*Asian Fisheries Science* **27** (2014): *149-159*

ISSN 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2014.27.2.006

The Journal of the Asian Fisheries Society

**Short Communication**

# First Record of the Calanoid Copepod *Pseudodiaptomus serricaudatus* (Scott, T. 1894), (Copepoda: Calanoida: Pseudodiaptomidae) in the Equatorial Indian Ocean

**VALETA REBELLO [1], JAYU NARVEKAR [1], PADMAVATI GADI [2], ARATI VERENKAR [3], MANGUESH GAUNS [1] and S. PRASANNA KUMAR [1]***

[1]CSIR-National Institute of Oceanography, Dona Paula, Goa-403004, India
[2]Dept. of Ocean Studies and Marine Biology, Pondicherry University, Port Blair, Andaman
[3]Happy Home Apartment, Near Canara Bank, Fatorda, Margao, Goa-403602

## Abstract

*Pseudodiaptomus serricaudatus* (Scott, T. 1894), a planktonic copepod belonging to the family Pseudodiaptomidae, though has worldwide distribution, has been reported only from estuarine and coastal waters. This is the first report of the occurrence of demersal calanoid copepod, *P.serricaudatus* in the open oceanic waters of the Equatorial Indian Ocean (EIO; 4ºN, 77ºE). This species, collected during September 2010, was found to be one of the most abundant copepods with a density of 113 $ind{\cdot}m^{-3}$. We suggest that this species might have advected from the estuarine and coastal waters off the southern parts of the west coast of India under the influence of prevailing monsoon currents.

## Introduction

The family Pseudodiaptomidae, belonging to Copepoda has restricted distribution from freshwater to coastal marine waters of tropical and temperate parts of the world ocean. Extensive studies have been carried out on its zoogeography (Pillai 1976; Grindley 1984; Walter 1986), which shows its worldwide distribution between latitudes 40°N and 40°S (Walter 1986). *Pseudodiaptomus serricaudatus* is a euryhaline organism and is confined to estuarine and coastal waters of Indian, Indo-Pacific and eastern Atlantic Oceans (for example, Scott 1902; Achuthankutty et al. 1998; Jerling 2008; Dahms et al. 2012) (see Fig. 1 for geographical spread).

*Corresponding author. E-mail address: prasanna@nio.org

In the present study, we report the occurrence of the coastal and estuarine species *P.serricaudatus* in the open oceanic waters of the EIO and explore the possible reasons for their occurrence, survival and proliferation in the new region.

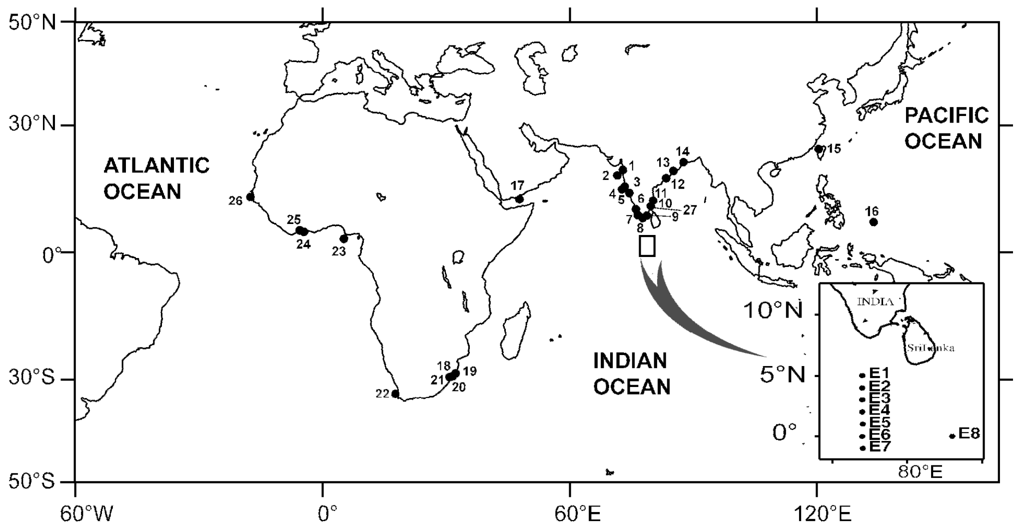


**Fig. 1.** Worldwide distribution of the species *Pseudodiaptomus serricaudatus* (1-27). **1.** Bombay Harbour (Ramaiah and Nair 1997); **2.** Dharamtar Creek (Tiwari and Nair 2002); **3.**Mandovi and Zuari estuaries (Achuthankutty et al. 1998); **4.** Goan coast(Madhupratap et al. 1990); **5.** Karwar; coast (Madhupratap et al. 1990); **6.** Cochin backwaters (Pillai et al. 1973); **7.** Trivandrum coast (Saraswathy 1967); **8.** Ceylon Pearl bank (Thompson and Scott 1903); **9.** Gulf of Mannar (Sewell 1914); **10.** Pichavaram Mangroves (Godhantaraman 1994); **11.** Muttukadu backwaters (Bharathi and Ramanibai 2012); **12.** Lawson's Bay (Ganapati and Shanthakumari 1961); **13.** Chilka Lake (Sewell 1924); **14.** Matla and Saptamukhi estuary (Chakraborty et al. 2009); **15.** Estuary-Lanyang River (Dahms et al . 2012); **16.** Iwayama Bay ,Palao (Mori 1942); **17.** Gulf of Aden (Scott 1902); **18.** Richards Bay Harbour (Jerling 2008); **19.** Agulhas current and bank (Verheye et al. 1994); **20.** St. Lucia estuary (Jerling et al. 2010); **21.** Mhlathuze estuary (Jerling 2008); **22.** Saldanha Bay (Grindley 1977); **23.** Gulf of Guinee (Dessier 1979); **24.** Grand- Lahou Lagoon (Etile et al. 2009); **25.** Plateau Ivoirien (Binet et al. 1972); **26.** Estuary of Casamance River (Debenay et al. 1989); **27.** Chennai coast (Shanthi Ramanibai 2011).( **INSET)** Station location for zooplankton sampling (marked as-●),(**E1**-5°N,77°E; **E2**-4°N,77°E; **E3**-3°N,77°E; **E4**-2°N,77°E; **E5**-1°N,77°E; **E6**-0°,77°E; **E7**-1°S,77°E; **E8**-0°N,83°E).

## Materials and Methods

As a part of the Equatorial Indian Ocean Process Study (EIOPS) vertical profiles of temperature and salinity were collected at 1-degree interval along 77$^{o}$E from 5$^{o}$N to 1$^{o}$S and at an additional station at the equator and 83$^{o}$E by operating a Conductivity-Temperature-Depth (CTD) system (Sea Bird, SBE 25) on-board the Indian research ship ORV *Sagar Kanya* from 21$^{st}$ September to 2$^{nd}$ October 2010 (Fig.1). Water samples were collected for chlorophyll *a* and phytoplankton using a rosette fitted with 5L Niskin samples. The phytoplankton samples were preserved in Lugol's solution, while chlorophyll *a* was determined by fluorometric analysis.

Zooplankton samples were collected at all stations by vertical haul from 150 m to surface using WP-2 Hydrobios net with a mouth area of 0.25 m$^2$ and mesh size of 200 µm fitted with a digital flow meter. Samples were preserved immediately in 5% solution of buffered formaldehyde and counted later in the laboratory using stereomicroscope (Nikon-SMZ 1500). The study on the external morphology of the species *P. serricaudatus* was undertaken to decipher the changes, if any, in the species.

In addition, the Ocean Surface Currents Real-Time Analysis (OSCAR) data (http://www.oscar.noaa.gov/) for the month of September 2010 along with monthly mean climatology of salinity from the World Ocean Atlas (WOA-09) (ftp://ftp.nodc.noaa.gov/pub/WOA09/DOC/woa09) was also used. The figures were plotted using Golden Software Surfer version 8 and Ferret.

## Results

The salient feature of the thermal structure was the presence of a warm and thick isothermal layer with temperature in excess of 28 °C in the upper ocean, with considerable spatial variability (Fig.2A). The thermocline showed a continuous shoaling from south to north. The salinity structure showed the presence of a lens of low salinity water, of 30 m thickness, located in the north with salinity as low as 35 psu (Fig.2B). Below the low salinity water, a high salinity core was noticed with salinity in excess of 35.5 psu, extending up to 80 m.

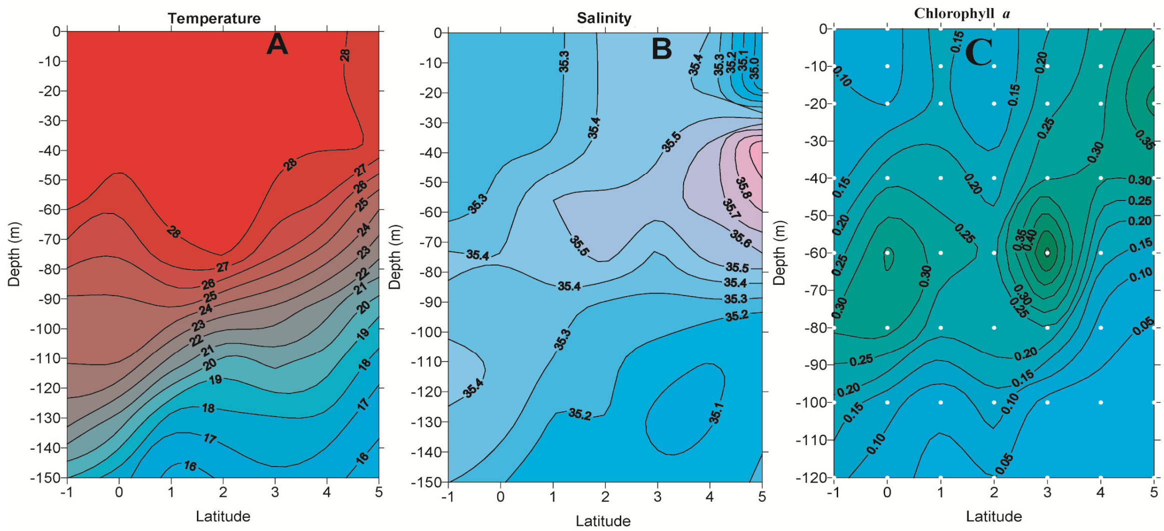


**Fig. 2.** Vertical profiles of (**A**) temperature (°C), (**B**) salinity (psu) and (**C**) chlorophyll *a* (mg·m$^{-3}$) along 77ºE in the EIO during September 2010.

The vertical structure of chlorophyll *a* was characterised by the presence of two subsurface chlorophyll maxima (SCM) located at the equator and 3°N respectively between 40 to 80 m (Fig.2C). Another region of high chlorophyll *a* (0.40 mg·m$^{-3}$) was seen in the north in the upper 30 m, which was disconnected from the SCMs.

The surface current clearly showed the presence of two organised flows, the southward flowing West Indian Coastal Current (WICC) and the eastward flowing Southwest Monsoon current (SMC). Note that south of Peninsular India and Sri Lanka, the WICC joins the SMC and the general direction of the current, in the vicinity of the station E1is eastward (Fig.3)

Sixty eight species of phytoplankton were identified from the EIO region; the most frequently observed phytoplankton species were *Coscinodiscus* sp., *Thalassiosira* sp., *Navicula* sp., *Gonyaulax* sp. and *Protoperidinium* sp. At station E1 the phytoplankton such as *Cerataulina* sp., *Dactyliosolen* sp., *Leptocylindrus* sp., *Rhizosolenia* sp., *Lioloma* sp., *Gonyaulax* sp., *Guinardia* sp. and *Protoperidinium* sp. were the most abundant forms (Supplementary Table 1).

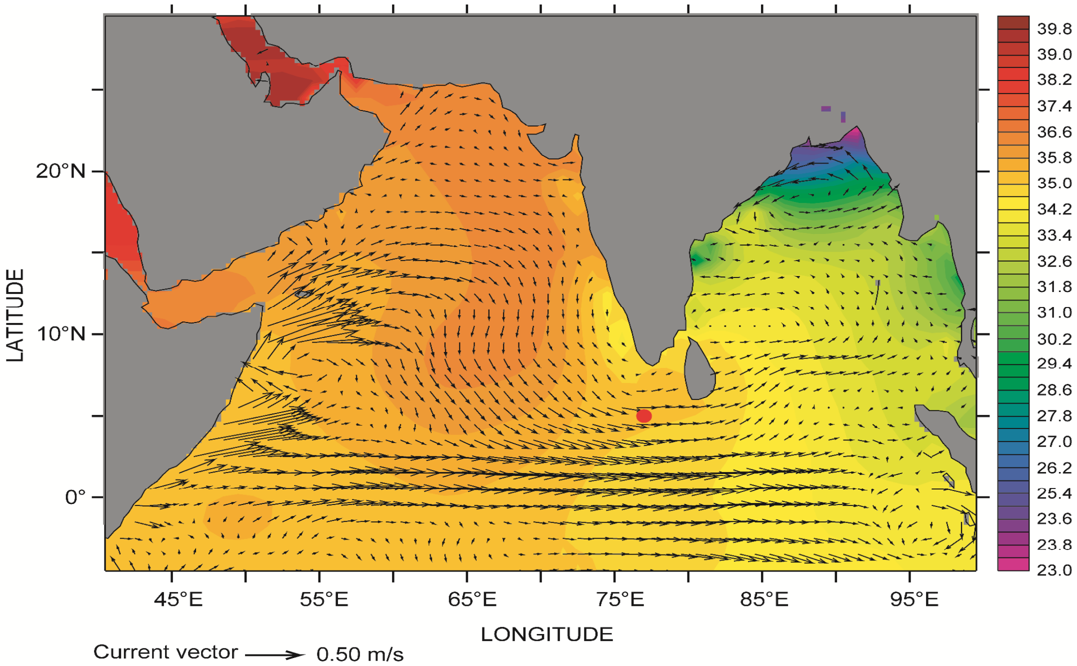


**Fig. 3.** Mean monthly salinity (psu) from World Ocean Atlas (WOA-09) superimposed with OSCAR currents. The filled red circle indicates the location of the station E1.

Fifty one copepod species were identified from the 8 stations namely, E1 to E8 in the EIO (Supplementary Table 2). The copepod such as *Acrocalanus* sp., *Paracalanus* sp., *Clausocalanus* sp., *Oithona plumifera* Baird 1843*, Oithona* sp., *Oncaea* sp., *Corycaeus* sp. and *Farranula* sp. were dominant in all the stations. *Pseudodiaptomus serricaudatus* was one of the most abundant species at station E1 with a density of 113 ind·m$^{-3}$, which contributed to 6.7% of the total copepod population. Out of the total population of *P.serricaudatus*: females contributed to 47%, males to 37% and juvenile copepodite to 16%. The body length of female and male, excluding setae on caudal rami, was 1.1-11.37 mm (mean ± S.D. = 1.22±0.08 mm, n=10) and 0.92-1.14 mm (mean ± S.D. = 1±0.07 mm, n=10) respectively. The species *P.serricaudatus* did not show any external morphological variation (Fig. 4) when compared to the original description of the species given by Scott 1894.

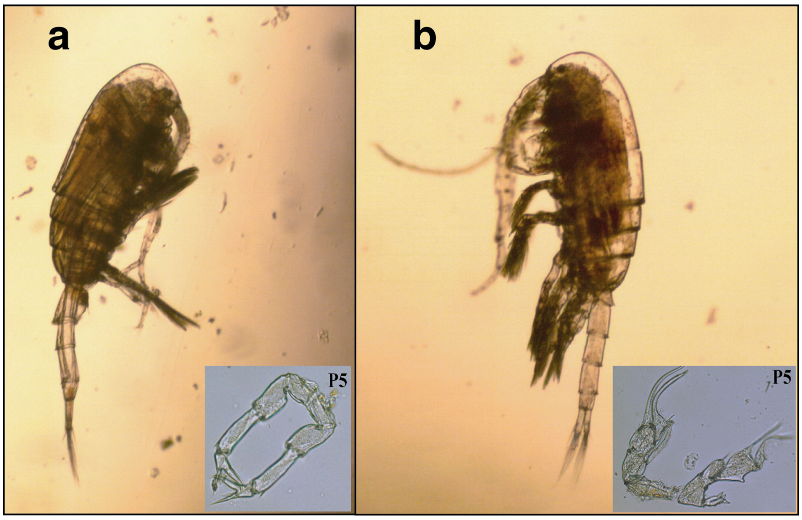


**Fig. 4.** *Pseudodiaptomus serricaudatus*: Female (**a**), Male (**b**).

## Discussion

To the best of our knowledge, this is the first record of the calanoid copepod *P. serricaudatus* in the open oceanic waters. The possibilities for the present observation are: (1) it was always present among the zooplankton population but remained unnoticed, or (2) it could have been advected to the EIO by the oceanic currents. Between the two, we discount the first possibility as we encountered the species *P. serricaudatus* only in one station (E1). Based on the surface currents during the period of observation, we infer that the southward moving WICC is capable of transporting coastal and near-shore waters from the southern parts of the west coast of India, further south. When the WICC meets SMC in the region south of Peninsular India and Sri Lanka, the waters from the WICC are moved further eastward along with SMC. The presence of less warmer and comparatively low salinity waters at E1 inferred from the data collected during the cruise also lend support to the suggestion of advection of waters from the coastal regions of the west coast of India, which is also low in salinity.

We, therefore, argue that the species *P. serricaudatus* which have their origin along the coastal waters of the west coast of India were advected to the open waters by the WICC-SMC currents prevalent during this time of the year. It is worthwhile to mention here, that an examination of previous data from the same location during 19$^{th}$ January to 8$^{th}$ February 2010 did not show the presence of this species (unpublished EIO data). This further supports our hypothesis of advection, since during January-February the westward flowing SMC is replaced by eastward flowing North Equatorial Current (NEC), while along the west coast of India the direction of flow of WICC changes from south to north.

One of the most important questions is whether this species will be able to survive in these waters or not? For this, an understanding of the physical factors such as temperature, salinity, turbidity, current and food availability, which determines the spatial distribution of zooplankton is needed (Breitburg et al. 1997; Epifanio and Garvine 2001; Kimmel et al. 2006). The temperature in the upper 150 m at station E1 varied from 15 to 28 ˚C, which is congenial for the species to thrive, as it is reported in the waters of Mhlathuze Estuary with a temperature range of 15 to 30 °C (Jerling 2008). The species being a euryhaline organism, can survive in the EIO waters where the salinity ranged from 34.8 to 36 psu. Since the phytoplankton abundance was low and diversity was quite different at EIO compared to that of the Cochin backwaters (Madhu et al. 2010), this can be an impediment for its survival and proliferation. The current finding encourages continuous monitoring of this species in the open oceanic waters and further understanding regarding its ecological adaptation.

## Acknowledgements

We wish to acknowledge Director, CSIR-National Institute of Oceanography (CSIR-NIO), Goa and Council of Scientific and Industrial Research (CSIR), New Delhi for all the support and encouragement. Special thanks to T. C. Walter for confirming our identification of *P. serricaudatus* and Dr. P. Haridas for his valuable advice. We acknowledge the help from Shweta, Genevieve and Byju for data collection and analysis. EIOPS was funded by the Ministry of Earth Science (MoES), New Delhi.

## References

Achuthankutty, C.T., N. Ramaiah, and G. Padmavati. 1998. Zooplankton variability and copepod assemblage in coastal and estuarine waters of Goa along the central west coast of India. Proceedings of the 2nd International Conference of Pelagic 2:1-11.

Bharathi Devi, N.S. and R. Ramanibai. 2012. Distribution and abundance of zooplankton in Muttukadu backwater, Chennai. Journal of Reseach in Biology 1 :035-041.

Binet, D., M. Gaborit, and M. Roux. 1972. Copépodes pélagiques du plateau ivoirien. Utilisation de I'analyse des correspondances dans l'étude des variations saisonnières. Documents Scientifiques, Centre de Recherches Océanographiques, Abidjan 3:47-79.

Breitburg, D.L., T. Loher, C.A. Pacey, and A. Gerstein. 1997. Varying effects of low dissolved oxygen on trophic interactions in an estuarine food web. Ecological Monographs 67:489-507.

Chakraborty, S.K., S. Giri, G. Chakravarty, and N. Bhattacharya. 2009. Impact of Eco-restoration on the Biodiversity of Sundarbans Mangrove Ecosystem, India. Water, Air, & Soil Pollution: Focus 9:303-320.

Dahms, H.U., L.C. Tseng, S.H. Hsiao, Q.C. Chen, B.R. Kim, and J.S. Hwang. 2012. Biodiversity of planktonic copepods in the Lanyang River (Northeastern Taiwan), a Typical Watershed of Oceania. Zooogical Studies 51:160-174.

Debenay, J.P., J. Pages, and P.S. Diouf. 1989. Ecological zonation of the hyperhaline estuary of the Casamance River (Senegal): Foraminifera, zooplankton and abiotic variables. Hydrobiologia 174:161-176.

Dessier, A. 1979. Ecologie dynamique des peuplements zooplanctoniques cotiers, et plus particulièrement des copépodes, du sud du Golfe de Guinée (côtes du Congo, du Gabon et de l'Angola). I. Texte: 1-274; II. Illustrations. Thèse Doc. Etat ès-Siences Naturelles, Univ. P. & M. Curie (Paris 6).

Epifanio, C.E., and R.W. Garvine. 2001. Larval transport on the Atlantic continental shelf of North America: a Review. Estuarine, Coastal and Shelf Science 52:51-77.

Etilè, N.R., M.K. Aka, M.N. Aka, M. Pagano, N. Valentin, and N.J. Kouassi. 2009. Spatio-temporal variations of the zooplankton abundance and composition in a West African tropical coastal lagoon (Grand-Lahou, Coˆte d'Ivoire). Hydrobiologia 624:171-189.

Ganapati, P.N., and K. Shanthakumari. 1961. The systematics and distribution of planktonic copepods in the Lawson´s Bay, Waltair. Journal of the Marine Biological Association of India 3:6-18.

Godhantaraman, N. 1994. Species composition and abundance of tintinnids and copepods in the Pichavaram mangroves (South India). Ciencias Marinas 20:371-391.

Grindley, J.R. 1977. The zooplankton of Langebaan Lagoon and Saldanha Bay. Transactions of the Royal Society of South Africa 42:341-370.

Grindley, J.R. 1984. The zoogeography of the Pseudodiaptomidae. Crustaceana. Supplement 7:217-228.

Jerling, H.L. 2008. The zooplankton community of Richards Bay Harbour and adjacent Mhlathuze Estuary, South Africa. African Journal of Marine Science 30:55-62.

Jerling, H.L., L. Vivier, and D.P. Cyrus. 2010. Response of the mesozooplankton community of the St Lucia estuary, South Africa, to a mouth-opening event during an extended drought. Estuarine, Coastal and Shelf Science 86:543-552.

Kimmel, D.G., M.R. Roman and X. Zhang. 2006. Spatial and temporal variability in factors affecting mesozooplankton dynamics in Chesapeake Bay: Evidence from biomass size spectra. Limnology and Oceanography 51:131-141.

Madhu, N.V., K.K. Balachandran, G.D. Martin, R. Jyothibabu, S.D. Thottathil, M. Nair, T. Joseph, and K.K. Kusum. 2010. Short-term variability of water quality and its implications on phytoplankton production in a tropical estuary (Cochin backwaters—India). Environmental Monitoring and Assessment 170:287-300.

Madhupratap, M., S.R.S. Nair, P. Haridas, and G. Padmavati. 1990. Response of zooplankton to physical changes in the environment: coastal upwelling along the central west coast of India. Journal of Coastal Research 6:413-426.

Mori, T. 1942. Systematic studies of the plankton organisms occurring in Iwayama Bay, Palao. IV. Copepoda from the bay and adjacent waters. Palao Tropical Biological Station Studies 2:549-580.

Pillai, P.P. 1976. A review of the calanoid copepod family Pseudodiaptomidae with remarks on the taxonomy and distribution of the species from the Indian Ocean. Journal of the Marine Biological Association of India 18:242-265.

Pillai, P.P., S.Z. Qasim, and A.K. Nair. 1973. Copepod component of zooplankton in a tropical estuary. Indian Journal of Marine Science 2:38-46.

Ramaiah, N. and V.R. Nair. 1997. Distribution and abundance of copepods in the pollution gradient zones of Bombay Harbour-Thana Creek-Bassein Creek, west coast of India. Indian Journal Marine Science 26:20-25.

Saraswathy, M. 1967. Pelagic copepods from the inshore waters off Trivandrum coast. Proceedings of the Symposium on Crustacea (India) 1:74-106.

Scott, T. 1894. Additions to the fauna of the Firth of Forth. Part VI. Annual Report of the Fishery Board for Scotland, Edinburgh 12(3):231-271, pls. 5-10.

Scott, A. 1902. On some Red Sea and Indian Ocean copepoda. Proceedings and Transactions of the Liverpool Biological Society 16:397-428.

Sewell, R.B.S. 1914. Notes on the surface Copepoda of the Gulf of Mannar. Spolia Zeylandica 9:191-262.

Sewell, R.B.S. 1924. Fauna of the Chilka Lake: Crustacea copepods. Memoirs of the Indian Museum 5:771-851.

Shanthi, M., and R. Ramanibai. 2011. Studies on copepods from Chennai coast (Cooum and Adyar), Bay of Bengal - During the Cruise. Current Research Journal of Biological Science 3:132-136.

Thompson, I.C., and A. Scott. 1903. Report on the copepoda collected by Professor Herdman, at Ceylon, in 1902. Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar, Supplementary Report **7**:227-307.

Tiwari, L.R., and V.R. Nair. 2002. Plankton biodiversity of Dharamtar creek adjoining Mumbai harbor. Proceedings of the National Seminar on Creeks, Estuaries and Mangroves - Pollution and Conservation. pp. 96-102.

Verheye, H.M., L. Hutchings, J.A. Huggett, R.A. Carter, W.T. Peterson, and S.J. Painting. 1994. Community structure, distribution and trophic ecology of zooplankton on the Agulhas Bank with special reference to copepods. South African Journal of Science 90:154-165.

Walter, T.C. 1986. The zoogeography of the genus *Pseudodiaptomus* (Calanoida: Pseudodiaptomidae). Syllogeus 58:502–508.

*Received: 29/01/2014; Accepted: 24/06/2014 (MS14-11)*

**Supplementary Table 1.** List of phytoplankton recorded for the Eight Stations. +++ abundant, ++ moderately abundant , + sparse and – absent.

| **Phytoplankton species** | **Stations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **E1** | **E2** | **E3** | **E4** | **E5** | **E6** | **E7** | **E8** |
| **DIATOMS** | | | | | | | | |
| *Bacteriastrum hyalinum* (Lauder 1864) | - | - | - | - | + | - | - | - |
| *Biddulphia* sp. | + | - | - | - | - | - | - | - |
| *Cerataulina* sp. | +++ | - | - | - | - | - | - | - |
| *Chaetoceros affinis* (Lauder 1864) | - | - | - | - | - | - | + | - |
| *C. simplex* (Ostenfeld 1901) | - | - | + | - | - | - | - | - |
| *Chaetoceros* sp . | - | - | ++ | - | - | - | - | - |
| *Climacodium frauenfeldianum* (Grunow 1868) | - | - | - | - | - | - | - | +++ |
| *Corethron* sp. | ++ | - | + | - | - | - | - | - |
| *Coscinodiscus* sp. | - | ++ | - | + | +++ | ++ | - | - |
| *Dactyliosolen* sp. | +++ | +++ | - | - | - | - | - | - |
| *Diploneis* sp. | + | - | - | - | - | - | - | - |
| *Fragilariopsis kerguelensis* (Hustedt 1952 ) | - | - | - | - | ++ | - | - | - |
| *Haslea wawrikae* (Simonsen 1974) | - | - | + | - | - | - | - | - |
| *Haslea* sp. | - | +++ | - | - | - | + | - | + |
| *Lauderia annulata* (Cleve 1873) | - | - | + | - | - | - | - | - |
| *Leptocylindrus minimus* (Gran 1915 ) | ++ | - | - | - | - | + | - | - |
| *Leptocylindrus* sp. | +++ | - | - | - | - | - | - | - |
| *Lioloma* sp. | +++ | ++ | - | - | - | - | - | + |
| *Meuniera membranacea* (P.C.Silva 1996) | - | - | ++ | + | - | - | - | - |
| *Navicula distans* (Ralfs 1861) | - | - | - | - | - | + | - | - |
| *N. septentrionalis* (Gran 1905) | - | - | ++ | - | - | - | - | - |
| *Navicula* sp. | ++ | +++ | +++ | ++ | - | ++ | - | +++ |
| *Neodenticula seminae* (F.Akiba & Y.Yanagisawa 1986 ) | - | - | + | - | - | - | - | - |
| *Neodenticula* sp. | - | + | - | - | - | - | - | - |
| *Nitzschia* sp. | + | + | + | - | - | - | - | - |
| *Planktoniella sol* (Schütt 1892 ) | - | - | + | - | - | + | - | - |
| *Pseudo-nitzschia* sp. | + | ++ | ++ | + | + | - | - | - |
| *Rhizosolenia* sp. | +++ | +++ | ++ | + | - | - | - | - |
| *Skeletonema* sp. | ++ | - | - | - | - | - | - | - |
| *Synedra parva* (Kützing ) | - | - | + | - | - | - | - | - |
| *Synedra* sp. | + | - | - | - | - | + | + | + |
| *Thalasionema* sp. | - | ++ | + | - | - | - | - | - |
| *Thalassiosira* sp. | + | ++ | ++ | - | + | ++ | + | +++ |
| **DINOFLAGELLATES** | | | | | | | | |
| *Alexandrium* sp. | ++ | + | - | - | - | - | - | - |
| *Amphidoma* sp. | + | + | - | - | + | - | - | - |
| *Amylax* sp. | + | - | - | - | - | - | - | - |
| *Ceratium* sp. | - | + | - | - | - | - | - | - |
| *Dinophysis caudata* (Saville-Kent1881) | - | - | + | - | - | - | - | - |
| *D. parvula* (Balech 1967 ) | - | - | - | - | - | + | - | - |
| *Dinophysis* sp. | + | - | + | - | - | - | - | + |
| *Diplopsalis* sp. | - | - | - | - | - | - | + | - |
| *Gonyaulax brevisulcata* (P.Dangeard 1927) | - | + | - | - | - | - | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Gonyaulax* sp. | +++ | +++ | ++ | - | - | + | - | - |
| *Gymnodinium* sp. | + | - | - | - | - | - | - | - |
| *Gyrodinium* sp. | ++ | ++ | - | - | - | - | - | - |
| *Heterodinium* sp. | + | - | - | - | - | - | - | - |
| *Ornithocercus* sp. | ++ | + | - | - | - | - | - | - |
| *Oxytoxum crassum* (Schiller 1937) | - | - | - | - | - | - | - | + |
| *O. globosum* (Schiller) | - | - | - | - | - | - | + | - |
| *Oxytoxum lativelatum* (F.J.R. Taylor 1976) | - | - | - | - | - | + | - | - |
| *O.variabile* (Schiller 1937) | - | - | + | - | - | - | - | - |
| *O.viride* (Schiller 1937 ) | - | - | - | - | - | - | + | + |
| *Oxytoxum* sp. | + | - | - | - | - | - | - | ++ |
| *Palaeophalacroma verrucosum* (Schiller 1928 ) | - | - | - | - | - | - | - | + |
| *Palaeophalacroma* sp. | ++ | + | - | - | - | - | - | - |
| *Pronoctiluca* sp. | + | + | - | - | + | - | - | + |
| *Prorocentrum compressum* (Abé ex Dodge 1975 ) | - | - | - | - | - | + | - | - |
| *P.gracile* (Schütt, 1895) | ++ | - | - | - | - | - | - | - |
| *P.minimum* (J.Schiller, 1933) | - | - | - | - | - | - | + | - |
| *Prorocentrum* sp. | - | - | - | - | - | + | - | + |
| *Protoperidinium latistriatum* (Balech, 1974) | - | - | - | + | - | - | - | - |
| *P. subpyriforme* (Balech 1974) | - | - | + | - | - | - | - | - |
| *P.trochoideum* (Lemmermann 1910) | - | - | + | + | - | - | - | - |
| *Protoperidinium* sp. | +++ | ++ | + | - | - | - | - | + |
| *Pyrocystis Noctiluca* (Murray ex Haeckel 1890) | - | - | - | - | - | - | + | - |
| *Pyrocystis* sp. | - | - | + | - | - | - | - | + |
| *Scripsiella* sp. | - | - | - | - | + | - | - | ++ |

**Supplementary Table 2.** List of copepods recorded for the Eight Stations. +++ abundant (>100 ind·m$^{-3}$), ++ moderately abundant (11-100 ind·m$^{-3}$), + sparse (1-10 ind·m$^{-3}$) and – absent.

| **Copepod Species** | **Stations** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **E1** | **E2** | **E3** | **E4** | **E5** | **E6** | **E7** | **E8** |
| **CALANOIDA** | | | | | | | | |
| *Acartia danae* (Giesbrecht 1889) | + | - | - | - | - | - | - | - |
| *A. erythraea* (Giesbrecht 1889) | ++ | + | - | - | - | - | - | - |
| *A. negligens* (Dana 1849) | - | + | - | - | - | - | - | - |
| *Acartia* spp. | - | + | - | + | + | + | + | + |
| *Acrocalanus* sp. | +++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| *Calanopia* sp. | - | + | + | + | + | - | - | - |
| *Calocalanus* sp. | - | + | ++ | ++ | ++ | ++ | ++ | ++ |
| *Candacia bradyi* (Scott A. 1902) | + | + | - | - | - | - | - | - |
| *C. curta* (Dana 1849) | - | + | - | - | - | - | - | - |
| *C. discaudata* (Scott A. 1909 ) | - | - | - | - | - | - | + | - |
| *Candacia* spp. | - | - | + | - | + | - | - | + |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Canthocalanus pauper* (Giesbrecht 1888) | ++ | ++ | - | ++ | ++ | - | - | + |
| *Centropages furcatus* (Dana 1849) | - | + | + | + | + | + | - | - |
| *Clausocalanus* sp . | ++ | ++ | ++ | ++ | +++ | ++ | ++ | + |
| *Cosmocalanus caroli* (Giesbrecht, 1888) | - | + | - | - | + | + | - | - |
| *Eucalanus subcrassus* (Giesbrecht 1888 ) | ++ | + | - | - | - | - | - | - |
| *Eucalanus* sp. | - | ++ | ++ | - | ++ | + | + | + |
| *Euchaeta* sp. | - | + | ++ | + | ++ | ++ | ++ | + |
| *Gaetanus* spp. | - | - | - | - | - | - | - | + |
| *Haloptilus* spp. | - | + | - | - | - | - | - | - |
| *Heterorhabdus* spp. | - | - | + | - | + | - | - | - |
| *Lucicutia flavicornis* (Claus 1863) | + | + | - | - | - | - | - | - |
| *Lucicutia* sp. | - | + | ++ | - | ++ | ++ | + | + |
| *Mecynocera* spp. | - | - | - | - | - | + | - | - |
| *Paracalanus* sp. | +++ | ++ | +++ | +++ | +++ | ++ | ++ | ++ |
| *Paracandacia* sp. | - | - | - | ++ | + | - | + | - |
| *Pleuromamma indica* (Wolfenden 1905 ) | - | + | - | - | - | - | - | - |
| *P. xiphias* (Giesbrecht 1889) | - | + | - | - | - | - | - | - |
| *Pleuromamma* spp. | - | + | - | + | ++ | - | - | - |
| *Pontellina plumata* (Dana 1849) | - | - | - | + | - | - | - | + |
| *Pseudodiaptomus serricaudatus* (Scott T. 1894) | +++ | - | - | - | - | - | - | - |
| *Rhincalanus cornutus* (Dana 1849) | - | - | + | - | ++ | + | + | + |
| *Scolecithrix* sp. | + | - | - | + | + | + | - | + |
| *Temora discaudata* (Giesbrecht 1889) | + | + | + | + | + | ++ | - | - |
| *T. turbinata* (Dana 1849) | ++ | + | - | - | - | - | - | - |
| *Undeuchaeta intermedia* (Scott A. 1909) | - | + | - | - | - | - | + | - |
| *U. major* (Giesbrecht 1888 ) | - | + | - | - | - | - | + | - |
| *U. plumosa* (Lubbock 1856) | - | - | - | - | - | - | + | - |
| **CYCLOPOIDA** | | | - | | - | - | - | |
| *Oithona plumifera* (Baird 1843) | ++ | + | + | ++ | ++ | ++ | ++ | ++ |
| *Oithona* sp. | +++ | ++ | +++ | +++ | +++ | +++ | ++ | ++ |
| **HARPACTICOIDA** | | | | | | | | |
| *Clytemnestra scutellata* (Dana 1847) | - | - | - | + | - | - | - | - |
| *Harpacticoid* spp. | - | + | - | + | - | - | + | - |
| *Microsetella* spp. | + | ++ | + | - | - | - | - | - |
| **POECILOSTOMATOIDA** | | | | | | | | |
| *Copilia hendorffi* (Dahl F. 1894) | - | - | - | - | + | - | - | + |
| *C. mirabilis* (Dana 1852 ) | + | - | - | - | + | - | - | - |
| *Copilia* spp. | + | - | - | - | - | + | - | + |
| *Corycaeus speciosus* (Dana 1849 ) | - | - | + | + | + | - | + | - |
| *Corycaeus* sp. | +++ | ++ | +++ | +++ | +++ | ++ | ++ | ++ |
| *Farranula* sp. | ++ | ++ | ++ | ++ | +++ | ++ | ++ | ++ |
| *Oncaea* sp. | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ |
| *Sapphirina* spp. | + | - | + | - | + | + | + | - |
| **Total mesozooplankton density (ind·m$^{-3}$)** | 2668 | 1262 | 1660 | 2005 | 2540 | 1674 | 834 | 796 |