



Free-living nematodes along the continental slope off northeast coast of India

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Abstract

The present study provides first time information about the systematics of nematodes along the continental slope of the Northeastern coast of India between Divi point (16°00'09"N; 81°29'57"E) in the south and Paradeep (20°00'24"N; 87°29'16"E) in the north. Altogether 89 species were identified, represented by 71 genera, 25 families and 3 orders. *Marylynna complexa*, *Aponema decraemerae*, *Desmodorella tenuispiculum*, *Desmoscolex laevis*, *Retrotheristus breviseta*, *Sphaerolaimus balticus*, *Siphonolaimus ewensis*, *Terschellingia goubaultae*, *Diplopeltula incisa*, and *Axonolaimus spinosus* were found to be new records from Indian waters. The detailed descriptions along with drawings of nematode species are presented here.

Keywords: Nematodes, continental slope, meiobenthos.

Introduction

Nematodes are one of the most abundant groups in the marine meiobenthos. Recently it has been proposed that nematodes are one of the three major radiations in multi-celled organisms that have produced a large part of the world's species, the others being insects and fungi (May, 1988; Gaston, 1991). Lamshead (1993) estimates that there may be as many as 1×10^8 nematode species in the deep sea, but the number of described species of nematodes is only about 20,000 of which

more than 4000 are free-living marine organisms (Gerlach, 1980). These figures are low in comparison with the estimated 80,000 species of insects described by Gaston (1991). An important feature of nematode ecology is the presence of a large number of species in a single habitat, often in an order of magnitude higher than for any other taxon (Platt and Warwick, 1980). However, a majority of species in most of the areas of the world, especially in the deep sea and tropics, are still remained as un-described (Boucher and Lamshead, 1995).

Comprehensive works on taxonomy or ecology of free-living marine nematodes from the Indian subcontinent are less as compared to other areas of the world. The marine biotopes around the British Isles already harbor 41 nematode families with 450 species. Another estimate for the North Sea sediments is 800 species while 1,625 species have been recorded in European seas (Costello *et al.*, 2006). The few reports on the systematic works on free-living marine nematodes from the Indian ocean were by Timm (1961; 1967a,b) from Sunderbans, northeast coast of India; by Rao and Ganapati (1968) from the Waltair coast, northeast coast of India; by Rao (1975) from the Andaman and Nicobar Islands, India; by Sultan Ali *et al.* (1998) from the Pitchavaram mangroves, southeast coast of India; by Muthumbi *et al.* (1997), Muthumbi and

Vincx (1998a,b;1999) from the Kenyan coast and continental slope and by Chinnadurai and Fernando (2006a,b) from Parangipettai artificial mangroves, southeast coast of India.

Three Cruises (No.225, No.236 and No.245) were conducted by FORV *Sagar Sampada* as part of extensive scientific investigations on benthos in the continental slope regions along the east and west coasts of India. The objective of this study was to enhance the knowledge available on the abundance and biodiversity of marine benthos of continental slope sediments of northeast coast of India.

Material and methods

As a part of investigations on benthic productivity along the continental slope of India (Arabian Sea and Bay of Bengal) during 2004-2006 (May - June, 2004, June - July, 2005, June - July, 2006) 46 samples from 18 locations were collected from the northeastern coast of India. The study area includes six transects between 16°00'09" N; 81°29'57"E and 20°00'24"N; 87°29'16"E from Divipoint in the south to Paradeep in the north (Fig.1). Samples were taken from the depths of 250, 500 and 1000m using a Smith-McIntyre Grab having an area of 0.1m². From these, sub samples were collected at each location using a 10 cm long glass corer (3.6 cm dia.). The samples were anaesthetized with MgCl₂ and preserved in 4% buffered formalin. At each sampling location, bottom water temperature, dissolved oxygen, salinity, sediment texture and organic matter were measured according to standard protocols (Holme and McIntyre, 1984). In the lab, nematode specimens were picked out by hand using a fine needle and transferred into pure glycerin (Seinhorst, 1959) and mounted on Cobb slides (Cobb, 1917). Taxonomic identifications were made based on the pictorial key of Platt and Warwick (1983; 1988); Warwick *et al.* (1998) and the NeMys online identification key (Steyaert *et al.*, 2005). Drawings were made with the camera

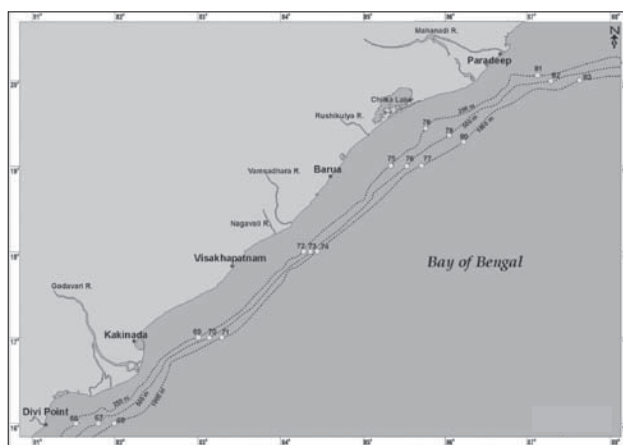


Fig. 1. Map showing sampling sites from Divipoint to Paradeep of Bay of Bengal

lucida. All measurements were carried out with the software ProgRes® Capture Pro.

The curved structures such as spicule length were measured along the arch.

the following measurements were taken

- L : Total body length
- a : Body length divided by maximum body diameter
- b : Body length divided by oesophagus length
- c : Body length divided by tail length
(a: b: c is deMan ratio's)
- a.b.d : anal body diameter

Results and discussion

In the study area, the temperature varied with depth and ranged between 6.6 (1000 m) and 22.7°C (250 m), salinity ranged from 34.9 to 35.0 PSU, dissolved oxygen ranged from 0.1 to 1.18 ml/l. Sediment organic matter ranged between 0.55 and 3.84% and sediments were homogenous clayey silt (Table.1)

Altogether, 89 species in 3 orders, 25 families and 71 genera were identified. The members of the order Chromadorida (*Marylynnia complexa*, *Aponema decraemerae*, *Desmodorella tenuispiculum* and *Desmoscolex laevis*) and the members from the order Monohysterida (*Retrotheristus breviseta*, *Sphaerolaimus balticus*, *Siphonolaimus ewensis*, *Terschellingia goubaultae*, *Diplopeltula incisa*, and *Axonolaimus spinosus*) were found to be new records for Indian waters. The characteristics of these species are described below.

- 1 Order: Chromadorida Filipjev, 1929
Family: Cyatholaimidae Filipjev, 1918
Genus: *Marylynnia* Hopper, 1977

Marylynnia complexa Warwick, 1971 (Plate I, Fig. a) 1988. *Marylynnia complexa* Platt and Warwick, Synopses of British Fauna (New series) part 2

Material examined: Two males

Diagnosis: Cuticle pores of two types, simple rounded and longitudinally oval, the latter situated between two dots and referred to as lateral modified punctations. Tail is distal half-cylindrical with swollen tip.

Measurements:

L=893-895 μ m; a=16.6-18.8; b=12.8-13.2; c=10.3-11.1

Table 1. Sea water temperature, salinity, dissolved oxygen (DO) and organic matter (OM) content of northeast continental slope. The values represent the range, mean \pm S.D; n=sample size

Depth (m)	Temperature (°C)	Salinity (PSU)	DO (ml.l-1)	OM (%)
200 (n=16)	13.1–22.70 (16.9 \pm 2.69)	34.7–34.90 (34.9 \pm 0.07)	0.1–0.64 (0.4 \pm 0.18)	0.55-1.96 (0.92 \pm 0.51)
500 (n=16)	9.7–11.40 (10.5 \pm 0.46)	35.0–35.03 (35.0 \pm 0.005)	0.1–0.62 (0.3 \pm 0.14)	0.60-3.54 (1.93 \pm 1.32)
1000 (n=14)	6.6–8.95 (7.6 \pm 0.67)	34.9–34.99 (34.9 \pm 0.02)	0.6–1.18 (0.9 \pm 0.19)	0.64-3.84 (1.95 \pm 1.27)

Description: Buccal cavity is narrow with six short labial setae and six longer jointed and four longer cephalic setae. Amphids with 6.5 to 7.5 turns. Lateral modified punctations (LMP) commence just behind the head and extend, two-thirds of the way down the length of the oesophageal region, quite dense in middle of oesophageal region, absent in the middle of body but a single file commences a short distance anterior to the anus and extends a short way down the length of the tail. Proximal third of the spicule more heavily cuticularised than the remainder, broad ventral alae, proximally cephalate, dorsal edge most sharply bent at the junction of the strongly and weakly cuticularised portion. Each half of gubernaculum crescentic, with distal half swollen and tipped with three laterally curving teeth, six small but distinct cup-shaped supplements in front of cloaca. The body length varied between 0.893- 0.895 mm, the maximum diameter 48-54 μ m and tail in male 2.7-2.9 a.b.d., amphid 3 μ m, and spicule 35-42 μ m.

Distribution: Divi point (500 m), Northeast coast of India, Northumberland coast, northeast England (sublittoral fine sand and silt).

Remarks: The material examined conforms well to the earlier description, except for minor variation in the relative measurements of the body. The total body length varied between 1.5–1.7 mm, the maximum diameter 52-78 μ m and tail 6.5 a.b.d., amphid 10-11 μ m, spicule 58-73 μ m (Platt and Warwick, 1988).

2 Family: Microlaimidae Micoletzky, 1922
Genus: *Aponema* Jensen, 1978

Aponema decraemerae Muthumbi and Vincx, 1999 (Plate I, Fig. b)
1999. *Aponema decraemerae* Muthumbi and Vincx, Hydrobiologia, 397 (Fig.1)

Material examined: Thirty two females and twenty males.

Diagnosis: Finely annulated cuticle, sexual dimorphism of the amphids (males have larger amphids), spicules with a poorly developed capitulum and tail with a pointed tip.

Measurements

Male : L=480-528 μ m; a=18.5-25; b=11.2-12.5; c=6.8-8.9

Female : L=548-598 μ m; a=12.5-17.6; b=8.9-12.2; c=6.8-9.1

Description: Cylindrical body attenuating on both anterior and posterior ends. Buccal cavity weakly cuticularised. Cuticle has fine annules starting from the level of constriction. Somatic setae were not seen. The inner and outer labial sensilla are inconspicuous, while the four cephalic ones are very short and setiform. The stoma is rather small with one small dorsal tooth and two sub-ventral ones. Amphid is simple and spiral. The pharynx has a well developed pyriform terminal bulb, which is 80-85% in diameter of total body width. Tail is long, conical and cylindrical on the posterior half and has a pointed tip. Gubernaculum is sclerotized and has a dorsal-caudal apophyse, which is dorsally curved. The body length was 0.48–0.59 mm, the maximum diameter 19-38 μ m and tail in male 0.9–2.1 a.b.d., in female 0.5–1.2 a.b.d.

Distribution: Coastal areas of Kenya; Indian Ocean; Divi point (250 and 500 m), Kakinada (250 m), Vizag (250 and 500 m) and Barua (250 and 500 m) northeast coast of India.

Remarks: The material examined conforms well to the earlier description, except for minor variation in the relative measurements of the body. The total body length varied between 0.6-0.7 mm, the maximum diameter 42–47 μ m and tail 51-71 μ m long in male (Muthumbi and Vincx, 1999).

3 Family: Desmodoridae Filipjev, 1922
Genus: *Desmodorella* Cobb, 1933

Desmodorella tenuispiculum (Allgén, 1928) (Plate I, Fig. c)
1988. *Desmodora (Desmodorella) tenuispiculum*, Platt and Warwick, Synopses of British Fauna (New series) Part 2

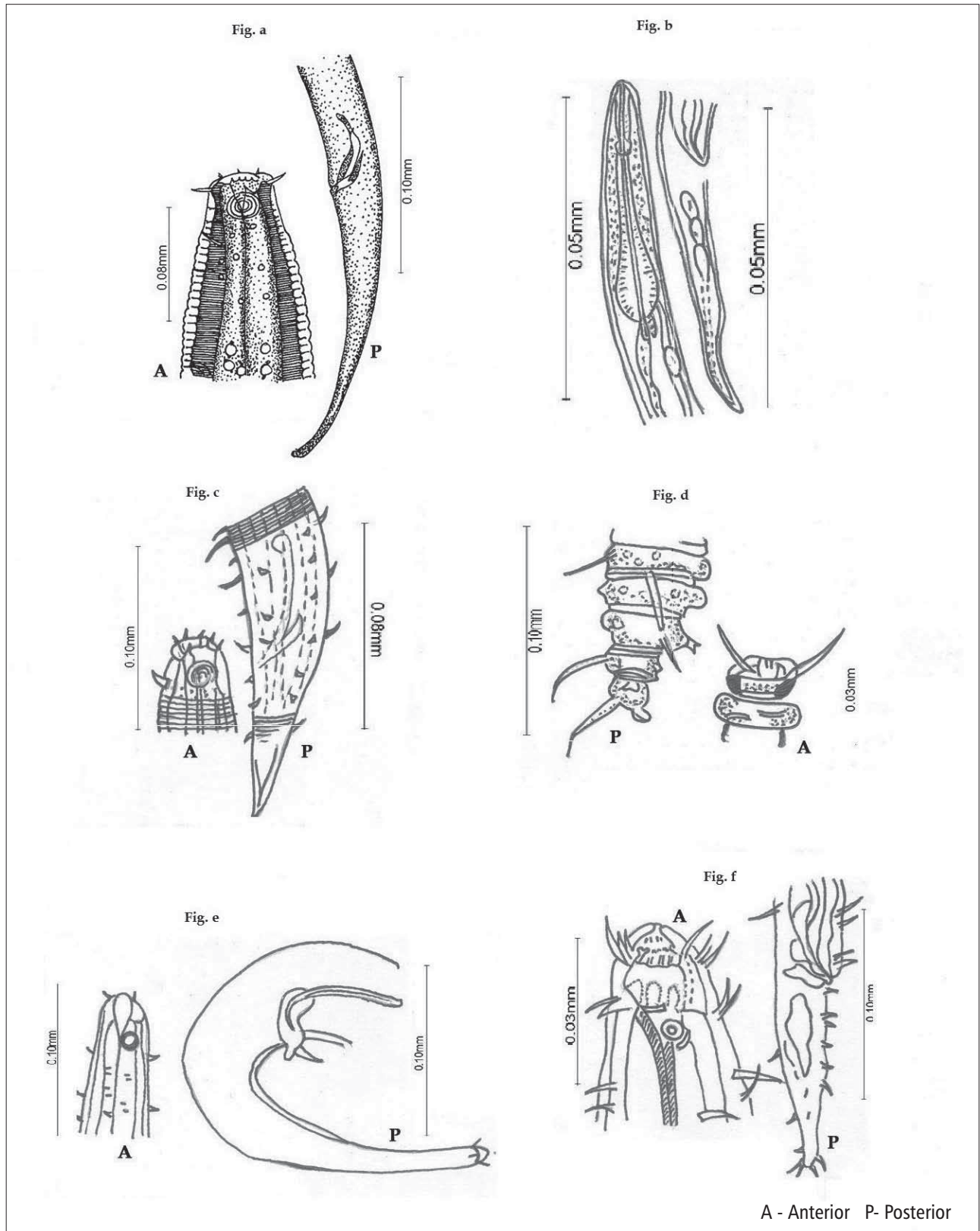


Plate I: Figure a: *Maryllynia complexa* ♂ b: *Aponema decraerae* ♀ c: *Desmodorella tenuispiculum* ♂ d: *Desmoscolex laevis* ♂
 e: *Retrotheristus breviseta* ♂ f: *Sphaerolaimus balticus* ♀

Synonym: Desmodora tenuispiculum (Allgén, 1928)

Material examined: Fifty males and seven females.

Diagnosis: Cuticle with coarse transverse striations and longitudinal files of ridges. Tail is conical with unstriated tip.

Measurements

Male: L=564-624 μm ; a=16.8-22.1; b=9.3-14.2; c=8.8-11.2
Female: L=688-720 μm ; a=13.2-14.8; b=10.9-12.1; c=11.2-11.5

Description: Buccal cavity with weakly cuticularised dorsal tooth. Posterior part of cephalic capsule with rounded punctations, Amphids spiral of 2.5 turns towards anterior side. Oesophagus with posterior bulb. Spicule slender and indistinct. Gubernaculum with proximal end free from spicule. Preloacal supplements absent. Vulva at 67% body length. The body length varied between 0.56-0.72 mm, the maximum diameter 26- 52 μm tail in male 0.8-2.1 a.b.d., in female 0.5–1.1 a.b.d.

Distribution: Divi point (250m) and Barua (250m), Northeast coast of India. Northumberland coast, Northeast England (sublittoral Fine Sand), recorded as *D. norvegica* Allgen, 1932.

Remarks: The material examined conforms well to the earlier description, except for minor variation in the relative measurements of the body. The total body length varied between 0.7-0.8 mm, the maximum diameter 40-56 μm and tail 2.4-2.5 a.b.d., amphid 12 μm , spicule 66-69 μm (Platt and Warwick, 1988).

4 Family: Desmoscolecidae Shipley, 1896
Genus: *Desmoscolex* Claparède, 1863

Desmoscolex laevis Kreis, 1928 (Plate I, Fig. d)
1988. *Desmoscolex laevis* Platt and Warwick, Synopses of British Fauna (New series) Part 2

Material examined: Single male.

Diagnosis: Cuticle with 17 large raised rings, covered with many dark, coarse concretion particles.

Measurements

Male: L=420 μm ; a=8.2; b=5.1; c=24.

Description: Body is covered with desmen-like structures. Anteriorly, in the region of the buccal cavity, the cuticle is sclerotised. The extreme anterior of the head is seen as a circular projection bearing fine obscure pegs. The main rings are separated from each other by interzones, composed of

2 (or) 3 secondary rings. These zones are maximally as wide as the corresponding main rings. The secondary rings mostly bear, short spines, which are not always distinct. The large distally swollen amphids taper towards the connection with the cuticular wall. Tail bears two connection rings. The terminal main ring is twice as long as the former and ends in a swollen zone, bent to the ventral side and bearing the spinneret.

Distribution: Barua (500 m), northeast coast of India, Scotland; Clew Bay, West Ireland; Northumber land coast, northeast England (sublittoral sediment); northeast coast of England (Kelp hold fast); Isles of Scilly (intertidal sea weeds).

Remarks: The material examined conforms well to the earlier description except for minor variation in the relative measurements of the body. The total body length varied between 0.42 and 0.52 mm, the maximum diameter 40-56 μm and tail 2.4-2.5 a.b.d. and spicule 38-52 μm . The length of the specimen was 0.42 mm, maximum diameter 51 μm , the tail 1.2 a.b.d. and spicule 42 μm (Platt and Warwick, 1988).

5 Order: Monhysterida Filipjev, 1929
Family: Xyalidae Chitwood, 1951
Genus: *Retrotheristus* Lorenzen, 1977

Retrotheristus breviseta (Juario, 1974) (Plate I, Fig. e)
1977. *Retrotheristus breviseta*. Revision der Xyalidae (freilebende Nematoden) auf der Grundlage einer kritischen Analyse von 56 Arten aus Nord – und Ostsee.

Synonym: Paramonhystera breviseta (Juario, 1974)

Material examined: Five males.

Diagnosis: Buccal cavity 'U' shaped and amphid is circular which is situated anteriorly.

Measurements

L =698-728 μm ; a=25-26.3; b=16.6-18.1; c=8.9-11.

Description: Cuticle is faintly striated; oesophagus is extended without any oesophageal bulb. Tail is conico-cylindrical with terminal setae. Spicule is bizarre shape. Body has somatic setae. The length was 0.72 mm, the maximum diameter 28 μm , the tail 1.0-1.1 a.b.d.

Distribution: India: Divi point (500m and 1000m), northeast coast of India. Sublittoral zone of German Bight.

Remarks: The material examined conforms well to the earlier description (Lorenzen, 1977)

- 6 Family: Sphaerolaimidae Filipjev, 1918
Genus: *Sphaerolaimus* Bastian, 1865

Sphaerolaimus balticus Schneider, 1906 (Plate I, Fig. f)
1998. *Sphaerolaimus balticus* Warwick, Platt and Somerfield, Synopses of British fauna (New series) Part 3

Material examined: Six males and three females.

Diagnosis: Buccal cavity with alternating heavily and weakly punctated areas.

Measurements

Male : L=720-738 μm ; a=21.8-23.7; b=14.5-15.1; c=9.8-10.9
Female : L=920-928 μm ; a=17.2-18.7; b=13.8-14; c=11.1-11.2

Description: Cuticle with faint transverse striations which are not always visible. Six small labial papillae, cervical setae in eight files. Somatic setae shorter and scattered. Amphids situated posterior of the buccal cavity. Oesophagus widens posteriorly, but has no distinct bulb. Tail is conical, with a slight terminal dilation. Spicule, distally slender with the proximal quarter dilated. Gubernaculum with single dorsal hook-shaped apophyse. Vulva at 71% of body length. The body length varied between 0.72-0.92 mm, the maximum diameter 31-53 μm , spicule 39-42 μm , amphid 3-6 μm , tail in male 1.22-1.9 a.b.d., in female 0.8-1.1 a.b.d.

Distribution: Divi point (1000 m), Kakinada (250 m), Vizag (1000 m), Paradeep (500 m), Blyth estuary, England; Strangford Lough, Ireland (intertidal sand and muddy sand); Loch Etive, West Scotland (Sub littoral sediments).

Remarks: The material examined conforms well to the earlier description, except for minor variation in the relative measurements of the body. The total body length varied between 1.6-1.8 mm, the maximum diameter 71-77 μm , amphid 8-9 μm wide situated at the posterior of the buccal cavity, the tail 3.2-3.9 a.b.d., and spicule 85-92 μm (Warwick *et al.*, 1998).

- 7 Family: Siphonolaimidae Filipjev, 1918
Genus: *Siphonolaimus* De Man, 1893

Siphonolaimus ewensis Warwick and Platt, 1973 (Plate II, Fig. a)
1998. *Siphonolaimus ewensis* Warwick, Platt and Somerfield, Synopses of British fauna (New series) Part 3

Materials examined: Five males and three females.

Diagnosis: Buccal cavity containing an axial cuticularised spear – like structure.

Measurements

Male: L=728-752 μm ; a=20.8-24.3; b=11.2-11.7; c=9.6-16.2
Female : L=842-848 μm ; a=11.8-12.5; b=10.1-10.3; c=16.2-16.6

Description: Buccal cavity with axial spear. Cuticle is transversely striated, amphid is circular and somatic setae sparsely present on the body. Tail is blunt. Posterior half of oesophagus dilated. Six prominent setose preloacal supplements. The body length of the present specimen 0.72-0.84 mm, the maximum diameter 30-71 μm , amphid 7-8 μm , spicule 25-28 μm , tail in male 1.2-1.5 a.b.d., female 0.7-1.0 a.b.d.

Distribution: Vizag (250 m), Barua (250 m), northeast coast of India, Loch Ewe and Firth of Clyde, West Scotland (intertidal sand)

Remarks: The material examined conforms well to the earlier description, except for minor variation in the relative measurements of the body. The total body length described varied between 3.9-4.4 mm. Maximum diameters 37 μm , amphids 17-18 μm , spicule 56-63 μm , tail 3.1-3.4 a.b.d (Warwick *et al.*, 1998).

- 8 Genus: *Terschellingia* De Man, 1888

Terschellingia goubaultae Austen, 1989 (Plate II, Fig. b)
1998. *Terschellingia goubaultae* Warwick, Platt and Somerfield, Synopses of British fauna (New series) Part 3

Material examined: Twenty seven males and twelve females.

Diagnosis: Oesophagus expanded posterior part (not a rounded bulb) and tail is posterior half filiform.

Measurements

Male: L=752-900 μm ; a=20.9-25.0; b=19.8-23.7; c=18.8-22.5
Female : L=836-902 μm ; a=23.2-25.1; b=22.0-23.7; c=20.9-22.6

Description: Buccal cavity absent. Cuticle faintly striated amphid circular in shape. Spicule slender, cephalate and ventrally bent proximally. Gubernaculum with a pair of dorsal apophyses. Vulva at 44-49% of body length. The body length varied from 0.75-0.90 mm, the maximum diameter 36-58 μm , amphid 3-6 μm , spicule 18-38 μm , tail in male 0.8-2.8 a.b.d., in female 0.8-2.8 a.b.d.

Distribution: Divi point (250 m), Vizag (500 m), Barua (250 m and 500 m), Tamar estuary, southwest England (intertidal mud)

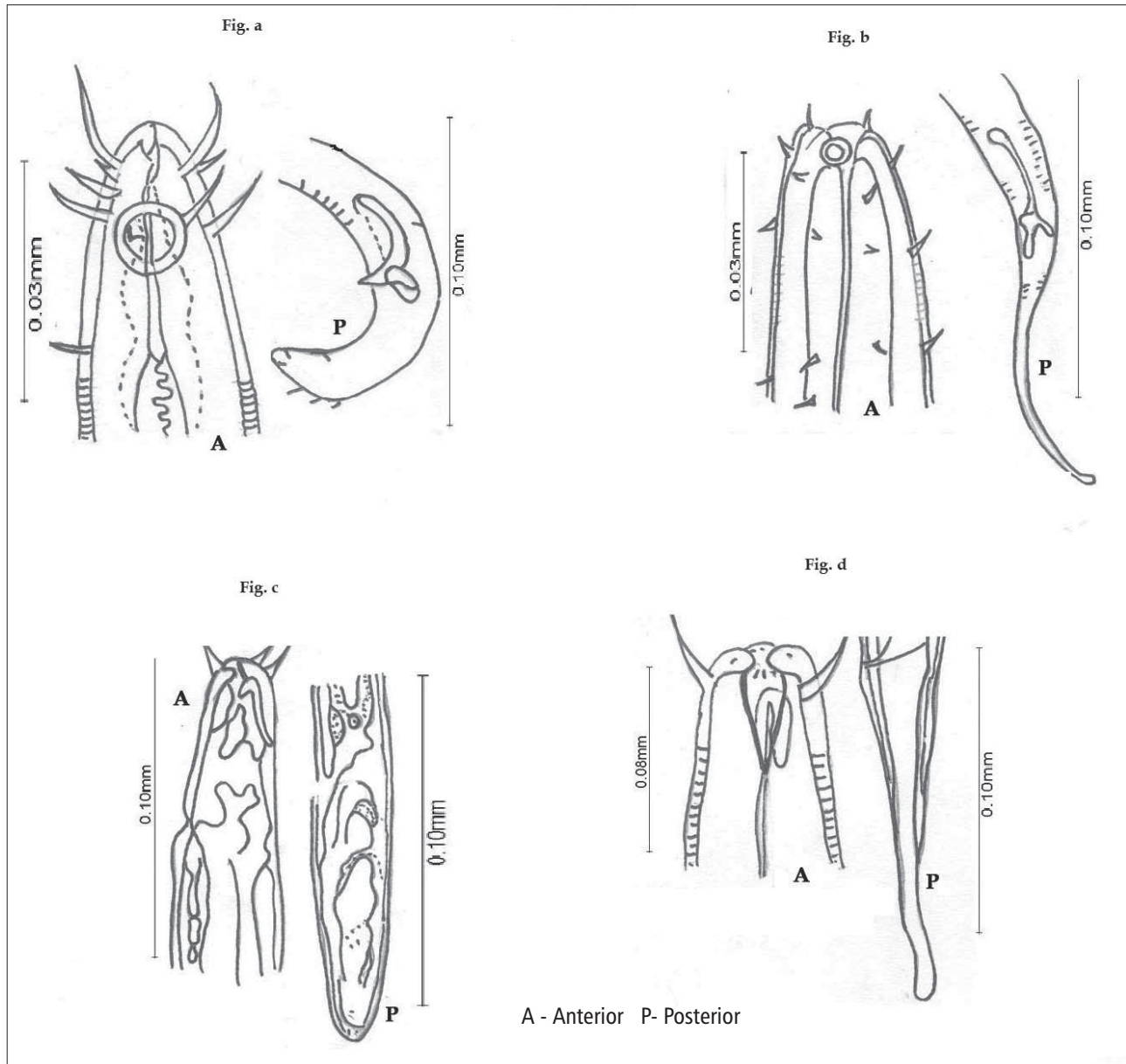


Plate II: Figure a: *Siphonolaimus ewensis* ♂ b: *Terschellingia gourbaulta* ♂ c: *Diplopeltula incisa* ♀ d: *Axonolaimus spinosus* ♀

Remarks: The material examined conforms well to the earlier description, except for minor variation in the relative measurements of the body. The total body length varied from 1.8-2.6 mm, the maximum diameter 50-96 μm , amphid 8-12 μm , spicule 80-88 μm , tail 5.5-8.0 a.b.d. (Warwick et al., 1998).

9 Family: Diplopeltidae Filipjev, 1918
Genus: *Diplopeltula* Gerlach, 1950

Diplopeltula incisa Southern 1914 (Plate II, Fig. c)

1998. *Diplopeltula incisa* Warwick, Platt and Somerfield, Synopses of British fauna (New series) Part 3

Material examined: Five females and three males.

Diagnosis: Mouth slightly displaced dorsally. Oesophagus cylindrical throughout. Cuticle striations very faint but can be seen in the mid- body region.

Measurements

Male: L = 638-646 μm ; a=11.2-12.5; b=8.9-9.3; c=17.2-18.7
Female: L= 718-724 μm ; a=10.3-10.9; b=7.6-8.7; c=13.8-14.5

Description: Buccal cavity small, mouth terminal or subterminal. Amphid wide and long, loop-shaped. Spicules as curve, with a short central lamella in the proximal portion. Gubernaculum with a pair of tapering dorsal apophyses. Vulva at 63-64% of body length. Tail is conical-blunt. The body length varied from 0.63-0.72 mm, the maximum diameter 52-70 μm , spicule 19-23 μm , tail in male 1.2- 1.8 a.b.d, in female 0.7-1.1 a.b.d.

Distribution: Vizag (250 m), and Barua (250 m), Exe estuary an exmouth, southwest England, Tamar estuary, Southwest England, Clew Bay, West Ireland, Northeast Coast of England.

Remarks: The material examined conforms well to the earlier description, except for minor variation in the relative measurements of the body. The total body length varied between 1.5–1.7 mm, the maximum diameter 32-48 μm , spicule 53-54 μm , tail 3.0- 3.6 a.b.d. (Warwick *et al.*, 1998).

10 Family: Axonolaimidae Filipjev, 1918
Genus: *Axonolaimus* De Man, 1889

Axonolaimus spinosus Bütschli, 1874 (Plate II, Fig. d)
1998. *Axonolaimus spinosus* Warwick, Platt and Somerfield, Synopses of British fauna (New series) Part 3

Material examined: Two females.

Diagnosis: Buccal cavity long, Amphid is wide and long, with the two arms lying parallel and contiguous.

Measurements

L=816-820 μm ; a=16.6-17; b=12.5-12.9; c=8.3-8.8

Description: Oesophagus broadens towards the base, but with no definite bulb. Tail is three quarters conical with the remainder more or less cylindrical. Vulva at 54-56% of body length. The body length of present specimens 0.81-0.82, the maximum diameter 48-49 μm , tail 2.1-2.4 a.b.d.

Distribution: Divi point (500 m), northeast coast of India. Exe estuary, southwest England (intertidal low-salinity mud); Isles of Scilly (intertidal sand), Northumberland coast, northeast England (Sub littoral mud).

Remarks: The material examined conforms well to the earlier description except for minor variation in the relative measurements of the body. The total body length varied between 1.4–1.7 mm, the maximum diameter 32-53 μm , tail 5 a.b.d. (Warwick *et al.*, 1998).

This study gives the first report on the systematics of free-living marine nematodes from the sediments of Indian northeastern continental slope. The buccal structures and general morphometrics of nematodes such as the width/length ratio and the general body mass, seem to be influenced by the availability and type of food and to be related to the feeding type (Tita *et al.*, 1999). With regard to species identified from Northeast coast slope of India most of them have been recorded from temperate waters supporting the statement about cosmopolitan nature of marine nematodes. Many genera of free-living marine nematodes are regarded as cosmopolitan based on morphology (Warwick *et al.*, 1998) but molecular data are necessary to clarify this conclusion since morphological evidence may be misleading in some taxa (Meldal *et al.*, 2007). For example some genera such as *Sabatieria* and *Terschellingia* have numerous species but the presence of few diagnostic morphological features hampers taxonomic discrimination and is problematic for ecological purposes (Soetaert *et al.*, 1995). *Terschellingia longicaudata*, a common shallow-water nematode of ubiquitous occurrence, demonstrated its genetic diversity only after thorough analysis of several nuclear and mitochondrial sequences (Bhadury *et al.*, 2008; Giere, 2008).

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