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TWO NEW RECORDS OF MEIOFAUNAL NEMATODES FROM THE SANDY SHORES OF LAKSHADWEEP

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ABSTRACT: The Lakshadweep archipelago is one of the country's most ecologically significant yet understudied marine ecosystems. The current study reports new distributional records of two meiofaunal nematodes from the sediments of this biodiversity hotspot, marking a noteworthy biogeographical extension of these taxa within the Indian Subcontinent. Meiofauna are microscopic invertebrates that inhabit aquatic sediments. Nematodes are the most abundant and ecologically significant group of meiofauna. These organisms play indispensable roles in marine and aquatic ecosystems by functioning as crucial trophic intermediaries. Because of their sensitivity to environmental fluctuations, meiofaunal nematodes are effective bioindicators of sediment quality, pollution, and broader ecological health.

Keywords: *Meiofauna, Nematodes, Lakshadweep, Distribution, Bio-monitoring.*

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INTRODUCTION

The Lakshadweep archipelago, a fragile and biodiverse coral atoll system located in the southeastern Arabian Sea off the southwest coast of India, represents one of the country's most ecologically significant yet understudied marine ecosystems. Comprising 17 uninhabited islets and 10 inhabited islands, including Kavaratti, Agatti, Amini, and Minicoy, the biologically rich Lakshadweep Sea surrounds this archipelago, also known as the Laccadive Sea, which is characterized by coral reefs, reef lagoons, and high marine productivity (Nair *et al.* 1986). These waters support a wide range of marine fauna and are ecologically crucial because of their sensitive coral ecosystems (Pillai, 1986). While existing research has primarily focused on the region's charismatic megafauna and coral reef systems, the benthic meiofauna, particularly nematodes, remain largely unexplored, despite their vital ecological role in sedimentary environments. Meiofauna, defined as microscopic invertebrates ranging from 63 µm to 1000 µm that inhabit aquatic sediments (Giere, 2009), are the most abundant and diverse metazoan group in marine sediments globally. Sandy beach habitats support a rich assemblage of meiofauna, often contributing to more than 50 percent of the benthic biomass and overall production (Ansari *et al.* 1990).

Nematodes are the most prevalent and ecologically significant group of meiofauna, frequently accounting for 60 – 90 percent of total meiofaunal abundance (Balsamo *et al.* 2012). Their dominance is attributed to their remarkable resilience, adaptability to adverse environmental conditions, tolerance to low oxygen levels (Cook *et al.* 2000), and ability to utilize diverse food sources, including bacteria (Nanajkar and Ingole, 2010) and detritus. These organisms play indispensable roles in marine and aquatic ecosystems by driving organic matter decomposition, facilitating nutrient recycling, and mediating energy transfer within benthic food webs (Danovaro *et al.* 2002; Bonaglia *et al.* 2014).

They also enhance sediment stability by mucus secretion, burrowing, and organic matter mineralization (Rosli *et al.* 2016) and function as crucial trophic intermediaries linking microbial communities with higher organisms (Schratzberger and Ingels, 2018).

Because of their sensitivity to environmental fluctuations, meiofaunal nematodes are effective bioindicators of sediment quality, pollution, and broader ecological health (Soko and Gyedu-Ababio, 2019; Zeppilli *et al.* 2015). Despite their global abundance and ecological importance, being the most numerous metazoans on Earth (Van den Hoogen *et al.* 2020), their biodiversity, functional roles, and responses to environmental stressors remain poorly documented in tropical island systems such as Lakshadweep. An updated compilation done by Datta *et al.* (2022) reported 617 valid nematode species belonging to 266 genera, 48 families, 21 super families, and 9 orders in India's coastal and island regions but a recent compilation of nematode diversity in Lakshadweep based on published literatures was only 47 species belonging to 2 classes, 6 orders, 22 families, 43 genera (Rizvi, Datta, and Raghunathan, 2024) highlighting the critical need for further investigation in understudied locales like Lakshadweep.

This lack of knowledge is particularly concerning in light of increasing pressures from climate change (Danovaro *et al.* 2008) and anthropogenic disturbances (Semprucci *et al.* 2019), which threaten the ecological balance of these fragile marine environments. Nematodes' rapid life cycles, high turnover rates, and immense taxonomic and functional diversity, including feeding guilds such as bacterial feeders, predators, and omnivores (Moens *et al.* 2013), make them essential contributors to ecosystem resilience. In the vulnerable benthic habitats of the Lakshadweep archipelago, monitoring nematode community dynamics could serve as an early warning system for ecological degradation and provide insights into the trajectory and potential for ecosystem recovery.

MATERIALS AND METHODS

Sediment samples were collected by a hand corer of 5 cm length and 3 cm diameter from the Bangaram island (Fig. 2) of the Lakshadweep archipelago (Fig.1). After collection, the sediment samples were stained using Bengal Rose. The samples were immediately preserved in 5% formalin. The extraction of meiofauna from preserved samples for quantitative analysis can be done by decantation method in which the sediments are sieved through an outer sieve made of stainless steel with a mesh size of 1000 µm (1 mm) and an inner sieve made of brass with a mesh size of 63 µm and the residues were examined. The decanted sediment sample was then observed under a petri dish, and the nematodes were handpicked using a fine needle under a stereo microscope. Handpicked meiofauna were transferred to pure glycerin and mounted on a microscopic glass slide for taxonomic identification. Identifications were carried out by referring to the descriptions and pictorial keys of Warwick *et al.* (1998).

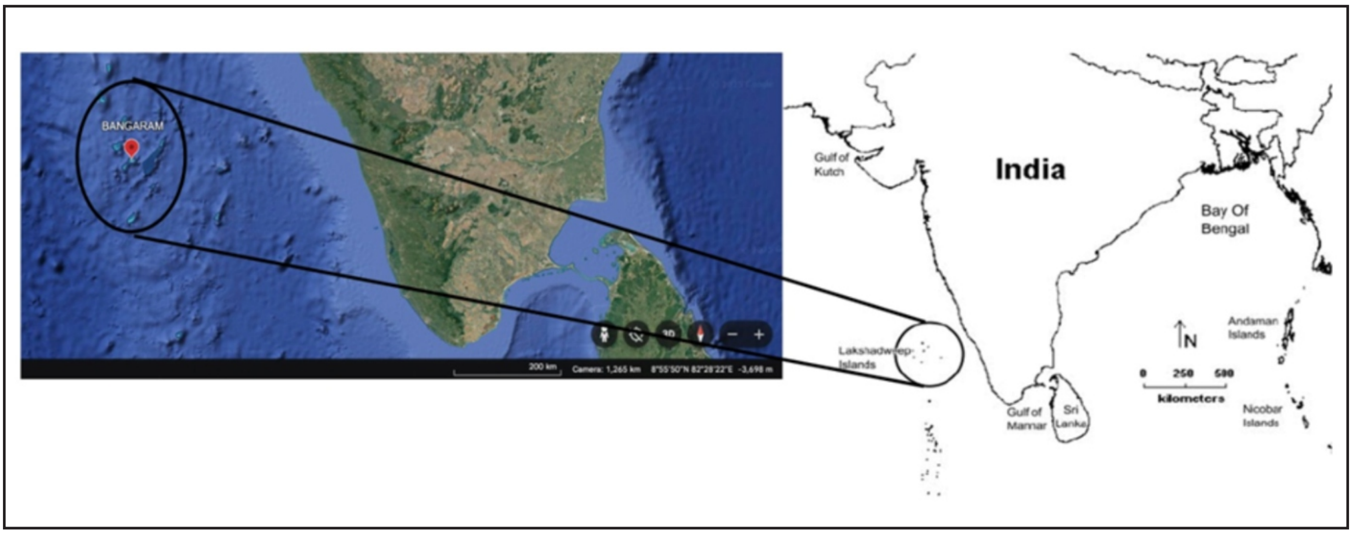

Fig. 1. Group of islands of Lakshadweep

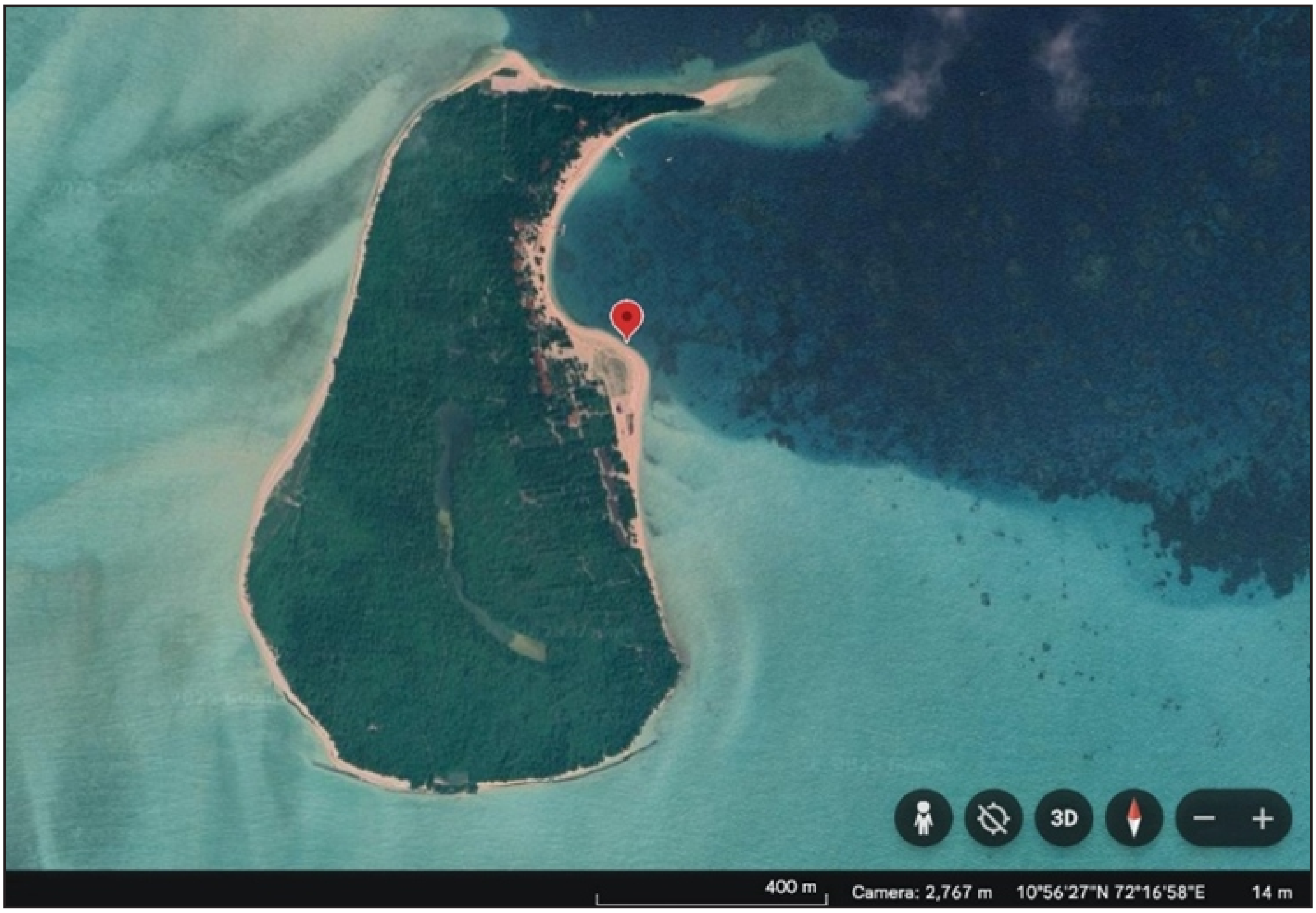

Fig. 2. Sampling site (Bangaram)

RESULTS

NEW RECORD TO LAKSHADWEEP:

Pselionema annulatum (Filipjev, 1922) Cobb, 1933

Systematic position of the species:

Chromadorea Inglis, 1983

Chromadoria Pearse, 1942

Plectida Gadea, 1973

Ceramonematina Cobb, 1933

Ceramonematoidea Cobb, 1933

Ceramonematidae Cobb, 1933

Pselionematinae De Coninck, 1965

Pselionema Cobb, 1933

Pselionema annulatum (Filipjev, 1922) Cobb, 1933

Original Name: Steineria annulata Filipjev, 1922

Synonymous Names: Ceramonema annulata (Filipjev, 1922) Schultz, 1938; Steineria annulata Filipjev, 1922

Material examined: 6 ex. Reg.No.N.893.

Sampling Station: Bangaram. Date: 06.02.2024.

Distribution: Black Sea, Crimea, Mediterranean, Balearic Islands.

DIAGNOSIS OF CERAMONEMATIDAE (PLATT AND WARWICK, 1988)

The family is characterized by a thick cuticle with coarse annulations formed by overlapping plates and prominent longitudinal ridges. The cephalic capsule is smooth (unstriated) and bears the amphids, which are typically D-shaped. Labial sensilla are not visible. Cephalic setae are generally arranged as 6 + 4, though in some cases only four are present. The buccal cavity is minute. The tail is conical with a smooth, unstriated tip. Both sexes have paired and opposed gonads: males with opposed testes, and females with opposed, reflexed ovaries.

DIAGNOSIS OF *PSELIONEMA* (PLATT AND WARWICK, 1988)

In addition to the diagnostic characters of the family (p. 466), *Pselionema* is distinguished by possessing 70–350 cuticular annules, only four cephalic setae, and a completely absent buccal cavity.

Pselionema has 4 species recorded in India

Pselionema simile De Coninck, 1942

Pselionema ornatum (Timm, 1961) Hopper, 1973

Pselionema beauforti Chitwood, 1936

Pselionema annulatum (Filipjev, 1922) Cobb, 1933

DIAGNOSIS OF *PSELIONEMA ANNULATUM* (FILIPJEV, 1922) COBB, 1933

Length 1.745 mm and 0.061 mm diameter. The head bears a distinct head capsule and four cephalic setae, each approximately equal in length to the corresponding head diameter. Lateral fields are broad, measuring about half the width of the corresponding body diameter. The oesophagus extends to the anterior end, surrounding a narrow oral slit. The amphid is shaped like an open loop and is located near the posterior region of the head. The tail is slender, maintaining a nearly uniform width along its length, and ending in a slightly swollen spinneret.

Table 1. A Comparative Table of all Pselionema spp. found in India

Species	Global distribution	Indian distribution	Head	Lips	Tail	Amphids	Cuticle	Spicule	Body
P. simile	Mediterranean Monaco	Pondicherry, Tamil Nadu	The head is elongated, obtuse, with a solid cephalic carapace	Welded lips that are not distinct, and papillae are invisible.		Elongated hook-shaped amphid	Coarsely ringed and thick	Curved	
P. ornatum		Tamil Nadu	Head not set off, strongly cuticularized with 4 cephalic setae.		Possesses cuticular inflation at the tip.	Shepherd's crook with parallel arms (posterior to head)	Thick	Arcuate and cephalated	Variable number of annules (67-93) broken by 6 long wings of rhomboidal plates
P. beauforti	North Caroline, Atlantic coast	Goa	Head with 4 well-developed cephalic setae			Open and spiral	With angulate or curved tiles		Around 110 annuli
P. annulatum	Black Sea, Crimea, Mediterranean, Balearic Islands.	Kerala	With a distinct head capsule and 4 cephalic setae		Slender	Open loop (posterior head end)			

NEW RECORD TO INDIA

Epacanthion gorgonocephalum Warwick, 1970

Systematic position of the species:

Enoplea sensu De Ley and Blaxter, 2004

Enoplia Pearse, 1942

Enoplida Filipjev, 1929

Enoplina (Filipjev, 1929) Chitwood, 1937

Enoploidea Dujardin, 1845

Thoracostomopsidae Filipjev, 1927

Enoplolaiminae De Coninck, 1965

Epacanthion Wieser, 1953

Epacanthion gorgonocephalum Warwick, 1970

Original name: *Epacanthion gorgonocephalum* Warwick, 1970

Material examined: 2 ex. Reg.No.N.896. Sampling Station: Bangaram. Date: 06.02.2024.

Distribution: Exe estuary; Isles of Scilly (intertidal sand).

DIAGNOSIS OF *THORACOSTOMOPSIDAE* (SMOL AND COOMANS, 2006)

Members of this family are characterized by high lips and the presence of only dorsolateral orthometanemes with a well-developed scapulus, but lacking a caudal filament. Inner labial sensilla are robust and setiform. Outer labial and cephalic setae are distinctly long and robust. The epidermal glands exhibit a notably well-differentiated outlet. The inner cuticular layer forms a cephalic capsule that serves as the attachment site for pharyngeal muscles. Cephalic organs are often present and vary in shape. Amphids are small, located posterior to the cephalic capsule, or may be absent entirely. The buccal cavity is spacious and typically equipped with three mandibles and three teeth (one dorsal and two ventrosublateral), or alternatively, a single long eversible spear. The female reproductive system is didelphic–amphidelphic with ovaries reflexed in an antidromous manner. Caudal glands extend into the precaudal region.

DIAGNOSIS OF *EPACANTHION* WIESER, 1953 (SMOL AND COOMANS, 2006)

Belonging to the subfamily *Enoplolaiminae*, *Epacanthion* species typically possess a smooth cuticle. The head is broadly wedge - or cone-shaped, with elevated, often striated lips. Inner labial setae are long and inserted at the base of the lip flaps, while outer labial and cephalic setae are positioned at the midpoint or anterior region of the cephalic capsule. Cervical setae are frequently present, often numerous in males, and display sexual dimorphism.

Mandibles are composed of two plate-like columns separated by a thin cuticular sheet; they are not solid in between and are joined only at the anterior end by a transverse bar, representing an intermediate condition between the genera *Enoploides* and *Mesacanthion*. Mandibular teeth are small and associated with a gland opening at their tips.

The pharynx is relatively long and cylindrical, ending in a pyriform (pear-shaped) cardia. Females are didelphic–amphidelphic with reflexed ovaries located on the left side of the intestine. Males are diorchic, also with both testes on the left side. The gubernaculum may be present or absent and lacks an apophysis. Spicules can be either long (equal to or exceeding 2.5 anal body diameters) or short. Gubernaculum without apophyses present or absent. Preanal supplements may be present or absent. The tail is narrowly conical or attenuated in shape, with three caudal gland cells located precaudally.

DIAGNOSIS OF *EPACANTHION GORGONOCEPHALUM* WARWICK, 1970

Length is 2.67748 mm and 0.038 mm in diameter. The body is slender and smooth, with a cuticle lacking ornamentation. The lips (0.018 mm diameter) are prominently raised and exhibit a distinct subsidiary lobe. Internally, the lips are marked by semi-lunar striations, while the outer regions show more widely spaced striations and a scalloped margin. The subsidiary lobes lack internal striations and scalloping. Labial and cephalic setae are well developed, with six longer and four shorter cephalic setae located at the level of the onchial bases.

In males, twelve groups of subcephalic setae are arranged in triplets, each consisting of one long, one medium, and one short seta. Females either lack subcephalic setae or possess only six short ones. The mandibles are slender and rod-like, joined by a thin cuticular sheet. The onchia are symmetrical and of equal size. Each onchial plate curves inward, forming a cup-like structure that defines the base of the buccal cavity.

Males exhibit numerous long and densely arranged cervical setae, with a concentrated zone of shorter setae located approximately one - third along the length of the oesophagus. In females, cervical setae are present but sparse. The oesophagus is anteriorly swollen near the base of the buccal cavity.

The tail is elongated and divided into a conical anterior half and a cylindrical posterior half, with males exhibiting a slightly longer tail than females. Spicules are short, slightly curved, and end in a pair of laterally curving distal knobs. The gubernaculum is a short, double-tubed structure with small lateral projections. No precloacal supplements are observed.

The female reproductive system consists of paired, symmetrical, and reflexed ovaries positioned in an opposed arrangement. The vulva is located slightly past the mid-body.

DISCUSSION AND CONCLUSION

The recent discovery of two meiofaunal nematode species, *Pselionema annulatum* (Filipjev, 1922) Cobb, 1933, and *Epacanthion gorgonocephalum* Warwick, 1970, from the Lakshadweep Islands represents more than just a taxonomic addition; since nematodes are sensitive ecological markers (Schratzberger and Ingels, 2018), they can highlight both the vulnerability and resilience of this fragile marine ecosystem.

The Lakshadweep archipelago is recognized for its dynamic coral reefs and rich marine biodiversity, but it is increasingly threatened by anthropogenic activities, particularly the accumulation of marine litter and plastic debris. In this context, the presence of these nematodes, especially as new biogeographical records, *Pselionema annulatum* (Filipjev, 1922) Cobb, 1933, being a first report for Lakshadweep, which was previously reported in Kerala (west coast of India) (Datta *et al*. 2022), and *Epacanthion gorgonocephalum* Warwick, 1970, a new record for India highlights the critical need for including meiofauna in long-term environmental monitoring programs.

These free-living nematodes are typically associated with well-oxygenated, organically balanced, and physically stable benthic environments (Giere, 2009). Their presence in selected sites indicates the persistence of localized zones of ecological integrity within the island sediments. *Pselionema annulatum* (Filipjev, 1922) Cobb, 1933, as deposit feeders, rely on detritus and microbial food sources, suggesting the presence of an active benthic food web. On the other hand, the presence of the sensitive predator, *Epacanthion gorgonocephalum* Warwick, 1970, indicates the habitat stability. Hence, their prevalence in sandy to muddy substrates further supports the notion of relatively undisturbed conditions, free from widespread erosion, dredging, or hypoxia (Semprucci *et al*. 2015).

Meiofaunal nematodes have long been recognized as powerful bioindicators of sediment quality, eutrophication, and pollution gradients (Balsamo *et al*. 2012; Schratzberger and Ingels, 2018). The distribution patterns and moderate abundance of *Pselionema annulatum* (Filipjev, 1922) Cobb, 1933, and *Epacanthion gorgonocephalum* Warwick, 1970 in Lakshadweep sediments indicate that acute pollution is either minimal or highly localized. However, the novelty of these records in such a biogeographically sensitive zone also calls for caution. While their occurrence may reflect ecological recovery from previous disturbances (e.g., construction or localized sewage discharge), dominance by moderately tolerant species may mask sublethal contamination from pollutants such as trace metals and microplastics (Giere, 2009; Hua *et al*. 2021).

Ecologically, nematodes contribute significantly to the cycling of organic matter and nutrients, playing foundational roles in benthic food web dynamics and supporting upper trophic levels, including crustaceans and fish larvae (Coull, 1999; Schratzberger and Warwick, 1999). The persistence of these communities implies that the nutrient cycling processes are still functional and active. Moreover, nematode diversity has been shown to stabilize benthic assemblages and buffer against environmental fluctuations (Danovaro *et al*. 2008), a critical trait for islands like Lakshadweep undergoing anthropogenic and climatic stress.

The occurrence of genera typically associated with medium-grained sediments, such as *Pselionema*, serves as a sedimentological marker, potentially reflecting changes in grain size distribution due to coastal runoff or mechanical disturbance. Similarly, shifts toward deposit-feeding nematodes may signal early eutrophication, often driven by nutrient inputs from sewage or tourism-related activities. Yet, the absence of opportunistic and pollution-tolerant genera suggests that while stress is present, it remains spatially confined and has not permeated the entire benthic system (Moreno *et al*. 2011).

These nematodes' resilience to moderate fluctuations in temperature and salinity enhances their role as climate-sensitive indicators (Ingels *et al*. 2010). Their presence in the current study area likely indicates a degree of environmental stability; however, future extremes associated with climate change warrant continued monitoring.

Despite moderate levels of organic enrichment, recent assessments highlight a serious emerging threat: plastic pollution. The critical values of plastic-related indicators — CCI (17.98), PAI (5.39), and PLI (34.25) — signal a growing hazard to marine life in Lakshadweep (Hp *et al*., 2025). Microplastics can disrupt meiofaunal communities by altering sediment properties, introducing hazardous chemicals, and impairing feeding and reproduction (Maes *et al*. 2012; Nizzetto *et al*. 2016). Given that the islands still exhibit low organic loading and rare hypoxic events, there exists a narrow window for anticipatory action.

The presence of normal benthic components like nematodes *Pselionema annulatum* (Filipjev, 1922) Cobb, 1933 and *Epacanthion gorgonocephalum* Warwick, 1970 suggests an ecosystem that is ecologically functional but susceptible to stress. Their occurrence offers critical biological evidence of existing sediment quality, active nutrient pathways, and the general absence of severe contamination. More importantly, these nematodes signal early warnings of sublethal stress, especially that from microplastic infiltration. This finding supports the urgent need for integrating meiofaunal monitoring into coastal conservation efforts.

To ensure the long-term ecological integrity of the Lakshadweep Islands, it is imperative to implement large-scale meiofaunal monitoring programs that emphasize both taxonomic resolution and functional trait diversity. Such programs can provide sensitive and high-resolution data on environmental changes, particularly in sediment quality and benthic ecosystem health. Alongside this, focused research is needed to understand the specific responses of meiofaunal communities-especially nematodes to emerging contaminants such as microplastics and heavy metals, which can subtly alter community structure and function. Equally important is the development and enforcement of regulatory frameworks aimed at reducing plastic waste, complemented by community-driven awareness and participation initiatives. Together, these actions form a comprehensive strategy to monitor, understand, and mitigate anthropogenic pressures on this vulnerable marine ecosystem.

In conclusion, meiofaunal nematodes-particularly new records such as *Pselionema annulatum* (Filipjev, 1922) Cobb, 1933, and *Epacanthion gorgonocephalum* Warwick, 1970 should not be viewed merely as additions to faunal checklists. They are crucial ecological sentinels. Their bioindicator potential must be harnessed as a practical tool for ecosystem assessment and conservation in island environments facing intensifying human and climatic pressures.

Fig. 3. *Pselionema annulatum* (Filipjev, 1922) Cobb, 1933

Fig. 4. *Epacanthion gorgonocephalum* Warwick, 1970

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