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New Species of Ciliates (Genus: *Strombidium* sp.) from hypoxic waters of the Bay of Bengal, Northern Indian Ocean

Sai Elangovan S & Mangesh Gauns*

CSIR-National Institute of Oceanography, Biological Oceanography Division,
Dona Paula, Goa - 403 004, India

Corresponding author* [E-mail: gmangesh@nio.org]

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Present study describes a new species of *Strombidium* (oligotrich ciliates) found in the cold sub-surface (125m below surface) oxic-hypoxic boundary of the Bay of Bengal. We name it as *Strombidium mansai* and describe its morphology.

[**Key words:** Bay of Bengal, Ciliates, Hypoxic waters, *Strombidium* sp]

Introduction

In the marine ecosystems, ciliates have been renowned as a dominant group in microzooplankton and serve as an efficient link between the microbial loop and metazoan food web[1-4]. Oligotrich ciliates generally dominate microzooplankton communities in both marine and freshwater habitats[5-6]. They are ubiquitous in the ocean surface and usually take over the planktonic ciliate communities[7]. Aloricate oligotrich ciliates exist in higher numbers and consume considerable quantities of autotrophic and heterotrophic microbial production[8-9]. The genera of oligotrich ciliates like *Strombilidium* and *Strombidium* are prominent components of microzooplankton in planktonic communities[10-11]. *Strombidium* genus has been recognized as a diverse group in the oligotrichs[4]. Although around 80 species of *Strombidium* have been recorded till date, many of them lack morphological details that need further investigation[12-15].

Northern Indian Ocean, comprised semi-enclosed water bodies of Bay of Bengal and Arabian Sea, has oxygen minimum zone at subsurface waters (~200-1000m)[16-17]. However, Bay of Bengal is less productive region than Arabian Sea[18]. The biological productivity of Bay of Bengal is governed by mesoscale eddies and tropical cyclones that trigger occasional higher productivity[19] that could also add to the consumption of dissolved nutrients at sub-surface depth. These zones of hypoxic waters are found to be dominated by large number of bacterial community probably driving unique microbial community in the Indian Ocean. Euphotic zone of this region remains enriched in bacterial abundance throughout the year, relative to other tropical regimes, apparently in response to overall high primary productivity[20]. The primary productivity is grazed upon by larger, herbivorous zooplankton communities, while biomass of smaller forms such as bacterioplankton is necessary for beneficiary of microzoans (ciliates, tintinnids, and heterotrophic flagellates) in the microbial loop of the region[21-22].

Materials and Methods

The sample was collected on 19th June 2013 during the cruise R.V Sindhu Sankalp (SSK-51) to Bay of Bengal at BOBTS station (lat: 17° 59.9193′N and long: 88° 59.83′ E). To collect even rare forms of microzooplankton, large volume (10 liters) of water sample was collected using CTD from the oxic-hypoxic boundary located at a depth of 125 meters and processed following JGOFS protocol[23]. Cold (21.2^{o}C), saline (34.8) and low oxygenated (0.1ml l^{-1}) waters of this depth was closely associated with a secondary pigment fluoroscence peak (Fig. 1). Sample for ciliate analysis was preserved and

processed with 1% acid Lugol's solution. Hydrographical parameters such as temperature, chlorophyll and salinity were recorded using CTD sensors. After the cruise, the sample was brought to the laboratory and allowed to settle for 48hrs, which were then concentrated to 100ml by siphoning supernatant. Utmost care was taken while sampling and during sample concentration to ensure minimal damage to delicate forms such as ciliates. Further, the concentrate was allowed to settle overnight in Utermohl's chamber. Sample was then analysed under inverted microscope (Nikon Eclipse t-u) at 40x magnification and NIS-Elements BR 4.00.00 Ink software system which was pre-calibrated using stage and occular scale. This study describes new species recorded at a depth of 125 meters in the hypoxic water of the study region. Section below describes the new species and it's closest relative *Strombidium lynni*.

Result and Discussion

Due to enormous fresh water discharges from major rivers and precipitation in the summer, salinity of surface water in the Bay of Bengal decreases by 3-7psu throughout the year than the Arabian Sea, which leads to strong stratification in the water column[24-25]. Intermediate depths of Bay of Bengal experience denitrification with nitrate deficiencies and as results low dissolved oxygen prevails in this area[26]. Oxygen minimum zones of oceans are known to harbor complex microbial communities (Protists, fungi and zooplankton) which are adapting their life in the low oxygen conditions[27-29]. Ciliates are active micro grazers hypoxic conditions controlling protists and prokaryote communities[30]. Our finding in the present study reveals a new species that belonged to the genus *Strombidium* from hypoxic waters of the Bay of Bengal.

New Species

Description:

Phylum : Ciliophora
Class : Oligotrichea Butschli, 1889
Subclass : Oligotrichia Butschli, 1889
Order : Oligotrichida Butschli, 1889
Family : Strombidiidae Faure Fremiet, 1970
Genus : *Strombidium* Claparede and Lachmann, 1859

The cell resembles heart shape with an anterior cylindrical and posterior conical profile. Orientation of the adoral membranelles on the peristomial rim shows a deep oral cavity with adoral polykinetids zone. Also, the ventral polykinetid is not clearly visible (Table. 1, Fig. 2 & Fig. 3).

Measurements

Length: 63 µm, Width: 70 µm, No. of Adoral polykinetid (Apk): 18–20, No. of Ventral polykinetid (Vpk): not visible.

Ecological data

Found in deep water (125m depth), Temperature: 21.2˚C, Salinity: 34.8 psu, Dissolved oxygen: 0.1 ml/l.

Remarks:

Found in deeper waters, Ventral polykinetid is not clearly visible and is similar to the shape of *Strombidium lynni*.

***Strombidium lynni* (Martin & Montagnes, 1993)[31]**

Description:

The cell almost looks like heart-shape possessing a deep oral cavity with complex pocket; adoral polykinetids zone and Ventral polykinetid zone, distinctly separated; girdle equatorial to subequatorial; Ventral kinety spirals clockwise; multiple spheroid macronuclei scattered throughout the cytoplasam (Table. 1).

Measurements

Length: 50 µm (35–60µm), Width: 35 µm (25–40 µm), No. of Adoral polykinetid (Apk): 15 (14–20), No. of Ventral polykinetid (Vpk): 18 (15–21).

Ecological data

Temperature: 6–7 ˚C; Salinity: 25 psu.

In the present study, the new species was obtained from deeper waters of Bay of Bengal, which was Lugol's preserved. Unfortunately, we could not take appropriate Scanning Electron Microscopic (SEM) image of this species due to the damage occurred during specimen preparation (gold coating). The heart shape of this species appeared similar to *Strombidium lynni* with the presence of Adoral polykinetid zone, and ventral kinety (Fig. 2). Based on similarity in shape to *Strombidium lynni* and the presence of polykinetid, we suggest that this ciliates species belongs to the genus *Strombidium* and named as *Strombidium mansai.*

This rare species, we believe has an ability to thrive low oxygen waters of oxic-hypoxic

boundary and feed on abundant bacteria sized particles (Fig. 1). However, it is not clear whether this cold water form is a permanent or temporary resident of this boundry in the twilight zone. Additionally, secondary fluorescence maxima generally dominated by prochlorophytes (data not shown here) at this depth possibly meets energy needs for its survival. It is interesting to study its biology and ecology, as we still have much to learn about the food and feeding habits of this ciliate and its overall role in the microbial food web of this specialized niche. However, we would like to caution readers to note that this species identification is fully based on morphological traits and lacks information on molecular methods and live observation, protargol-impregnation and statistic analyses of the morphometric data, which are valuable.

Table 1-Comparison between *Strombidium lynni* and the new species (*Strombidium mansai)* of Bay of Bengal.

Description	*Strombidium lynni* (Martin & Montagnes, 1993)	New species (*Strombidium mansai*)
Measurements	Length : 50 (35–60) µm Width : 35 (25–40) µm No of Adoral polykinetid (Apk): 15 (14–20) No of Ventral polykinetid (Vpk): 18 (15–21)	Length: 63 µm Width: 70 µm No of Adoral polykinetid (Apk): 18–20 No of Ventral polykinetid (Vpk): not visible
Ecological data	Found in coastal waters Temperature: 6–9 ˚C, Salinity: 25 psu	Found in deep water (125m depth). Temperature: 20˚C, Salinity: 34.8 psu Dissolved oxygen: 0.02 ml/l
Key features	Cell almost heart shaped, anterior cylindrical, posterior conical.	Cell almost heart shaped, anterior cylindrical, posterior conical.

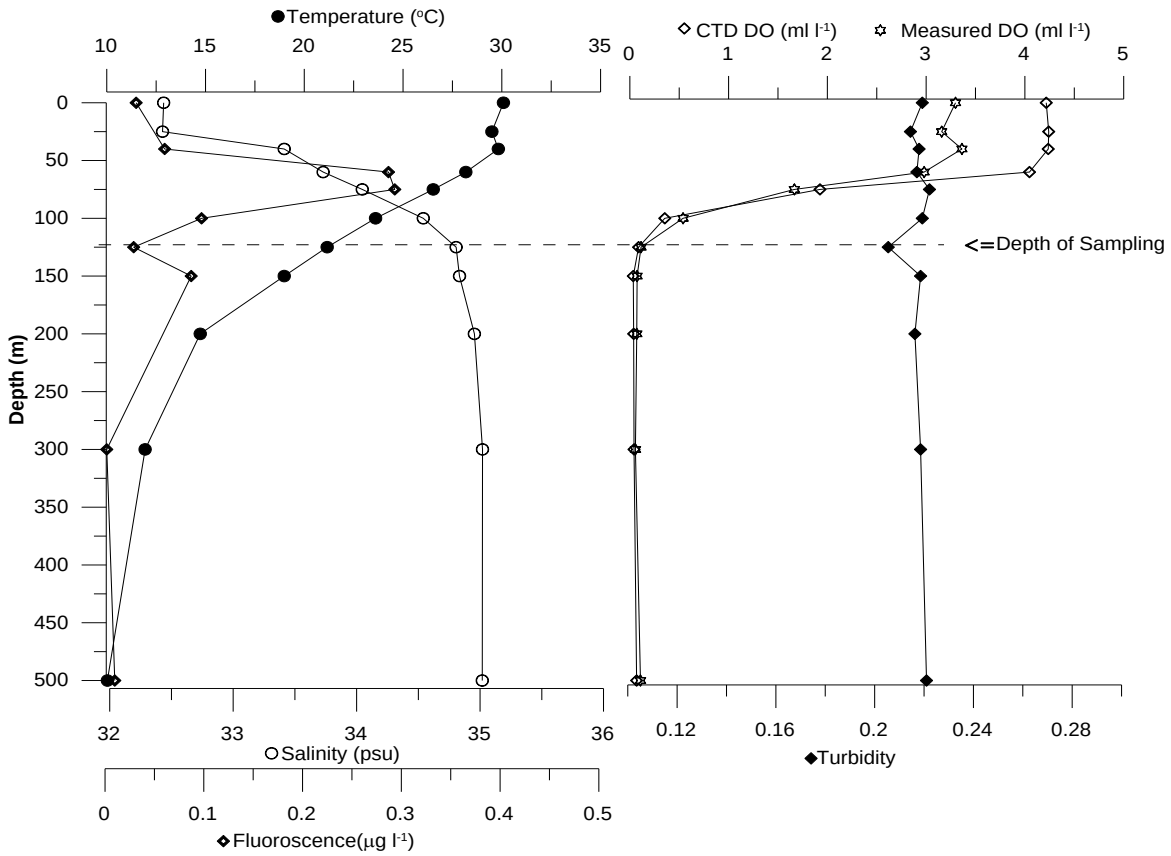

Fig. 1-CTD profile showing hydrographic parameters at depth of sample collection in the Bay of Bengal.

Conclusion

Present work highlights the need to understand the population of specialized life of microbes (protists) adapted morphologically and physiologically in the subsurface low oxygen layer in the ocean.

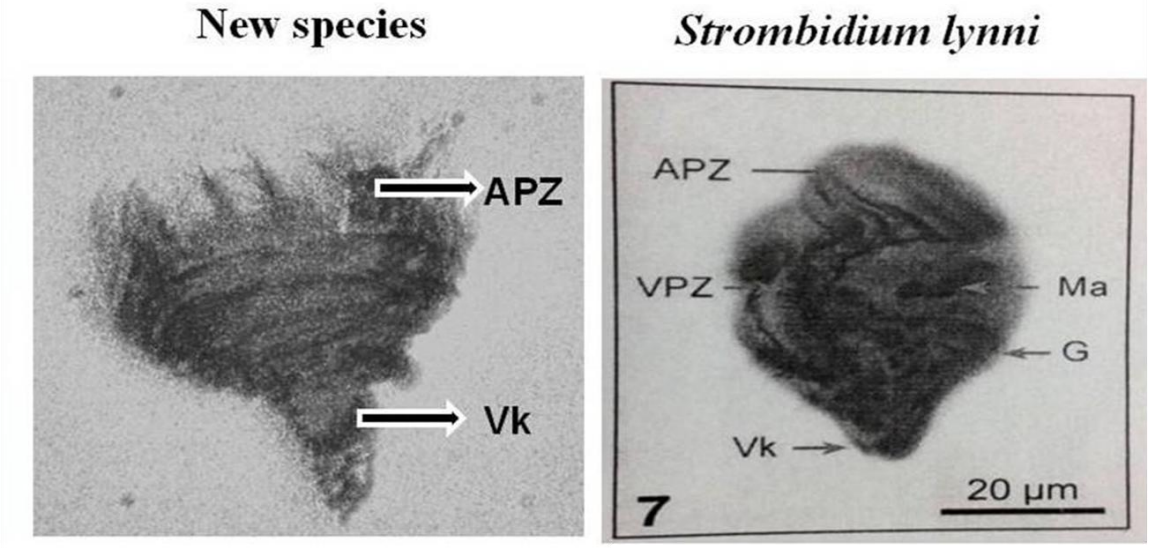

Fig. 2-Microscopic details of new species (*Strombidium mansai*) from hypoxic waters of Bay of Bengal with comparison of *Strombidium lynni* (Martin & Montagnes, 1993). APZ-Adoral polykinetid zone; VPZ-Ventral polykintenetid zone; Ma-Macronucleus; G-Girdle kinety; Vk-Ventral kinety.

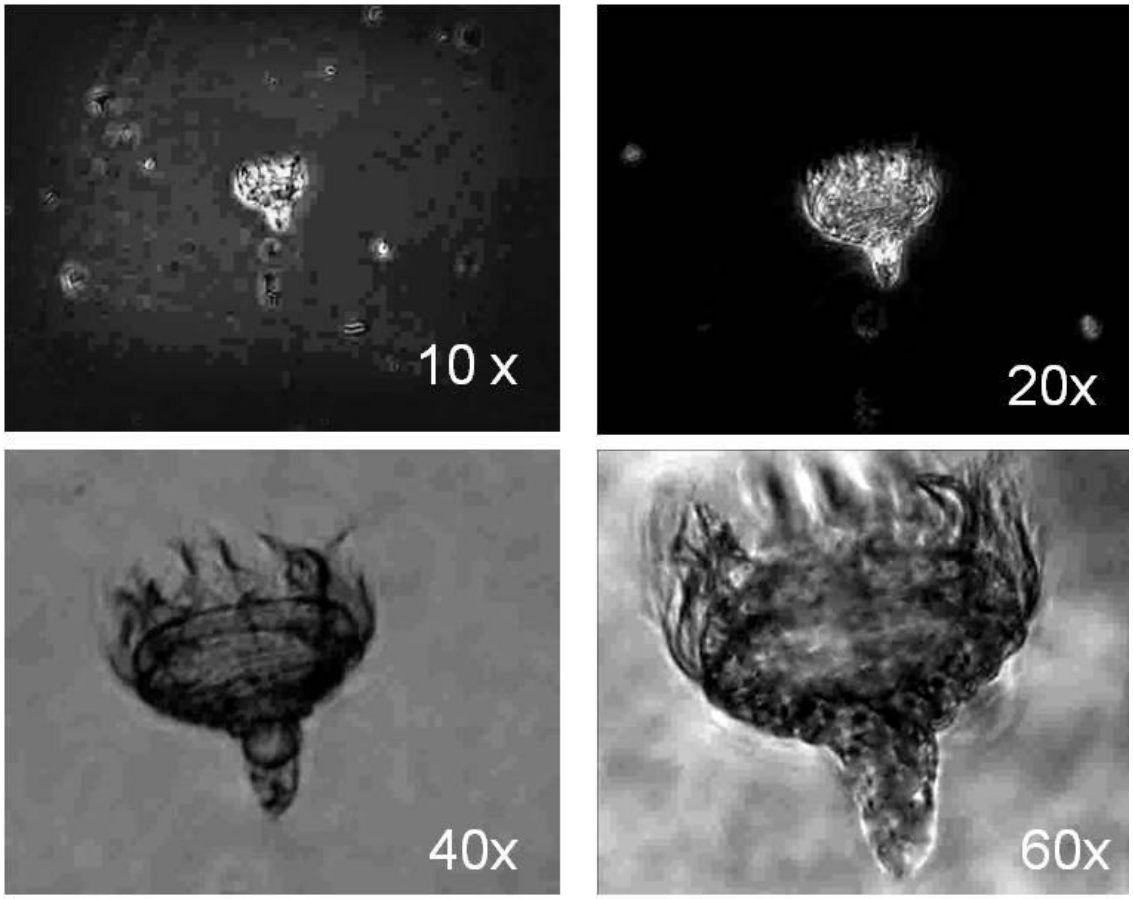

Fig. 3-Images of new species (*Strombidium mansai*) at different magnifications.

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