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Water quality and proximate composition of zooplankton of Muthukkuda coast of Palk Bay, southeastern India

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Original Article

Abstract

Investigations on basic biochemical composition of mixed zooplankton with respect to seasons were estimated using standard methods in two sampling stations along the Muthukkuda coastal area from January 2012 to December 2012. Among the biochemical components, protein formed the major constituent which varied from 8.70 to 41.11% followed by lipids which were found to vary from 5.12-25% and carbohydrates were in the range of 3.49-11.35%. The recorded minimum and maximum values of atmospheric temperature, surface water temperature, salinity, pH and dissolved oxygen in sampling area were 26-36°C, 25-33°C, 26-33.5‰, 7.05-8.69 and 0.43-7.42 ml l^{-1} respectively. The recorded inorganic nutrients *viz*., nitrate, nitrite, phosphate and silicate of study area were in the range of 0.01-0.35, 0.06-1.2,0.04-1.12 and 1.19-28.86 μM respectively. The present study revealed the prevailing of seawater hydrography and biochemical composition of and mixed zooplankton from Muthukkuda coastal waters which exhibited significant seasonal variations.

Keywords*: Zooplankton, salinity, inorganic nutrient, biochemical composition, Muthukkuda coast.*

Introduction

Zooplanktons are minute aquatic organisms that live in both freshwater and marine environments and play a major role in food chain (Ovie, 2011). They form a direct link between primary producers and organisms in the upper tropic levels. Most fish feed on zooplankton during their larval stages, and some fishes eat zooplankton throughout their lives. They also act as a bio-indicators and intimate the status of water pollution (Ekpo, 2013).

Biochemical fractions of zooplankton are of great importance in tracing physiological state, nutritive value and energy path in pelagic food web. Analysis of biochemical composition and energy content of zooplankton is essential to gain a better perception of organic production, productivity and cycling of biogeochemical elements in the marine environment (Perumal *et al*., 2009) and such information is of great importance in estimating the energy available to higher trophic levels, which in turn, can be used to calculate approximately harvestable fishery resources. Distribution and harvest of zooplankton have an imperative compartment on natural source of the ocean (Sharma and Cyril, 2007). Proximate composition of different zooplankton groups play an important role in the ecological, physiological functions, metabolism, nutritive value as well as reproductive and energetic aspects of the marine ecosystem (Arunkumar *et al.*, 2013; Ashok *et al.*, 2005).

Lipids are energy reserves, membrane components, antioxidants, trophic markers, driving anatomical and also as buoyancy aid. They also control biochemical and behavioral adaptations of all organisms within the marine area (Hagen and Auel, 2001; Pond, 2012). The role of carbohydrates is unclear, since there is so little information on the glycogen content and on the amount of monosaccharide in zooplankton. High glycogen values give a sharp reduction in free-swimming larvae. It also was of significance to analyse whether the quantity of carbohydrate varied with feeding and activity, since this might specify whether carbohydrate was generally used as an energy source (Raymont and Conover, 1961).

The high content of protein and water in zooplankton are contributive factors for feeding. Free amino acids are there in the frozen fluid that surrounds the zooplankton and these form a powerful attractant and desired stimulant for fish (Kumar *et al.*, 2005). Assay of biochemical constituents of zooplankton from Indian origin is available to some extent (Nageswara Rao and Ratnakumari, 2002; Perumal *et al.*, 2009; Santhanam and Perumal, 2012; Arunkumar *et al.*, 2013). Muthukuda is one of the important fishery grounds. However no information is available on the biochemical composition of zooplankton from Muthukkuda coastal water in southeastern India. Hence an attempt is made here to study the biochemical composition of mixed zooplankton with reference to monthly variations in Muthukkuda coastal waters, southeastern India.

Material and methods

Study site

The study site selected for this investigation was Muthukkuda located at Palk Bay, in Pudukkottai district of Tamil Nadu, India. The sampling was carried out at 2 stations namely Palk Bay (Neritic water) and Pambanar estuary (Estuarine water) for a period of one year from January 2012 to December 2012. Station 1 was located at Lat.9.86° N and Long.79.13°E. The bottom of the station is covered by sand and the average depth is 3 m. Station 2 was Pambanar estuary, which covers luxuriant mangrove vegetation along the banks. It is positioned at 1 km away from station 1 and the average depth is 1 m. The bottom of the station is muddy.

Water sample collection and analysis

The water samples were collected at monthly intervals. The parameters like temperature and salinity were recorded at the field itself using standard centigrade thermometer and hand refractometer (Atago, Japan) respectively. The pH was estimated using Elico pH meter (Model LC-120). Dissolved oxygen was measured by the modified Winkler's method. For the analysis of inorganic nutrients, surface water samples were collected in clean polyethylene bottles and kept in an ice box and transported immediately to the laboratory. The water samples were filtered through 47μm GF/C filter paper using a Millipore filtering system and analyzed for inorganic phosphate, nitrate, nitrite and reactive silicate by adopting the standard methods described by Strickland and Parsons (1972).

Zooplankton collection and analysis

Zooplankton samples were collected by horizontal hauls from surface using a plankton net (0.35 m mouth diameter), made up of nylon cloth with a mesh size of 158 μm equipped with a flow meter (Digital flow meter; Model 23.090) at center of the mouth for 10 minutes. In estuary, 1 L water sample was filtered through hand zooplankton net. All the samples are collected in the early morning. A part of each sample was preserved in 5% formalin for the taxonomical studies (Davis, 1955; Kasturirangan, 1963; Santhanam and Perumal, 2008) and the remaining samples were stored in ice box and immediately transported to the laboratory. In the laboratory, samples were intensively rinsed with distilled water to eliminate the debris and salt, and utilized for the determination of biochemical constituents. Wet weight was calculated after removing the excess moisture by using filter paper (Rajendran, 1973). Then the sample was dried in a hot air oven at a constant temperature of 60° C until the wet sample dried completely. Proteins, carbohydrates and lipids were estimated according to Lowry *et al.* (1951), Dubois *et al.* (1956) Folch *et al.* (1957) respectively. Ash content was measured by burning oven-dried sample in a muffle furnace at 551° C according to AOAC (1995).

Results and discussion

Atmospheric and surface water temperatures were found to be in the range of 26-36°C and 25-33°C respectively in the study area, with minimum mean values ($\pm$SD) 29.41$\pm$1.97°C at Stn. 1 and 30.25$\pm$3.19°C at Stn. 2 and maximum mean values ($\pm$SD) 28.15$\pm$1.70°C at Stn. 1 and 28.82$\pm$2.37°C at Stn. 2 (Figs. 1a, 1b). Salinity varied from 26-33.5psu in the study area, with minimum mean values ($\pm$SD) of 30.14$\pm$1.33 psu at Stn. 2 and maximum mean values ($\pm$SD) 30.54$\pm$2.16 psu at Stn. 1 (Fig. 1c). pH in water was ranged between 7.05 and 8.69 at Muthukkuda waters, with minimum and maximum mean values ($\pm$SD) of 7.98$\pm$0.51 at Stn. 2 and 8.07$\pm$0.34 at Stn. 1 (Fig. 1d). The recorded variation in dissolved oxygen concentration in the study area was 0.43-7.42 ml l-1, with a minimum and maximum mean values ($\pm$SD) of 4.55$\pm$1.85 ml l-1 (Stn.1) and 4.64$\pm$1.57 ml l-1 at Stn. 2 (Fig. 1e). The recorded phosphate concentration varied from 0.04-1.12 μM, with a minimum and maximum mean values ($\pm$SD) of 0.44$\pm$0.32 μM at Stn. 1 and 0.54$\pm$0.23 μM at Stn. 2 (Fig.

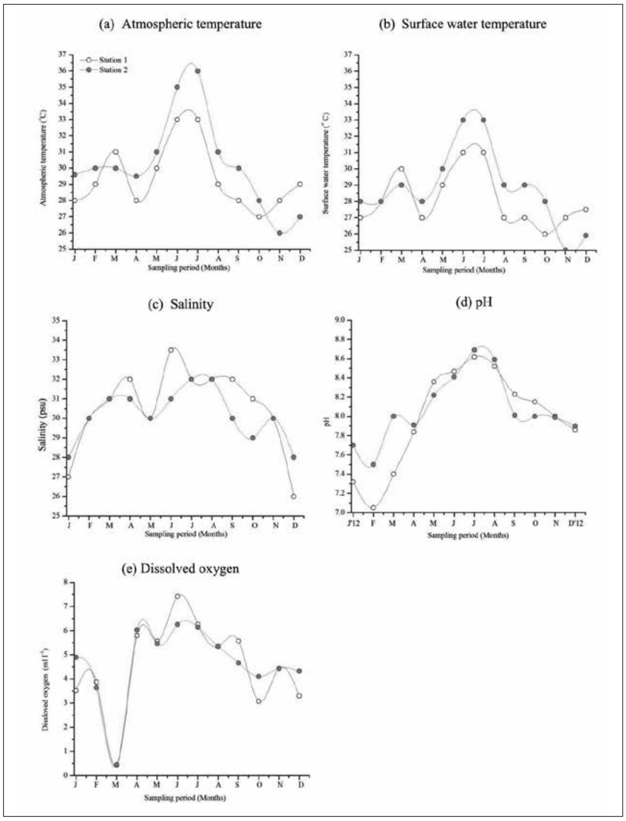

Fig. 1. Monthly variations in average physico-chemical characteristics of Muthukkuda coastal waters during January-December, 2012 at stations 1 and 2 (a) atmospheric temperature, (b) surface water temperature, (c) salinity, (d) pH, (e) dissolved oxygen.

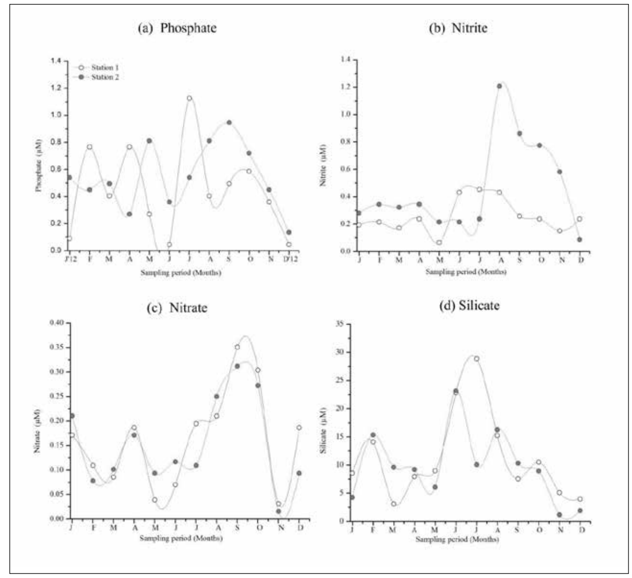

Fig. 2. Monthly variations in average inorganic nutrients characteristics of Muthukkuda coastal waters during January-December, 2012 at stations 1 and 2 (a) nitrate, (b) nitrite, (c) phosphate, (d) silicate.

2a). Nitrite values ranged between 0.06 and 1.2 μM, with a minimum and maximum mean values ($\pm$SD) of 0.25$\pm$0.12 μM at Stn. 1 and 0.45$\pm$0.33 μM at Stn. 2 (Fig. 2b). The recorded nitrate values varied from 0.01-0.35 μM in the study area, with a minimum and maximum mean values ($\pm$SD) of 0.15$\pm$0.09 μM at Stn. 2 and 0.16$\pm$0.09 μM at Stn. 1 (Fig. 2c). The reactive silicate values ranged between 1.19 and 28.86 μM, with a minimum and maximum mean values ($\pm$SD) of 9.69$\pm$6.27 μM at Stn. 2 and 11.39$\pm$7.76 μM at Stn. 1 (Fig. 2d).

Difference in temperature is one of the most important factors that influence the distribution and abundance of organisms (Soundarapandian *et al*., 2009) in the coastal and estuarine ecosystem. In the present study, the surface water temperature increased from April to July because of high solar radiation, evaporation and freshwater incursion. The water temperature was low during October because of cloudy sky and high rainfall and the recorded high value during July could be attributed to longer photoperiod, bright sunshine and dry wind (Govindasamy *et al*., 2000; Santhanam and Perumal, 2003; Ajithkumar *et al*., 2006; Ashok Prabhu *et al*., 2008; Perumal *et al*., 2009; Palpandi, 2011; Santhanam *et al*., 2012).

Salinity is also one of the most essential factors which establish the composition of biological constituents in the marine environment. This is due to osmosis. The salinity was found to be high during June - August which can be due to higher rate of evaporation, reduced fresh water inflow, land drainage and rise in temperature (Gowda *et al*., 2001; Rajasegar, 2003; Asha and Diwakar, 2007; Perumal *et al*., 2009; Soundarapandian *et al*., 2009). During December (monsoon season), heavy rain fall and large quantity of fresh water inflow from land reasonably reduced the salinity.

Throughout the study period the pH values were found to be alkaline, at both the stations with higher value during April - May and lower value during September - November as reported by earlier workers in other regions of India (Murugan and Ayyakkannu, 1991; Santhanam and Perumal, 2003; Perumal *et al*., 2009; Soundarapandian *et al*., 2009; Palpandi, 2011; Muthukumaravel *et al*., 2012). Generally, variation in pH during different months of the year is attributed to factors like climate change, rainfall, least primary productivity, decrease of salinity and temperature and breakdown of organic matter (Paramasivam and Kannan, 2005; Bragadeeswaran *et al*., 2007; Sankar *et al*., 2010; Gadhia *et al*., 2012). The recorded high pH in April - June might be due to the influence of seawater incursion and high biological action (Solai *et al*., 2010) besides the occurrence of high photosynthetic activity (Santhanam *et al*., 2012).

In the present study, higher values of dissolved oxygen were recorded during July-September which was related to the rainfall and freshwater influx (Saravanakumar *et al*., 2008; Sankar *et al*., 2010). Dissolved oxygen was low during

October - November and April - June, which could be due to the gradual saline water incursion and increasing temperature which can affect the dissolution of oxygen (Govindasamy *et al.*, 2000; Saravanakumar *et al.*, 2008; Perumal *et al.*, 2009).

The high phosphate value observed during monsoon season might possibly be due to the renewal and flow of total phosphorus from bottom mud into the water column by turbulence and mixing (Saravanakumar *et al.*, 2008; Perumal *et al.*, 2009; Babu *et al.*, 2010). The low phosphate value observed during summer could be ascribed to partial flow of freshwater, high salinity and utilization of phosphate by phytoplankton (Rajasegar, 2003; Vengadesh *et al.*, 2009). The variation may be due to the various processes like adsorption and desorption of phosphates and buffering action of sediment under varying environmental conditions (Rajasegar, 2003; Ashok *et al.*, 2008).

The higher nitrite values recorded during August could be due to the improved phytoplankton degradation, oxidation of ammonia and fall of nitrate by recycling of nitrogen and also due to bacterial disintegration of planktonic debris present in the environment (Govindasamy *et al.*, 2000). Further, the denitrification and exchange of gases due to air-sea interaction are also responsible for this increased value (Rajasegar, 2003; Ashok *et al.*, 2008). The low value recorded during summer and pre-monsoon seasons might be due to less freshwater inflow and high salinity (Murugan and Ayyakkannu, 1991; Ashok *et al.*, 2008; Santhanam *et al.*, 2012).

The highest nitrates recorded during September could be a possible mode nitrate entry through oxidation of ammonia form of nitrogen to nitrite formation (Rajasegar, 2003). The low values recorded during November might be due to its consumption by phytoplankton as evidenced by high photosynthetic activity (Rajaram *et al.*, 2005; Bragadeeswaran *et al.*, 2007).

The silicate content was higher than that of the other nutrients and the high values recorded in monsoon season might be due to heavy inflow of monsoonal fresh water derived from land drainage carrying silicate leached out from rocks. Additionally, due to the turbulent nature of water, the silicate from the bottom sediment might have been exchanged with overlying water (Vasudevan *et al.*, 2012). The removal of silicates by adsorption and co-precipitation of soluble silicate silicon with humic compounds and iron might also be responsible for the increased value (Rajasegar, 2003). The low values observed during post-monsoon could be attributed to uptake of silicates by phytoplankton especially diatoms for their biological activity (Ashok *et al.*, 2008; Perumal *et al.*, 2009).

Proximate composition of zooplankton

In the present study, the biochemical components like moisture, protein, lipid, carbohydrate and ash contents of the zooplankton, in dry weight basis were analyzed and the results were presented in Fig. 3a-e. Moisture values varied from 59.49-95.74% with a minimum and maximum mean values (±SD) of 74.88±11.27 % (Stn.1) and 78.19±11.48 % (Stn.2) respectively. Protein values varied from 8.70-41.11% with a minimum and maximum mean values (±SD) of 19.02±7.16 % (Stn.1) and 24.12±7.99 % (Stn.2) respectively. Lipid values varied from 5.12-25% at both stations, with a minimum and maximum mean values (±SD) of 8.79±3.91 % (Stn. 1) and 13.07±5.61 % (Stn.2) respectively. The recorded carbohydrate values found to vary between 3.49 and 11.35% with a minimum and maximum mean values (±SD) of 5.48±1.64 % (Stn. 1) and 6.94±1.83 % (Stn.2). Ash content was found ranged between 3.70 and 4.90%, with a minimum and maximum mean values (±SD) of 4.07±0.25 % (Stn. 1) and 4.44±0.34 % (Stn.2) respectively.

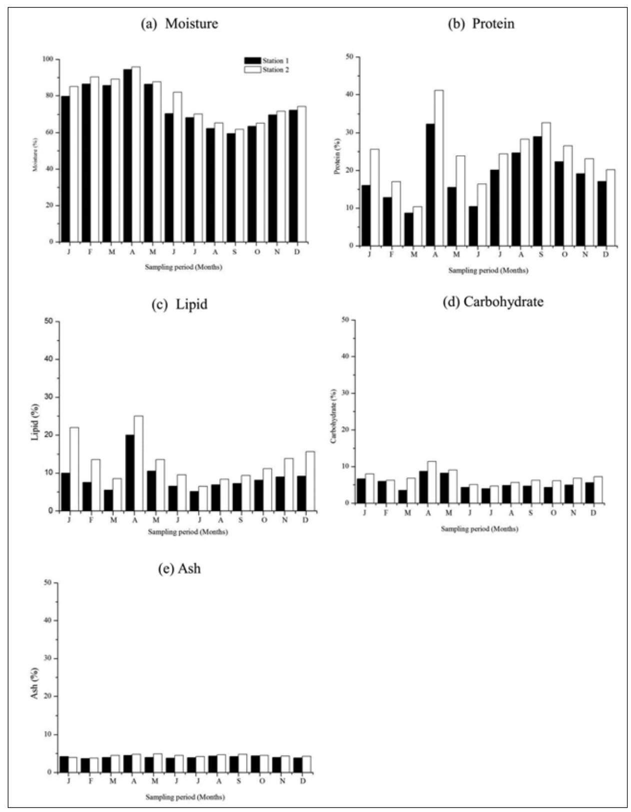

Fig. 3. Monthly variations in biochemical constituents of zooplankton at Muthukkuda coastal waters during January-December, 2012 stations 1 and 2 (a) moisture, (b) protien,(c) lipid, (d) carbohydrate, (e) ash

The present study indicates that protein is the major biochemical component in zooplankton and the values are higher than those of the earlier reports (Nageswara Rao and Krupanidhi, 2001) from Andaman Sea. The protein content of zooplankton were higher in station 2 compared to station 1 indicating the influence of mangrove nutrients and litter. Proteins form the major fraction, indicating their usefulness as energy reserve. The observed variations in the protein content might be due to its utilization a metabolic substrate (Nageswara and Krupanidhi, 2001; Perumal *et al.*, 2009). Zooplankton utilizes the protein as an additional source of energy at the time of stress (Vengadesh *et al.*, 2010).

The lipid content was slightly higher than that of carbohydrate and lower than that of protein. The lipid content of tropical zooplankton is considerably low when compared to that of temperate zooplankton which may be due to the hydrological conditions and the type of food organisms available in the environment (Ashok *et al.*, 2005). Nageswara and Krupanidhi (2001) described that variations in the lipid content can be attributed to its storage and utilization during the periods when it serves as an effective energy reserve. Usually lipids are stored for energy in critical periods (Jagadeesan *et al.*, 2010; Arun Kumar *et al.*, 2013).

Carbohydrate content was low in zooplankton as compared to protein and lipid. Lower values of carbohydrate in wild copepods have been reported earlier by many workers (Maruthanayagam and Subramanian, 1999; Nageswara and Krupanidhi, 2001; Ashok *et al.*, 2005; Perumal *et al.*, 2009). Low carbohydrate content reflects the short term variation of glycogen storage of marine organisms, which depends upon their feeding behavior (Nageswara and Ratnakumari, 2002). Besides, the utilization of carbohydrate glucosamine during the chitin synthesis in crustaceans may be prone to the decrease of carbohydrate level in copepods (Ashok Prabu *et al.*, 2005; Perumal *et al.*, 2009). Based on feeding activities the level of glycogen varies (Nageswara and Krupanidhi, 2001; Perumal *et al.*, 2009). The low carbohydrate content and high levels of protein in zooplankton suggest that protein, in addition to lipid, may function as a food reserve (Prabu *et al.*, 2005). Maruthanayagam and Subramanian (1999) stated that the carbohydrate from the food might be oxidized directly by zooplankton and fats might be oxidized on demand or stored as principal reserve food.

The present study indicate that the biochemical composition of zooplankton from Muthukkuda coastal waters having enough amount of nutrition to the fish and crustacean larvae in the wild and this zooplankton can be cultured at mass scale level in hatcheries for the production of fish and shrimp seeds on a large scale.

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