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New record of *Ficopomatus uschakovi* (Pillai, 1960) (Polychaeta: Serpulidae) from the Northern Bay of Bengal, India: A multivariate approach

Madhurima Bose*, Santanu Mitra

ABSTRACT

The present paper reports the occurrence *Ficopomatus uschakovi* for the first time from a brackish water pond of West Bengal as well as from the entire Northern Bay of Bengal ecoregion. This study includes a brief diagnosis of the species *Ficopomatus uschakovi* with specific emphasis on its habitat. Principal component analysis revealed substantial variability (PC1: 49.1%) among the species and the most influenced morphometric characters contributing to this variation were thoracic membrane followed by direction of Opercular Spine and tube. Additionally, Canonical Analysis of Principal Coordinates exhibited significant differences among the congeners of the genus *Ficopomatus* based on morphometric characteristics.

Keywords: Polychaete, Serpulidae, Brackish water, morphometric analysis, West Bengal

1. INTRODUCTION

Serpulids are tubicolous polychaetes that are notable for their presence on hard substrates. Only the members of the serpulid family can build a calcareous tube. Though some serpulids are solitary, other species like Hydroides are gregarious (Bastida-Zavala and Hove, 2003). They live in large communities spanning from estuarine or brackish tidal canals in mangrove forests to solid surfaces on coral reefs and coastal lagoons (Bastida-Zavala and Salazar-Vallejo, 2000). These benthic, sessile organisms attach their tubes to various surfaces, including wood, mollusk shells, rocks and roots, thereby facilitating their dispersal (Salgado-Barragán et al., 2004). Some species of serpulids exhibit free tubes that are not attached to any substratum but instead reside on sandy bottoms. The polychaetes of this family are perceptible by their colored branchial crown as well as by the structure of the operculum (Bastida-Zavala and Salazar-Vallejo, 2000; Bastida-Zavala et al., 2017). The body of serpulid polychaetes typically comprises a thorax with a thoracic membrane and limbate chaetae, along with an abdomen featuring ventral chaetae and dorsal uncini, as described by Fauchald (1977). The genus *Ficopomatus* is distinctly characterized by

its white tube, which gradually increases in diameter toward the anterior end and is semicircular in cross-section (Ten Hove & Weerdenburg, 1978). The genus *Ficopomatus* encompasses six species Arteaga-Florez et al., (2014): *F. miamiensis* Treadwell, (1934); *Ficopomatus enigmaticus* Fauvel, (1923); *F. uschakovi* Pillai, (1960); *F. macrodon* Southern, 1921; *F. talehsapensis* Pillai, 2008; and *F. shenzhensis* Li, Wang & Deng, 2012. *F. uschakovi* was initially described by Pillai in 1960 from Sri Lanka and is known to have a wide distribution across the Indo-West Pacific (Ten Hove and Weerdenburg, 1978). The recorded occurrence of 69 species across 48 genera and 25 families in the brackish aquatic habitat of West Bengal underscores the considerable biodiversity within this ecological niche (Misra, 1995). Previously, only *Ficopomatus macrodon* Southern 1921, was reported from the estuarine regions of West Bengal. This study reports that *Ficopomatus uschakovi* has been identified in India specifically in a brackish water pond, after eluding identification for many years. Although Swami and Udhyamkumar, (2010) reported the presence of *F. uschakovi* along the Maharashtra coast but they did not provide any data on the examined material supporting their records. Therefore, the data presented in this report is not considered herein. Hence, this finding represents the first confirmed record of *Ficopomatus uschakovi* with intact specimens, and nest tube found nationwide in the last nine decades. Thus, the discovery of this specimen represents a significant turning point in the taxonomy field.

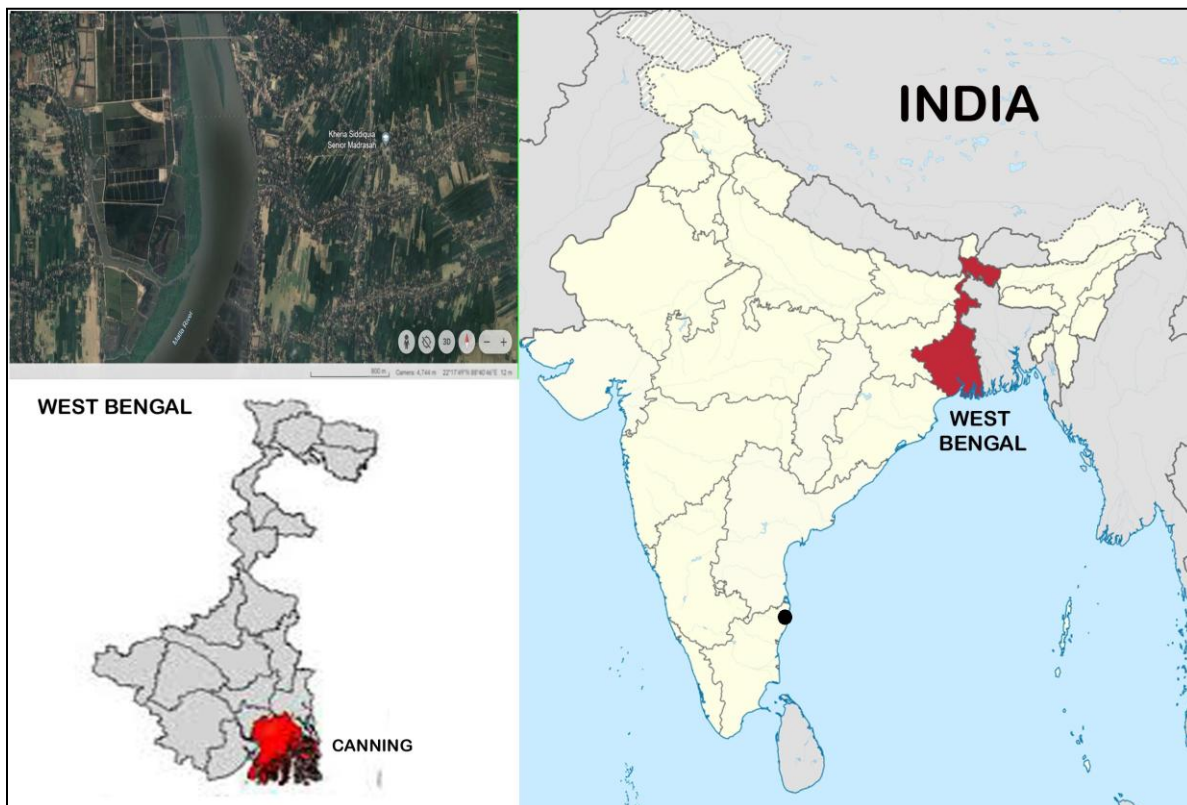


Figure 1 Map showing the study sites where *Ficopomatus uschakovi* (Pillai, 1960) recorded earlier (Black dot) and the present location (Red mark).

2. MATERIALS AND METHODS

The sampling was carried out during May 2023 from a brackish water pond approximately 1 km away from the Matla River of Canning, West Bengal (Fig. 1). The tubes were attached to a dried tree branch lying near the pond. The tubes and the samples, were scraped from the tree branch and transported to the laboratory in containers filled with brackish water for further studies. The samples were extracted and fixed in 10% formalin, followed by preservation in 70% alcohol (Bastida-Zavala and García-Madrugal, 2012). Morphometric measurements and photographs taken in the laboratory. The tubes in the habitat have been photographed with the Nikon P900 camera. The Leica EZ4 stereozoom binocular microscope and compound microscope are used for the identification and documentation of the specimen. The keys used for species determination were Pillai, (1960); Ten Hove and Weerdenburg, (1978);

Bastida-Zavala et al., (2017); Tovar-Hernández et al., (2022). Multivariate analyses, including Principal Component Analysis (PCA) [to identify the influenced taxonomical variables between the species within the genus, *Ficopomatus*] and Canonical Analysis of Principal Coordinates (CAP) [to distinguish the proposed range extension species from its congeners] were performed by using PRIMER version 7.0.5 (Clarke and Gorley, 2015).

3. RESULTS

Systematic account

Phylum: Annelida Lamarck, 1802

Class: Polychaeta Grube, 1850

Order: Sabellida Levinsen, 1883

Family: Serpulidae Rafinesque, 1815

Genus: *Ficopomatus* Southern, 1921

Ficopomatus uschakovi (Pillai, 1960)

Neopomatus uschakovi Pillai, 1960: 28–32, text-figs 10H, 11A–H, 12A–H, plate I, figs 1–2

Neopomatus uschakovi var. *lingayanensis* Pillai, 1965: 170–172, Fig. 23A–I.

Neopomatus similis Pillai, 1960: 32–33, text-figs 12I–M, plate II, fig. 1.

Neopomatus similis var. *rugosus* Pillai, 1960: 33–35, plate II, fig. 2.

Mercierella enigmatica (not Fauvel, 1923): ten Hove and Weerdenburg 1978: 109–110. Studied several incorrect uses of this name.

Ficopomatus uschakovi: ten Hove and Weerdenburg 1978: 109–112, figs 2a–d, 3a, f–k, 4j–n, r, x–z, jj–mm, yy, 5d, revision; de Assis et al. 2008: 51–58, Fig. 2A–G, eastern Brazil; Liñero-Arana and Díaz-Díaz 2012: 234–237, fig. 1a–j, Gulf of Paria, Venezuela.

Material examined

ZSIHQ/GNC/An8014/2; 30 ex; date 19.05.2023; Matla River bank, Canning, West Bengal; Lat.- 22.3112 N, Long.- 88.6764 E; Coll. Santanu Mitra

Diagnosis

Ficopomatus uschakovi is a gregarious species and lives in smaller aggregations. The tubes are calcareous and exhibit an irregular, curved morphology. In the live material, the tubes display reddish-brown coloration that changes to white in the preserved condition. The tube measures approximately 15.63 mm in length and 1.01 mm in width (other tube ranges from 7.08 mm to 17.09 mm in length and 0.89 mm to 1.56 mm in width). The tubes are sometimes coated with a layer of brown algae on them. The cross-section of the tube exhibits semi-circular structure with longitudinal keels (Fig. 2h) (Assis et al. 2008). Usually three keels are visible (Fig. 2g). Sometimes, the lateral ones are absent or very faint. The tubes exhibit flat peristomes or annulations spaced at irregular intervals (Fig. 2g). The operculum is spherical and has radial symmetry with a distally convex horny plate. Spines are transparent and arranged in 1–4 rows directed outwards; occasionally, the rows are partial or fused with other rows (Fig. 2a). The peduncle of the operculum exhibits a smooth surface (Fig. 2a). Dark-brown spots are distributed sparsely on the dorsal side of the operculum and densely arranged laterally (Fig. 2a). The peduncle widens at the base of the operculum and gradually tapers towards the bottom of the branchial crown (Fig. 2a). The branchial crown comprises 12–15 branchial radioles, with six radioles on the left side and nine radioles on the right side; these radioles are distinguished by the presence of alternating black and white transverse bands ranging from 3–4 in number (Fig. 2b). The operculum arises from the left branchial lobe. The branchial radioles bear double rows of pinnules, which gradually increase in size towards the end of the filaments (Fig. 2a) (Hove and Weerdenburg, 1978). Both the thorax and abdomen regions are pale yellow. The ventral side of the thorax displays six pairs of blackish pigment bands (Fig. 2e, f). The pigmented bands are situated anterior to the uncinigerous torus. The collar is entire and has no lobes. The thoracic membrane is fused on the dorsal and ventral side forming a transparent apron (Fig. 2d). The thorax bears capillary chaetae and the abdomen exhibits trumpet-shaped chaete (Tovar-Hernández et al., 2022). Pygidium is rounded.

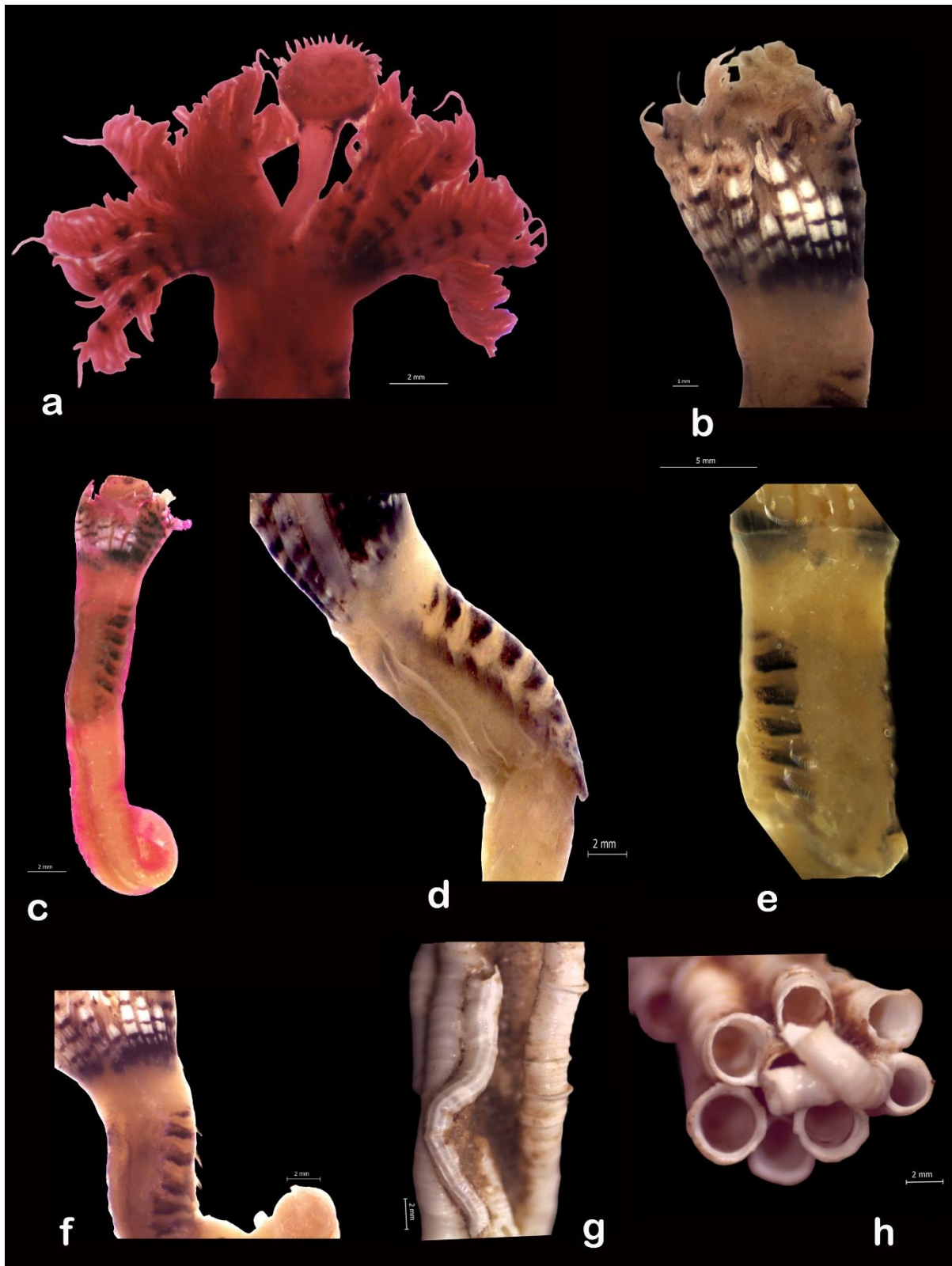


Figure 2 *Ficopomatus uschakovi* (Pillai 1960) from Canning **a.** Operculum; **b.** Branchial radiole; **c.** Full Body; **d.** Thoracic membrane, dorsal view; **e.** Thoracic membrane, ventral view; **f.** Lateral view; **g.** Tube with 3 longitudinal ridge; **h.** Tube



Figure 3 Habitat information. (a-d), Tubes of *Ficopomatus uschakovi* attached to dried tree branch; e. Brackish water pond; f. Matla River

Distribution

Madras Coast, Ennore Backwater (Fig:1) West Bengal (Present record); Sri Lanka (Type locality) Indian Ocean Pillai, (1960); North-eastern Brazil Assis et al., (2008); Western Atlantic- Colombia, Venezuela Liñero-Arana and Díaz-Díaz, (2012), and Eastern Pacific in Southern Mexico Bastida-Zavala and García-Madrigal, (2012); Gulf of Guinea Hartmann-Schroder, (1971).

Table 1. Morphometric characters of *Ficopomatus* sp. considered for Canonical analysis of principal coordinates.

Sl. No.	Species Name	Taxonomical Characters	References
1	<i>Ficopomatus enigmaticus</i> (Fauvel, 1923)	Tube white; large peristomes with one longitudinal ridge; semicircular cross section Operculum is fig-shaped; horny plate bear spines curved inwardly; Thoracic membrane is not fused dorsally; Branchial radioles 5-9 on left side and 7-10 on right side.	Hove and Weerdenburg, (1978); Bastida-Zavala et al., (2017)
2	<i>Ficopomatus miamiensis</i> (Treadwell, 1934)	Tube white with no longitudinal ridges; peristomes small; cross- section of tube semicircular; Operculum spherical; spines absent; Branchial radioles 6-9 on the left side and 6-10 on the right side. Thoracic membrane not fused dorsally.	Hove and Weerdenburg, (1978); Bastida-Zavala et al., (2017)
3	<i>Ficopomatus macrodon</i> Southern, 1921	Tube shining white with a sharp median keel; semi-circular in cross-section; Operculum bulb shaped with conical horny cap; opercular spines absent; Thoracic membrane not fused dorsally; Branchial radioles six on the left side	Ten Hove & Weerdenburg, (1978)

		and seven on the right side.	
4	<i>Ficopomatus shenzhensis</i> Li Wang and Deng, 2012	Tube with no longitudinal ridges; circular in cross-section; Operculum pear or oval shaped; horny plate with “V” shaped furrow; Thoracic membrane not joined over thorax; Branchial radioles nine on both side.	Li et al., (2012)
5	<i>Ficopomatus talehsapensis</i> Pillai, 2008	Tube white, bears one single longitudinal ridge; Tube semicircular in cross-section; Operculum pear-shaped, spines absent; Branchial radioles 5-7 on each side; Thoracic membrane not fused.	Pillai, (2008)

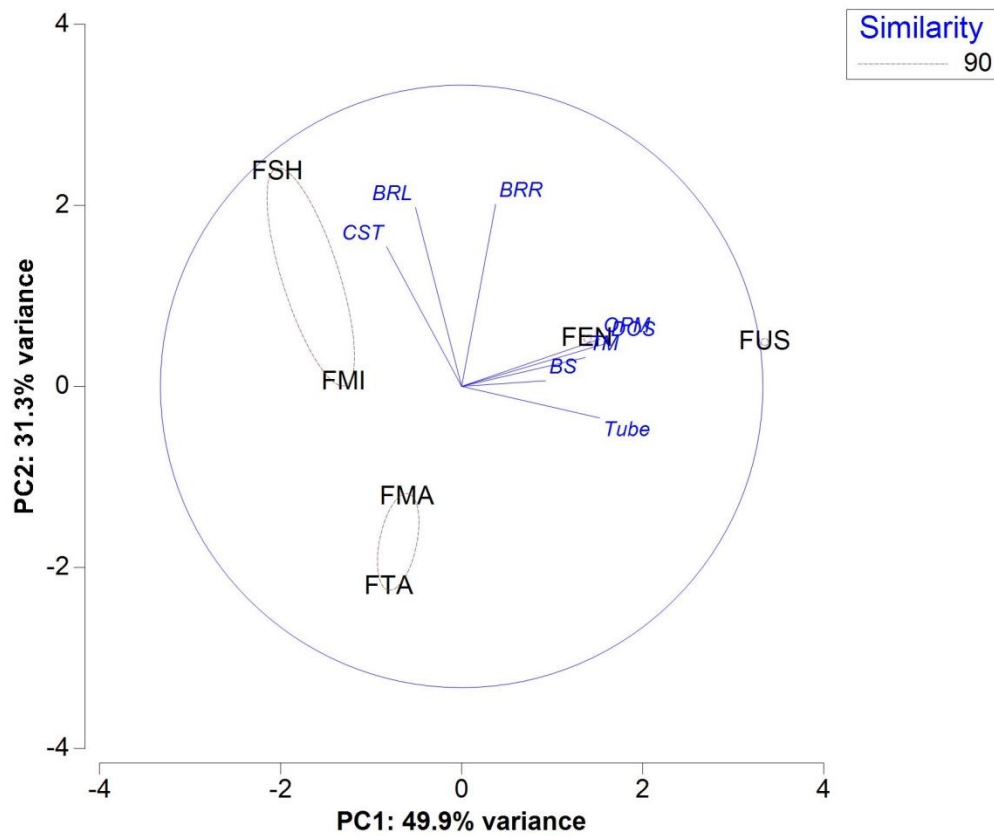


Figure 4 Principal Component Analysis (PCA) based on morphometric characters of species within the genus *Ficopomatus*. *FUS*- *Ficopomatus uschakovi*; *FSH*- *Ficopomatus shenzhensis*; *FMI*- *Ficopomatus miamiensis*; *FMA*- *Ficopomatus macrodon*; *FTA*- *Ficopomatus talehsapensis*; *FEN*- *Ficopomatus enigmaticus*; *CST*- Cross section of tube; *BRL*- Branchial radiole left side; *BRR*- Branchial radiole right side; *OPM*- Operculum; *DOS*- Direction of Opercular spine; *TM*- Thoracic membrane; *BS*- Body size

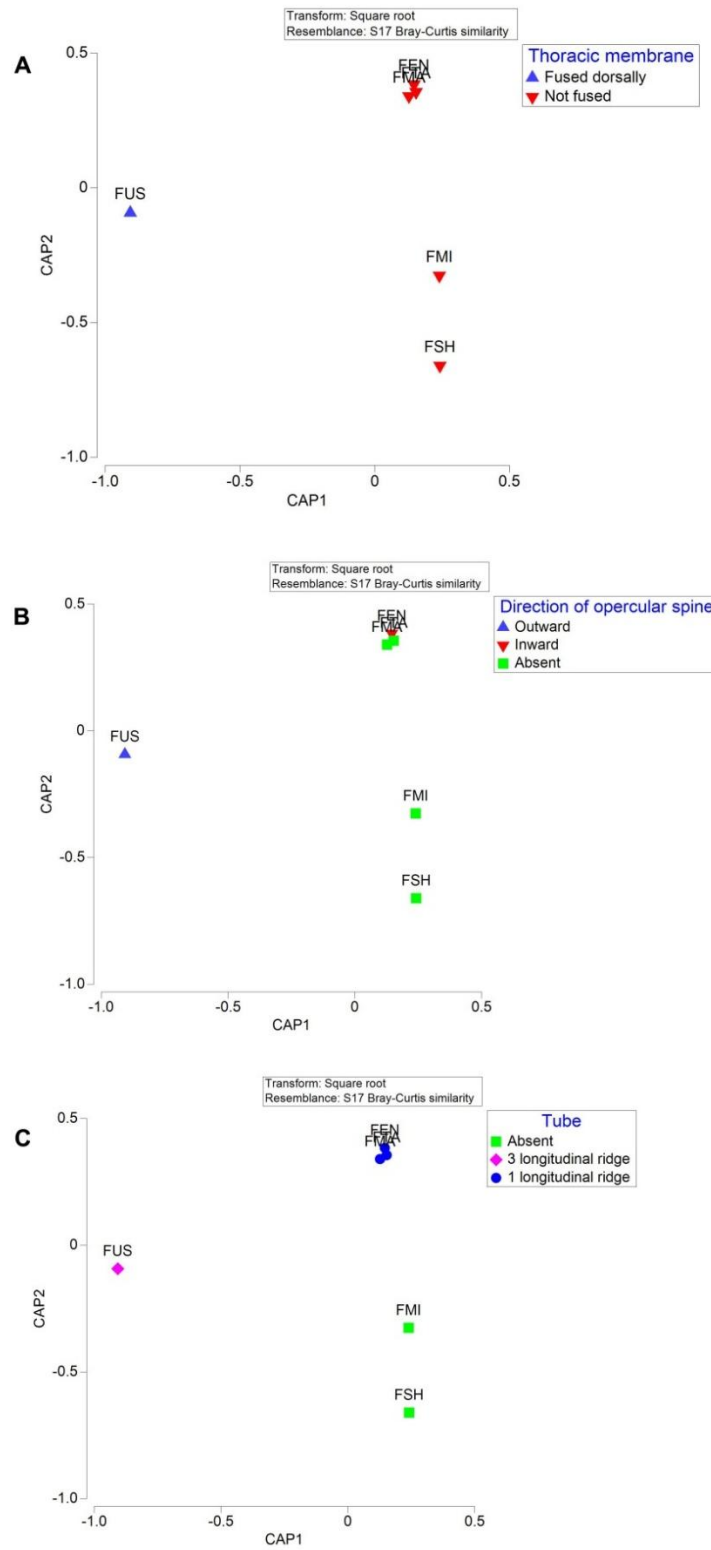


Figure 5. Structural variability of species within the genus *Ficopomatus* through Canonical Analysis of Principal Coordinates. **A.** Fusion traits of Thoracic Membrane; **B.** Direction of opercular spine; **C.** Presence of longitudinal ridges on tube. FUS- *Ficopomatus uschakovi*; FSH- *Ficopomatus shenzhensis*; FMI- *Ficopomatus miamiensis*; FMA- *Ficopomatus macrodon*; FTA- *Ficopomatus talehsapensis*; FEN- *Ficopomatus enigmaticus*

Remarks

Ficopomatus uschakovi was compared with other congeners based on influenced morphometric characteristics and the variability (Table 1) between them through Principal Component Analysis and Canonical Analysis of Principal coordinates. PCA (Figure. 4) showed a substantial variability (PC1: 49.9% variance) between the species of *Ficopomatus*. The most influenced variables observed were the thoracic membrane followed by the direction of the Opercular Spine and tube. The variables that demonstrated minimal variability (PC2:31.3% variance) among the species is the branchial radioles of the right side followed by the tube. The morphometric characteristics such as the thoracic membrane, direction of the Opercular Spine, and tube are considered as factors in the Canonical Analysis of Principal coordinates to distinguish these species within the genus *Ficopomatus* (Fig. 5). CAP showed that *Ficopomatus uschakovi* was completely outlier from its congeners due to the observed factors such as dorsal fusion of the thoracic membrane, direction of the opercular spine, and tube structure. A significant difference was observed in one of the taxonomical variables, thoracic membrane fusion trait (fused dorsally), *Ficopomatus uschakovi* became an outlier whereas the other species, such as *Ficopomatus miamiensis* and *Ficopomatus shenzhensis* are closer to each other. It signifies that both the species share more similar morphological characteristics such as pear-shaped operculum, absence of spine, and 6-9 branchial radioles on each side for *F.miamiensis*, whereas *F. shenzhensis* bears nine radioles on each side. Additionally, other taxonomical variables such as the direction of the opercular spine and the structure of the tube (Fig.5B, 5C) played an essential role in distinguishing the proposed range extension species from its congeners. The rationale behind its segregation was observed due to its outward direction of the opercular spine, whereas *Ficopomatus miamiensis* and *Ficopomatus shenzhensis* are grouped together as having no opercular spine. However, the sample *Ficopomatus enigmaticus* having an inward opercular spine, which is plotted closely to *Ficopomatus macrodon* and *Ficopomatus talehsapensis* having no opercular spine, indicates similarities in other morphological traits like the cross-section of tube is semi-circular, presence of ridges on tube. If the tube structure taken into account, the samples are classified based on the presence of median ridges. *Ficopomatus uschakovi* has three longitudinal ridges, which distinguish it from other congeners. Conversely, *Ficopomatus enigmaticus*, *Ficopomatus macrodon*, and *Ficopomatus talehsapensis* are clustered together due to one longitudinal ridge. *Ficopomatus miamiensis* and *Ficopomatus shenzhensis* do not have longitudinal ridges on the tube and are plotted closely.

4. DISCUSSION

In Fauvel, (1932) the species was recorded as *Mercierella enigmatica* from the Ennore backwater, Madras coast, India, adhering to oyster shells. Ten Hove & Weerdenburg (1978) studied the specimens collected by N. Annandale from Ennore backwater (BMNH 1938) identified as *Mercierella enigmatica* Fauvel, (1932). Still, they were doubtful and commented: "re-examination of part of this material, from this locality, labeled *Mercierella enigmatica*, showed tubes with three prominent ridges, containing *F. uschakovi*." (Ten Hove & Weerdenburg 1978). Both Hartmann-Schroder, (1971) and Ten Hove & Weerdenburg, (1978) confirmed the distribution of *F. uschakovi* in the paleotropical area. They noted that *F. uschakovi* is distributed throughout the southern hemisphere from India, spanning to the Philippines and northern Australia. Ten Hove & Weerdenburg, (1978) in their paper provided a comprehensive overview of the distribution of different species of *Ficopomatus* on a global map, highlighting the areas where the specimens were studied and where literature recorded on these species (Hove and Weerdenburg, 1978; Fig.6) The present record from Canning, West Bengal, is the first confirmed record of *Ficopomatus uschakovi* Pillai, (1960).

The study conducted at the site of occurrence revealed a remarkable phenomenon- densely aggregated reefs of the species flourished on a dried tree branch (Fig. 3a-d). Usually, this species is found in brackish water or areas that experience salinity fluctuations due to tides and freshwater inflows. (Fig. 3e) The presence of *F. uschakovi* in a brackish water pond and the salinity fluctuations during the high tide inflows from the nearby Matla River, provide a key insight into its adaptability and resilience (Fig.3f). Such ecological flexibility is rare among organisms, especially in environments with varying salinity conditions. This discovery highlights the intricate interplay between environmental factors and species habitat preferences.

5. CONCLUSIONS

The presence of *Ficopomatus uschakovi* in West Bengal, India, has not previously been reported. This study is noteworthy as the present location is almost 1723 km from the previously recorded locality, the Ennore backwater, highlighting the significance of such range expansion from a zoo-geographical aspect. From an economic perspective, this finding carries significant implications, as very few marine organisms can survive in brackish water habitats, and these worms may serve as a vital food source for many fish species

inhabiting brackish water environments. The occurrence of *Ficopomatus uschakovi* in such habitats may significantly enhance local fisheries and also maintain the ecological stability of the region. This discovery highlights the need for further investigation to comprehensively examine the distribution and diversity of polychaetes belonging to the Serpulid group along the east coast of India.

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Conflict of Interest

The authors declare that there are no conflicts of interests.

Authors' Contributions

MB: Identification and drafting manuscript; SM: Collection and Review

Informed consent

Not applicable.

Ethical approval & declaration

Specimens were collected as part of primary mandates of ZSI (Zoological Survey of India) by using local survey. The animal ethical guidelines are followed in the study for species identification.

Data and materials availability

All data generated or analyzed during this study are included in this published article.

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