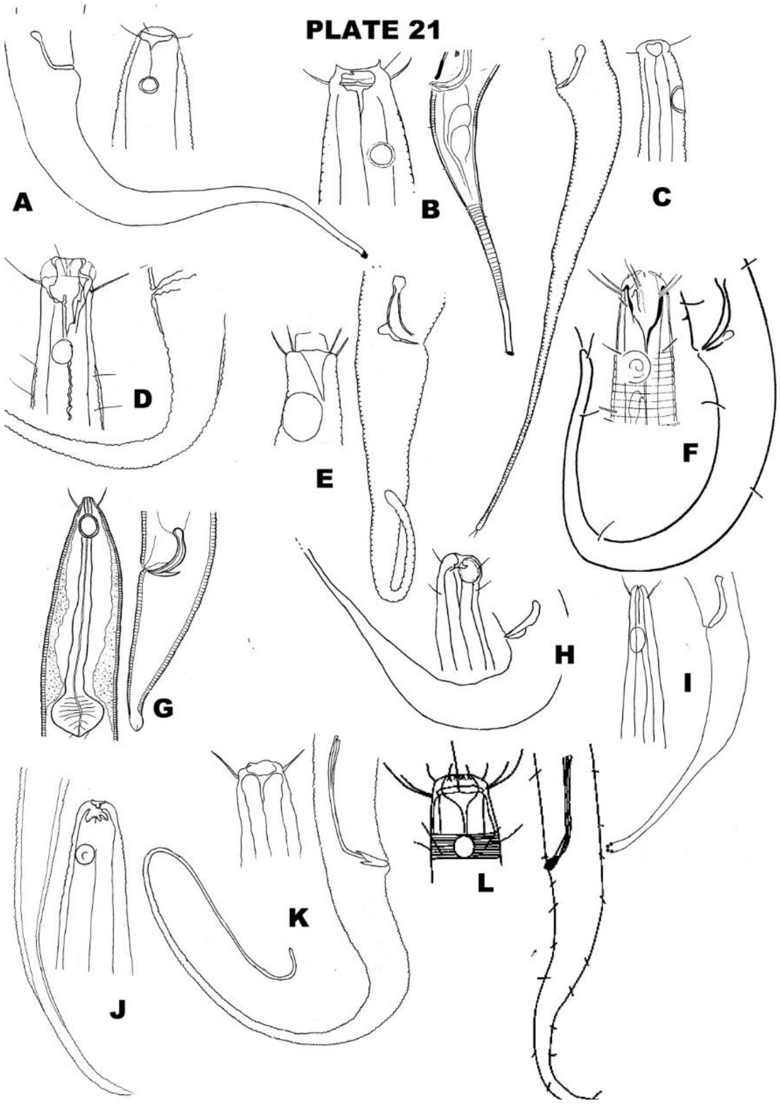


**Plate 21 (A)** *Daptonema setihyalocella* Aryuthaka & Kito, 2012, **(B)** *Daptonema williamsi* Vinx & Coomans, 1983, **(C)** *Cobbia* sp de Man, 1907 **(D)** *Gonionchus africanus* Vincx & Furstenberg, 1988, **(E)** *Gonionchus cumbraensis* Benwell, 1981, **(F)** *Gonionchus intermedius* Jensen, 1986, **(G)** *Manganonema* sp Bussau, 1993, **(H)** *Metadesmolaimus aversivulva* Gerlach, 1953, **(I)** *Metadesmolaimus heteroclitus* Lorenzen, 1972, **(J)** *Metadesmolaimus tersus* Gerlach, 1956, **(K)** *Paramonhystera albigensis* Riemann, 1966, **(L)** *Promonhystera* sp Wieser, 1956

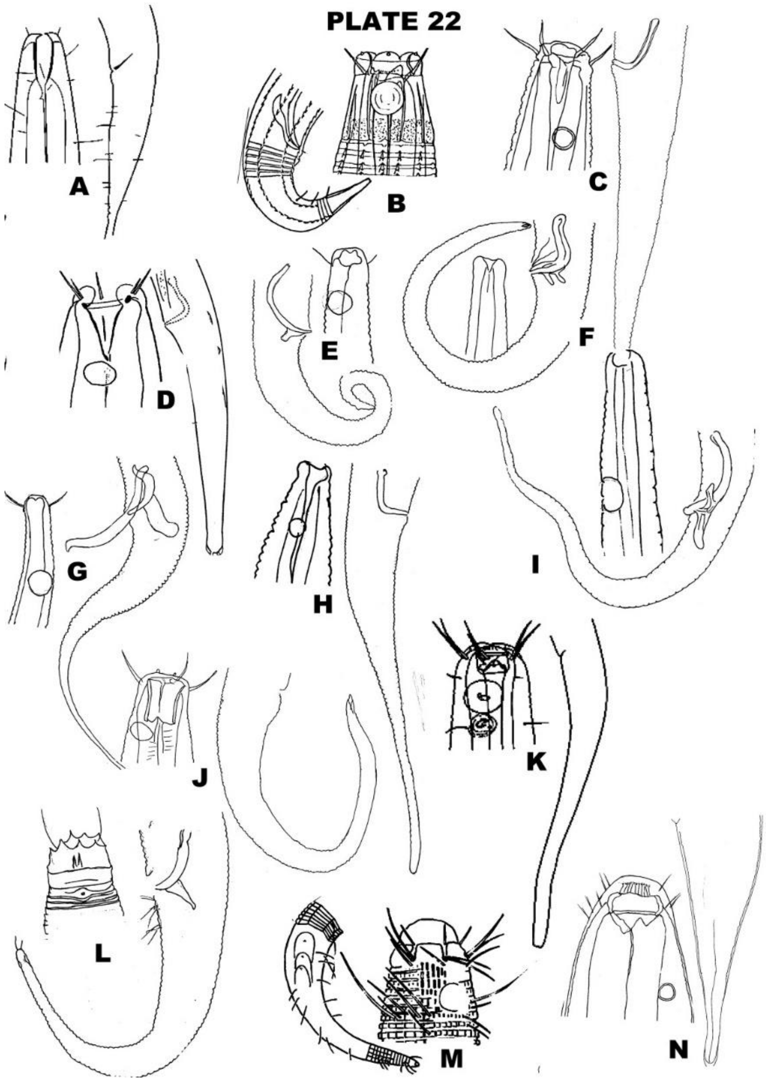


**Plate 22 (A)** *Retrotheristus* sp Lorenzen, 1977, **(B)** *Rhinema* sp Cobb, 1917, **(C)** *Theristus altenbachi* Jensen, 1991, **(D)** *Theristus anoxybioticus* Jensen, 1995, **(E)** *Theristus balticus* Lorenzen, 1973, **(F)** *Theristus bastiani* Gerlach & Riemann, 1973 , **(G)** *Theristus denticulatus* Warwick, 1970, **(H)** *Theristus fistulatus* Wieser & Hopper, 1967, **(I)** *Theristus heterospiculum* Allgén, 1932, **(J)** *Theristus otoplanobius* Gerlach, 1951, **(K)** *Valvaelaimus* sp Lorenzen, 1977, **(L)** *Xenolaimus striatus* Cobb, 1920, **(M)** *Xyala* sp Cobb, 1920, **(N)** *Metasphaerolaimus cancellatus* Gourbault & Boucher, 1981

PLATE 23

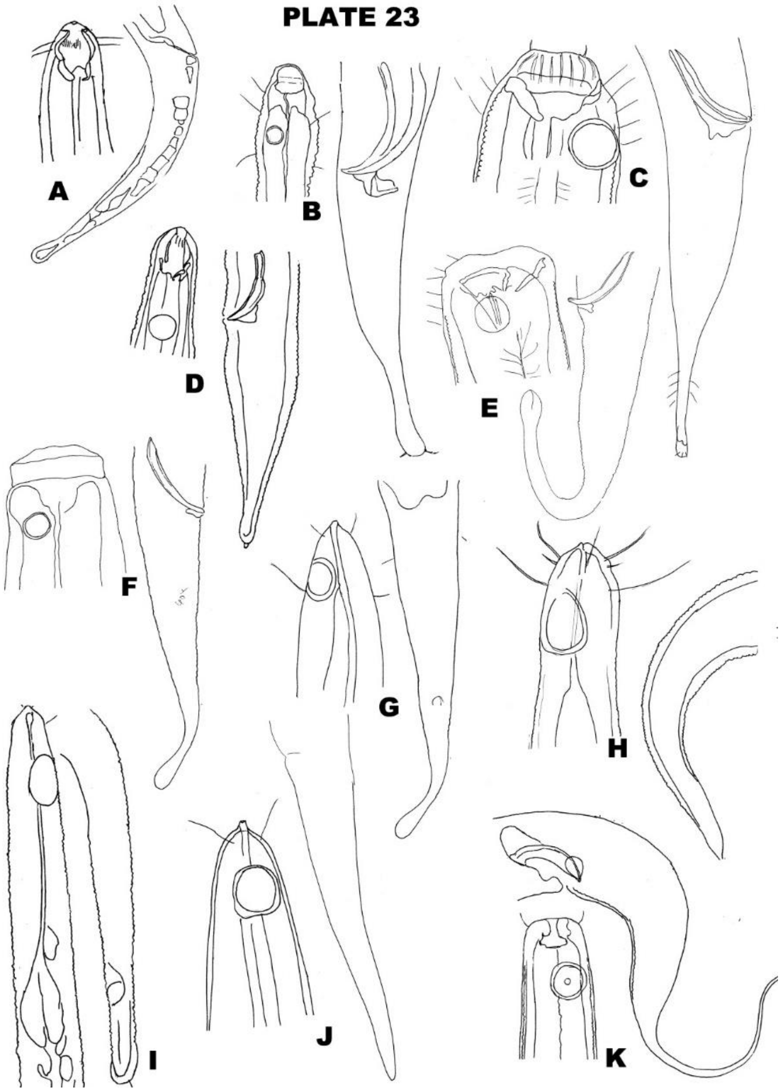


**Plate 23 (A)** *Metasphaerolaimus inglisi* Gourbault & Boucher, 1981, **(B)** *Sphaerolaimus crenellatus* Warwick, 1973, **(C)** *Sphaerolaimus dispar* Filipjev, 1918, **(D)** *Sphaerolaimus glaphyrus* Vitiello, 1971, **(E)** *Sphaerolaimus gracilis* de Man, 1876, **(F)** *Sphaerolaimus macrocirculus* Filipjev, 1918, **(G)** *Siphonolaimus elongatus* (Schuurmans Stekhoven, 1950) Vitiello, 1971, **(H)** *Siphonolaimus ewensis* Warwick & Platt, 1973, **(I)** *Siphonolaimus obscurus* Boucher & Helléouët, 1977, **(J)** *Siphonolaimus profundus* Warwick, 1973, **(K)** *Desmolaimus greenpatchi* Allgén, 1959

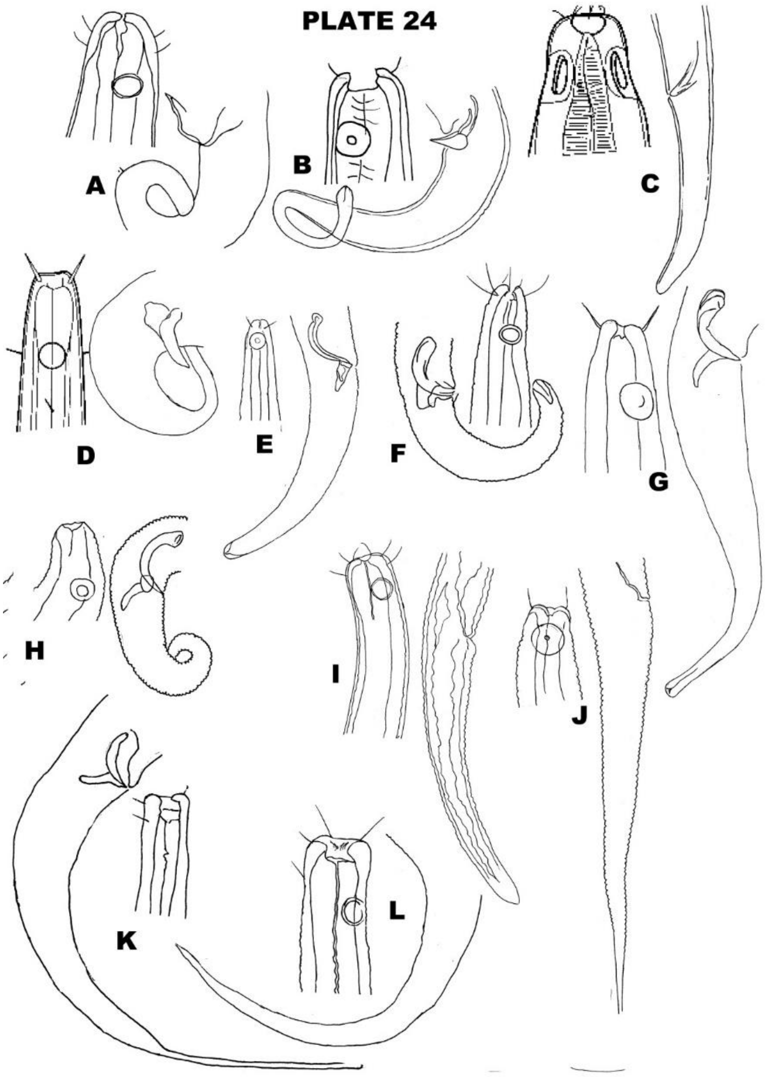


**Plate 24 (A)** *Desmolaimus zosterae* Allgén, 1933, **(B)** *Didelta scutata* Wieser, 1954, **(C)** *Disconema* sp Filipjev, 1918, **(D)** *Eleutherolaimus hopperi* Timm, 1967, **(E)** *Eleutherolaimus nutus* Gerlach, 1964, **(F)** *Linhomoeus filaris* Lorenzen, 1973, **(G)** *Megadesmolaimus contortus* Timm, 1962, **(H)** *Megadesmolaimus falcatus* Gerlach, 1963, **(I)** *Megadesmolaimus uncinatus* Gerlach, 1963 , **(J)** *Metalihomoeus gracilis* (Kreis, 1929) Wieser, 1956, **(K)** *Metalinhomoeus biformis* Juario, 1974, **(L)** *Metalinhomoeus effilatus* Schuurmans Stekhoven, 1942

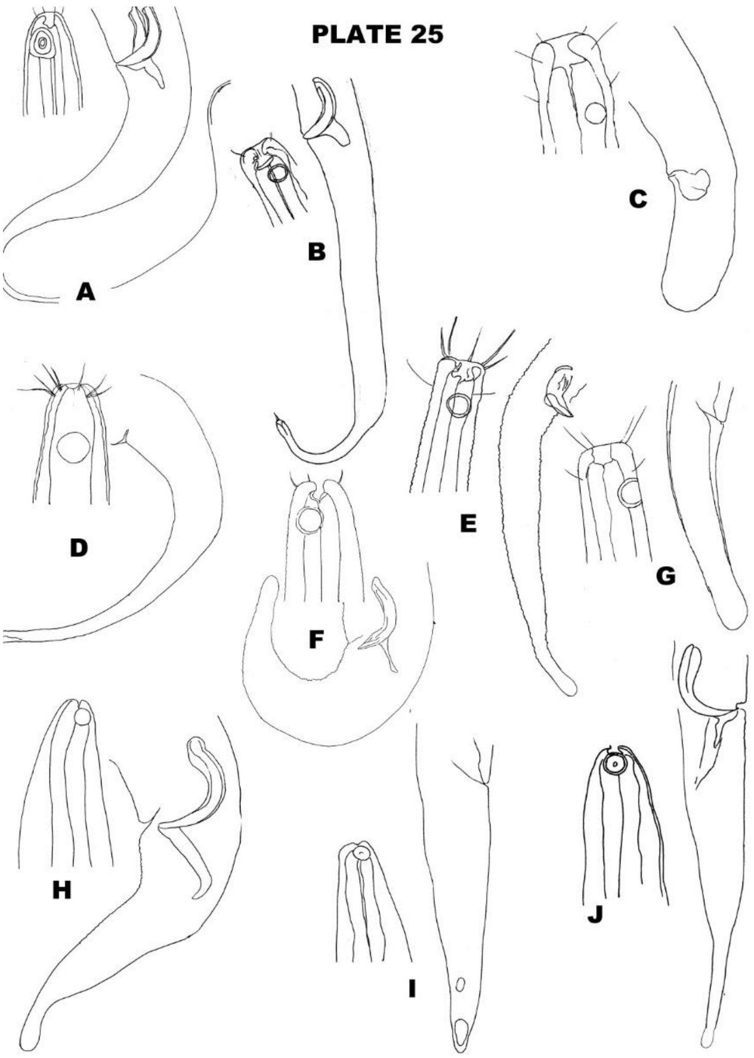


**Plate 25 (A)** *Paralinhomoeus anteporus* Vitiello, 1969 , **(B)** *Paralinhomoeus appendixocaudatus* Allgén, 1959, **(C)** *Paralinhomoeus brevicaudatus* Schuurmans Stekhoven, 1950, **(D)** *Paralinhomoeus conspicuus* Gerlach, 1957, **(E)** *Paralinhomoeus fuscacephalus* (Cobb, 1920) Gerlach, 1963, **(F)** *Paralinhomoeus lepturus* de Man, 1907, **(G)** *Paralinhomoeus longisetosus* Schuurmans Stekhoven, 1950, **(H)** *Paralihomoeus meridionalis* (Cobb, 1930) Wieser, 1956, **(I)** *Terschellingia baylisi* Allgén, 1959, **(J)** *Terschellingia brevicauda* Ott, 1972

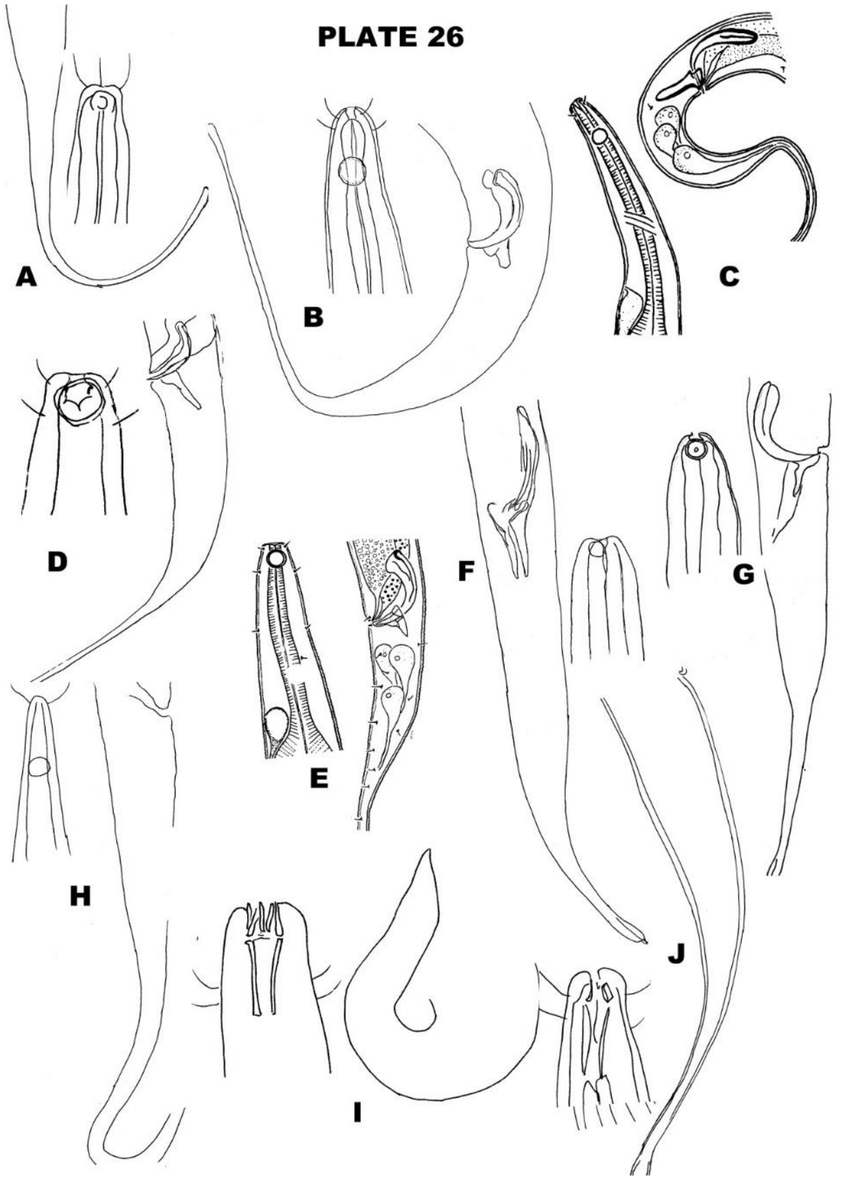


**Plate 26 (A)** *Terschellingia claviger* Wieser, 1956, **(B)** *Terschellingia communis* de Man, 1888, **(C)** *Terschellingia distalamphida* Juario, 1974, **(D)** *Terschellingia lissa* Timm, 1962, **(E)** *Terschellingia longicaudata* de Man, 1907, **(F)** *Terschellingia mora* Gerlach, 1956, **(G)** *Terschellingia parva* Vitiello, 1969, **(H)** *Terschellingia viridis* Timm, 1961, **(I)** *Odontophora falcifera* Ott, 1972, **(J)** *Parodontophora brevamphida* Timm, 1952

PLATE 27

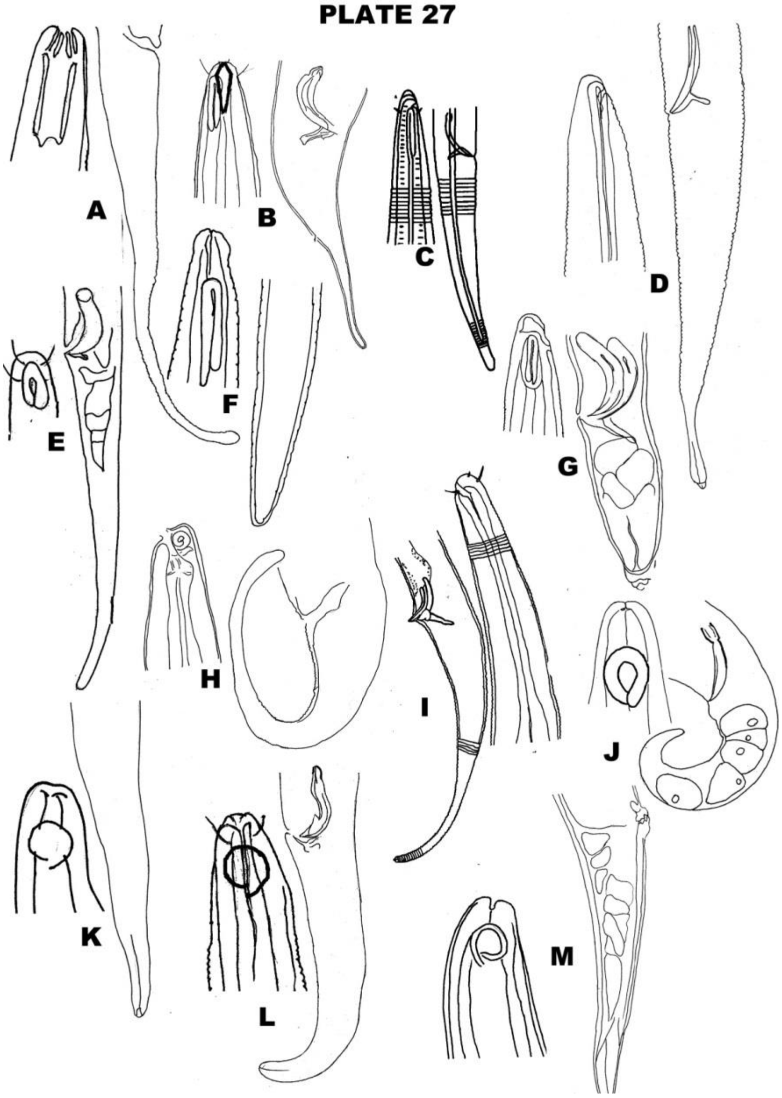


**Plate 27 (A)** *Parodontophora danka* Belogurov & Kartavtseva, 1975, **(B)** *Parodontophora xenotricha* Boucher, 1973, **(C)** *Campylaimus gerlachi* Timm, 1961, **(D)** *Campylaimus rimatus* Vitiello, 1974, **(E)** *Diplopeltis ornatus* Gerlach, 1950, **(F)** *Diplopeltula asetosa* Juario, 1974, **(G)** *Diplopeltula incisa* Southern, 1914, **(H)** *Morlaixia contusa* Vincx & Gourbault, 1989, **(I)** *Morlaixia obscura* Vincx & Gourbault, 1989, **(J)** *Pararaeolaimus rumohri* Jensen, 1991, **(K)** *Southerniella conicauda* Schuurmans Stekhoven, 1950, **(L)** *Southerniella nojii* Jensen, 1991, **(M)** *Southerniella simplex* Allgen, 1932

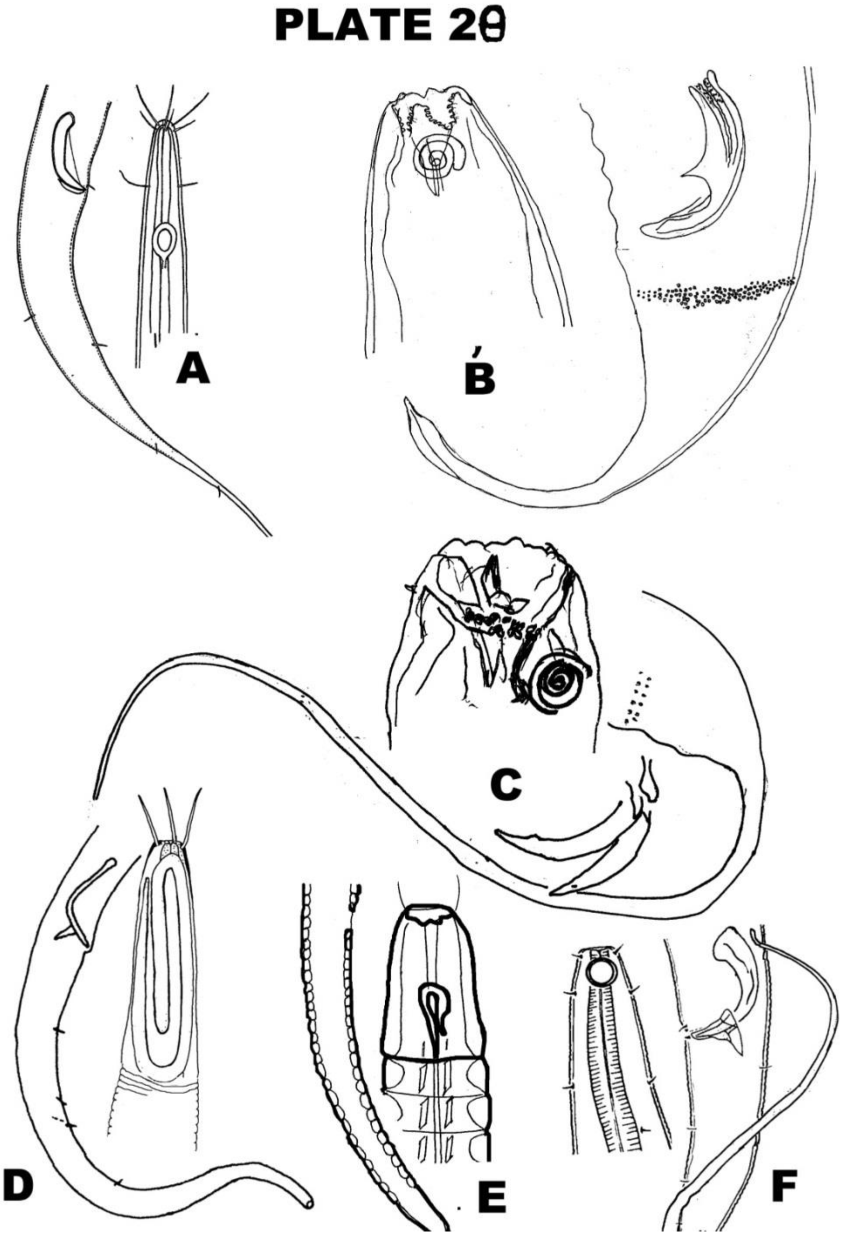


**Plate 28 (A)** *Wieseria scotlandica* Zhang, 1983, **(B)** *Demonema* Cobb, 1894, **(C)** *Halichoanolaimus dolichurus* Ssaveljev, 1912**, (D)** *Tarvaia angusta* Gerlach, 1953, **(E)** *Ceramonema filipjevi* de Coninck, 1942, **(F)** *Terschellingia filicaudata* Wang, Ligou An and Huang, 2017

## VI. 2.3. Novel species of free living nematodes from the continental margin (200-1000m) of Eastern Arabian Sea, Indian Ocean

**Modified version from the published articles:**

Jini Jacob, Abdul Jaleel K. U. & Anil Kumar Vijayan (2015) A new species of the rare nematode genus *Paramicrolaimus* Wieser, 1954 (Chromadorida: Paramicrolaimidae) from the south eastern Arabian Sea. Zootaxa, 3904 (4): 563–571.

Jini Jacob, Abdul Jaleel K. U., Rosamma Philip & R. Damodaran (2015). A new species of *Scaptrella* (Nematoda: Monhysterida) from the continental margin of the south eastern Arabian Sea. Marine Biology Research, DOI: 0.1080/17451000.2015.1009468.

Jini Jacob, Anilkumar P. R., Rosamma Philip & R. Damodaran (2015). *Psammonema kuriani* (Nematoda: Desmodoroidea), a novel species from the margin of north eastern Arabian Sea. Journal of the Marine Biological Association of the United Kingdom, doi:10.1017/S0025315415001691.

A total of 385 species were found during the current intensive ecological studies of the free living nematodes from continental margin of eastern Arabian Sea. Majority of these species were identified in to morphotypes or were assigned to putative species for ecological analysis since it was not possible to ascertain the species with respect to the available literatures. Many of them are found to be novel species and formal taxonomic descriptions of some novel species belonging to rare genera are presented here. The genera are recognised as 'rare' whose species are known from a few individual specimens or there are few reports on their species despite the volume of work carried out on diversity and systematics of marine free living nematodes across the world's oceans. Rare genera such as *Paramicrolaimus*, *Scaptrella* and *Psammonema* were chosen. However many of the species which are identified with certainity are reported for the first time from the study area.

The genus *Paramicrolaimus* Wieser, 1954 is the type and sole genus in Paramicrolaimidae, a rare family of free living nematodes whose species are known from a few individual specimens (Holovachov 2014). Given its general body shape, circular amphid, rounded blunt head with crowns of cephalic setae, the typical shape and teeth of the sclerotised buccal cavity and the preanal papillae, the genus was originally placed under family Microlaimidae by Wieser, 1954. However, it differed from the other genera of Microlaimidae in having the two circles (6+4) of cephalic setae of more or less equal size, transversely oval shaped amphids with a small dorsal limb, oesophageal bulb almost absent or weakly developed and females with two antidromously reflexed ovaries. While revising the Microlaimidae, Jensen (1978) discussed the obscurity of the systematic position of *Paramicrolaimus*. The slender and similar setae of the second and third crowns of cephalic sense organs, reduced buccal cavity and male gonads with one anteriorly directed outstretched testis suggest affinity of this genus with the Stilbonematinae (Spiriniidae); prompting Jensen (1978) to assign the genus to this family. Jensen (1978) also mentioned that *Paramicrolaimus* resembles the genus *Coninckia* in the arrangement of the cephalic sense organs, the shape of the male amphids, the structure of the oesophagus and the shape of the tail, but regarded these features as additional characters for distinguishing species. Lorenzen (1981) in classifying free living nematode species, contributed significant new interpretations and clarified the ambiguities in the systematics of *Paramicrolaimus* by erecting a new family Paramicrolaimidae. Since this revision, only one species, *Paramicrolaimus mirus* Tchesunov, 1988 has been described. In all, only 3 species of Paramicrolaimus are currently known.

Xyalidae Chitwood, 1951 is among the most species-rich and often ecologically dominant families of marine free-living nematodes, which inhabit nearly all types of marine environments. A review by Venekey et al. (2014) recognized 46 valid genera, 450 valid species and 73 species inquirendae (descriptions without enough morphological information for identification) from the family Xyalidae. Even though some Xyalid genera contain hundreds of species, *Scaptrella* Cobb, 1917 is a rare genus with only two valid species described.

Members of the family Desmodoridae have documented in most of the ecological studies on marine nematode assemblages from the deep sea sites but their density was always low, with a relative abundance reaching a maximum of 1% of the total mass (Soetaert & Heip, 1995). Species belonging to the family Desmodoridae are typical components of nemato community in sandy substrates (de Jesús-Navarrete, 2007) where most of the deep sea habitat is covered with finer sediments. In the recently published Handbook of Zoology, family Desmodoridae belongs to the superfamily Desmodoroidea Filipjev, 1922 and is composed of six subfamilies, 43 genera and 321 species (Tchesunov, 2014); but these figures are arbitrary and vary according to the source. The genus *Psammonema* was erected by Verschelde and Vinx in 1995, which is a monotypic genus ie the genus contains only the type species and no other species have been added till date.

Despite analysing 288 core samples, the new species is represented by few individuals and are highly restricted in distribution along EAS margin mostly from a single location,. The description and diagnosis of each species contains type locality, habitat and etymology of that species. All holotype and paratype materials were submitted to FORV Referral Centre, CMLRE, Kochi, Kerala and the registration numbers of each one are included in description of respective species. The methodology of sample collection, preservation, mounting and taxonomic identification for individuals are detailed in Chapter 3 as well as in Jacob et al., 2015a; Jacob et al 2015b and Jacob et al 2015c. Reference slides of type material of each species were prepared following serial dehydration (Seinhorst, 1956) and permanently mounted them in 100% glycerol. All drawings were made using Leica DM 1000 with attached drawing tube at 400x and 1000x magnification. Hand drawn images were scanned and subsequently edited using GIMP software pakage.

### VI.2.3.1. *Systematics Paramicrolaimus damodarani* sp. nov.

Order Chromadorida Filipjev, 1929
Family Paramicrolaimidae Lorenzen, 1981
Genus *Paramicrolaimus* Wieser, 1954
*Paramicrolaimus damodarani* sp. nov

## Figures VI.1

***(a) Description Holotype (male):*** Body cylindrical, long and thread like. Total body length 1280 µm, *a*=51.2, *b*=9.14, *c*=20.32. Body diameter 20 µm at the level of posterior cephalic setae, with maximum 25 µm at mid body and 25 µm at anus. Cuticle thick, striated; striation in the cephalic region weak, distinct at mid body and caudal region. Hypodermal gland cells present. Head without striation, slightly constricted at the level of amphids. Labial sensillae barely visible. Cephalic setae in two separate circles (6+4), with similar lengths (13–14 µm). Somatic setae present in cephalic (5 µm) and caudal (7 µm) regions. Buccal cavity irregular, with deep and narrow anterior part and posterior part with sclerotized walls, two teeth present as dorsal and right subventral projections. Amphids wide (11 µm), thick walled, transversely oval-shaped with a small dorsal limb, located 19 µm away from the anterior end. Oesophagus 140 µm long with swollen anterior end, middle part thin and cylindrical; posterior end swollen resembling a slightly elongated or weak oesophageal bulb (35 µm long and 10 µm wide). Males diorchic. Spicules paired, equal in size, 28 µm long, strongly arcuate, proximally cephalate with a distinct ventral, raised keel-like structure at mid-length. Gubernaculum parallel to spicule, simple in shape with lateral wing in the middle part. Seven distally expanded, cuticularised, protruding, precloacal supplements, each with distal thorn-like structures at their tips. First anterior and last posterior precloacal supplements slightly smaller than those between. Tail conoid, attenuated, ventrally coiled; 63 µm in length. Short, broad terminal spinneret present, strongly cuticularised, with long terminal setae arising from it dorsally.

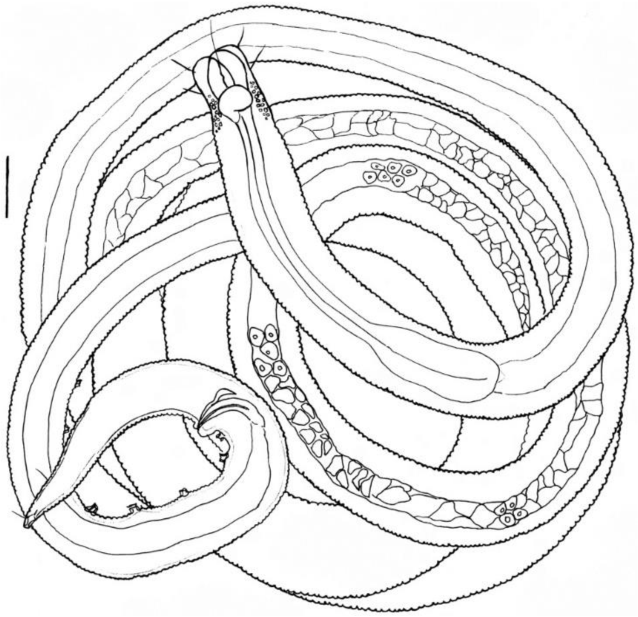


**Figure VI. 1.** *Paramicrolaimus damodarani* sp. nov. entire organism.

***(b) Remarks and comparisons:*** The general shape of the body and the spicular apparatus, position and number of cephalic setae, and position and shape of the amphid place the present specimens in *Paramicrolaimus* Wieser, 1954 (Figs 1–3). They are most similar to *Paramicrolaimus mirus* Tchesunov, 1988 in the general shape of the body, buccal cavity, oesophagus, size and shape of amphid and shape of gubernaculum. *Paramicrolaimus damodarani* sp. nov. strongly differs from *P. mirus* in body length (1.28 mm vs 4.06 mm), length of cephalic setae (6+8 µm vs 13+14–15 µm), *a*-value (105–106 vs 51–52.4), *b* - value (21.7–21.8 vs 8.8–9.1), *c*-value (28–40.5 vs 18.8–20.3), number of precloacal supplements (7 vs 9), shape and size of spicular apparatus (28 µm vs 23 µm), and in having a terminal spinneret which is absent in *P. mirus*. Specimens of *P. mirus* from the Yellow Sea (Huang & Zhang, 2005) showed larger measurements in all morphological characters compared with *P. damodarani* sp. nov. Also, the spicule of *P. mirus* has a velum (Huang & Zhang 2005) whereas *P. damodarani* sp. nov. has a central keel at mid-length. The gubernaculum in both the species were plate-shaped with a lateral wing in middle part but is of different size (19 µm vs 18 µm).

The spinneret of *P. damodarani* sp. nov. has strongly cuticularised on walls, and the setae in the caudal region are longer than in *P. mirus.*

*Paramicrolaimus damodarani* sp. nov. can be differentiated from *P. spirulifer* in being smaller (1.28 mm vs 4.43 mm) and in all morphological measurements in addition to the number of precloacal suppliments (7 vs 6) and the shape of the gubernaculum. While Wieser, 1959 reported 6 precloacal supplements in *P. spirulifer*, Jensen (1978) counted 10 in the redescription of the species. The gubernaculum in *P. spirulifer* is weakly sclerotized and apparently surrounds the distal parts of the spicules but in *P. damodarani* sp. nov. it is plate-shaped with a lateral wing in the middle part.

### VI.2.3.2. *Systematics Scaptrella filicaudata* sp. nov.

Order Monhysterida Filipjev, 1929
Family Xyalidae Chitwood, 1951
Genus *Scaptrella* Cobb, 1917
*Scaptrella filicaudata* sp. nov.
**Figure VI.2**

***(a) Description of holotype (male):*** Large, thick cylindrical body. Total body length 1800 µm. Maximum body diameter 55 µm. Head rounded, diameter 26 µm, distinct without striation, 40 µm long and 32 µm wide with a small constrictionat the level of cephalic setae. Labial setae 15 µm long and thick. Lateral setae 50 µm and 35 µm long; submedian setae 70 µm and 35 µm long. Subcephalic setae not observed. Buccal cavity 50 µm deep and 16 µm wide, strongly cuticularized and anteriorly armed with six extendable jointed mandibles and odontia. Somatic setae thin, long and numerous. Cuticle 3 µm thick, finely striated, striations start posterior to head region; striations are 3 µm wide and visible throughout body. Amphid thick, circular with internal spiral, measures 10 µm in width and located 31 µm away from the anterior region. Oesophagus 280 µm long and 34 µm in width at its posterior base. Posterior end of oesophagus slightly flattened or swollen, without forming a true bulb. Excretory pore and nerve ring not seen. Reproductive system monorchic. Sperm cells not observed. Spicules paired, equal and arcuate or swan-shaped (45 µm long), with proximal cephalization open. Gubernaculum 20 µm long, simple, with long dorsal apophysis. Three caudal glands located posterior to spicules. Tail tapering or filiform, with striations, 1.2 mm long, without terminal setae. Females and juveniles were not found.

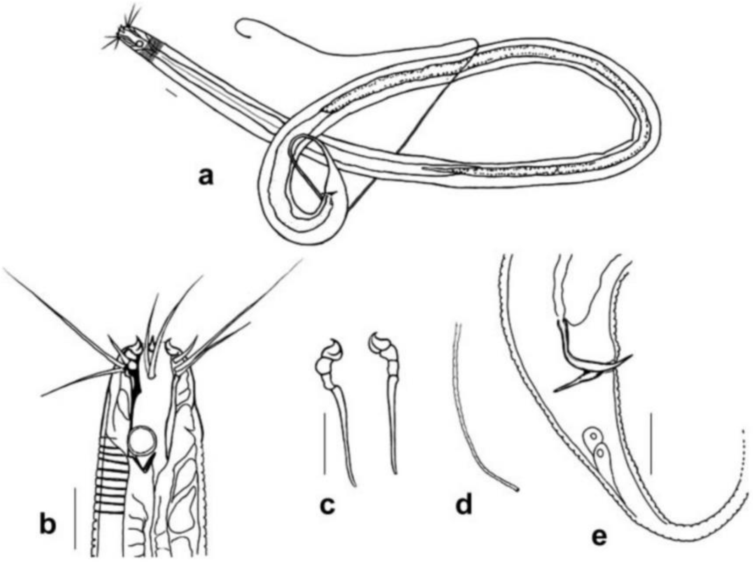


**Figure VI.2.** *Scaptrella filicaudata* sp. nov. (a) Holotype full specimen, (b) Cephalic region, (c) Jointed mandibles, (d) Tail tip, (e) Caudal region showing spicular apparatus.

***(b) Remarks and comparisons:*** The genus *Scaptrella* was erected by Cobb, based on Scaptrella cincta Cobb, 1917 from California. Subsequently, *Scaptrella brevicaudata* was described by Gerlach in 1953 from the Mediterranean. There are only two valid species of the genus, *Scaptrella cincta* Cobb, 1917 and *S. brevicaudata* Gerlach, 1953. Although a third species, *Scaptrella tenuicaudata*, was described by Gerlach (1956) from Germany, it is considered a species inquirenda here since the description was based on a single female. *Scaptrella filicaudata* sp. nov. differs from *S. cincta* in having longer labial setae (15 vs 6–7 µm), lateral setae (50 + 36 vs 30 + 18 µm) and submedian setae (68–70 + 35 vs 50 + 30 µm), deeper buccal cavity (50 vs 30–36 µm), lesser a value (32.7–33.2 vs 38.5–41.6) and a swan-shaped, longer spicule (43–45 vs 34 µm). The gubernaculum in *S. filicaudata* sp. nov. is simple, with a dorsally directed long apophysis, but in the case of *S. cincta* it is mentioned as a faint accessory organ. However, from the redescription of *S. cincta* by Wieser & Hopper (1967), the gubernaculum has a bidentate lateral guiding piece. Similarly, the long blunt tail (360 µm) of S. cincta possesses numerous caudal setae and a pair of 20 µm long terminal setae, whereas the long filiform tapering tail (1.2 mm) of *S. filicaudata* sp. nov. bears no terminal setae. *Scaptrella brevicaudata* Gerlach, 1953 can easily be distinguished from *S. filicaudata* sp. nov. by the smaller amphid (8 vs 10 µm), shallower buccal cavity (25 vs 50 µm), smaller lateral setae (22–25 + 36 vs 50 + 35–36 µm), smaller submedian setae (22–25 + 36 vs 68–70 + 35 µm), higher a value (37–54 vs 32.7–33.2) and c value (10.4–13.3 vs 1.4–1.5) and smaller spicule (28 vs 45 µm). The spicule in *S. brevicaudata* is slightly curved, with rounded capitulum at the proximal end and two tooth-like projections at the distal end, whereas in *S. filicaudata* sp. nov., proximal cephalization is open and the distal end tapering without any projection. The gubernaculum in *S. brevicaudata* encircles the spicule but in *S. filicaudata* sp. nov. the gubernaculum is simple, with a dorsally directed apophysis. The tail in *S. brevicaudata* is short and with terminal setae, whereas in *S. filicaudata* sp. nov. the tail is long, filiform and tapering to its end without any setae, as its name depicts. The differentiation of *S. filicaudata* sp. nov. from the other two valid species is straightforward (Figures 4-5), based on the size and shape of spicular apparatus and tail.

### VI.2.3.3. Systematics of *Psammonema kuriani* sp. nov.

Order Desmodorida De Coninck, 1965
Family Desmodoridae Filipjev, 1922
Genus *Psammonema* Verschelde & Vincx, 1995
**Figure VI.3.**

***(a) Description of Holotype (male) (Figure 6):*** Large, thick cylindrical body with distinct cephalic capsule. Total body length 1115 µm. Maximum body diameter 45 µm. Cephalic capsule rounded triangle, well set off with thick cuticle. Labial region of cephalic capsule can be differentiated from the main region by the thickness of cuticle (Figure 6 C& E). Main region of the cephalic capsule highly thickened while cuticle of the labial region is thin. Cephalic capsule ornamented with small vacuoles except in the labial region. Six smaller external labial papillae; four cephalic setae located at the base of amphid. No real sub cephalic setae or additional setae. Amphids spiral, 1.25 turns, anteriorly placed, anterior edge of the amphid touching the anterior edge of the cephalic capsule. Somatic setae situating just behind the cephalic capsule. Buccal cavity equipped with twelve longitudinal rugae, one strong dorsal tooth, two latero-ventral teeth and a circle of denticles (Figure 6E). Pharyngeal end bulb tripartite with clear partition (Figure 6B). Thin lumen cuticle. Pharynx 185 µm long. Body annuli slender with multi-layered cuticle. Lateral alae present beginning 48 µm posterior to pharyngeal bulb; narrow, without interdigitation and formed by local raising of each annule. Somatic setae - slender and long, arranged in eight rows at pharyngeal and posterior third of body, but in six rows at midbody region. At last third body region, latero-ventral row of somatic setae spliting in to two rows of thickened setae, the more ventrally located ones being more thick (3 µm), long (20 µm) and firm. The thick setae posterior to cloacal region shorter (9 µm).

Reproductive system monorchic. Long testis and vas deference, located on ventral side (Fig. 2C). Spicules long (63 µm), strongly cuticularised, arcuate with short ventral beak-like projection in rounded capitulum. Gubernaculum with two lateral pieces surrounding spicule. Velum hardly visible. Precloacal suppliments 10 numbers, in form of heavily cuticularised protrusion of the cuticle and without any setae. Single thick, stout and blunt precloacal seta. Tail long, conoid with rows of thick and thin somatic setae and short, cuticularised with non annulated tip.

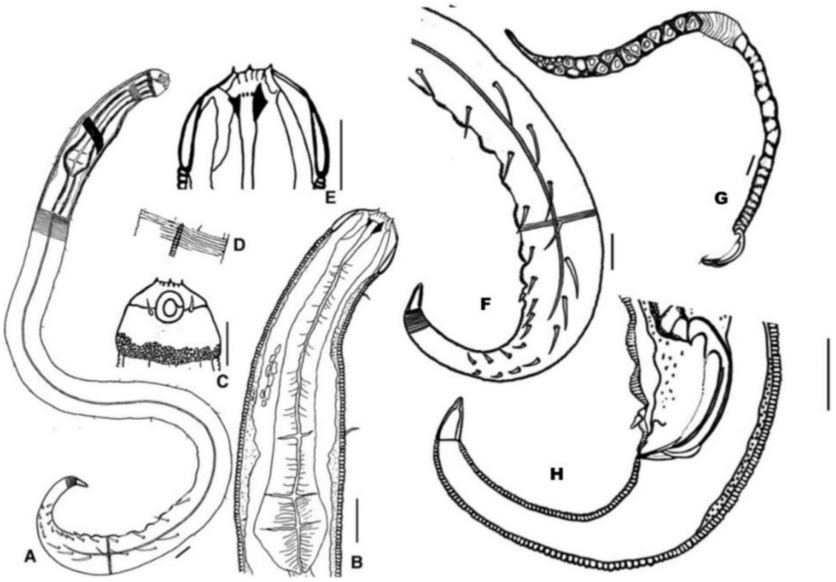


**Figure VI.3.** *Psammonema kuriani* sp. nov. holotype male (A) Habitus, (B) Pharyngeal region, (C) Head capsule showing amphid, (D) Beginning of lateral alae, (E), Buccal cavity and dentition. Scale bars 20 mm. Fig. 2. *Psammonema kuriani* sp. nov. holotype male caudal region (A) External morphology, (B) Pre-cloacal supplements, setae and spicule, (C) Reproductive system.

Even though the present specimens shows some characters of the genus *Pseudochromadora* Daday, 1899, such as lateral alae extending from posterior to the cardia, the present specimens differ from *Pseudochromadora* in having a crown of denticles, tripartite pharyngeal end bulb, narrow lateral alae and cephalic setae placed at the posterior edge of amphid. In addition to this, the somatic setae of genus *Pseudochromadora* are thin and uniform in size whereas those of *Psammonema* are of different sizes in different body regions.

The genus *Psammonema* was raised by Verschelde & Vincx, 1995 based on the specimens of *P. ovisetosum* which is the type species. *Psammonema kuriani* sp.n. is the second species assigned to this genus. The new species are sporadic in distribution and represented by only four individuals at a single location, despite analysing 288 core samples from an extensive survey along the eastern Arabian Sea margin covering 06$^{0}$ 57’ 19” North – 21$^{0}$ 30’ 639” North. The genus *Psammonema* Verschelde & Vincx, 1995 was previously described from the estuarine sediments of Indian Ocean region and the present study reports the genus from deep sea for the first time.

## VI.3. DISCUSSION

The descriptions of the nematode species provided in this chapter make an important contribution to our knowledge of the taxonomy of free-living nematodes in the sediments of Arabian Sea and will be invaluable for ecological studies that incorporate this phylum. This contribution is particularly relevant considering the paucity of taxonomic publications on this group in the Indian Ocean especially in the Arabian Sea. The present ecological studies have highlighted that many nematode species of this region remain undescribed. In particular there are several undescribed species within the Chromadoridae, Comesomatidae, Oncholaimidae and Xyalidae which were numerically important as well as being of value characterising the nematofauna of eastern Arabian Sea margin.

# Chapter VII

# SUMMARY AND CONCLUSION

Deep sea benthic studies especially in the northern Indian Ocean region have gained attention in recent years, owing to the overall significance of this region in global biogeochemical cycles. Despite this, the qualitative and quantitative aspects of benthic fauna in this region remain poorly known considering other parts of the world ocean. Within the northern Indian Ocean, the Arabian Sea is a unique system, being characterized by processes such as coastal upwelling, convective mixing, intrusion from landlocked seas (Persian Gulf, Red Sea and the central Indian Ocean) and Bay of Bengal, high biological production, massive seasonal phytoplankton blooms and a persistent open ocean Oxygen Minimum Zone (OMZ).

The present study provides baseline data on standing stock of meiobenthos from the NEAS (200-1000 m, Latitude 15º 25'N - 21º 30'N; Longitude 67º 28'E - 72º48' E) and community structure of free living nematodes in the continental margin (200-1000 m) of the eastern Arabian Sea (EAS, Latitude 07º 06'N to 21º 30'N and Longitude 76º 28'E to 67º 28'E), based on systematic, seasonally resolved sampling along three depth contours in sixteen bathymetric transects between December 2003 and May 2007. The surveys were carried out on board FORV *Sagar Sampada* as part of the project "Benthic fauna of continental slope from 200-1000m depths of Arabian sea and Bay of Bengal" funded by the Centre for Marine Living Resources and Ecology (CMLRE), Ministry of Earth Science, Government of

India, to gain information on the marine benthos in the Exclusive Economic Zone (EEZ) of India.

During the study, 144 stations (288 core samples), representing replicates of 48 sites at 200, 500 and 1000 m depths, along 16 transects in EAS margin, west coast of India (located in between Cape Comorin and Porbander) were surveyed for the community structure of free living nematodes. For meiofauna standing stock, 63 stations (125 core samples), representing replicates of 21 sites at 200, 500 and 1000 m depths, along 7 transects in NEAS (located in between Goa and Porbandar) were surveyed.

The study sites located at the southern region of eastern Arabian Sea (SEAS) was characterized by a highly heterogeneous environmental conditions. The temperature of bottom water decreased considerably with depth while there were no marked temporal or latitudinal differences. Even though minor, consistent variations in salinity with depth and latitude were observed. Salinity progressively increased from south to north and higher salinity was note down around 500 m depth in all transects. Consistently low DO was recorded at the shelf edge (200 m, 0.395±165 ml $l^{-1}$) and intermediate depth (500 m, 0.497±0.172 ml $l^{-1}$), with higher value at the deeper sites (1000 m, 0.667±0.217 ml $l^{-1}$). In addition, a latitudinal trend of decreasing DO concentration with increasing latitude was also noted. Five textural classes of sediments could be recognized from the SEAS continental margin and these were sand, silty sand, sandy silt, clayey sand and a homogeneous admixture of sand, silt and clay. The proportion of sand was high at the 200m sites of all transects and decreased progressively towards deeper sites. The finer fractions (silt and clay) contributed over 80% in the deeper sediments (500 and 1000 m). A clear latitudinal distinction was observed in sediment texture, with the relative high proportion of sand (>70% at 200m and >50% at 500m) in the three southern transects (Cape Comorin, Trivandrum and Kollam) compared to isobathic sites of the north. In the SEAS region, total OM content showed significant bathymetric variation, with high values at 1000 m in all transects and without any latitudinal trends. Temporal variations was found to be significant for OM content, with peak values during the May 2007 survey. The OM showed a strong positive correlation with silt content, which in turn was strongly correlated with depth.

The study area alongside the NEAS was characterized by significant spatial heterogeneity as well as seasonal variations in hydrographic parameters. In general, salinity was highest along the 500 m contour, with a gradual increase from south to extreme north at all depths. A bathymetric trend of decreasing temperature with increasing depth was also prominent for NEAS regions. The shelf edge and upper slope sites of the study area revealed the impingement of the Arabian Sea OMZ (ASOMZ), and were characterized by oxygen depleted conditions as low as <0.3 ml $l^{-1}$, with an increasing severity towards the north. In the mid-slope sites (1000m), which fell beyond the core of the ASOMZ, dissolved oxygen (DO) values were comparatively higher. In the NEAS margin major textural class was found to be clayey silt. Sediment texture also showed significant bathymetric variations, with sand-dominated substrates at the shelf edge, and a progressive shift towards finer (clayey silt) sediments in the mid-slope. The organic matter (OM) content of sediments was found to be higher at the OMZ core region (500 m depth), followed by the mid-slope, whereas OM was lowest in the sandy sediments of the shelf edge. Temporal or seasonal variations were not evident in sediment OM content in the NEAS region.

Along the NEAS margin average meiofaunal biomass was 0.492±0.659 mg $10cm^{-2}$ (0 to 4.181 mg 10 $cm^{-2}$) and average abundance was 232.4±614.2 Ind.10 $cm^{-2}$ (0 to 4755 Ind.10 $cm^{-2}$) with significant spatial variations. As with the general trends predicted for the deep sea, standing stock of meiofauna showed a decreasing trend with increase in depth, with a higher standing stock in the shelf edge (200m) sites and gradually decreasing towards higher depths. However, the variation was statistically not significant (R= -0.103; P =93.7 %). On the other hand, the standing stock of meiofauna varied significantly between latitudes with high abundance recorded from southern transects (R= 0.323; P =0.1 %). In addition, there was a significant variation with respect to season. The meiofauna abundance decreased drastically from WM (FORVSS 219) to SIM (FORVSS 254) (ANOSIM Global R=0.413, P=0.2 %).

Among the environmental variables, meiofauna standing stock showed a positive correlation with hydrographical parameter dissolved oxygen concentration. At group level abundance of nematodes and foraminifera showed a positive correlation with oxygen concentration. Nematodes (49 %) were the dominant group among meiofauna, followed by foraminiferans (43 %) and crustaceans (5 %). Other groups like kinorhynchs, ciliates, terebellarians, gastrotrichs, gnathostomulids and polychaetes altogether accounted for 3 % of the total abundance.

The spatial trends in nematode standing stock mirrored that of meiofauna as a whole. The EAS margin harboured by very diverse assemblages of free-living marine nematodes. At the 48 sampling sites, 385 putative species, belonging to 141 genera and 29 families were represented. Of these, many are new to science and >100 species were recorded for the first time from the Eastern Arabian Sea. Species diversity of nematode showed variation with respect to season, depth and latitude none of them were not significant.

Multivariate analysis of nematode species composition revealed that assemblages in the SEAS were distinct from those of the NEAS, being characterised by relatively high species richness and diversity. The regional distinctions (SEAS and NEAS) were due to variations in relative abundance of common species along with presence or absence of certain exclusive species from the regions. These distinctions also reflected in functional ecology of nematodes across the margin in the SEAS and NEAS.

The SEAS communities were characterized by dominance of species like *Sabatieria* spp, *Richtersia bathyalis* and *Daptonema oxycerca*, with extremely diversity in terms of number of species represented. A total of 338 species were observed from the SEAS sites, of which 159 species were exclusive to the SEAS. The communities at the NEAS margin, which are under the influence of the ASOMZ, were characterized by low density and diversity, with a dominance of *Acantholaimus quintus, Desmodorella* spp, *Daptonema* sp1, *Desmodora* sp1, *Microlaimus* sp1 and *Desmodora* sp2. Within the OMZ impinged region in the NEAS margin the oxygen concentration were extremely low in the northern region (Porbandar, Veraval and Mumbai 2), relative to the southern part (Goa to Mumbai 1) which was also reflected in the meiofaunal standing stock and nematode species composition.

Nematodes are known to prefer well oxygenated environments. In general, their response to oxygen stress includes changes in abundance, diversity and community structure. They also show varying abundance of some dominant species. In other words, responses of nematode communities to oxygen stress are species–specific and related to the duration of exposure. The present study reveals low nematode diversity along the NEAS when compared to SEAS, where oxygen deficiency was less pronounced. The environmental conditions, particularly sediment texture and OM, in the northern part of the SEAS, were comparable to isobathic depths of the NEAS, while DO levels showed significant differences owing to the impingement of the ASOMZ in the NEAS. In the SEAS, the shallow 200 m and 500 m sites especially the southernmost transects such as Cape Comorin, Trivandrum and Kollam, were characterised by high density and high diversity of nematode species. Meiofauna was absent or meagrely represented at many sites of the NEAS, owing to the extremely low DO. These observations emphasise the key role of the ASOMZ in determining meiofaunal standing stock and community structure in the eastern Arabian Sea.

Oxygen minima are undergoing expansion and intensification globally, under natural and anthropogenic influences. The present study, provides a robust dataset on meiobenthic standing stock and community structure in a continental margin impinged by the Arabian Sea OMZ, which is known to be the thickest and second most intense in the world. It reveals the reduction in standing stock and diversity of fauna and diminished ecosystem functions under severely oxygen depleted conditions (<0.2 ml/l). The study is limited to the 1000m depth contour, where OMZ conditions only begin to relax.

The present study has led to the description of several novel species; it has also provided numerous morphotypes of deep-sea genera which could prove to be new to science, and also presents specimens of many rare deep-sea taxa, which are otherwise known only from a few specimens. Despite the strong influence of the ASOMZ in the eastern Arabian Sea, the occurrence of highest known nematode diversity in the Indian Ocean highlights the ecological and biological importance of this region. Moreover, the relatively high abundance of nematodes in the OMZ impacted regions, where other benthic fauna (macro and megafauna) are known to show severely reduced in standing stock and diversity, clearly indicates the key role of nematodes in the functioning of the EAS margin ecosystem. Considering these findings and taking into account the scarcity of taxonomic descriptions of free-living marine nematodes from the Indian Ocean as a whole, more studies need to be undertaken in the entire EAS margin (also beyond 1000m depth), with a thrust on systematics and functional ecology.

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# PUBLICATIONS

1. Jini Jacob, Abdul Jaleel K. U. & Anil Kumar Vijayan (2015) A new species of the rare nematode genus *Paramicrolaimus* Wieser, 1954 (Chromadorida: Paramicrolaimidae) from the south eastern Arabian Sea. Zootaxa, 3904 (4): 563–571.

2. Jini Jacob, Abdul Jaleel K. U., Rosamma Philip & R. Damodaran (2015). A new species of *Scaptrella* (Nematoda: Monhysterida) from the continental margin of the south eastern Arabian Sea. Marine Biology Research, DOI: 0.1080/17451000.2015.1009468.

3. Jini Jacob, Anilkumar P. R., Rosamma Philip & R. Damodaran (2015). *Psammonema kuriani* (Nematoda: Desmodoroidea), a novel species from the margin of north eastern Arabian Sea. Journal of the Marine Biological Association of the United Kingdom, doi:10.1017/S0025315415001691.

4. Abdul Jaleel K. U., Anilkumar P. R., Nousher Khan K., Correya N. S., Jacob J., Philip R., Sanjeevan, V. N., Damodaran R. (2014). Polychaete community structure in the South Eastern Arabian Sea continental margin (200-1000m). Deep-sea Research Part I, 93: 60-71.

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# A new species of the rare nematode genus *Paramicrolaimus* Wieser, 1954 (Chromadorida: Paramicrolaimidae) from the south eastern Arabian Sea

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## Abstract

A new paramicrolaimid nematode, *Paramicrolaimus damodarani* **sp. nov.**, is described based on specimens from the continental shelf (95 m) of the south eastern Arabian Sea. *Paramicrolaimus damodarani* **sp. nov.** differs from other known species of the genus in having a smaller body size, form of the spicular apparatus, presence of 7 cuticularised protruding precloacal supplements and a strongly cuticularised terminal spinneret. This is the first record of the genus *Paramicrolaimus* from the northern Indian Ocean. A pictorial key to the four species of *Paramicrolaimus* is also provided, supplemented with comparative characters, based on published information.

**Key words:** Nematode, Arabian Sea, Indian Ocean, *Paramicrolaimus*, morphology, taxonomy, Identification key

## Introduction

The genus *Paramicrolaimus* Wieser, 1954 is the type and sole genus in Paramicrolaimidae, a rare family of free living nematodes whose species are known from a few individual specimens (Holovachov 2014). There are few reports on the species of *Paramicrolaimus*, despite the volume of work carried out on diversity and systematics of marine free living nematodes across the world's oceans. Given its general body shape, circular amphid, rounded blunt head with crowns of cephalic setae, the typical shape and teeth of the sclerotised buccal cavity and the preanal papillae, the genus was originally placed under family Microlaimidae by Wieser, 1954. However, it differed from the other genera of Microlaimidae in having the two circles (6+4) of cephalic setae of more or less equal size, transversely oval shaped amphids with a small dorsal limb, oesophageal bulb almost absent or weakly developed and females with two antidromously reflexed ovaries.

While revising the Microlaimidae, Jensen (1978) discussed the obscurity of the systematic position of *Paramicrolaimus*. The slender and similar setae of the second and third crowns of cephalic sense organs, reduced buccal cavity and male gonads with one anteriorly directed outstretched testis suggest affinity of this genus with the Stilbonematinae (Spiriniidae); prompting Jensen (1978) to assign the genus to this family. Jensen (1978) also mentioned that *Paramicrolaimus* resembles the genus *Coninckia* in the arrangement of the cephalic sense organs, the shape of the male amphids, the structure of the oesophagus and the shape of the tail, but regarded these features as additional characters for distinguishing species. Lorenzen (1981) in classifying free living nematode species, contributed significant new interpretations and clarified the ambiguities in the systematics of *Paramicrolaimus* by erecting a new family Paramicrolaimidae. Since this revision, only one species, *Paramicrolaimus mirus* Tchesunov, 1988 has been described. In all, only 3 species of *Paramicrolaimus* are currently known.

A new species of *Paramicrolaimus* is described here, based on specimens collected off the southwest coast of India, in the south eastern Arabian Sea. This is the first record of *Paramicrolaimus* in the northern Indian Ocean.

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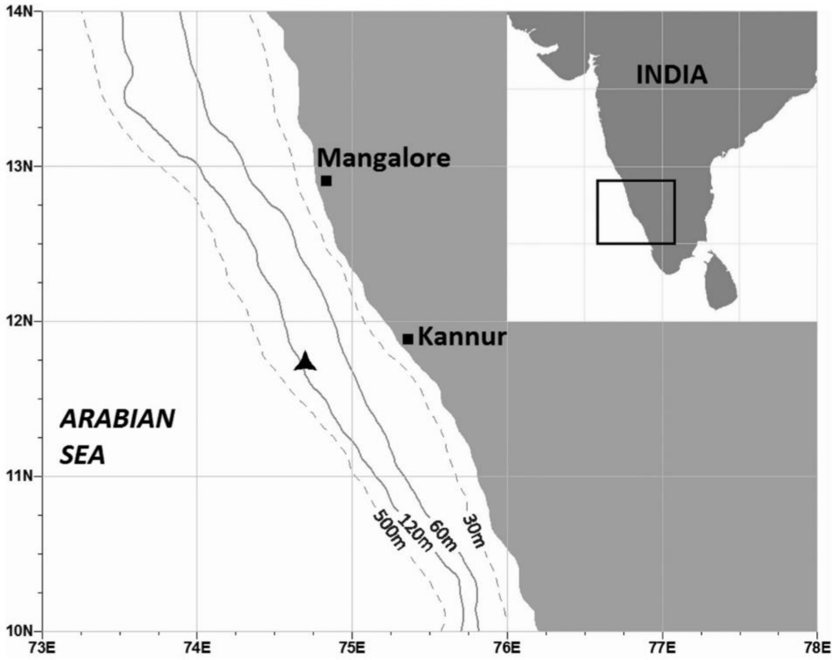

**FIGURE 1.** Map of south eastern Arabian Sea showing area of collection of *Paramicolaimus*.

## Material and methods

Adult males of *Paramicrolaimus* Wieser, 1954 were recovered among meiofaunal samples collected using a Smith McIntyre grab from the continental shelf of south eastern Arabian Sea, during a benthic survey on-board Fishery Oceanographic Research Vessel *Sagar Sampada* (FORVSS 295). The collection site was located off Kannur in the southwest coast of India, at a depth of 95 m. Juvenile specimens of the same species had been collected during previous surveys in the continental slope off Cape Comorin at a depth of 207 m (FORVSS 233). The meiofauna were sub-sampled from the grab using a glass corer of diameter 2.5 cm, and fixed and preserved in 7% formalin, stained with Rose Bengal. Salinity, temperature and dissolved oxygen of the water column just above the sediment were measured using the on-board Sea Bird CTD (SBE 911). Sediment texture was analysed using a Particle Size Analyser (Sympatec). Onshore, meiofauna were separated using a set of sieves (63 µm & 500 µm), and sorted manually using a stereo microscope (Leica EZ4). Nematodes were then processed to pure glycerine by the slow evaporation technique (Seinhorst 1959) and mounted on glass slides for detailed examination and taxonomic identification. Descriptions and drawings were made based on the glycerine mounts, using a Leica DM 1000 microscope with an attached drawing tube. The specimens were identified to genus level following Platt & Warwick (1988) and NeMys (Vanaverbeke *et al*. 2014).

Adult males of *Paramicrolaimus* were only collected at one location off Kannur (at 95 m depth). Type specimens are deposited in the FORV Referral Centre, Centre for Marine Living Resources and Ecology, Kochi, Kerala, India. All measurements are in micrometers and all curved structures are measured along the arc.

Abbreviations in the text are as follows: *a*, body length/maximum body diameter; abd, anal body diameter; *b*, body length/pharynx length; *c,* body length/tail length; L, total body length; mbd, maximum body diameter; hd, head diameter; cs, length of cephalic setae; ss, length of somatic setae; aw, amphid width; S, spicule length; t, tail length.

## Systematics

### Order Chromadorida Filipjev, 1929

### Family Paramicrolaimidae Lorenzen, 1981

### Genus *Paramicrolaimus* Wieser, 1954

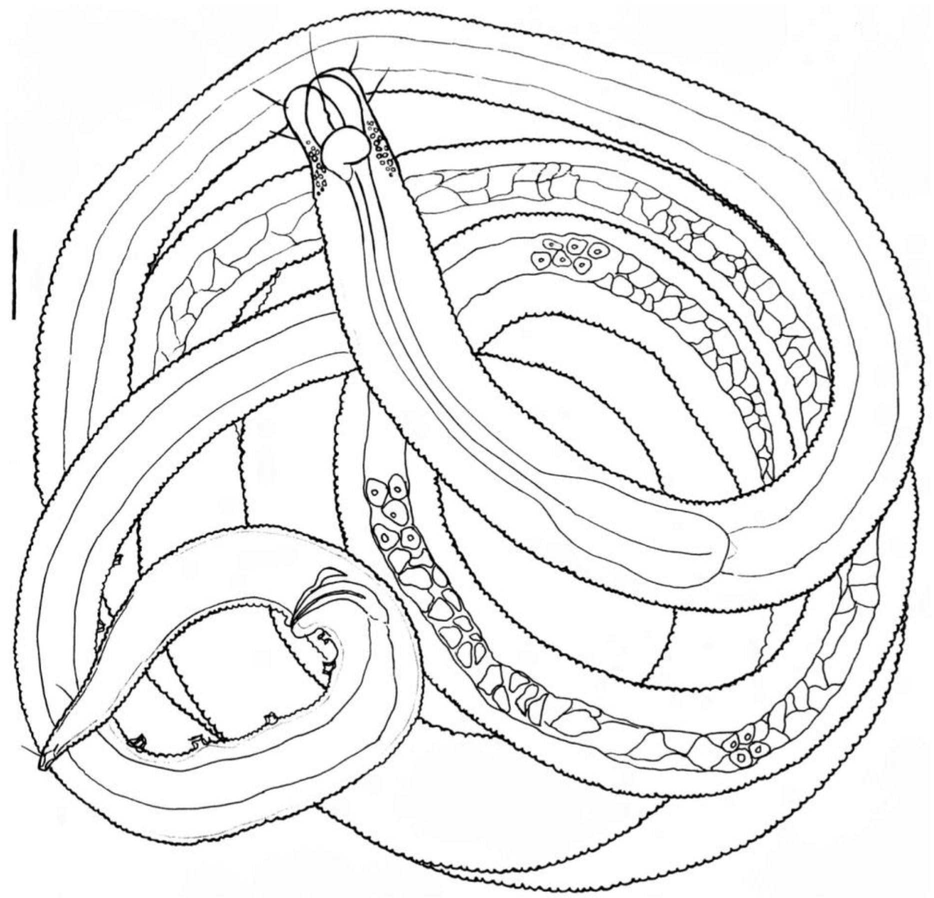

**FIGURE 2.** *Paramicrolaimus damodarani* **sp. nov.** entire organism. Scale bar 20 µm.

**Diagnosis.** Finely striated cylindrical body. Labial sensilla papilliform, barely visible. Cephalic setae in two separate circles (6+4), almost equal in size. Amphids ventrally coiled, spiral, with a loop. Buccal cavity narrow, tubular, with two denticle-like projections. Males with two opposed testes. Females with two antidromously reflexed ovaries. Ventrally placed pre-anal papillae present in males. Tail conoid.

### List of valid species

*Paramicrolaimus primus* Wieser, 1954
*Paramicrolaimus spirulifer* Wieser, 1959
*Paramicrolaimus mirus* Tchesunov, 1988
**Type species:** *Paramicrolaimus primus* Wieser, 1954

### Description of *Paramicrolaimus damodarani* sp. nov.

(Figs 2–4)

**Material examined.** Holotype, two paratype males and two juveniles [Slide No.IO/SS/NEM/00021; Deposited at FORV Referral Centre, Centre for Marine Living Resources and Ecology, Kochi, Kerala, India.] collected from continental margin of south eastern Arabian Sea.

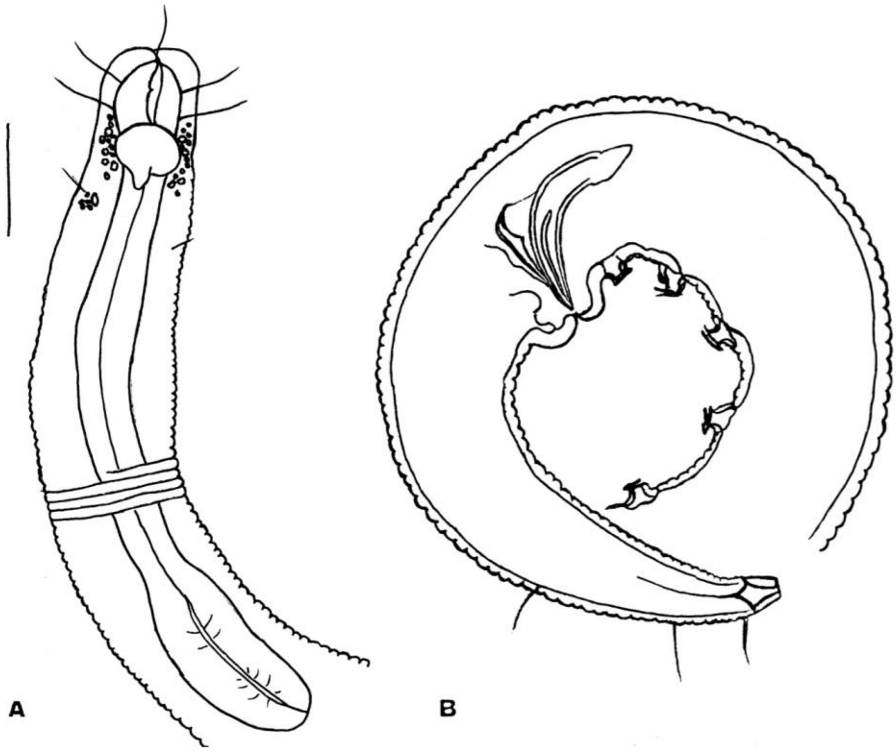

**FIGURE 3.** *Paramicrolaimus damodarani* **sp. nov.** Holotype (A) Cephalic region, (B) Caudal region showing spicule and precloacal supplements. Scale bar 20 µm.

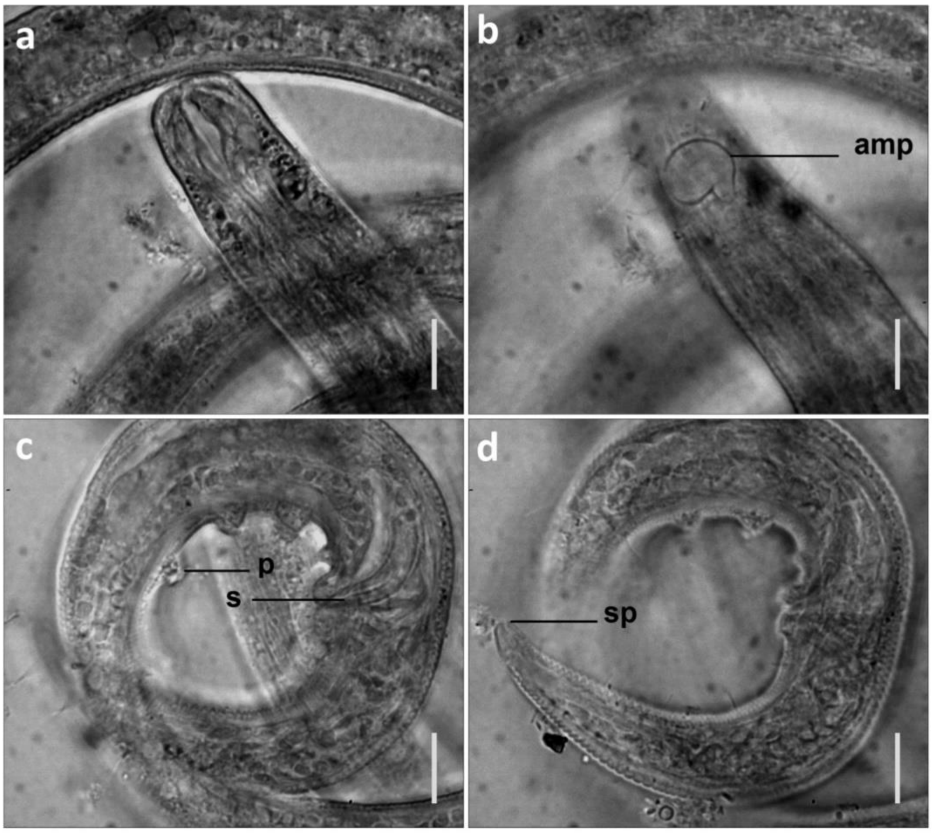

**FIGURE 4.** *Paramicrolaimus damodarani* **sp. nov.** (A) Cephalic region, (B) Amphid, (C) Spicule and precloacal suppliments, (D) Caudal region (amp, amphid; p, precloacal suppliments; s, spicule; sp, spinneret) Scale bars 10 µm.

**Type locality.** Holotype and paratype males: Continental margin of south eastern Arabian Sea—off Kannur, 11° 45' 02" N, 74° 41' 47" E, 95 m, 11.02.2012 (FORVSS 295). Two juveniles: South eastern Arabian Sea—off Cape Comorin, 7° 09' 12" N, 77° 19' 14" E, 207 m, 21.04.2005 (FORVSS 233). Sediment texture was silt with low percentages of clay, bottom temperature 26.6°C, bottom salinity 35.65 psu, bottom dissolved oxygen concentration 2.98 ml/l.

**Description.** Holotype (male): Body cylindrical, long and thread like. Total body length 1280 µm, *a*=51.2, *b*=9.14, *c*=20.32. Body diameter 20 µm at the level of posterior cephalic setae, with maximum 25 µm at mid body and 25 µm at anus. Cuticle thick, striated; striation in the cephalic region weak, distinct at mid body and caudal region. Hypodermal gland cells present. Head without striation, slightly constricted at the level of amphids. Labial sensillae barely visible. Cephalic setae in two separate circles (6+4), with similar lengths (13–14 µm). Somatic setae present in cephalic (5 µm) and caudal (7 µm) regions. Buccal cavity irregular, with deep and narrow anterior part and posterior part with sclerotized walls, two teeth present as dorsal and right subventral projections. Amphids wide (11 µm), thick walled, transversely oval-shaped with a small dorsal limb, located 19 µm away from the anterior end. Oesophagus 140 µm long with swollen anterior end, middle part thin and cylindrical; posterior end swollen resembling a slightly elongated or weak oesophageal bulb (35 µm long and 10 µm wide). Males diorchic. Spicules paired, equal in size, 28 µm long, strongly arcuate, proximally cephalate with a distinct ventral, raised keel-like structure at mid-length. Gubernaculum parallel to spicule, simple in shape with lateral wing in the middle part. Seven distally expanded, cuticularised, protruding, precloacal supplements, each with distal thorn-like structures at their tips. First anterior and last posterior precloacal supplements slightly smaller than those between. Tail conoid, attenuated, ventrally coiled; 63 μm in length. Short, broad terminal spinneret present, strongly cuticularised, with long terminal setae arising from it dorsally.

**Females and Juveniles.** Females not found; juveniles resemble males in general morphology (Table 1).

**TABLE 1**. Morphometry of *Paramicrolaimus damodarani* **sp. nov.**

| Material examined | Holotype ♂ | Paratype ♂1 | Paratype ♂2 | Juvenile 1 | Juvenile 2 |
|---|---|---|---|---|---|
| L (μm) | 1280 | 1310 | 1225 | 1230 | 1285 |
| mbd (μm) | 25 | 25 | 24 | 23 | 25 |
| a | 51.2 | 52.4 | 51.0 | 53.5 | 51.4 |
| b | 9.1 | 9.0 | 8.8 | 8.7 | 9.0 |
| c | 20.3 | 20.2 | 18.8 | 18.9 | 19.8 |
| hd (μm) | 20 | 20 | 20 | 20 | 20 |
| cs (μm) | 13+14 | 13+15 | 13+14 | 13+14 | 13+14 |
| ss (μm) | 5–7 | 5–7 | 5–7 | 5–7 | 5–7 |
| aw (μm) | 11 | 12 | 11 | 11 | 11 |
| Distance from anterior end (μm) | 19 | 20 | 19 | 19 | 19 |
| Oesophagus length (μm) | 140 | 145 | 140 | 142 | 142 |
| Spicule length as arc (S) (μm) | 28 | 29 | 28 | – | – |
| L. of gubernaculum (μm) | 19 | 19 | 19 | – | – |
| No. of supplements | 7 | 7 | 7 | – | – |
| t (μm) | 63 | 65 | 65 | 65 | 65 |

**Diagnosis.** Cuticle finely striated. Conspicuous amphids with thick wall, transversely oval-shaped with a small dorsal limb. Spicules paired, strongly arcuate, proximally cephalate with a distinct central keel. Gubernaculum simple, plate-like, with a lateral wing in the middle part. Seven cuticularised, protruding, ventrally placed precloacal supplements. Tail conoid with a cuticularised terminal spinneret.

**Relationships.** The general shape of the body and the spicular apparatus, position and number of cephalic setae, and position and shape of the amphid place the present specimens in *Paramicrolaimus* Wieser, 1954 (Figs 2–4; Tables 1 & 2). They are most similar to *Paramicrolaimus mirus* Tchesunov, 1988 in the general shape of the body, buccal cavity, oesophagus, size and shape of amphid and shape of gubernaculum. *Paramicrolaimus damodarani* **sp. nov.** strongly differs from *P. mirus* in body length (1.28 mm vs 4.06 mm), length of cephalic setae (6+8 μm vs 13+14–15 μm), *a*-value (105–106 *vs* 51–52.4), *b* - value (21.7–21.8 *vs* 8.8–9.1), *c*-value (28–40.5 *vs* 18.8–20.3), number of precloacal supplements (7 *vs* 9), shape and size of spicular apparatus (28 μm *vs* 23 μm), and in having a terminal spinneret which is absent in *P. mirus* (Figs 2–4, Tables 1 &2 ). Specimens of *P. mirus* from the Yellow Sea (Huang & Zhang, 2005) showed larger measurements in all morphological characters compared with *P. damodarani* **sp. nov.** (Table 2). Also, the spicule of *P. mirus* has a velum (Huang & Zhang 2005) whereas *P. damodarani* **sp. nov.** has a central keel at mid-length. The gubernaculum in both the species were plate-shaped with a lateral wing in middle part but is of different size (19 μm *vs* 18 μm). The spinneret of *P. damodarani* **sp. nov.** has strongly cuticularised walls and the setae in the caudal region are longer (Figs 2, 3) than in *P. mirus*.

*Paramicrolaimus damodarani* **sp. nov.** can be differentiated from *P. spirulifer* in being smaller (1.28 mm vs 4.43 mm) in all morphological measurements in addition to the number of precloacal suppliments (7 vs 6) and the shape of the gubernaculum (Figure 2–4; Table 2). While Wieser, 1959 reported 6 precloacal supplements in *P. spirulifer,* Jensen (1978) counted 10 in the redescription of the species. The gubernaculum in *P. spirulifer* is weakly sclerotized and apparently surrounds the distal parts of the spicules but in *P. damodarani* **sp. nov.** it is plate-shaped with a lateral wing in the middle part.

**Etymology.** The species is named in honour of Prof. R. Damodaran, with deep gratitude and in appreciation of his invaluable contributions to benthic studies in India.

### Pictorial key to species of the genus *Paramicrolaimus* Wieser, 1954

Since morphometric characters or some details of nematodes are difficult to describe in a conventional dichotomous key, an identification guide with a pictorial key, coupled with descriptions of most important diagnostic characters has proved useful for generic identification of marine nematodes (Platt & Warwick 1988). Here, a similar pictorial key to the four known species of *Paramicrolaimus* is provided (Figure 5), and supplemented with morphometrics of these species, summarized from available descriptions (Table 2).

1. Cuticular ornamentation absent. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
2. Cuticular ornamentation present in the form of longitudinal bars (Figure 5A) . . . . . . . . . . . . . . . . . . . *Paramicrolaimus primus*
3(a). Spicular alae present . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
3(b). Spicular alae absent (Figure 5B). . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Paramicrolaimus spirulifer*
4(a). Alae in the form of velum (Figure 5C) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Paramicrolaimus mirus*
4(b). Alae in the form of central keel (Figure 5D). . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Paramicrolaimus damodarani* **sp. nov.**

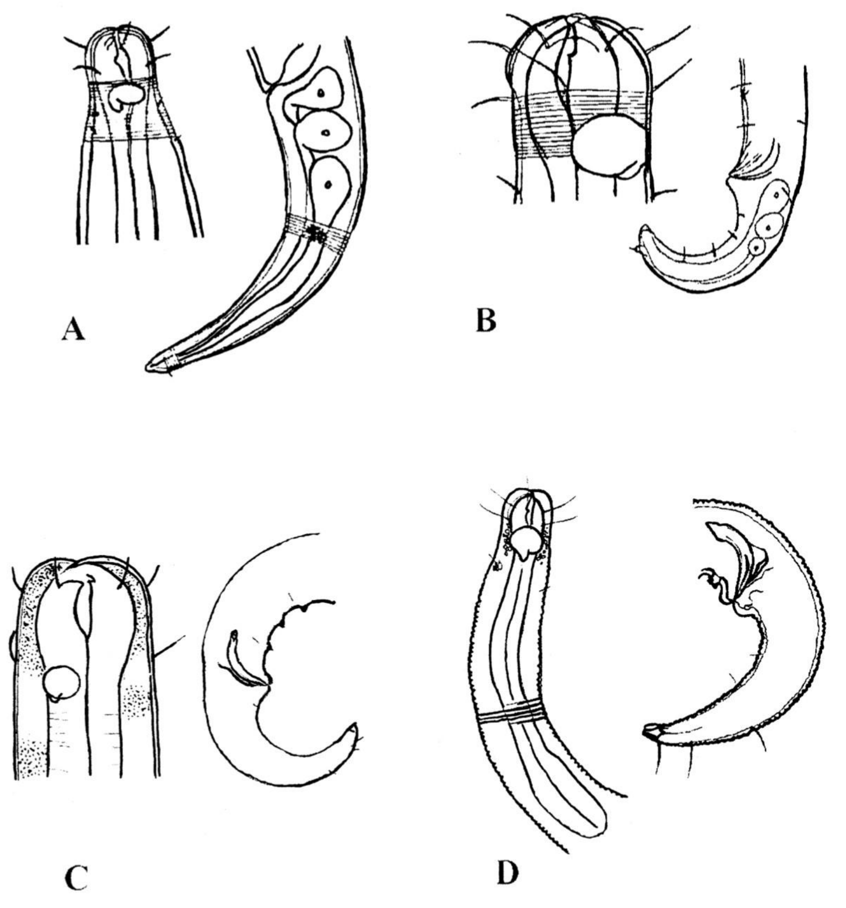

**FIGURE 5.** Pictorial key to *Paramicrolaimus* species: Anterior and posterior body region of holotypes of (A) *P. primus*, (B) *P. spirulifer*, (C) *P. mirus*, (D) *P. damodarani* **sp. nov.**

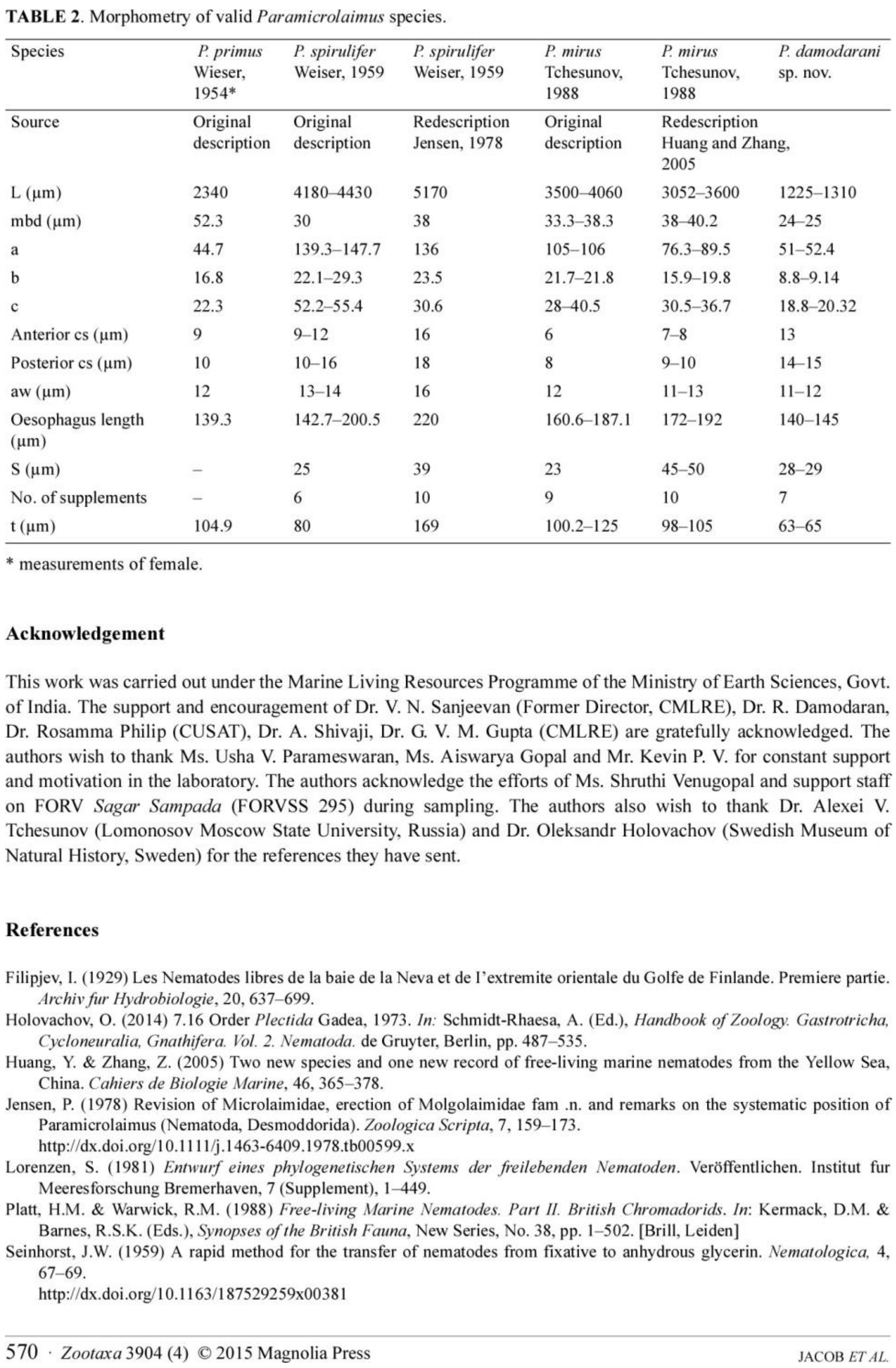

**TABLE 2**. Morphometry of valid *Paramicrolaimus* species.

| Species | *P. primus* Wieser, 1954* | *P. spirulifer* Weiser, 1959 | *P. spirulifer* Weiser, 1959 | *P. mirus* Tchesunov, 1988 | *P. mirus* Tchesunov, 1988 | *P. damodarani* sp. nov. |
|---|---|---|---|---|---|---|
| Source | Original description | Original description | Redescription Jensen, 1978 | Original description | Redescription Huang and Zhang, 2005 | |
| L (μm) | 2340 | 4180–4430 | 5170 | 3500–4060 | 3052–3600 | 1225–1310 |
| mbd (μm) | 52.3 | 30 | 38 | 33.3–38.3 | 38–40.2 | 24–25 |
| a | 44.7 | 139.3–147.7 | 136 | 105–106 | 76.3–89.5 | 51–52.4 |
| b | 16.8 | 22.1–29.3 | 23.5 | 21.7–21.8 | 15.9–19.8 | 8.8–9.14 |
| c | 22.3 | 52.2–55.4 | 30.6 | 28–40.5 | 30.5–36.7 | 18.8–20.32 |
| Anterior cs (μm) | 9 | 9–12 | 16 | 6 | 7–8 | 13 |
| Posterior cs (μm) | 10 | 10–16 | 18 | 8 | 9–10 | 14–15 |
| aw (μm) | 12 | 13–14 | 16 | 12 | 11–13 | 11–12 |
| Oesophagus length (μm) | 139.3 | 142.7–200.5 | 220 | 160.6–187.1 | 172–192 | 140–145 |
| S (μm) | – | 25 | 39 | 23 | 45–50 | 28–29 |
| No. of supplements | – | 6 | 10 | 9 | 10 | 7 |
| t (μm) | 104.9 | 80 | 169 | 100.2–125 | 98–105 | 63–65 |

* measurements of female.

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# *Psammonema kuriani* (Nematoda: Desmodoroidea), a novel species from the margin of the north-eastern Arabian Sea

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*A novel species of nematode belonging to the rare genus* Psammonema *Verschelde & Vincx, 1995 is described from the continental margin of the north-eastern Arabian Sea (214 m).* Psammonema kuriani *sp. nov. shows a different position of the lateral alae compared with the original genus diagnosis, hence an emended genus diagnosis is given. The genus* Psammonema *was previously described from the estuarine sediments of Indian Ocean region and the present study reports the genus from the deep sea for the first time.*

**Keywords:** Deep sea, Nematode, *Psammonema*, rare species, Arabian Sea, continental slope, Indian Ocean, Desmodorida

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## INTRODUCTION

The deep-sea nematodes are known to be very rich in species numbers and most of the species still remain to be described (Fonseca *et al*., 2006). The true extent of their species diversity is still unknown. In a recent review of the published literature on nematodes, 638 valid species belonging to 175 genera and 44 families are described from the deep sea (Miljutin *et al*., 2010). The major impediment in describing new species from the deep sea is the small size, difficulty to get enough specimens of the same species for descriptions and the low proportion of males present in samples. Even though several hundred unknown species can be found in a sample of 1000 nematodes, most of them may be represented by only a few or even one specimen (Miljutin *et al*., 2010). Members of the family Desmodoridae have been documented in most of the ecological studies on marine nematode assemblages from deep-sea sites but their density was always low, with a relative abundance reaching a maximum of 1% of the total mass (Soetaert & Heip, 1995). Species belonging to the family Desmodoridae are typical components of the nematode community in sandy substrates (De-Jesús Navarrete, 2007) where most of the deep-sea habitat is covered with finer sediments. In the recently published *Handbook of Zoology*, family Desmodoridae belongs to the superfamily Desmodoroidea Filipjev, 1922 and is composed of six subfamilies, 43 genera and 321 species (Tchesunov, 2014); but these figures are arbitrary and vary according to the source.

The free-living marine nematode fauna has been studied in many regions of the world. Vast areas of the deep-sea floor have not been studied due to logistical difficulties associated with deep-sea sampling and the scarcity of taxonomic expertise. The Indian Ocean is one among the geographic regions which has not been studied extensively. The deep-sea nematode fauna in the Indian Ocean region, in particular, is very poorly known. No species have been described from the northern region of the deep Indian Ocean to date.

## MATERIALS AND METHODS

Adult male specimens of the new species were recovered during a benthic survey on board the Fishery and Oceanographic Research Vessel 'Sagar Sampada' (*FORVSS*). Sediment samples were collected using a Smith McIntyre grab from the continental slope of the north-eastern Arabian Sea. The specimens of genus *Psammonema* were obtained from *FORVSS* cruise no. 219 at a depth of 214 m. The meiofauna were subsampled from the grab using a glass corer of diameter 2.5 cm, fixed and preserved in 10% formalin, stained with Rose Bengal. Salinity, temperature and dissolved oxygen of the water column just above the sediment were measured using the Sea Bird CTD (SBE 911), from *FORVSS*. Sediment texture was analysed using a Particle Size Analyser (Sympatec, Germany). The percentage of organic matter in the sediment was estimated by the wet oxidation method (El Wakeel & Riley, 1957). Organic matter is expressed as percentage of sediment dry weight examined. Onshore, meiofauna were separated using a set of sieves (63 and 500 µm), and sorted manually using a stereo microscope (Leica EZ4). Nematodes were then processed to pure glycerine by the slow evaporation technique (Seinhorst, 1959) and mounted on glass slides for detailed examination and taxonomic identification. Descriptions and drawings were made based on the glycerine mounts, using a Leica DM 1000 microscope with an attached drawing tube. The specimens were identified to genus level following Platt & Warwick (1988) and NeMys (Vanaverbeke *et al*., 2014).

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Four type specimens have been deposited in the *FORV* Referral Centre, Centre for Marine Living Resources and Ecology, Cochin, Kerala, India. All measurements are in micrometres and all curved structures are measured along the arc. Abbreviations in the text are as follows: (a) body length divided by maximum body diameter; (b) body length divided by pharyngeal length; (c) body length divided by tail length.

## RESULTS

### SYSTEMATICS

Taxonomic classification, according to Decraemer & Smol (2006)
Order DESMODORIDA De Coninck, 1965
Suborder DESMODORINA De Coninck, 1965
Superfamily DESMODOROIDEA Filipjev, 1922
Family DESMODORIDAE Filipjev, 1922
Subfamily DESMODORINAE Micoletzky, 1924
Genus *Psammonema* Verschelde & Vincx, 1995

### EMENDED DIAGNOSIS

Desmodorinae. Cuticle multi-layered, finely annulated. Lateral alae narrow, without interdigitation, extending from the level of the pharynx or just posterior to it as far as the cloacal or anal region. Different types of somatic setae arranged in 6–8 rows. Cephalic capsule ornamented with small vacuoles and possessing thick inner cuticle. Offset labial region with thin cuticle. No subcephalic setae but additional setae may be present. Anteriorly placed amphids. Amphideal fovea in male loop-shaped, sexual dimorphism in the shape of amphid may be present. Buccal cavity with a crown of denticles, a strong dorsal tooth and two small ventrosublateral teeth. Pharynx with tripartite slightly prolonged end bulb. Thin cuticle of pharyngeal internal lumen. Precloacal supplements and thick pre-anal seta present.

**Type species:** *Psammonema ovisetosum* Verschelde & Vincx, 1995

*Psammonema kuriani* sp. nov.
(Figures 1–4, Table 1)

### TYPE SPECIMENS

Holotype male, Paratypes: one male and two juveniles [Slide No. IO/SS/NEM/00023]; Deposited at FORV Referral Centre, Centre for Marine Living Resources and Ecology, Cochin, Kerala, India, collected during cruise *FORVSS* 219 on 3.12.2003.

### TYPE LOCALITY

Continental margin of north-east Arabian Sea – off Goa, 15°25′459″N 72°52′855″E, 214 m. Silty sand sediments with 3.61% organic matter content, bottom temperature 16.9°C, bottom salinity 35.30 psu, bottom dissolved oxygen concentration 0.55 ml $l^{-1}$.

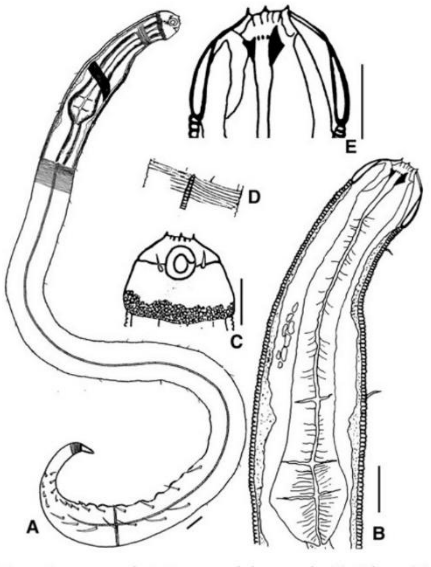

**Fig. 1.** *Psammonema kuriani* sp. nov. holotype male (A) Habitus, (B) Pharyngeal region, (C) Head capsule showing amphid, (D) Beginning of lateral alae, (E), Buccal cavity and dentition. Scale bars 20 μm.

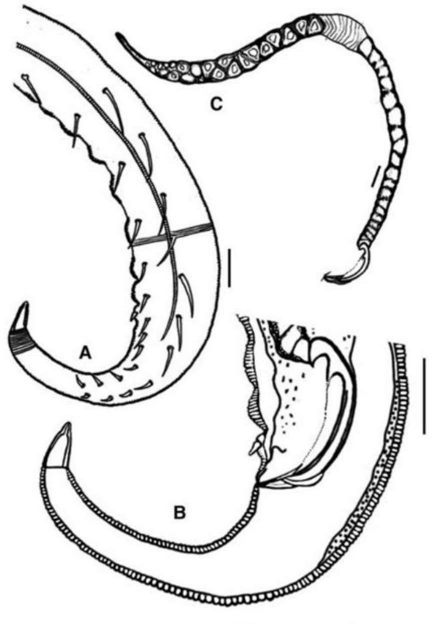

**Fig. 2.** *Psammonema kuriani* sp. nov. holotype male caudal region (A) External morphology, (B) Pre-cloacal supplements, setae and spicule, (C) Reproductive system. Scale bars 20 μm.

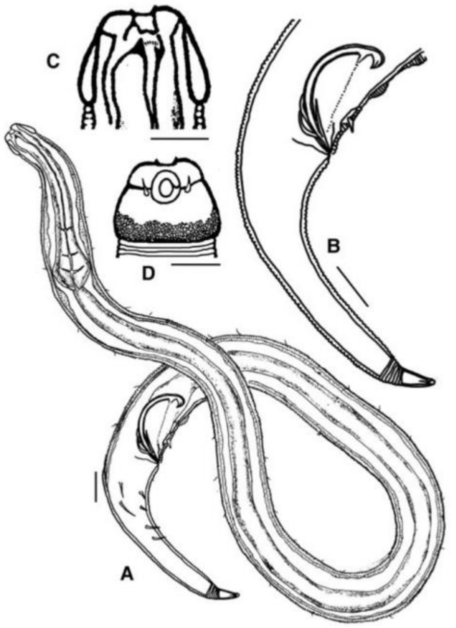

**Fig. 3.** *Psammonema kuriani* sp. nov. paratype male (A) Habitus, (B) Caudal region (C) Cephalic capsule, (D) Cephalic capsule external morphology. Scale bars 20 μm.

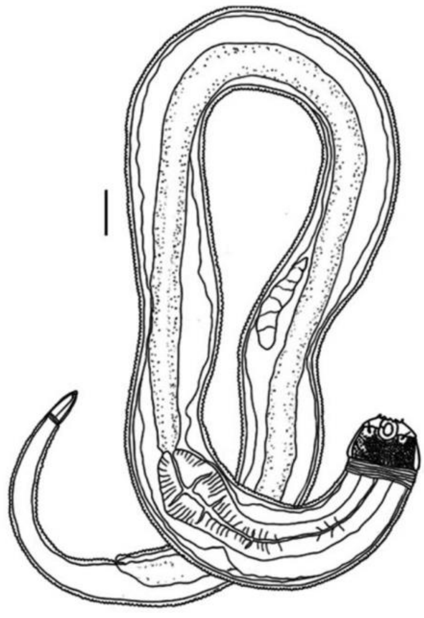

**Fig. 4.** *Psammonema kuriani* sp. nov. juvenile habitus. Scale bar 20 μm.

### ETYMOLOGY

The species is named in honour of Dr C.V. Kurian, with deep gratitude and appreciation of his invaluable contributions to benthic studies in India.

### DESCRIPTION OF HOLOTYPE (MALE)

(Figures 1 & 2): Large, thick cylindrical body with distinct cephalic capsule. Total body length 1115 μm. Maximum body diameter 45 μm. Cephalic capsule rounded triangle, well set off with thick cuticle. Labial region of cephalic capsule can be differentiated from the main region by the thickness of cuticle (Figure 1C, E). Main region of the cephalic capsule highly thickened while cuticle of the labial region is thin. Cephalic capsule ornamented with small vacuoles except in the labial region. Six smaller external labial papillae; four cephalic setae located at the base of amphid. No real subcephalic setae or additional setae. Amphids spiral, 1.25 turns, anteriorly placed, anterior edge of the amphid touching the anterior edge of the cephalic capsule. Somatic setae situated 10 μm behind the cephalic capsule. Buccal cavity equipped with 12 longitudinal rugae, one strong dorsal tooth, two latero-ventral teeth and a circle of denticles (Figure 1E). Pharyngeal end bulb tripartite with clear partition (Figure 1B). Inner pharyngeal lumen with thin cuticular walls. Pharynx 185 μm long. Body annuli slender with multilayered cuticle. Lateral alae present beginning 48 μm posterior to pharyngeal bulb; narrow, without interdigitation and formed by local raising of each annule (Figure 1D). Somatic setae – slender and long (8–10 μm), arranged in eight rows at pharyngeal and posterior third of body, but in six rows at midbody region. At last third body region, latero-ventral row of somatic setae splitting into two rows of thickened setae, the more ventrally located ones being more thick (3 μm), long (20 μm) and firm. The thick setae posterior to cloacal region shorter (9 μm) (Figure 1A).

Reproductive system monorchic. Long testis and vas deferens, located on ventral side (Figure 2C). Spicules long (63 μm), strongly cuticularized, arcuate with short ventral beak-like projection in rounded capitulum. Velum hardly visible (Figures 2B & 3B). Gubernaculum with two lateral pieces surrounding spicule. Ten precloacal supplements, in the form of heavily cuticularized protrusion of the cuticle and without any setae. Single thick, stout and blunt precloacal seta. Tail long, conoid with rows of thick and thin somatic setae and short, cuticularized with non-annulated tip.

### PARATYPE MALE

(Figure 3) Paratype male was slightly longer than that of holotype. All characters were similar to holotype but with comparatively large measurements in some of the morphological characters (Table 1).

### PARATYPE JUVENILES

(Figure 4) Similar to adult males in general morphological appearance but differing in the morphological measurements.

**Table 1.** Morphometry of valid *Psammonema* species, all measurements are in micrometres.

| Characters | *P. ovisetosum* Verschelde & Vincx, 1995 | *P. kuriani* sp. nov. | | | |
|---|---|---|---|---|---|
| | | **Males** | | **Juveniles** | |
| | | **Holotype** | **Paratype 1** | **Paratype 2** | **Paratype 3** |
| L: body length | 861–1106 | 1115 | 1215 | 630 | 900 |
| mbd: maximum body diameter | 38–90 | 45 | 47 | 45 | 43 |
| ph: pharyngeal length | 154–178 | 185 | 185 | 150 | 182 |
| ph: pharyngeal width | – | 29 | 30 | 30 | 30 |
| *a* | 10.9–23.9 | 24.8 | 25.9 | 14 | 20.9 |
| *b* | 5.5–7.1 | 6.0 | 6.6 | 4.2 | 4.9 |
| *c* | 8.8–10.9 | 11.4 | 12.2 | 5.7 | 9.0 |
| cs: length of cephalic setae | 4–7 | 2 | 4 | 2 | 2 |
| cephalic capsule width | 20–27 | 25 | 27 | 26 | 25 |
| cephalic capsule height | – | 20 | 21 | 23 | 20 |
| amphidial width | 9–12 | 9 | 10 | 9 | 10 |
| amphidial length | – | 10 | 11 | 11 | 11 |
| bdcs: body diameter at level of the cephalic setae | 20–27 | 25 | 25 | 25 | 25 |
| spic: length of spicules measured along the arc | 46–52 | 63 | 65 | – | – |
| gub: length of gubernaculum measured along the arc | 23–30 | 29 | 30 | – | – |
| abd: anal body diameter | 24–36 | 30 | 30 | 25 | 28 |
| *t*: tail length | 93–114 | 98 | 100 | 110 | 100 |
| tmr: length of non-annulated tail end | 8–19 | 10 | 10 | 13 | 10 |
| precloacal supplements | 10 | 10 | 10 | – | – |
| precloacal papillae | 2 | 1 | 1 | – | – |

Early stage of genital primordium consisting of a group of cells, located in the posterior half of the body.

### FEMALES

Not found.

## DISCUSSION

The general morphology such as well set off labial region with thin cuticle, presence of narrow lateral alae without interdigitation, absence of real sub-cephalic setae or additional setae, presence of strong single dorsal tooth, two lateroventral teeth and a circle of denticles, tripartite pharyngeal end bulb with thin cuticle of internal lumen, presence of different sized somatic setae in the posterior third region, presence of precloacal supplements and pre-cloacal papillae, all place the present specimens in the genus *Psammonema* Verschelde & Vincx, 1995 (Figures 1–4; Tables 1). Even though the present specimens show some characters of the genus *Pseudochromadora* Daday, 1899, such as lateral alae extending from posterior to the cardia, the present specimens differ from *Pseudochromadora* Daday, 1899 in having a crown of denticles, tripartite pharyngeal end bulb, narrow lateral alae and cephalic setae placed at the posterior edge of amphid. In addition to this, the somatic setae of genus *Pseudochromadora* are thin and uniform in size whereas those of *Psammonema* are of different sizes in different body regions.

The genus *Psammonema* was raised by Verschelde & Vincx, 1995 based on the specimens of *P. ovisetosum* which is the type species. *Psammonema kuriani* sp. nov. is the second species assigned to this genus. The new species is sporadic in distribution and represented by only four individuals at a single location, despite analysing 288 core samples from an extensive survey along the eastern Arabian Sea margin covering 06°57′19″N – 21°30′639″N. The genus *Psammonema* Verschelde & Vincx, 1995 was previously described from the estuarine sediments of the Indian Ocean region and the present study reports the genus from the deep sea for the first time.

## Differential diagnosis

The differentiating characters of *Psammonema kuriani* sp. nov. from *P. ovisetosum* are as follows. Amphids of males of *P. kuriani* sp. nov. are in the form of a spiral or closed loop whereas amphids in males of *P. ovisetosum* are in the shape of an open loop reaching the entire length of the cephalic capsule. Since females of the present species could not be retrieved it was not possible to comment on the sexual dimorphism of the present species. Cephalic setae are situated at mid-amphid level in *P. ovisetosum* whereas in *P. kuriani* sp. nov. cephalic setae are located below the base or at the posterior half of the amphid. Cephalic setae of *P. kuriani* sp. nov. are shorter compared with those of *P. ovisetosum* (2–4 *vs* 4–7 μm). Lateral alae of the *P. ovisetosum* begin a few micrometres below the cephalic capsule and run below the level of cloaca whereas in the case of *P. kuriani* sp. nov., they begin 48 μm behind the base of pharyngeal bulb and reach up to the cloacal region. Ten precloacal supplements of *P. kuriani* sp. nov. formed as thickened cuticular protrusions without any setae, but in addition to the supplements, a single thick, stout and blunt pre-cloacal seta was observed. In *P. ovisetosum*, there were 10–14 short spine-like setae which are considered as precloacal supplements and a pair of short and firm pre-cloacal setae were present. The gubernaculam of *P. kuriani* sp. nov. encircles the spicules with two lateral pieces lying parallel to it while that of *P. ovisetosum* is stretched out around the spicule with lateral pieces (Verschelde & Vincx, 1995).

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**SHORT REPORT**

# A new species of *Scaptrella* (Nematoda: Monhysterida) from the continental margin of the southeastern Arabian Sea

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**Abstract**

A novel species of nematode belonging to the family Xyalidae is described from the continental margin of the southeastern Arabian Sea (1100 m). The new species, *Scaptrella filicaudata* sp. nov., is differentiated from the existing species by the swan-shaped longer spicule (45 μm), gubernaculum with dorsocaudally directed apophysis and long filiform tapering tail. A pictorial key to all the valid species of *Scaptrella* Cobb, 1917 is provided.

**Key words:** *Arabian Sea, continental slope, deep sea, nematode,* Scaptrella, *Xyalidae*

## Introduction

In a recent review of the published literature on nematodes, 638 valid species belonging to 175 genera and 44 families are described from the deep sea alone (Miljutin et al. 2010). The deep-sea bottom contains a surprisingly diverse community of nematodes and at present the true extent of their species diversity is impossible to evaluate. Deep-sea nematodes are known to be very rich in species numbers and most of the species still remain to be described (Fonseca et al. 2006). The major impediments in describing new species from the deep sea are their small size, difficulty of obtaining sufficient specimens for species descriptions and the low proportion of males present in samples. In a sample of 1000 deep sea nematodes, there can be several hundred unknown species but most of them may be represented by only a few or even one specimen (Miljutin et al. 2010).

The free-living marine nematode fauna has been studied in many regions of the world. The Indian Ocean is among the geographic regions which have not been studied extensively. The deep-sea nematode fauna in the Indian Ocean region, in particular, is very poorly known, with only descriptions from the coast of Kenya covered during the Netherlands Indian Ocean Programme (Muthumbi & Vincx 1996, 1997, 1998, 1999). No new species of free-living nematodes have been described from the northern region of the deep Indian Ocean to date.

Xyalidae Chitwood, 1951 is among the most species-rich and often ecologically dominant families of marine free-living nematodes, which inhabit nearly all types of marine environments. A review by Venekey et al. (2014) recognized 46 valid genera, 450 valid species and 73 *species inquirendae* (descriptions without enough morphological information for identification) from the family Xyalidae. Even though some xyalid genera contain hundreds of species, *Scaptrella* Cobb, 1917 is a rare genus with only two valid species described.

A new species, *Scaptrella filicaudata* sp. nov., is described from the continental margin of the southeastern Arabian Sea. The new species is represented by only two individuals from a single location, despite analysing 288 core samples from an

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extensive survey along the eastern Arabian Sea margin covering 06°57′19″N to 21°30′639″N.

## Materials and methods

Adult male specimens of the new species were recovered from the benthic survey on board FORV *Sagar Sampada*. Meiofaunal samples were collected using a Smith McIntyre grab from the continental slope of the southeastern Arabian Sea. Specimens belonging to the genus *Scaptrella* Cobb, 1917 were recovered during FORVSS 225. The site of collection was located on the southwest coast of India (Eastern Arabian Sea), at a depth of 1100 m (Figure 1). The meiofauna were sub-sampled from the grab using a glass corer of diameter 2.5 cm, fixed and preserved in 10% formalin and stained with Rose Bengal. Salinity, temperature and dissolved oxygen in the water column just above the sediment were measured using a Sea Bird CTD (SBE 911), on board FORV *Sagar Sampada*. Sediment texture was analysed using a Particle Size Analyser (Sympatec, Germany). The percentage of organic matter in the sediment was estimated by the wet oxidation method (El Wakeel & Riley 1957). Organic matter is expressed in terms of the percentage of sediment dry weight examined. In the laboratory, meiofauna was sieved using a set of sieves (63 µm and 500 µm), sorted and separated manually under a stereo microscope (Leica EZ4). Nematodes were then processed by the slow evaporation technique (Seinhorst 1959), transferred to pure glycerine and mounted on glass slides for detailed examination and taxonomic identification. Descriptions and drawings were made based on the glycerine mounts, with the aid of a Leica DM 1000 microscope with attached drawing tube. The specimens were identified to genus level following Platt & Warwick (1988) and NeMys, the general taxonomic database on Mysida and Nematoda (Vanaverbeke et al. 2014). Type specimens have been deposited in the FORV Referral Centre (CMLRE: Centre for Marine Living Resources and Ecology, Cochin, Kerala, India).

All measurements are in micrometres and all curved structures are measured along the arc. Abbreviations are as follows: a: body length divided by maximum body diameter; abd: anal body diameter; aw: amphidial width; b: body length divided by pharyngeal length; c: body length divided by tail length; gub: length of gubernaculum measured along the arc; hw: head width; L: body length; mbd: maximum body diameter; spic: length of spicules; t: tail length.

## Taxonomy

**Order Monhysterida** Filipjev, 1929
**Family Xyalidae** Chitwood, 1951
**Genus *Scaptrella*** Cobb, 1917

### *Diagnosis*

Cuticle striated. Buccal cavity deep, armoured with six mandibles or odontia at the anterior end. Circular amphid. Cephalic setae long and thick. Spicules with only faint accessory pieces. Tail cylindrico-conical, with or without terminal setae.
Type species: *Scaptrella cincta* Cobb, 1917
Other valid species: *Scaptrella cincta* Cobb, 1917, *Scaptrella brevicaudata* Gerlach, 1953

### ***Scaptrella filicaudata* sp. nov.**

(Table I; Figures 2–4)

### *Material examined*

Holotype and one paratype male [Slide No. IO/SS/NEM/00022; deposited at FORV Referral Centre, CMLRE], collected during cruise FORVSS 225 on 14 May 2004. Continental margin of southeastern Arabian Sea. Southeastern Arabian Sea – off Cape Comorin, 06°57′19″N, 77°21′99″E, 1100 m. Sediment texture predominantly sand with low percentages of clay. Organic matter content was 5.70%, bottom temperature 14.49°C, bottom salinity 35.08 psu and bottom dissolved oxygen concentration 0.42 ml/l.

### *Diagnosis*

Cuticle finely striated, amphid circular with thick walls. Non-striated cephalic region with labial setae, lateral setae and submedian setae. Buccal cavity cylindrical and deep, anteriorly armed with jointed mandibles and odontia. Numerous long somatic setae. Spicule curved, with proximal cephalization. Gubernaculum with dorsally directed apophysis. Tail long, filiform, without terminal setae.

### *Description of holotype (male)*

Large, thick cylindrical body. Total body length 1800 µm. Maximum body diameter 55 µm. Head rounded, diameter 26 µm, distinct without striation, 40 µm long and 32 µm wide with a small constriction at the level of cephalic setae. Labial setae 15 µm long and thick. Lateral setae 50 µm and 35 µm long; submedian setae 70 µm and 35 µm long. Subcephalic setae not observed. Buccal cavity 50 µm deep and 16 µm wide, strongly cuticularized and anteriorly armed with six extendable jointed mandibles and odontia. Somatic setae thin, long and numerous.

Table I. Morphometry of valid *Scaptrella* species (abbreviations explained in Materials and methods section).

| | *S. cincta* | *S. cincta* | *S. brevicaudata* | *S. filicaudata* sp. nov. | |
|---|---|---|---|---|---|
| Characters | Cobb 1917 | Wieser & Hopper 1967 | Gerlach 1953 | Holotype | Paratype |
| *L* | 1600–1900 | 1700 | 1310–1617 | 1800 | 1760 |
| Mbd | 41.6–45.6 | 41 | 29.94–35.41 | 55 | 53 |
| *a* | 38.5–41.6 | 41.46 | 37–54 | 32.7 | 33.2 |
| *b* | 7.7 | 7.72 | 6.7–8.1 | 6.43 | 6.54 |
| *c* | – | 4.72 | 10.4–13.3 | 1.5 | 1.4 |
| Labial setae | – | 6 to 7 | – | 15 | 15 |
| Lateral setae | – | 30 + 18 | 22–25 + 36 | 50 + 35 | 50 + 36 |
| Submedian setae | – | 50 + 30 | 22–25 + 36 | 70 + 35 | 68 + 35 |
| Buccal cavity length | 33.6–36.1 | 30 | 25 | 50 | 50 |
| Buccal cavity width | 30.4 | – | 18 | 16 | 16 |
| hw: head width | – | 20 | 18 | 32 | 32 |
| Aw | – | 10 | 8 | 10 | 10 |
| Oesophagus length | 208–247 | 220 | 122–126 | 280 | 269 |
| Oesophagus width | – | 33 | 18 | 34 | 33 |
| Abd | 28.5–30.4 | – | – | 36 | 36 |
| Spic | – | 34 | 28 | 45 | 43 |
| Gub | – | – | – | 20 | 20 |
| *T* | – | 360 | – | 1200 | 1200 |

Cuticle 3 μm thick, finely striated, striations start posterior to head region; striations are 3 μm wide and visible throughout body. Amphid thick, circular with internal spiral, measures 10 μm in width and located 31 μm away from the anterior region. Oesophagus 280 μm long and 34 μm in width at its posterior base. Posterior end of oesophagus slightly flattened or swollen, without forming a true bulb. Excretory pore and nerve ring not seen.

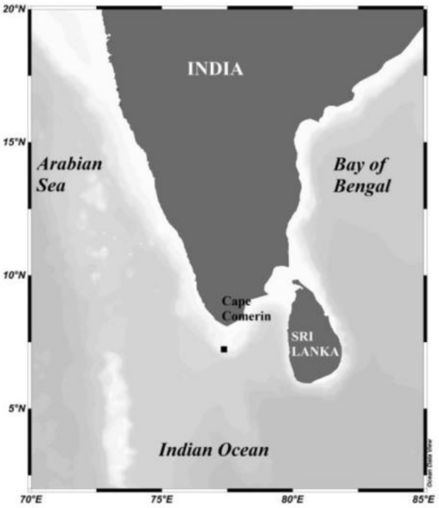

Figure 1. Map of southeastern Arabian Sea showing area of collection.

Reproductive system monorchic. Sperm cells not observed. Spicules paired, equal and arcuate or swan-shaped (45 μm long), with proximal cephalization open. Gubernaculum 20 μm long, simple, with long dorsal apophysis. Three caudal glands located posterior to spicules. Tail tapering or filiform, with striations, 1.2 mm long, without terminal setae.

Females and juveniles were not found.

### *Etymology*

The species name *filicaudata* refers to the characteristic filiform tail of this species.

### *Remarks and comparisons*

The genus *Scaptrella* was erected by Cobb, based on *Scaptrella cincta* Cobb, 1917 from California. Subsequently, *Scaptrella brevicaudata* was described by Gerlach in 1953 from the Mediterranean. There are only two valid species of the genus, *Scaptrella cincta* Cobb, 1917 and *S. brevicaudata* Gerlach, 1953. Although a third species, *Scaptrella tenuicaudata*, was described by Gerlach (1956) from Germany, it is considered a *species inquirenda* here since the description was based on a single female.

*Scaptrella filicaudata* sp. nov. differs from *S. cincta* in having longer labial setae (15 vs 6–7 μm), lateral setae (50 + 36 vs 30 + 18 μm) and submedian setae (68–70 + 35 vs 50 + 30 μm), deeper buccal cavity (50 vs 30–36 μm), lesser *a* value (32.7–33.2 vs 38.5–41.6) and a swan-shaped, longer spicule (43–45 vs 34 μm).

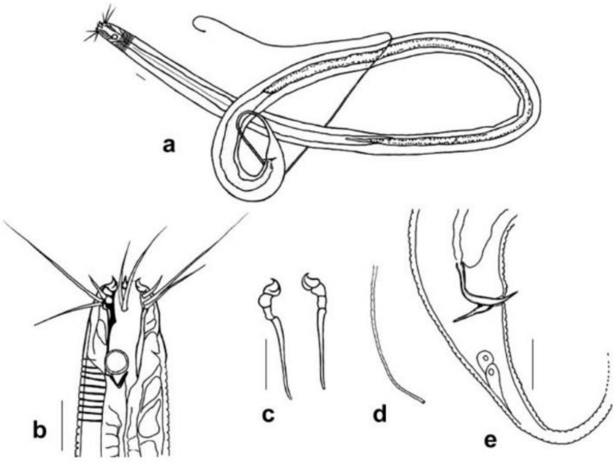

Figure 2. *Scaptrella filicaudata* sp. nov. (a) Holotype full specimen, (b) Cephalic region, (c) Jointed mandibles, (d) Tail tip, (e) Caudal region showing spicular apparatus. Scale bar 20 μm.

The gubernaculum in *S. filicaudata* sp. nov. is simple, with a dorsally directed long apophysis, but in the case of *S. cincta* it is mentioned as a faint accessory organ. However, from the redescription of *S. cincta* by Wieser & Hopper (1967), the gubernaculum has a bidentate lateral guiding piece. Similarly, the long blunt tail (360 μm) of *S. cincta* possesses numerous caudal setae and a pair of 20 μm long terminal setae, whereas the long filiform tapering tail (1.2 mm) of *S. filicaudata* sp. nov. bears no terminal setae.

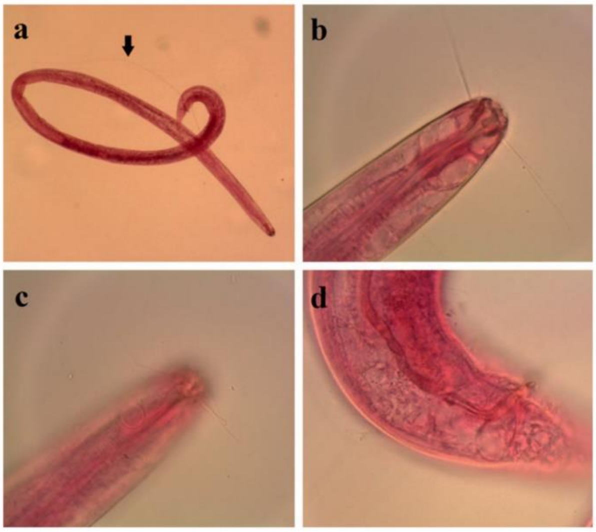

Figure 3. *Scaptrella filicaudata* sp. nov. (a) Holotype, entire organism, (b) Cephalic region, (c) Amphid, (d) Caudal region. Arrow mark indicates filiform tail.

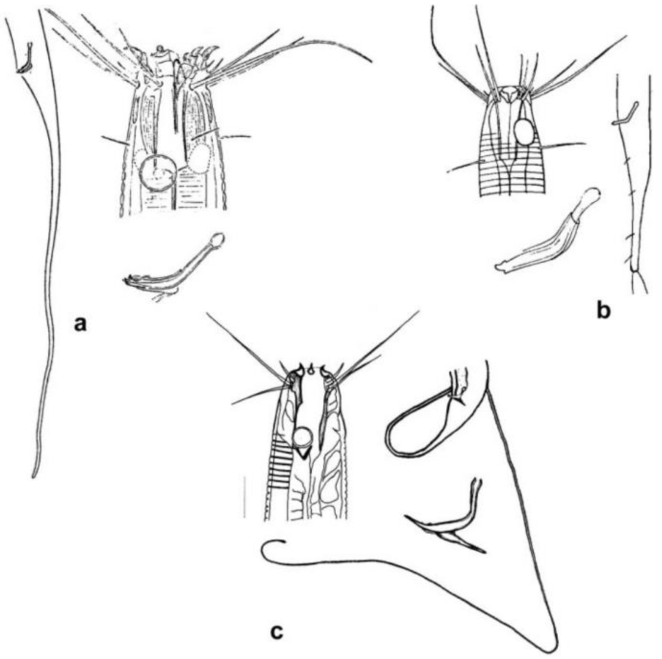

Figure 4. Pictorial key to *Scaptrella* species. Holotype: anterior and posterior body region, and gubernaculum. (a) *Scaptrella cincta* Cobb, 1917, (b) *Scaptrella brevicaudata* Gerlach, 1953, (c) *Scaptrella filicaudata* sp. nov.

*Scaptrella brevicaudata* Gerlach, 1953 can easily be distinguished from *S. filicaudata* sp. nov. by the smaller amphid (8 vs 10 μm), shallower buccal cavity (25 vs 50 μm), smaller lateral setae (22–25 + 36 vs 50 + 35–36 μm), smaller submedian setae (22–25 + 36 vs 68–70 + 35 μm), higher *a* value (37–54 vs 32.7–33.2) and *c* value (10.4–13.3 vs 1.4–1.5) and smaller spicule (28 vs 45 μm). The spicule in *S. brevicaudata* is slightly curved, with rounded capitulum at the proximal end and two tooth-like projections at the distal end, whereas in *S. filicaudata* sp. nov., proximal cephalization is open and the distal end tapering without any projection. The gubernaculum in *S. brevicaudata* encircles the spicule but in *S. filicaudata* sp. nov. the gubernaculum is simple, with a dorsally directed apophysis. The tail in *S. brevicaudata* is short and with terminal setae, whereas in *S. filicaudata* sp. nov. the tail is long, filiform and tapering to its end without any setae, as its name depicts.

The differentiation of *S. filicaudata* sp. nov. from the other two valid species is straightforward (Figures 2–4; Table I), based on the size and shape of spicular apparatus and tail.

### *Pictorial key to species of the genus* Scaptrella

A key based on pictures (Figure 4) of the species of *Scaptrella* is provided. In Table I, the most important metric characters of all the species of the genus *Scaptrella* are summarized on the basis of currently available species descriptions.

1a. Tail long, filiform ………………………………. 2
1b. Tail short (Figure 4b) ……………………………… …………………………... *Scaptrella brevicaudata*
2a. Terminal setae present and gubernacular apophysis absent (Figure 4a) …………….. *Scaptrella cincta*
2b. Terminal setae absent and gubernacular apophysis present (Figure 4c) ………………………………… …………………….. *Scaptrella filicaudata* sp. nov.

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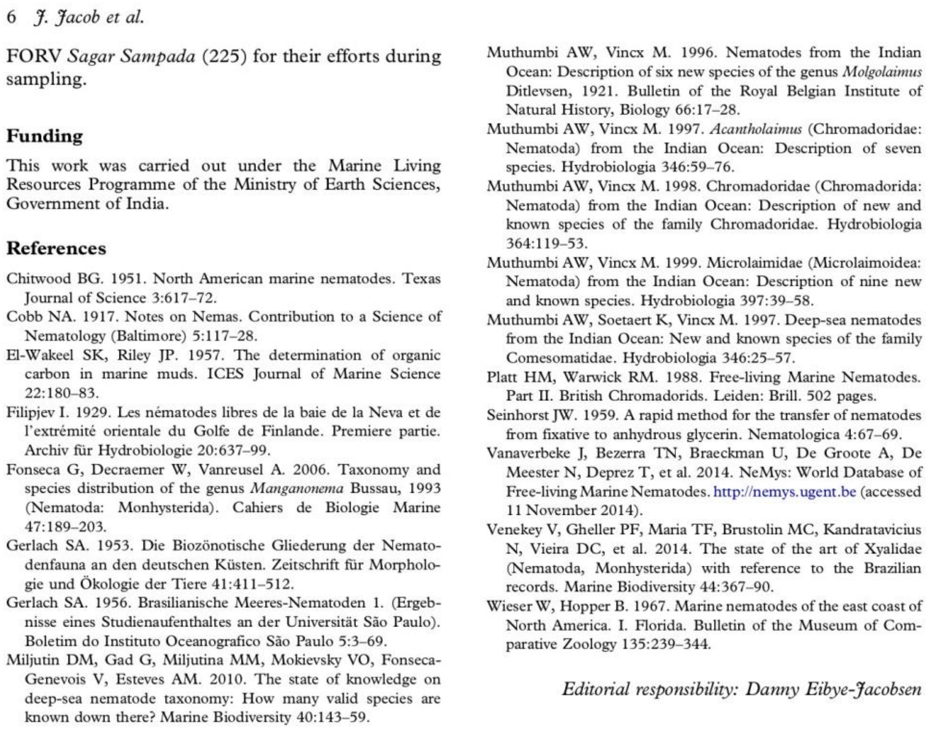

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