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Copepod population in Vellar estuary, Parangipettai coast in relation to environmental conditions

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Abstract

Distribution and abundance of copepods were studied in relation to environmental conditions at two different ecosystems viz: Neritic (Bay of Bengal) and estuarine (Vellar estuary) of Parangipettai coast from September, 1998 to August, 2000. Over the study period, total 85 species of copepods were reported. Among these, the calanoid copepods constituted the major component with 63.52% followed by cyclopoids (29.41%) and harpacticoids (7.05%). The copepods population density was found to be high (2, 53, 000 org l^{-1}) in estuarine water, while the species diversity was higher (5.47) in neritic water. The observed spatio-temporal variations in the population density and species diversity of copepods were more related to the environmental state of respective study area.

Key words

Bay of Bengal, Vellar estuary, Nutrients, Copepods, Diversity

Introduction

Physico-chemical parameters are responsible for the spatio-temporal variations of all aquatic organisms. The investigations on meteorological and hydrographical features are necessary for assessing the fertility and productivity of any ecosystems (Rajasekar, 2003). A number of researchers have studied the physical and chemical characteristics of some Indian estuaries (Anilkumar and Dineshkumar, 2002; Thillai Rajasekar *et al*., 2005; Perumal *et al*., 2008).

Several papers have been published based on the study in Vellar estuary with reference to physico-chemical characters (Santhanam and Perumal, 2003; Rajasekar, 2003; Perumal *et al*., 2008). Moreover, an estuary is a unique geographic area known for its high seasonally oscillating productive zone of copepods (Perumal *et al*., 2008). The distribution and abundance of copepods are mainly influenced by the hydrographical conditions specific to the locality (Santhanam and Perumal, 2003). Investigation on the species composition, population density and diversity of the copepods is necessary to ecosystem health and wealth assessment (Paffenhofer, 1993). The present study was made to obtain the present status of composition, density and diversity of copepods in Vellar estuary and adjacent sea (Bay of Bengal) in relation to the prevailing hydrographical conditions. This information would be helpful in the ecological monitoring of this ecosystem.

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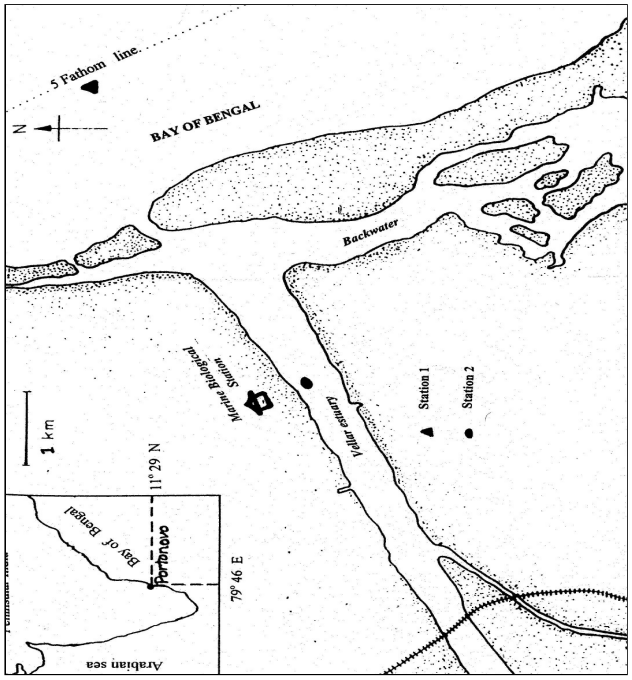

Fig. 1: Map showing the neritic (Station 1) and estuarine (Station 2) waters of Parangipettai coast (11° 29' N; 79° 46 E)

Materials and Methods

The Vellar estuary is a highly dynamic one on the east coast of India and it has variable environment with considerable tidal influence. It has year round connection with Bay of Bengal and undergoes rhythmic fluctuations in marine and estuarine biotic community. Four channels viz., freshwaters from Vellar river and Buckingham channel, brackishwater from Killai backwater and neritic water from Bay of Bengal are discharging into the estuary and the tidal influence can be felt up to 10km from the mouth. The surface water samples were collected from the study areas at monthly intervals (11°29' N latitude; 79° 46' E longitude) for a period of two years from September 1998 to August 2000. Station 1 (Bay of Bengal) is situated 3 km away from the mouth of the Vellar estuary and station 2 (Vellar estuary) located just opposite to the Centre of Advanced Study in Marine Biology, and is about 1.5 km from the mouth of the estuary (Fig.1). The water samples were collected in polyethylene bottles in an icebox and transported to the laboratory for nutrient analysis. Water samples were filtered using a millipore filtering system and analysed for dissolved inorganic nitrate, nitrite, phosphate and reactive silicate adopting the standard procedures described by Strickland and Parsons (1972). Rainfall data were obtained from the meteorological unit of Government of India, located at Parangipettai. Atmospheric and surface water temperature was measured using a standard centigrade thermometer. Salinity was estimated with the help of a refractometer (ERMA, Hand Refractometer, Japan). The pH was measured using an ELICO grip pH meter and dissolved oxygen was estimated by the modified Winkler's method (Strickland and Parsons, 1972).

Copepod samples were collected at monthly intervals from September 1998 to August 2000 by horizontal towing of a plankton net (0.35 mouth diameter), made up of bolting silk cloth (No 10: mesh size 158 µm) for 20 min. The collected samples were

Table- 1: Seasonal variations in physico-chemical parameters of neritic (Station-1) and estuarine waters (Station-2) of Parangipettai coast from September 1998 to August 2000

Season	Rain-fall (mm)	Atmospheric temperature (°C)		Surface water temperature (°C)		Salinity (ppt)		pH		DO (ml^{-1})		Nitrate (µM)		Nitrite (µM)		Phosphate (µM)		Silicate (µM)	
Y-1		**St.1**	**St.2**	**St.1**	**St.2**	**St.1**	**St.2**	**St.1**	**St.2**	**St.1**	**St.2**	**St.1**	**St.2**	**St.1**	**St.2**	**St.1**	**St.2**	**St.1**	**St.2**
M	355 ±183	29.8 ±2	29.83 ±1	27.6 ±2	29.5 ±2	29.5 ±1	22.6 ±7	7.6 ±0	7.6 ±0	6.13 ±1	7.03 ±1	27.4 ±5	33 ±5	4.5 ±0	5.53 ±1	1.26 ±0	1.7 ±0	69.9 ±32	75 ±35
PM	3.4 ±3	32.3 ±1	31.3 ±2	30.6 ±1	31 ±.8	33.16 ±2	29.6 ±2	8.46 ±0	8.26 ±0	3.66 ±0	3.9 ±0	20.06 ±15	22.7 ±18	2.93 ±2	3.63 ±2	0.83 ±0	1.16 ±0	15.9 ±7	15.1 ±8.1
S	16.1 ±17	30.5 ±1	30.5 ±1	29.5 ±1	30.5 ±1	34.83 ±0	33.3 ±2	8.16 ±0	8.46 ±0	3.60 ±0	3.93 ±0	6.96 ±2	9.26 ±3	1.13 ±0	2.03 ±0	0.80 ±0	1.2 ±0	9.70 ±2	11.8 ±2.3
PRM	34.3 ±10	29.8 ±1	30.86 ±0	29.16 ±1	29.93 ±1	34.5 ±1	32 ±1	7.33 ±0	7.8 ±0	4.0 ±0	5.46 ±0	5.1 ±0	5.6 ±0	1.70 ±0	2.2 ±0	1.13 ±0	1.36 ±0	17.5 ±3	21.3 ±2.7
Y-2																			
M	333.5 ±290	29.5 ±1	28.6 ±1	27.33 ±2	28.5 ±1	27.83 ±4	15 ±9	7.40 ±0	7.4 ±0	6.73 ±1	7.43 ±1	27.96 ±16	39.3 ±21	5.0 ±2	6.2 ±2	1.9 ±1	2.9 ±0	70.4 ±16	80.3 ±63
PM	101.1 ±130	30.8 ±1	30.83 ±1	30.5 ±1	30 ±1	33 ±2	25.83 ±7	8.03 ±0	8.2 ±0	4.9 ±0	5.23 ±2	19.33 ±8	29.3 ±14	2.8 ±1	3.46 ±1	1.50 ±0	2.56 ±0	19.1 ±11	23.5 ±14
S	40.4 ±9	29.6 ±1	30.33 ±1	29.5 ±1	28.6 ±0	33 ±1	30.0 ±1	7.46 ±0	8.4 ±0	3.4 ±0	3.93 ±0	9.03 ±6	9.46 ±5	1.70 ±0	2.23 ±0	1.23 ±0	2.2 ±0	13.9 ±1	15.3 ±1.6
PRM	36.1 ±25	31.8 ±1	31.5 ±1	31.1 ±0	29.9 ±0	33.9 ±2	30.6 ±1	8.13 ±1	8 ±1	3.66 ±0	4.26 ±0	9.66 ±0	11.5 ±10	1.66 ±0	2.53 ±1	1.40 ±0	2.4 ±1	19.7 ±8	23.1 ±10

Y-1: 1st year; Y-2: 2nd year; M: Monsoon; PM: Postmonsoon; S: Summer; PRM: Premonsoon

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preserved in 5% neutralized formalin and used for qualitative analysis. The identification of copepods was made by the key provided by Davis (1955), Kasturirangan (1963) and Perumal *et al*. (1998). For quantitative analysis, a known quantity of water (500 l) was filtered through a bag net with mesh size of 158 µm and the samples were preserved in 5% formalin, counting of plankton was carried out using a binocular microscope. Species diversity index (H') was calculated using Shannon and Weaner's (1949) formula. Species richness (SR) was calculated as described by Simpson index. Evenness index (J') was calculated using the formula of Pielou (1966). Simple correlation coefficient (r) was made for the statistical interpretation of the physico-chemical characteristics and one-way analysis (ANOVA) was employed for all the hydrographical and biological parameters between stations using SPSS statistical software (Version 16 for Windows, SPSS, Chicago, IL, USA).

Results and Discussion

The rainfall pattern mainly influenced the major changes that occurred in the abiotic and biotic components of neritic and estuarine habitats of Parangipettai coast. The recorded monthly rainfall ranged between 5 and 606 mm. No rainfall was recorded during the month of March. However, the maximum was recorded during October-December and minimum during summer and post-monsoon seasons (Table 1).

The recorded atmospheric temperature ranges of station 1 and 2 were 29.5-32.33 and 28.6-31.5 °C respectively. However, surface water temperature was 27.3-31.1 (St.1) and 28.5-31.0 °C (St. 2). The estuary is usually cooler than the sea during monsoon season and warmer in summer (Rajani Kumara and Mrutyunsaya, 2009). The low monsoonal water temperature was recorded because of strong land sea breeze whereas high during summer could be attributed to high solar radiation (Ajithkumar *et al.,* 2006). The observed salinity ranged between 23 and 35.5 ppt (St.1) and 15 and 34 ppt (St. 2). Salinity values revealed increasing trend during post monsoon and premonsoon seasons and attained a peak during summer and started declining during monsoon because of northeast monsoonal rainfall besides dilution by freshwater input (Anilkumar and Dineshkumar, 2002). The high post-monsoon and summer salinity can be attributed to evaporation as well high temperature (Asha and Diwakar, 2007). A wide range of pH was encountered ranging between 7.2 and 8.7 (St. 1) and 7.3 and 8.7 (St. 2). It was found always on the alkaline side (7.2-8.7) at Dhamra estuary, Orissa (Prasanna and Ranjan, 2010). However, low monsoonal pH due to the influence of organic matter decomposition in Arasalar estuary, Tamil Nadu was reported (Bragadeeswaran *et al.,* 2007). The maximum post monsoon and summer pH reported might be due to the influence of seawater penetration (Saravanakumar *et al.,* 2008). The range of dissolved oxygen was found between 3.0 and 7.8 ml^{-1} (St. 1) and 3.5 and 8.5 ml^{-1} (St. 2). High monsoonal DO can be attributed to the influx of freshwater (Renjith *et al.,* 2004). Dissolved oxygen concentration declined from monsoon to pre-monsoon and post-monsoon because of increased evaporation beside high temperature (Govindasamy *et al.,* 2000).

The recorded level of inorganic nutrients such as nitrate, nitrite, phosphate and reactive silicate were 4.7-45.7 (Stn.1), 5.3-63.5 (Stn. 2); 0.9-7.2 (Stn.1), 1.4-8.3 (Stn. 2); 0.6-2.6 (Stn. 1), 0.9-3.8 (Stn. 2) and 8.2-121.5 (Stn. 1) and 9.7-136.5 µM (Stn. 2), respectively (Table 1) In the present study, all the inorganic nutrients were found to be maximum during monsoon season which may be possibly due to high organic matter contribution from catchment areas and putrefaction of detritus (Senthilkumar *et al.,* 2002; Rajasekar, 2003; Perumal *et al.,* 2009; Damotharan *et al.,* 2010). However, the minimum nutrients content acquired during summer, pre and post monsoon seasons in stations 1 and 2 could be attributed to uptake by phytoplankton for their energy production and low freshwater discharges from catchment areas due to lack of rainfall (Angadi *et al.,* 2005; Thillai Rajasekar *et al.,* 2005; Soundarapandian, 2009). Among the nutrients studied, the silicate was always found to be very high in both the stations as compared to other nutrients. This can be ascribed to least consumption of silicate by phytoplankton than other nutrients (Santhanam and Perumal, 2003). In common, inorganic nutrients were found to be high in station 2 (estuary) than station 1 (neritic water), it is inferred that estuary receives more organic waste than inshore area (Pradhan *et al.,* 2009). Statistical findings indicated that the rainfall was positively significant with dissolved oxygen, nitrite and silicate (r-0.864, 0.857 and 0.979 at station 1 and 0.852, 0.872 and 0.980 at station 2) (Tables 2 and 3). Similarly, ANOVA trial showed the significant results (0.005) for salinity and phosphate, while other parameters were not significant (Table 4).

In total, 85 species of copepods belonging to 24 families representing 34 genera were recorded in the present investigation. Of these, 54 species belonged to calanoida, 6 to harpacticoida and 25 to cyclopoida. At station 1, 77 species of copepods were observed, which comprised of 53 species of calanoids, 18 cyclopoids and 6 harpacticoids. At station 2, 60 species of copepods comprising 30 calanoids, 24 cyclopoids and 5 harpacticoids were reported. In the present investigation, 51 species were found to be common at both the stations, constituting 29 species of calanoids, 5 harpacticoids and 17 cyclopoids.

Generally, calanoid copepods were found to be dominant (63.52%) followed by cyclopoids (29.41%) and harpacticoids (7.05%). Copepod population density varied from 13,000 to 1,59.000 org l^{-1} at station 1 and 7000 and 2,53,000 org l^{-1} at station 2 (Fig. 2). While the species diversity values ranged between 3.0 and 5.47 (Stn.1) and 2.52 and 5.08 (Stn. 2) (Fig. 3). The range of evenness values were 0.90-0.97 (Stn. 1) and 0.84-0.97 (Stn. 2) (Fig. 4). Likewise the richness values for stations 1 and 2 were 0.86-0.96 and 0.75-0.95, respectively (Fig. 5). Copepod species diversity was highly significant with population density ($P < 0.001$) and species richness with species diversity ($r = 0.938$) at station 1 (Table 4). In station 2, the species diversity was significant ($P < 0.01$) with population density ($r = 0.779$) and species richness ($r = 0.797$) (Table 5).

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Table- 2: Simple correlation coefficient (r) values for the physico-chemical parameters at neritic water of Parangipettai coast (Station 1)

	Rainfall (mm)	Atmospheric temperature (°C)	Surface water temperature (°C)	Salinity (ppt)	pH	DO (ml^{-1})	Nitrate (µM)	Nitrite (µM)	Phosphate (µM)	Silicate (µM)
Rainfall	1									
At.Temp	-0.60165*	1								
S.W.Temp	-0.8061****	0.696713***	1							
Salinity	-0.83257****	0.492566	0.600354*	1						
PH	-0.46878	0.687291***	0.48294	0.470069	1					
DO	0.864945****	-0.48891	-0.67943***	-0.88265***	-0.44562	1				
Nitrate	0.712982***	-0.29079	-0.37414	-0.89058***	-0.26523	0.769214***	1			
Nitrite	0.857093****	-0.36466	-0.59597*	-0.90047****	-0.37884	0.862464****	0.885325****	1		
Phosphate	0.657127**	-0.28943	-0.5032	-0.60432*	-0.3169	0.58603*	0.442713	0.634239**	1	
Silicate	0.979556****	-0.54889*	-0.80476***	-0.83938****	-0.47909	0.849471****	0.713521***	0.870864****	0.626188**	1

* P< 0.05; ** P< 0.02; *** P< 0.01; **** P< 0.001

Table- 3: Simple correlation coefficient (r) values for the physico-chemical parameters at estuarine water of Parangipettai coast (Station 2)

	Rainfall (mm)	Atmospheric temperature (°C)	Surface water temperature (°C)	Salinity (ppt)	pH	DO (ml^{-1})	Nitrate (µM)	Nitrite (µM)	Phosphate (µM)	Silicate (µM)
Rainfall	1									
At.Temp	-0.60739*	1								
S.W.Temp	-0.47784	0.684908***	1							
Salinity	-0.86314****	0.6228878*	0.573651*	1						
PH	-0.551*	0.48832	0.221298	0.579466*	1					
DO	0.852724****	-0.6198*	-0.4759	-0.84959****	-0.79339***	1				
Nitrate	0.719609***	-0.43088	-0.30559	-0.8407****	-0.5196*	0.686177***	1			
Nitrite	0.872114****	-0.40657	-0.31512	-0.89673****	-0.58885*	0.819305****	0.863126****	1		
Phosphate	0.219162	-0.16532	-0.487	-0.47126	-0.11669	0.300802	0.330824	0.256498	1	
Silicate	0.98085****	-0.58038*	-0.4352	-0.85692****	-0.60371*	0.8485****	0.680733***	0.879202****	0.173558	1

* P< 0.05; ** P< 0.02; *** P< 0.01; **** P< 0.001

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Table- 4 : Simple correlation co-efficient (r) values between the biological parameters of the copepods and physico-chemical parameters prevailed at neritic water (station 1) of Parangipettai coast

Parameters	Population density	Species diversity	Species richness	Species evenness
Rainfall (mm)	-0.48332	-0.73619***	-0.73177***	0.376208
Atmostheric temp. (°C)	-0.08333	0.184373	0.221835	-0.11894
Surface water temp. (°C)	0.325154	0.484667	0.509181	-0.39531
Salinity (ppt)	0.483028	0.714314***	0.720254***	-0.35458
pH	0.069872	0.29379	0.257413	-0.25516
Dissolved oxygen (ml^{-1})	-0.57315*	-0.75468***	-0.70338***	0.417649
Nitrate (μM)	-0.50761	0.67093***	-0.65793**	0.261209
Nitrite (μM)	-0.63223**	-0.76583***	-0.73554***	0.41687
Phosphate (μM)	-0.38978	-0.43889	-0.38149	0.50778
Silicate (μM)	-0.5175	-0.75631***	-0.747***	0.400147
Population density	1	0.823987****	0.658989**	-0.51296
Species diversity		1	0.938091****	-0.3117
Species richness			1	-0.0745
Species evenness				1

* P < 0.05; ** P < 0.02; ***P < 0.01; **** P < 0.001

Table- 5 : Simple correlation co-efficient (r) values between the biological parameters of the copepods and physico-chemical parameters prevailed at estuarine water (station 2) of Parangipettai coast

Parameters	Population density	Species diversity	Species richness	Species evenness
Rainfall (mm)	-0.51556	-0.70923***	-0.48361	0.577583*
Atmostheric temp. (°C)	0.239372	0.333926	0.259348	-0.42491
Surface water temp. (°C)	0.133989	0.385732	0.402685	-0.1685
Salinity (ppt)	0.603064**	0.719101***	0.453811	-0.66852***
pH	0.70741***	0.745639***	0.532186*	-0.49312
Dissolved oxygen (ml^{-1})	-0.69048***	-0.84416****	-0.65233**	0.572013*
Nitrate (μM)	-0.56866*	-0.57084*	-0.28799	0.719455***
Nitrite (μM)	-0.60895**	-0.69688***	-0.4306	0.634327**
Phosphate (μM)	-0.21639	-0.4645	-0.31198	0.027104
Silicate (μM)	-0.53589*	-0.72003***	-0.51143*	0.544858*
Population density	1	0.779602***	0.538574*	-0.49002
Species diversity		1	0.79759***	-0.35089
Species richness			1	0.082512
Species evenness				1

* P < 0.05; ** P < 0.02; ***P < 0.01; **** P < 0.001

In the present observation, copepods distribution can be divided into 3 distinct categories based on the period of existence in the Vellar estuary (Station 2). Copepods such as *Paracalanus parvus*, *Acrocalanus gracilis*, *A.gibber*, *Acartia spinicauda*, *A.danae*, *Labidocera pavo*, *L.pectinata*, *Oithona rigida* and *O.brevicornis* were classified under Category I due its occurrence throughout the year in considerable numbers. Species viz. *Eucalanus crassus*, *Pseudodiaptomus aurivilli*, *Centropages furcatus*, *Corycaeus danae*, *Microsetella rosea*, *Macrosetella gracilis*, *Euterpina acutifrons* and *Oncaea venusta* was classified in Category-II seeing as existed for short duration in the study areas. Category-III included low salinity tolerant species and high salinity tolerant species and casual migrants viz. *Rhincalanus cornutus*, *Temora turbinata*, *T.discaudata*, *Pontella danae*, *Metis jousseaumei*, *Corycaeus catus*, *Copilia vitrea* and *Sapphirina ovatolanceolata*. It is very obvious that the salinity is one of the most vital environmental parameter for the distribution and abundance of copepods in estuarine and inshore waters (Pipan and Branceli, 2004). Among the total copepods, the species such as *Paracalanus parvus, Acartia spinicauda* and *Oithona rigida* were found predominant round the year as its adaptation to unreliable environmental conditions prevailed in the study area further its continuous breeding habit and high reproductive competence (Rezai *et al.,* 2004).

Geetha Antony *et al.* (1997) reported copepods constituting 67.9 to 97% of the total zooplankton population in Andaman Seas.

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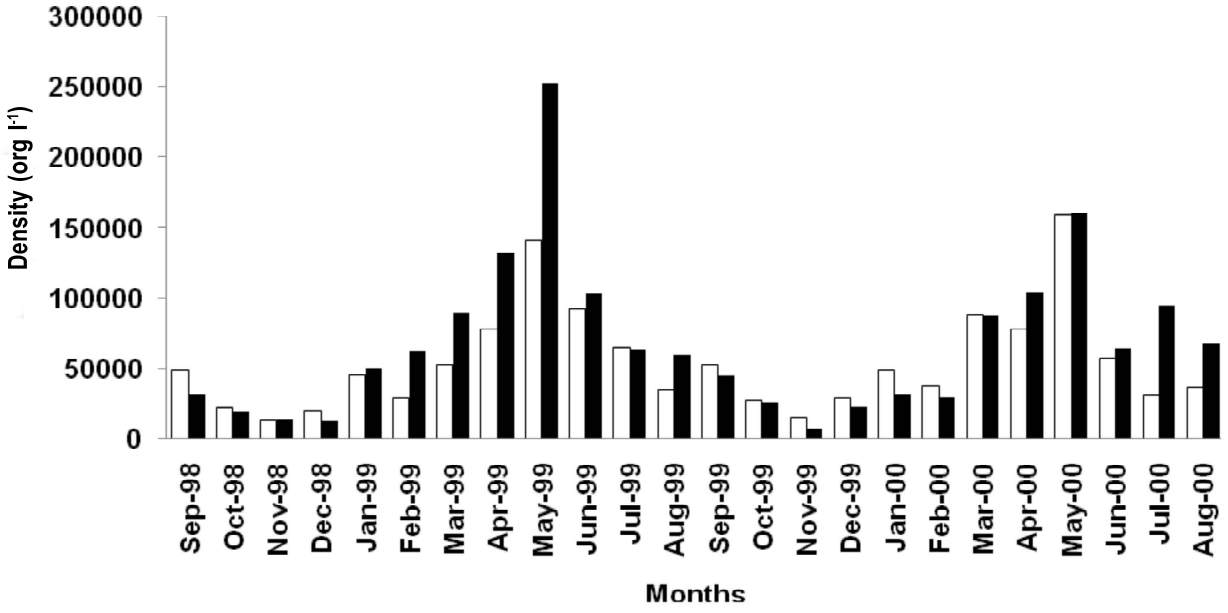

Fig. 2: Seasonal variations in copepods population density at neritic (Station 1) and estuarine (Station 2) waters of Parangipettai coast

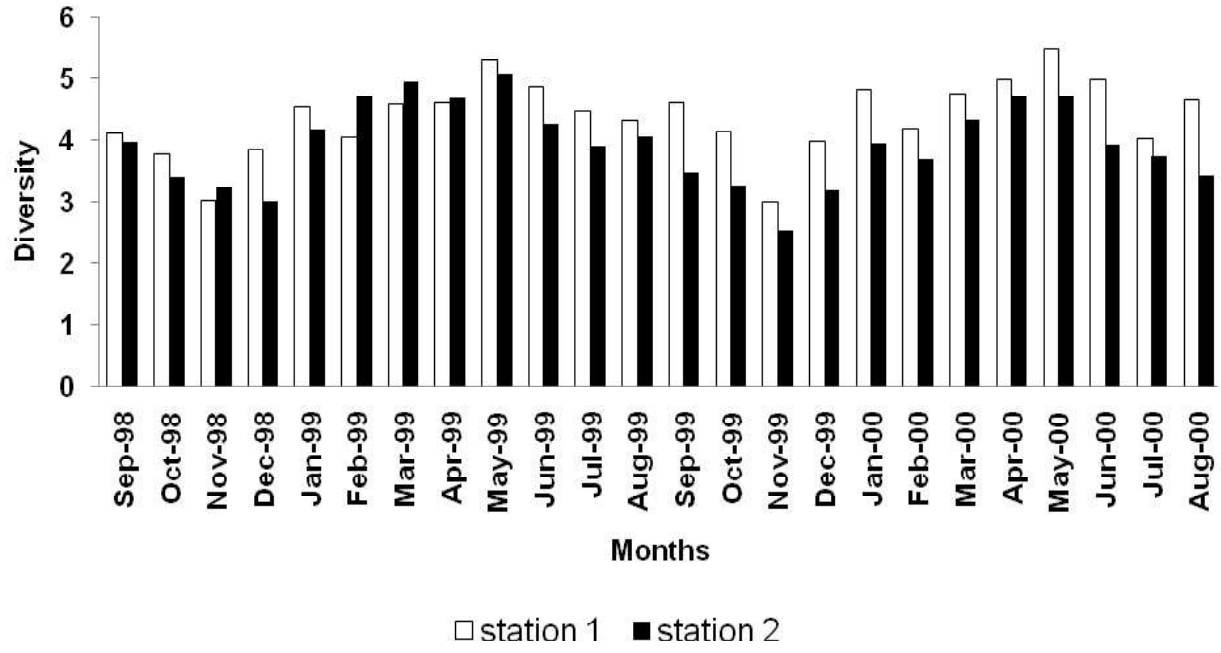

Fig. 3: Seasonal variations in copepods species diversity at neritic (Station 1) and estuarine (Station 2) waters of Parangipettai coast

Among these, the suborder, calanoida occupied a major component with more species (Santhanam and Perumal, 2003). The copepods observed in the present study showed a bimodal type of distribution in Vellar estuary. The primary peak was encountered during April and May (1999) and the secondary peak during June and July (2000). The similar type of copepods peak was also earlier reported by Santhanam and Perumal (2003) in the same study area.

The recorded low monsoonal copepod density was owing to low salinity (Nilssen and Waervagen, 2003) while the high density achieved in summer season might be due to favourable salinity as

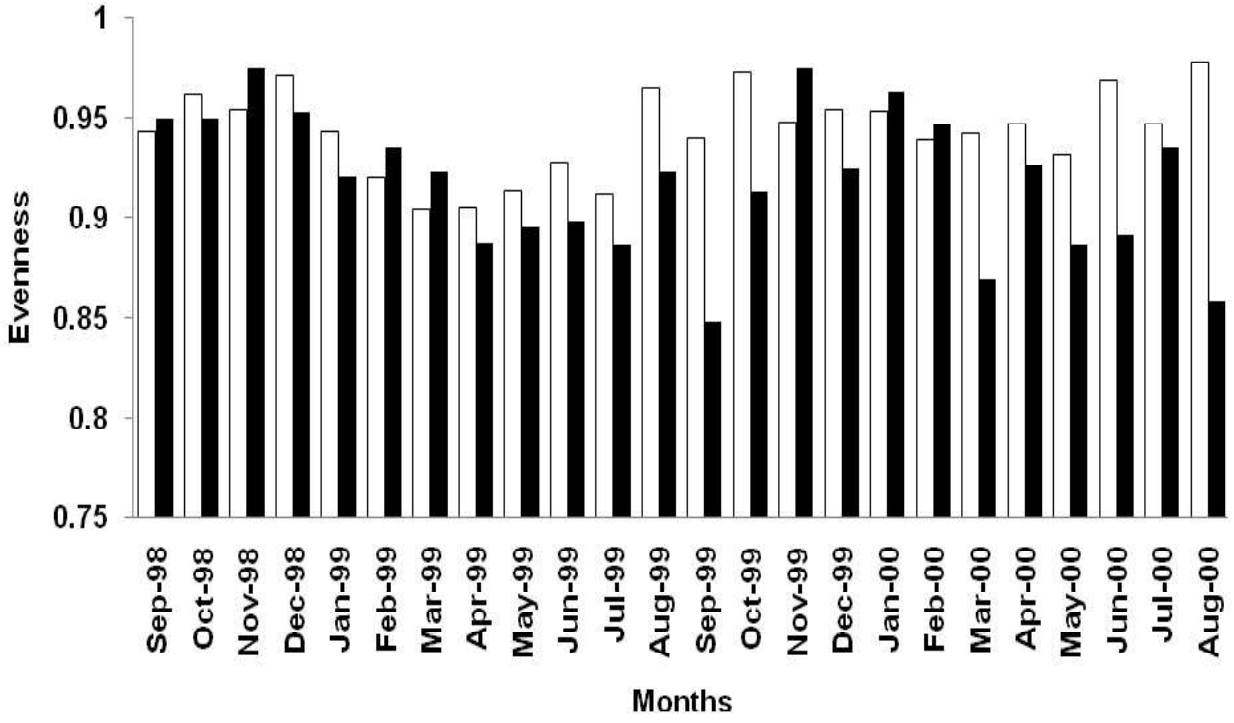

Fig. 4: Seasonal variations in copepod species evenness at neritic (Station 1) and estuarine (Station 2) waters of Parangipettai coast

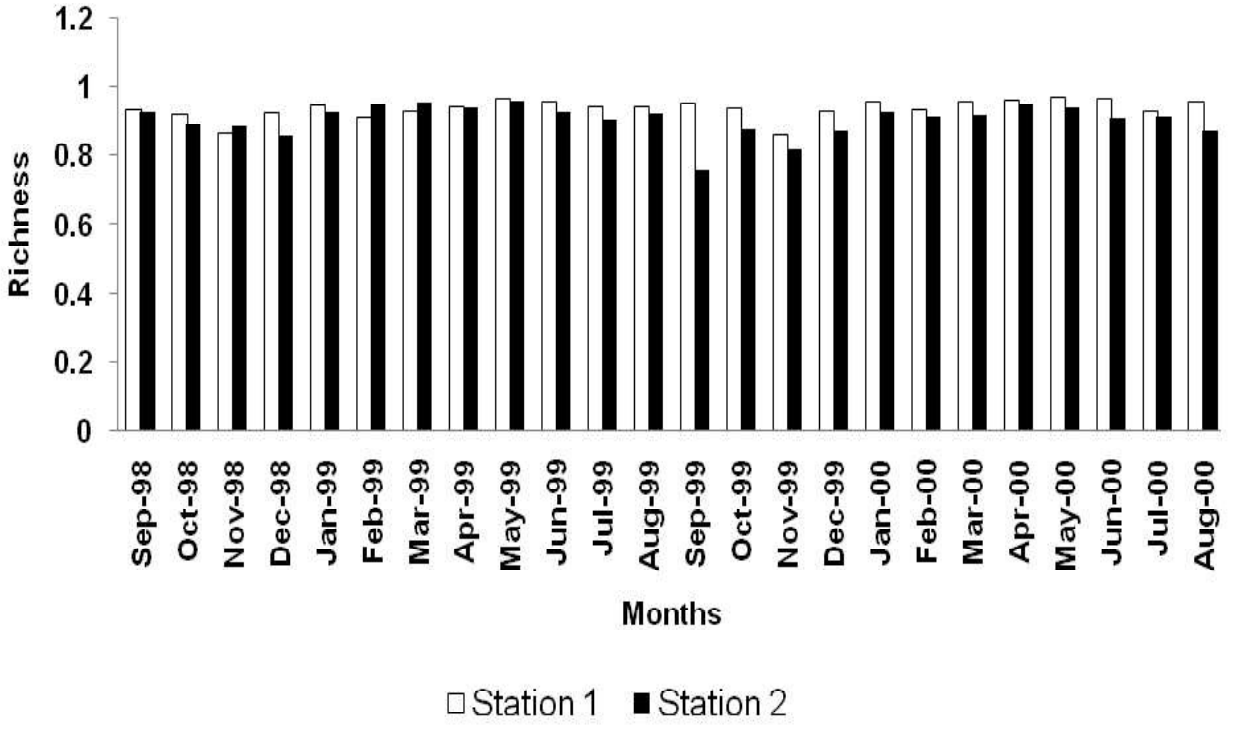

Fig. 5: Seasonal variations in copepod species richness at neritic (Station 1) and estuarine (Station 2) waters of Parangipettai coast

well other environmental conditions (Godhantaraman, 2001). The copepods population was comparatively well-off in station 2 than station 1 because the estuary receives more organic matter supporting rich copepods density (Santhanam and Perumal., 2003; Perumal *et al.,* 2008). Nevertheless, species diversity was more in station 1 than in 2 owing to the occurrence of more neritic species in the particular area (Kazmi, 2004). The observed low species diversity at estuary might be due to the constant changes owing to high freshwater supply from adjacent channels and agriculture lands which were making the estuary more dynamic leading to fluctuations in diversity values. It is implied that the seasonally oscillating environmental conditions thus intricate the Vellar estuary and adjacent neritic water to maintain its productivity. It is concluded that the Vellar estuary and adjacent neritic waters can be considered as one of the most productive habitat in south east India with rich diversity of copepods which can support for fish potential of this ecosystem.

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