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# Diversity of planktonic Ostracods (Crustacea: Ostracoda) in the mixed layer of northeastern Arabian Sea during the summer monsoon

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**Abstract:** Planktonic ostracods contribute significantly to the biomass of zooplankton in the Arabian Sea with an unusually high density due to swarming. However, due to the small size, their abundance is often underestimated. In this paper, the diversity of planktonic ostracods in the mixed layer depth of the northeastern Arabian Sea in relation to environmental parameters during the summer monsoon is presented. The mean abundance in the mixed layer depth was very high. About 26 species belonging to 17 genera representing two families were recognized. Out of this, 25 species belonged to (3 sub families, 16 genera) the order Myodocopa and one to the order Myodocopida. The dominant species were *Cypridina dentata*, *Euconchoecia aculeata, Conchoecia subarcuata* and *Orthoconchoecia atlantica. Cypridina dentata* and *Euconchoecia aculeata* contributed to about 89% of the total abundance. The results suggest that the distribution and diversity of ostracods were very much influenced by the hydrographic conditions of the Arabian Sea during the summer monsoon.

**Keywords:** Arabian Sea, Halocyprida, mixed layer depth, Myodocopa, Myodocopida, Ostracoda, summer monsoon.



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## INTRODUCTION

Among the zooplankters, ostracods are numerically the second most abundant taxonomic group after copepods. They are often numerically less in zooplankton samples, particularly in subthermocline waters of all oceans, but in the Indian Ocean they are also important in the wind-mixed layer above the thermocline (George 1968). Planktonic ostracods are deep dwelling diel migrators and detritus feeders. They belong to the subclass Myodocopa, and most of these belong to the order Halocyprida, which lack obvious eyes. They occur almost everywhere from the surface to the depths. This group has not received much attention in ecological studies, in spite of their relatively high abundance throughout the water column and the important role they play in recycling material in pelagic ecosystems (Angel 1999). The Arabian Sea (AS) is one of the most productive ecosystems in the world ocean and is unique due to the seasonally reversing monsoon and the persistent upwelling during the summer monsoon (Qasim 1982; Kumar et al. 2001). The zooplankton studies in the Arabian Sea have been well documented (Panikkar 1968; Krishnakumari & Achuthankutty 1989; Madhupratap et al. 1990, 1992, 2001; Padmavathy et al. 1998). The information on the Indian Ocean planktonic ostracods is mainly confined to Müller's (1906) work on Valdivia material and Poulsen's work on Dana material, which had covered only a few stations, mainly from off of Sumatra and in the Central and Western Indian Ocean. Only a few earlier reports have addressed the distribution and species composition of ostracods in the Indian waters. Recently, more publications on planktonic ostracods from the northern Indian Ocean (George 1968, 1975; James 1972, 1973; George & Nair 1980; Mathew 1980; Nair & Madhupratap 1984) have come out. However, planktonic ostracods have received scanty attention from an ecological point of view (Angel 1999). Most of the ecological studies have been done in the Chilean waters (Martens 1979), Atlantic (Angel et al. 2007) and in the Humbolt current off Peru (Castillo et al. 2007). In the Arabian Sea, a recent study has been conducted on halocyprids by Drapun & Smith (2012). In the northeastern Arabian Sea, no detailed ecological studies have been undertaken on marine planktonic ostracods till now. The aim of this work was to give a comprehensive account on the diversity of planktonic ostracods in the mixed layer depth of the northeastern Arabian Sea during the summer monsoon.

## MATERIALS & METHODS

The sampling was done onboard FORV Sagar Sampada Cruise 237 in the northeastern Arabian Sea during the summer monsoon (August 2005) under the umbrella project "Marine Research - Living Resources (MR-LR)" funded by the Ministry of Earth Sciences (MoES), Govt. of India. Sampling was carried out at one degree intervals along seven latitudinal transects viz.: $8^0$N, $10^0$N, $13^0$N, $15^0$N, $17^0$N, $19^0$N and $21^0$N (Fig. 1). Zooplankton samples were collected using HYDROBIOS Multiple Plankton Net ($0.25m^2$ mouth area and mesh size 200µm) from different strata and the samples collected from the mixed layer (top of thermocline to surface) at all stations were analyzed for this study. The mixed layer depth (MLD) was determined as the depth up to which a decrease of $0.5^0$C temperature occurred from the surface seawater temperature

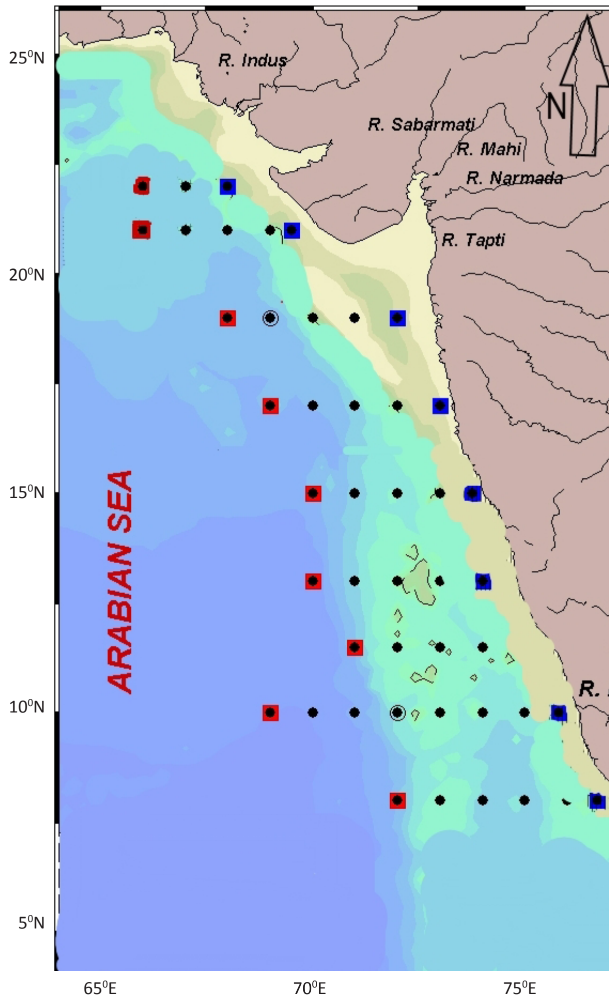


**Figure. 1 Station locations in the Arabian Sea indicating the oceanic stations (Red square) and coastal stations (Blue square).**

(SST). The collected samples were preserved in 4–5 % formaldehyde. Halocypridostracods were picked from the total sample, identified and counted. Species identification was according to Muller (1890), Angel (1969a,b, 1999), Poulsen (1969, 1973), and Martens (1979). Abundances were computed to numbers of individuals per m$^3$ of water filtered.

A SBE Seabird 911 plus Conductivity Temperature Depth profiler (CTD) was used to record profiles of temperature (accuracy ± 0.001$^0$C) and salinity (conductivity ± 0.0001 S/m). Surface meteorological parameters (SST and wind) were collected continuously along the ship's track using a ship borne automated weather station. Water samples were collected using a Rosette sampler connected to the CTD from the pre-determined depths (surface, 10, 20, 30, 50 m). These samples were used for analyzing both physico-chemical (salinity, dissolved oxygen, nutrients) and biological parameters (chlorophyll a and primary productivity). Dissolved Oxygen was analysed by Winkler's method (Carpenter 1965) and the nutrients were analyzed with a Segmented Flow Auto-analyzer SKALAR (Model 51001-1). The chlorophyll a analysis was undertaken on the basis of the work of Strickland & Parsons (1972) and primary production was by the $^{14}$C - technique (Nielsen 1952).

## RESULTS & DISCUSSION

During the summer monsoon, winds were predominantly southwesterly with occasional north westerlies near the southern coast (8–15 $^0$N). Strong winds (~12m/s) prevailed off the northern and southern transects, while relatively weak winds (<5m/s) were experienced along the southern coastal stations and southern most transect. The most significant feature of the AS during the summer monsoon was the observed cooling (<26.5$^0$C) effect along the southwestern coast of India and northern AS (Fig. 2a). Sea Surface Temperature (SST) along the southern coastal stations was almost 2.7$^0$C lower than that in the open ocean. Intense cooling was noticed along the coastal station of 10$^0$N (~26.1$^0$C), which was about 3.4$^0$C cooler than the open ocean waters. Northern stations also showed cooling, but the cooling was lower compared to the southern coastal stations. Maximum SST was observed at 15$^0$N transect which extended to oceanic stations of 10$^0$N and 13$^0$N. The sea surface salinity (SSS) of coastal waters varied from 34.5 (southern) to 36.8 (northern) (Fig. 2b) and the oceanic regions did not exhibit any variation. Subsurface salinity near the coast along 8$^0$N and 10$^0$N was about 0.6 higher than the oceanic station, indicative of the coastal upwelling, where the cool highly

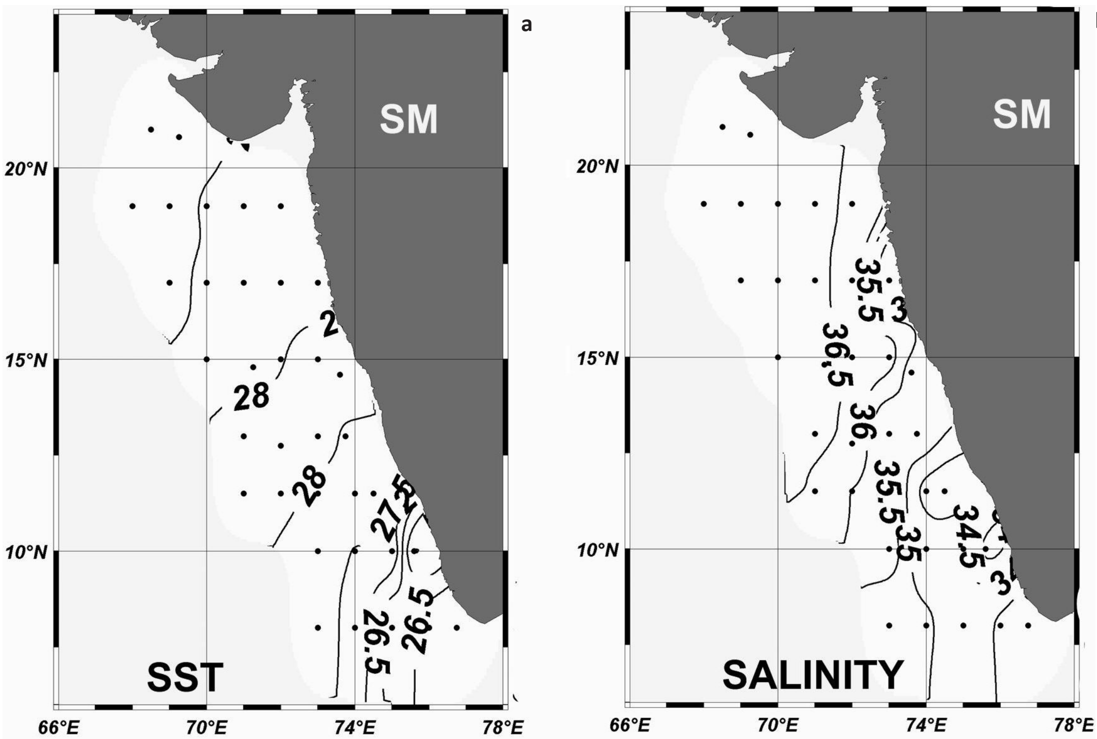


Figure 2. Spatial distribution of (a) surface temperature ($^0$C) and (b) surface salinity in Arabian Sea during the summer monsoon.

**Table 1. Values of environmental and biological parameters such as dissolved oxygen, nutrients and chlorophyll a along the oceanic and coastal stations.**

| Latitude (⁰N) | Oceanic/ Coastal | Dissolved Oxygen (ml/l) | Nitrate (µM) | Phosphate (µM) | Silicate (µM) | Surface Primary Production (mg/ m³/d) | Surface Chlorophyll a (mg m⁻³) | Column Chlorophyll a (mgm⁻²) |
|---|---|---|---|---|---|---|---|---|
| 8⁰N | Oceanic | 195.38 | 0.01 | 0.3 | 2.35 | 2.14 | 0.21 | 16.08 |
| | Coastal | 190.82 | 2.15 | 0.49 | 3.46 | 38.57 | 1.20 | 55.75 |
| 10⁰N | Oceanic | 193.22 | 0.01 | 0.1 | 2.5 | 15.54 | 0.46 | 28.65 |
| | Coastal | 111.64 | 9.24 | 1.11 | 7.41 | 121.98 | 1.98 | 46.09 |
| 13⁰N | Oceanic | 205.84 | 0.01 | 0.37 | 2 | 4.61 | 0.24 | 14.29 |
| | Coastal | 209.16 | 0.02 | 0.88 | 3.74 | 6.04 | 0.21 | 16.28 |
| 15⁰N | Oceanic | 192.1 | 0.05 | 0.5 | 2.44 | 0.92 | 0.18 | 28.13 |
| | Coastal | 203.27 | 1.57 | 0.89 | 3.11 | 17.09 | 0.68 | 18.58 |
| 17⁰N | Oceanic | 167.16 | 2.51 | 1.01 | 3.9 | 9.28 | 0.32 | 32.74 |
| | Coastal | 202.27 | 0.05 | 0.62 | 7.89 | 8.05 | 0.24 | 20.07 |
| 19⁰N | Oceanic | 179.28 | 2.95 | 0.83 | 3.27 | 1.31 | 0.19 | 21.84 |
| | Coastal | 212.48 | 0.04 | 0.6 | 3.43 | 1.42 | 0.23 | 11.53 |
| 21⁰N | Oceanic | 170.07 | 0.01 | 0.95 | 2.25 | 1.93 | 0.12 | 19.22 |
| | Coastal | 198.29 | 0.23 | 1.11 | 2.99 | 1.96 | 0.21 | 20.74 |

saline waters replaced the warm, waters that were low in salinity. During summer monsoon, temperature - salinity relations in the AS showed low saline and low temperature water overlapping with low temperature and highly saline waters in the upper layers. A detailed analysis revealed that low temperature and highly saline waters were confined to the oceanic regions and low temperature and waters with low salinity to the coastal regions (Fig.2b). The dissolved oxygen (DO) remained the same (~200µM) in the oceanic stations compared to the coastal stations (Table 1). A slight decrease in the DO was noticed at the southeastern coast (190µM) and the oceanic region along 17°N (180 µM). Nutrients ($NO_3$, $PO_4$ and $SiO_4$) were present in surplus (> 0.2µM, > 0.4µM, > 1.5µM, respectively) especially in the surface layers, where nitracline varied from 10µM to 80µM. The surface chlorophyll a was in the range 0.12–1.98 mg $m^{-3}$ (av. 0.50mg $m^{-3}$) in the oceanic stations (Table 1). The corresponding column values varied from 11.53 to 55.75mg $m^{-2}$ (av. 26.74mg $m^{-2}$). The average surface chlorophyll a in the north coastal station was 0.34mg $m^{-3}$ and the column chlorophyll a was 17.73mg $m^{-2}$. The offshore value of average surface chlorophyll a was 0.21mg $m^{-3}$and the corresponding column value was 25.48mg $m^{-2}$. The maximum surface primary production was recorded in the inshore station off 10⁰ latitude (122 mg C $m^{-3}d^{-1}$), which was experiencing strong upwelling. The MLD varied greatly and ranged between 19 and 50 m. MLD was minimum along 8⁰N and 10⁰N (28.4±6 m) and maximum along 15⁰N (32.5±5.2 m).

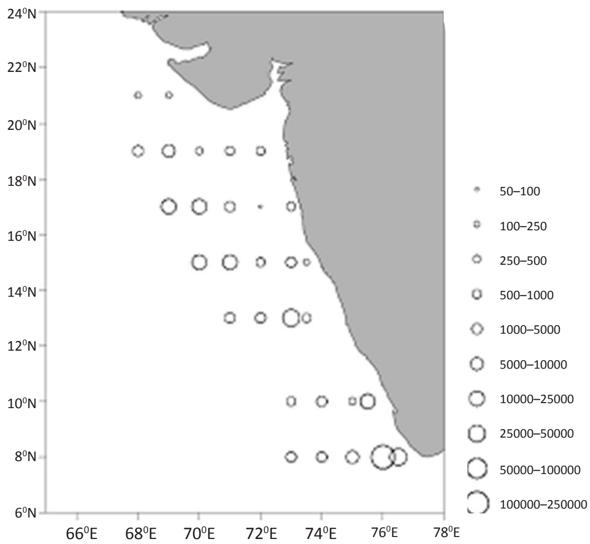


**Figure 3. Spatial distribution of planktonic ostracod abundance in the mixed layer of the Arabian Sea during the Summer monsoon**

The mean abundance of ostracods in the AS during the summer monsoon was very high. About 26 species belonging to 17 genera of two families were recognized during this period. Out of this, 25 species belonged to the order Myodocopa (3 sub families, 16 genera) and one species belonged to the order Myodocopida (1 family, 1 genus). During this season, the ostracods in the MLD were dominated by *Cypridina dentate* (64%), *Euconchoecia aculeata* (25%), *Conchoecia subarcuata*

**Table 2. Mean abundance of ostracod species (ind.m³) in the mixed layer depth (MLD) of Arabian Sea during the summer monsoon**

| Mean abundance (ind.m³) of Species | Mixed layer depth (MLD) |
|---|---|
| Subclass : Ostracoda<br>Order: Myodocopa<br>Suborder: Halocypridina | |
| Family: Halocyprididae<br>Subfamily: Conchoecinae | |
| *Alacia alata* (Muller,1894) | 25.06 |
| *Conchocetta acuminata* (Claus,1890) | 47.77 |
| *Conchocetta giesbrechtii* (Muller, 1906) | 27.15 |
| Subfamily: Conchoecinae | |
| *Conchoecia magna* (Claus,1874) | 5.8 |
| *Conchoecia subarcuata* (Claus,1890) | 694.24 |
| *Conchoecilla daphnoides* (Claus,1874) | 0.31 |
| *Conchoecissa imbricata* (Brady,1880) | 0.28 |
| *Conchoecissa symmetrica* (Muller,1906) | 0.29 |
| *Discoconchoecia discophora* (Muller,1906) | 2.12 |
| *Metaconchoecia krytophora* (Lubbock,1860) | 27.85 |
| *Metaconchoecia rotundata* (Muller,1890) | 13.25 |
| *Mikroconchoecia curta* (Lubbock,1860) | 4.42 |
| *Orthoconchoecia atlantica* (Lubbock,1856) | 200.49 |
| *Orthoconchoecia bispinosa* (Claus,1890) | 8.99 |
| *Orthoconchoecia haddoni* (Brady &Norman,1896) | 18.43 |
| *Orthoconchoecia striola* (Muller,1906) | 0.85 |
| *Paraconchoecia oblonga* (Claus,1890) | 0.68 |
| *Paraconchoecia spinifera* (Claus,1891) | 4.11 |
| *Platyconchoecia prosadene* (Muller,1906) | 0.53 |
| *Proceroecia procera* (Muller,1894) | 13.89 |
| Subfamily: Euconchoecinae | |
| *Euconchoecia aculeata* (Scottt,1894) | 2451 |
| *Euchonchoecia chierchiae* (Muller,1890) | 21.07 |
| Subfamily: Halocypridinae | |
| *Felia bicornis* ( Muller,1906) | 0.15 |
| *Halocypria globosa* (Claus,1874) | 0.18 |
| *Halocypris brevirostris* (Dana,1849) | 0.57 |
| Order Myodocopida<br>Family: Cypridinidae | |
| *Cypridina dentata* (Muller,1906) | 7090 |
| Mean abundance of all species | 10727 |

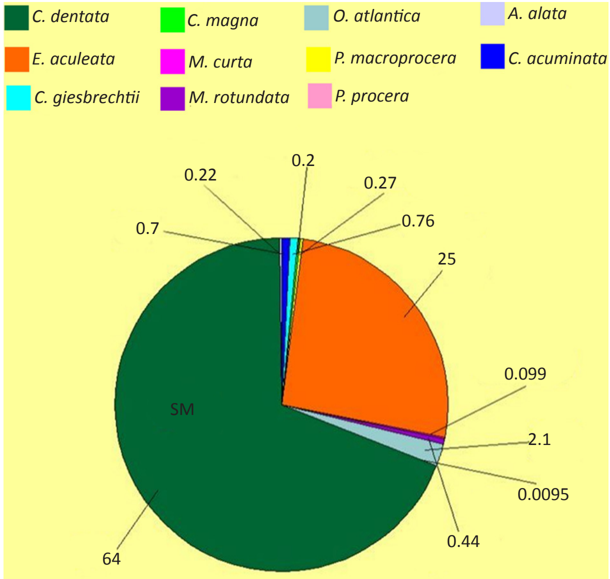


**Figure 4. Percentage composition of planktonic ostracod species in the mixed layer of the Arabian Sea during the Summer monsoon**

and *Orthoconchoecia atlantica* (Fig. 4; Table 2) and the first two species together contributed to about 89% of the total abundance. The mean abundance of ostracods was 10660±1780 ind.m$^{-3}$ (Fig.3). The other species encountered were *Alacia alata*, *Conchoecetta giesbrechtii, Metaconchoecia krytophora, Proceroecia procera* and *Orthoconchoecia haddoni* (Fig. 4 & Table 2). During this season, the abundance of the ostracods were high in the oceanic stations off 15–10 $^0$N (Fig. 3).

Earlier studies have shown that the north and northeastern AS is 4–10 times richer in zooplankton biomass compared to the entire Indian Ocean (Paulinose & Aravindhakshan 1977). An increase in biomass during night at some of the northern stations was mostly attributable to the higher density of ostracods (Krishnakumari & Achuthankutty 1989). Among the zooplankton, copepods generally dominate numerically, but in the northern latitudes large swarms of ostracods replace the dominance of copepods. These swarms are generally confined to the mixed layer or sometimes up to the bottom of the thermocline, the latter mostly during the day time (Madupratap et al. 1996). Ostracods contributed significantly to the biomass of zooplankton in the AS with an unusually high density due to swarming. However, due to the small size, their abundance is often underestimated. In the AS, studies on planktonic ostracods received very little attention. George et al. (1975), George (1979), James (1972, 1973), George & Nair (1980), Mathew (1980) have published papers on planktonic ostracods in the northern Indian Ocean, but no detailed attempt has been made to understand the seasonal difference of this community and their relation to the hydrographical and productivity variations. In warmer oceans, ostracods reach peak numbers in the upper 500m, contributing to total biomass except for certain coastal tropical regions where they become very abundant. Their population generally decreases with depth.

George (1968) recorded 33 species of ostracods from the Indian Ocean belonging to 18 genera. *E. aculeata* was the most abundant species in the northern Indian Ocean. However, for the AS alone *C. dentata* was the most abundant species (George 1968). In this study 26 species were recorded. *C. dentata* has been reported mainly in the neritic waters (George 1968) of the AS and off the western coast of India. *C. dentata* often forms swarms in the AS and a high density of this species was also reported from the Laccadive Seas (George 1979). In this study, the distribution of this species showed coastal and open ocean variation in their abundance. Off the Maharashtra coast the species coexisted along with swarms of chaetognaths, *Sagitta enflata* (Nair 1978). Even though *C. dentata* could tolerate a salinity range of 35–36, they were not frequently recorded from the Bay of Bengal and equatorial regions of the Indian Ocean (George & Nair 1980). Most of the ostracods species enjoy a wide distribution and are cosmopolitan in Atlantic, Pacific and Indian Oceans. Many of the ostracod species like *E. aculeata, H. brevirostris, C. giesbrechti, M. rotundata, O. striola* and *S. porrecta* were better represented in the upper 200m water column (George 1968). *C. dentata* showed an accumulation above the thermocline and this is in agreement with the observation made by Madhupratap et al. (1996). Ostracods are distributed from the epipelagic to the abysso-pelagic depths and play an important role, primarily as detritivores (Angel 1983), but can be herbivores and carnivores as well (Hopkins 1985; Hopkins & Torres 1988; Vannieret al. 1998). Results suggest that some of the planktonic ostracods in the AS, mostly in the oceanic waters could be predominantly detritivores, whereas the species like *C. dentata*, *E. aculeata*, and those flourishing at the surface may be herbivores. This was supported by the high chlorophyll content and primary production in the surface layers during the period of study. *D. elegans, D. discophora, P. procera, P. decipiens, Conchoecetta acuminata, Orthoconchoecia bispinosa, P. parthenoda, Conchoecia magna* and *Conchoecilla daphnoides* were the other species also represented in low numbers in the AS. *P. spinirostris* is an epipelagic species that migrates in to the mesopelagic zone especially during spring while the other species *P. porrecta*, *C. magna, M. curta, M. echinulata, P. procera* and *D. elegans* are mesopelagic species that migrate in the epipelagic zone (Angel 1993). *M. rotundata* was also abundant in the mesopelagic zone irrespective of seasons, since it is a typical mesopelagic species (Angel 1993). *C. dentata* has shown some dependence with the Arabian Sea high saline water mass (ASHSW), and the species distribution clearly indicates its association corresponding with the spreading of ASHSW (Jasmine et al. 2007). During the summer monsoon, the abundance of *C. dentata* was high in the oceanic stations off 15–10 $^0$N. A detailed analysis revealed that low temperature and highhly saline water were confined to the southwestern coast of India and extended northward up to 17$^0$N during the summer monsoon. Also during this period, after the upwelling event there has been an increase in the herbivorous community followed by carnivorous organisms in the southern coastal AS (Madhupratap et al. 1996). This coincided almost with the total absence of *P. inermis* and *D. elegans*. Surface dwelling species of ostracods in the AS were highly dependent on the phytoplankton biomass and other hydrographic features predominant in the seasons. The present study suggests that the environmental factors, salinity and temperature and also the productivity patterns seem to be important factors affecting their distribution.

## REFERENCES


**Angel, M.V. (1983).** A review on the progress of research on halocyprid and other oceanic planktonic ostracods 1972–82, pp. 529–548. In: Maddocks, R.F. (eds.). *Applications of Ostracoda*. University of Houston Geoscience Department, Houston Texas.

**Angel, M.V. (1993).** Marine planktonic ostracods, pp. 1–239. In: Kermack, D.M., R.S.K. Barnes & J.H. Crothers (eds.). Synopsis of the British Fauna, 48, Linnean Society of London and The Estuarine and Coastal Sciences Association by the Field Studies Council: Shrewsbury, New Series.

**Angel, M.V. (1969a).** Planktonic ostracods from the Canary Island region; their depth distributions, diurnal migrations and community organisation. *Journal of Marine Biological Association U.K.*, 44: 515–553.

**Angel, M.V. (1969b).** The redescription of three halocypridostracods, *Conchoeciahyalophyllum* Claus, *C. magna* Claus and *C. parthenoda* Müller from the North Atlantic. *Crustaceana* 17: 45–63.

**Angel, M.V. (1999).** Ostracoda, pp. 815–868. In: *South Atlantic Zooplankton*. Boltovskoy, D. (eds.), Backhuys Publishers, Leiden.

**Angel, M.V., K. Blachowiak-Samolyk, I. Drapun & R. Castillo (2007).** Changes in the composition of planktonic ostracod populations across a range of latitudes in the Northeast Atlantic. *Progress in Oceanography* 73: 60–78; http://dx.doi.org/10.1016/j.pocean.2006.11.002

**Castillo, R., T. Antezana & P. Ayon (2007).**The influence of El Nino 1997-98 on pelagic ostracods in the Humbolt Current Ecosystem off Peru. *Hydrobiologia* 585: 29–41; http://dx.doi.org/10.1007/s10750-007-0626-5

**Carpenter, J.H. (1965)**. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. *Limnology & Oceanography* 10: 141–143.

**Drapun, I. & S.L. Smith (2012).** *Halocyprid Ostracods of The Arabian Sea Region*. SultanQaboos University, Academic Publication Press, 223pp.

**George, J. (1968).** A preliminary report on the distribution and abundance of planktonic ostracods in the Indian Ocean. *Bulletin of National Institute of Oceanography India* 38: 641–648.

**George, J. (1979).** Redescription of *Archiconchoecia striata* Muller

(Ostracoda, Halocyprididae) and its distribution in the Northern Indian Ocean. *Crustaceana* 36: 123–128.

**George, J. & V.R. Nair (1980).** Planktonic ostracods of the northern Indian Ocean. *Mahasagar - Bulletin of National Institute of Oceanography* 13: 29–44.

**George, J., K.S. Purushan & M. Madhupratap (1975).** Distribution of planktonic ostracods along the south west coast of India. *Indian Journal of Marine Science* 4: 210–202.

**Hopkins, T.L. (1985).** Food web of an Antarctic midwater ecosystem. *Marine Biology* 89: 197–212; http://dx.doi.org/10.1007/BF00392890

**Hopkins, T.L. & J.J. Torres (1988).** The zooplankton community in the vicinity of the ice edge, Western Weddell Sea, March 1986. *Polar Biology* 9: 79-87; http://dx.doi.org/10.1007/BF00442033

**James, M.C. (1973).** On *Bathyconchoecia lacunosa* (Muller) a rare halocyprid from the Arabian Sea. *Journal of Marine Biological Association India* 15: 433–438.

**James, M.C. (1972).** *Conchoecia indica*, a new ostracod from the south west coast of India. *Journal of Marine Biological Association India* 14: 819–826.

**Jasmine, P., K.R. Muraleedharan, T.V. Raveendran & C.T. Achuthankutty (2007).** Can swarming of the ostracod *Cypridina dentata* be an indicator of the Arabian Sea high saline water mass, pp. 36–39. In: Proceedings of the Symposium of the Arabian Sea International Conference on Science & Technology of Aquaculture, Fisheries and Oceanography, Kuwait.

**Krishnakumari, L.K. & C.T. Achuthankutty (1989)**. Standing stock and biochemical composition of zooplankton in the northeastern Arabian Sea. *Indian Journal of Marine Sciences* 18: 103–105

**Kumar, S.P., M. Madhupratap, M.D. Kumar, P.M. Muraleedharan, S.N. de Souza, M. Gauns & V.V.S.S. Sarma (2001).** High biological productivity in the central Arabian Sea during summer monsoon driven by Ekman pumping and lateral advection. *Current Science* 81: 1633–1638.

**Madhupratap, M., T.C. Gopalakrishnan, P. Haridas & K.K.C. Nair (2001).** Meso zooplankton biomass, composition and distribution in the Arabian Sea during the fall intermonsoon: implications of oxygen gradients. *Deep Sea Research* II 48: 1345–1368; http://dx.doi.org/ 10.1016/S0967-0645(00)00142-9

**Madhupratap, M., P. Haridas, N. Ramaiah & C.T. Achuthankutty (1992).** Zooplankton of the southwest coast of India: abundance, composition, temporal and spatial variability in 1987, pp. 99–112. In: Desai, B.N. (eds.). *Oceanography of the Indian Ocean*. New Delhi.

**Madhupratap, M., S.R.S. Nair, P. Haridas & G. Padmavati (1990).** Response of zooplankton to physical changes the environment: coastal upwelling along the central west coast of India. *Journal of Coastal Res*earch 6: 413–426.

**Madhupratap, M., T.C. Gopalakrishnan, P. Haridas, K.K.C. Nair, P.N. Aravindakshan, G. Padmavati & S. Paul (1996).** Lack of seasonal and geographic variation in mesozooplankton biomass in the Arabian Sea and its structure in the mixed layer. *Current Science* 71: 863–868.

**Martens, J.M. (1979).** Die pelagischen Ostracoden der Marchile I - Expedition (Südost Pazifik), 1: Verbreitung, Zoogeographie und Bedeutung als Indikatoren für Wasserkörper. (Crust. Ostracoda: Myodocopida). *Studies on Neotropical Fauna and Environment* 16: 57–97.

**Mathew, K.J. (1980).** Studies on quantitative abundance of euphausiacea (Crustacea) with special reference to distribution in space and time along the southwest coast of India. *Journal of Marine Biological Association of India* 22: 123–148.

**Muller, G.W. (1890).** UeberHalocypriden. *ZoologischeJahrbücher: AbteilungfürSystematik, Geographie und Biologie der Tiere* 5: 253–280.

**Muller, G.W. (1906).** Ostracoda. *Wissenschaftliche ergebnisse der Deutschen Tiefsee-Expedition 1898–1899.* 8: 29–154.

**Nair, V.R. (1978).** Coincident occurrence of *Sagitta enflata* (Chaetognatha) & *Cypridina dentata* (Crustacea: Ostracoda: Cypridinidae) off Maharashtra Coast. *Indian Journal of Marine Science* 7(4): 304–306.

**Nair, V.R. & M. Madhupratap (1984).** Latitudinal range of epiplanktonic Chaetognatha and Ostracoda in the western tropical Indian Ocean. *Hydrobiologia* 112: 209–216.

**Nielsen, E.S. (1952).** The use of radioactive carbon ($^{14}C$) for measuring organic production in the sea. *Journal du Conseil*., 18: 117–140.

**Padmavathi, G., P. Haridas, K.K.C. Nair, T.C. Gopalakrishnan, S. Paul & M. Madhupratap (1998).**Vertical distribution of zooplankton in the central and eastern Arabian Sea during the winter monsoon. *Journal of Plankton Research* 20(2): 343–354; http://dx.doi.org/10.1093/plankt/20.2.343

**Panikkar, N.K. (1968).** Maps on total zooplankton biomass in the Arabian Sea and Bay of Bengal, pp. 16–19. In: *Plankton Atlas.* International Indian Ocean Expedition (eds.). New Delhi.

**Poulsen, E.M. (1969).** Ostracoda-Myodocopa from the eastern tropical Atlantic. *Videnskabelige Meddelelserfra Dansk Naturhistorisk Forening* 132: 129–197.

**Poulsen, E.M. (1973).** Ostracoda-Myodocopa. 3b. Halocypriformes-Halocypridae. Conchoecinae. *Dana Report*, No. 84, 223pp.

**Paulinose, V.T. & P.N. Aravindakshan (1977).** Zooplankton biomass abundance and distribution in the north and northwestern Indian Ocean*,* pp. 132–136. In: *Proceedings of the Symposium of Warm Water Zooplankton*, NIO, Goa, India.

**Qasim, S.Z. (1982)**. Oceanography of the northern Arabian Sea. *Deep Sea Research* 29: 1041–1068; http://dx.doi.org/10.1016/0198-0149(82)90027-9

**Strickland, J.D.H. & T.R. Parsons (1972)**. A practical handbook of sea water analysis. *Bulletin of Fisheries (Research Board, Canada)* 167: 310pp.

**Vannier, J., K. Abe & K. Ikuta (1998).** Feeding in mydocopidostracods: functional morphology and laboratory observations from videos. *Marine Biology* 132: 391–408; http://dx.doi.org/10.1007/s002270050406