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Unusual thickening of collarette in *Sagitta bedoti* (Chaetognatha) from the polluted environments of Bombay coast

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Sagitta bedoti dominated the chaetognath fauna of the nearshore waters of Bombay. *S. bedoti* from the polluted creek environments developed an unusually bulky collarette which extended from the neck to the seminal vesicles. Such extensive development of epidermal thickening probably serves as a protective sheath to withstand the unfavourable water quality.

Chaetognaths being very sensitive to variations in water quality it is puzzling how they withstand the deteriorating environmental conditions. However, reports indicate mortality of chaetognaths during ebb tide at intensively polluted zones around Bombay[1]. Environmental deterioration will exert stress on biota which as a result may undergo an active adaptation to withstand the unfavourable conditions. Contemplating on this aspect chaetognaths collected from polluted creek environments off Bombay were examined to evaluate the morphological variations, if any, in the species living in polluted environments. This is the first report of pollution induced morphological variations in zooplankton from the coastal waters of Bombay.

Zooplankton samples were collected from 4 locations (Fig. 1). Stations 2 and 3 are located at the interior part of the creek where deteriorating water quality prevailed due to disposal of domestic and industrial wastes[2]. Relatively low levels of dissolved oxygen content and high concentrations of nutrient at this zone indicate considerable input of organic waste at the inner creek region (Table 1). Effect of pollution was nullified at sts 1 and 4 due to effective mixing which resulted in relatively better water quality indicating normal levels of dissolved oxygen and nutrients (Table 1) comparable to the nearshore waters of India. In the text sts 1 and 4 are referred as outer zone while sts 2 and 3 as creek area. Collections were made during August 1985 to October 1986 by oblique hauls using an HT net (mouth area 0.25 m^2; mesh 0.3 mm) with an attached flow meter. Chaetognaths were sorted out from the samples and identified. For scanning specimens of *S. bedoti* were dehydrated in ethyl alcohol gradients, dried in a critical-point drying apparatus (Hitachi, HCP-2) and coated with gold in an ion spattering appartus (JFC-1100). These prepared specimens were observed in an Alpha 25 scanning electron microscope (SEM).

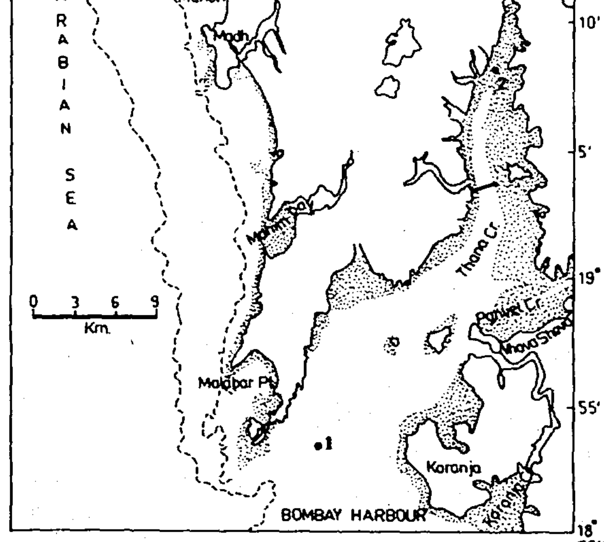

Fig. 1—Location of stations

Chaetognaths formed an appreciable part of total zooplankton population and the percentage contribution ranges in terms of density at outer and creek zones were respectively 0.18-15.46 and 0.01-21.27. The wider fluctuation at sts. 2 and 3 was characteristic of polluted environment[2]. Four species namely *S. bedoti*, *S. enflata*, *S. oceania* and *S. robusta* were encountered in the collection. *S. bedoti* dominated the chaetognath population except on a few occasions, when it was replaced by *S. oceania*[2].

Numerical variation (no. 100 m^{-3}) in *S. bedoti* during 1985-86 was 77-5490 (*av* 940), 2-14499 (*av* 1656), 6-13103 (*av* 2811) and 29-19201 (*av* 4856) at sts 1-4 respectively. The average contribution of *S. bedoti* to total chaetognath for the year was 73.7, 53.9, 98.7 and 79.7% at sts 1-4 respectively. Tidal influence into the interior part of the creek beyond st. 2 is very weak and this may result in the build up of pollutants[2] at st 3. *S. bedoti* being the most tolerant species often contributed 100% to the total chaetognath population at this location[2].

S. bedoti of different size group (8-14 mm) collected during the premonsoon season (February - May), when the pollution effect was maximum[2], were examined carefully for the various meristic and morphological characters. All these characters tallied well with the diagnostic characteristics of *S. bedoti*[3] except the collarette in specimen collected from the interior creek zone (sts 2, 3). Normally, the collarette covers only the neck side of *S. bedoti* and the same was observed in *S. bedoti* collected from the outer zone. However, in specimens of *S. bedoti* collected from the creek stations the collarette was relatively very thick extending all along the body upto the seminal vesicles (Fig. 2). Thickening of the lateral epidermis produced an excessive development of collarette which showed almost uniform dimension between the ventral ganglion and tail septum. This extends over the paired fins showing a false expansion of the anterior part of the fin (Fig. 3) and also filled the area between the two paired fins. This gave a froathy appearance to the chaetognath collected from the polluted creek envrionment. Such morphological abberation was observed in all size groups of *S. bedoti* and the frequency of occurrence varied from 40-70%. When the specimens were graded through alcohol the collarette shrunk heavily creating difficulty in getting a clear picture (Fig. 4). Collarette formed a thick covering over the body (Fig. 4A, B) and is made of large inflatable cells (Fig. 4C). Hyman[4] reported collarette as a stratified epidermis of large bladdery cells.

Presence of collarette is a common feature in many species of chaetognaths and its dimension and

Table 1—Range in various physico-chemical parameters at different stations during the premonsoon period

Parameters	Stations			
	1	2	3	4
Temp. (°C)	26.5-30.0	26.5-32.0	26.2-33.0	24.0-32.0
*p*H	7.9-8.2	7.6-8.0	7.6-8.0	7.9-8.1
Sal. ($\times 10^{-3}$)	35.6-37.5	33.4-37.0	13.1-28.0	34.1-36.9
DO($mg.l^{-1}$)	6.1-8.1	2.1-6.5	2.5-7.1	5.1-9.3
BOD ($mg.l^{-1}$)	0.8-2.6	1.3-4.1	2.0-4.6	1.0-4.3
Phosphate ($\mu g\text{-}at.l^{-1}$)	0.3-2.6	8.2-13.2	3.8-9.9	1.2-2.0
Nitrite ($\mu g\text{-}at.l^{-1}$)	0.1-2.8	4.6-17.9	0.3-12.9	0.1-0.6
Nitrate ($\mu g\text{-}at.l^{-1}$)	1.4-17.3	8.0-37.8	45.2-69.0	11.2-22.6

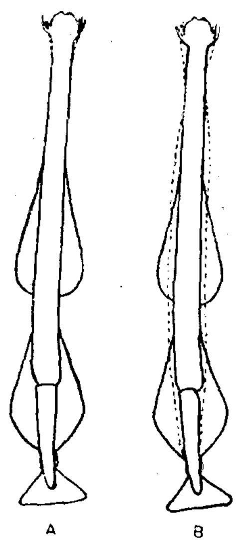

Fig. 2—Diagramatic sketch of *S. bedoti* from offshore (A) and creek (B) area (scale 1.4 cm = 1 mm)

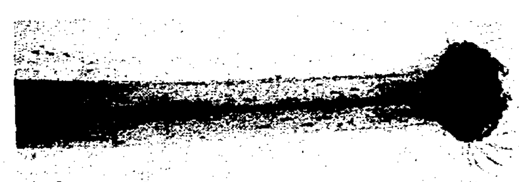

Fig. 3—Anterior part of *S. bedoti* indicating the expansion of the collarette merging with the anterior fin (scale 2.3 cm = 1 mm)

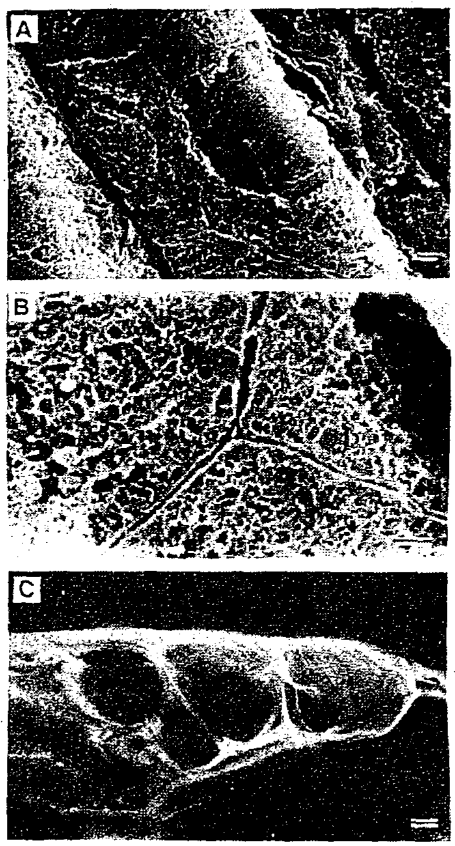

Fig. 4—Scanning electron micrographs showing the body of *S. bedoti* with peeled off collarette (A), an intact part of the collarette (B) and the vacuolated nature of the cell (C) [Scale bars indicate 1 μm (A, B) and 10 μm (C)]

extension vary between species. The development of the collarette is found maximum in *Pterosagitta draco*, a typical pelagic chaetognath and *Spadella cephaloptera*, a benthic chaetognath. Hence, the function of these vacuolated cells as an aid to flotation cannot be accepted fully. Collarette is absent or much less developed in widely distributed species like *S. bipunctata*, *S. decipiens*, *S. bedoti*, *S. enflata*, *S. hexaptera*, *S. pacifica* etc. The development of the collarette does not seem to imply any phylogenic significance[5] and originally it might be useful as a protective tissue[6]. The newly-hatched larvae were covered with a thick collarette as observed in *S. elegans*[7,8], *S. nagae*[9], *S. crassa* and *S. helenae* (Nagasawa, unpublished data), but a few days after hatching, most collarette of *S. nagae* disappeared[7]. No special attention has been given to the presence of thick collarette in newly-hatched larvae, the function of this tissue and the mechanism of its disappearance. Newly-hatched larvae are not strong enough to endure new conditions. Hence, a bulky collarette may play a role in protecting the larvae against new surroundings.

Change in morphological characters associated with water quality is not a common feature among zooplankton. However, some species of zooplankton like the rotifer *Anuraea* and the cladoceran *Hyalodaphnia* are reported to show seasonal polymorphism due to certain changes in the physico-chemical conditions of the water[10]. Kado and Hirota[11] reported on the size variation in the collarette between two forms of *S. crassa* from the sea of Mukaishima, Japan depending on the variations of chlorinity and temperature. They concluded that the development of large collarette of *S. crassa* was associated with the lowering of water temperature in winter.

It is surprising to observe *S. bedoti* in the creek environments of Bombay with unusual thickening of collarette. Phylogenically the collarette might have developed as a protective tissue apart from its function to aid in buoyancy and later retained full dimension by a few genera which are less diverse. In *Sagitta*, the most successful genus among chaetognaths[12], development of collarette has been curtailed. *S. bedoti* dominated the estuarine habitats all along the coastal waters of India and the unusual expansion of collarette has never been observed in the tropical estuarine systems undergoing drastic variations in salinity[12]. Probably the development of a bulky collarette in *S. bedoti* from the polluted environment acts as a protective sheath to withstand the unfavourable water quality associated with widely fluctuating chemical conditions. This hypothesis may be supported by the evidence that a thick collarette is also present in newly hatched larvae which may need temporary protection from the new surroundings.

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