Chemical Components of Zooplankton from Nagore Coastal Area, Southeast Coast of Tamilnadu

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Abstract- **Chemical components of zooplankton is important in considerate their metabolism, nutritive value and energy transfer which are relevant to the coastal ecosystem. Proximate composition, zooplankton biomass, dry weight, protein, lipid, carbohydrate and calorific content of mixed zooplankton were estimated from the Nagore coastal water Southeast coast of Tamilnadu during July 2016 to June 2017. Protein formed the major fraction of the organic constituents. Seasonal variation was observed in the protein content. Protein and lipid fractions were inversely proportional. Neither lipid nor carbohydrate appeared to be significant energy sources. Lipid was the most variable component. Carbohydrate content of the organism was found complementary to its lipid content. Decrease in carbohydrate content was recorded during periods of low salinity. Caloric value obtained in this study ranged from 1.35 to 2.40 kcal/g dry weight ($\bar{X}$=1.62±0.15) and ($\bar{X}$=1.99±0.25) in the estuarine and marine waters respectively. Relatively higher values were attributed to the dominance of calanoid copepods in the zooplankton population almost throughout the year. Zooplankton did not show extensive lipid storage suggesting that protein may serve as metabolic reserve. It is therefore evident that zooplankton can be utilized as nutritional live feed for the cultivable species of fish and prawn in aquaculture farms. The ranges of dry weight, protein, lipid and carbohydrate (%) contents (Zooplankton) were: 0.17 - 2.9; 19.15 - 34.97; 10.12 - 17.56; 1.15 - 6.98 and 0.64 - 2.18; 20.9 - 40.34; 13.89 - 19.43; 1.65 - 9.73 respectively. This study is the first report on chemical components and Calorific Value of Zooplankton from the coastal waters of Nagore, Southeast coast of Tamilnadu.**

IndexTerms- **Zooplankton biomass, dry weight, chemical components, calorific content and Nagore coast.**

I. INTRODUCTION

Zooplankton are considered to be "nutritionally superior live feeds" for commercially important cultivable species, as they are valuable source of proteins, lipids, carbohydrates and Caloric value all of which play an important role in digestion and the metamorphosis of larvae [1, 2]. Studies on proximate composition of various zooplankton groups involve that the composition values may have an important role in the ecological, physiological functions, metabolism and nutritive value besides reproductive and energetic aspects of the marine ecosystem. Estimation of chemical components of zooplankton is important in understanding their metabolism, nutritive value and energy transfer. Information about the chemical constituents of zooplankton from Indian Ocean is limited [3-5].

Protein is an essential substance of life and accordingly exists in the largest quantity of all the nutrients as component of the living beings. The protein requirements vary with age, physiological status and stress. More proteins are utilized by growing infants, children, pregnant women, lactating women and individuals during infections and illness or stress. At the same time, the proteins contribute 15-20% of the total calories for the body maintenance. It is absolutely essential to human diets and it ensures that amino acids are available to build new tissue and to maintain old tissue. Lipids are major sources of metabolic energy and of essential materials for the formation of cell and tissue membranes. They are very important in the physiology and reproductive process of marine animals and reflect the special chemical and ecological conditions of the marine environment.

A carbohydrate is important and less expensive source of energy than any other energy component in the diet. It provides energy of 4.1Kcal/g and also it is found that 60-70% of the total calories are being contributed by carbohydrates in human diet. In the biosphere, carbohydrates are the major organic compounds produced photosynthetically by autotrophic organisms. Because carbohydrates are omnipresent and abundant, they play an important role in biogeochemical cycles occurring in the coastal water column and sediment–water interface. The present study deals with the annual variations in biomass, chemical components and calorific content of zooplankton collected from the coastal waters of Nagore.

II. MATERIALS AND METHODS

The present study was carried out from two stations namely Vettar Estuarine and Nagore Marine water. It is extending from 10º49' to 10º 55'N latitude and 79º 51' to 79º 55' E longitude and medium tropical transition climate characterized by monthly average temperature of above 29º C. The relative humidity ranges from 70 – 77%. The Nagore coastal water is situated near Nagapattinam on the Southeast coast of India. The Nagore coastal water has its source in the Cauvery river basin of Tamil Nadu (Figure 1) during July 2016 to June 2017. This river flows in to the Bay of Bengal near Nagapattinam of Tamil Nadu. In the harbor at Nagore, there are about many hundreds of mechanized boats and catamarans employed for fishing. In the fishing vessels they are using paints and fuels from it the waste materials are released in to the harbor area. The domestic sewages agricultural drainages and the other sewage effluents are carried out into the Bay of Bengal through the small canals and rivers. . The mean and standard deviation was calculated.

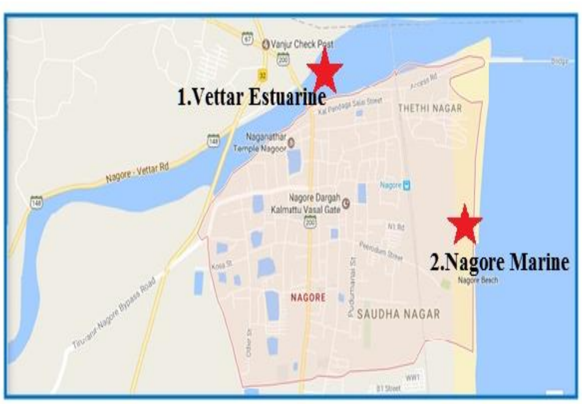

Figure 1: Study area map

Zooplankton samples were collected fortnightly in every month and hence the results are given in I and II from the study areas by horizontal hauls from surface by using a plankton net (150µm; 0.25m^2) fitted with a calibrated flow meter at mouth of the net. One half of each sample was preserved in 4% formalin for the taxonomical studies [6, 7] and the other half of samples were immediately transported to the laboratory, thoroughly rinsed with distilled water to remove the debris and utilized for the determination of chemical constituents and then dried at 60ºC until constant weight was obtained for the purpose to determine the chemical composition. Protein was measured spectrometrically by the Birutte method [8]. Carbohydrate was measured by [9]. Lipid content was estimated by [10]. Caloric density was calculated using conversion factors of 5.7, 4.0 and 9.3 K.cal g^{-1} for protein, carbohydrate and lipid respectively as given by Elliot and Davison [11].

III. RESULTS AND DISCUSSION

Zooplankton biomass values ranged from 16.0 to 75.0 ml. 100 m^{-3} ($\bar{x}$=32.33±16.99 ml m^{-3}) in the estuarine waters. Values for the coastal water fluctuated between 11.0 to 67.0 ml. 100 m^{-3} ($\bar{x}$=27.66±14.77 ml m^{-3}) (Figure 2). In terms of dry weight, biomass values ranged from 0.17 to 2.9 mg m^{-3} ($\bar{x}$=1.25±0.84 mg m^{-3}) and from 0.64 to 2.18 mg m^{-3} ($\bar{x}$= 1.34±0.54 mg m^{-3}) in the estuarine and marine waters respectively (Figure 3). The values of biomass (displacement volume) obtained here are higher than the values reported earlier for the same area [12] but the biomass values in terms of weight were similar. It clearly reflects the differences in season of collection. It appears that abundance of gelatinous organisms like salps in the samples may account for values of biomass in terms of displacement volume and low dry weight.

Protein, lipid and carbohydrate of zooplankton calculated as a percentage of dry weight were presented. Protein constituted the major chemical component and ranged from 19.15-40.34 mg/g ($\bar{X}$=26.64±4.68) and ($\bar{X}$=31.37±6.60) in the estuarine and marine waters respectively. Protein values were generally high when higher number of calanoid copepods, Cyclopoida, Harpacticoida, Mysidacea, Amphipoda, tintinnids, decapods larvae, bivalve larvae, Euterpina acutifrons, Polychaete larva, Ophiopluteus larva and chaetognaths contributed mostly to the total zooplankton. High protein value

(40.34% dry weight) for the zooplankton was recorded at station - II during Post monsoon season followed by 34.97% at station - I during Pre monsoon season (Table 1 and 2). The lowest value (19.15 mg/g) at station - I during Post monsoon and station - II during Monsoon (20.9 mg/g) was due to the low abundance of calanoid Copepods which is associated with low primary productivity during these periods. Overall mean protein values were higher at Station - I compared to Station - II in the study area (Figure 4) Abundance of some gelatinous forms such as Hydromedusae, Siphonophores at Station - II might have attributed to low protein content in zooplankton in this area. Furthermore, it has been documented that protein content varies with season, the zooplankton organisms at the time of collection and environmental conditions [13]. This may account for the observed differences in the protein values reported by different authors at different time of the year.

Lipid was the second major components in zooplankton and ranged from 10.12 - 19.43% ($\bar{X}$= 13.64±2.80) and ($\bar{X}$= 16.56±2.11% dry weight) in the estuarine and marine waters respectively. The lipid content was more in zooplankton collected during summer and pre monsoon seasons in Station - I and Station – II (Table 1 and 2). Average lipid content was higher at Station – II compared to other regions could be due to the occurrence of high lipid containing groups such as zooplanktons, tintinnids, sergestids, Polychaete larva, bivalve larvae and oil globules of Invertebrate, Fish eggs and larvae (Figure 5) from this area. The lipid content was low (10.12-12.13%) at Station - I and Station - II during Pre monsoon – Monsoon when the water temperature was high (29.5ºC) which inhibits lipid position in zooplankton [14]. Continuous and high rate of primary production and high temperature in the tropical water is believed to inhibit lipid deposition in the zooplankton [15].

S. No.	Months	Zooplankton Biomass ml.100 m^{-3}	Percent of dry weight (mg)	Percent dry weight			Caloric value k cal/g dry wt
				protein	lipid	Carbohydrate	
1.	July 2016	39	1.97	29.98	16.35	1.27	1.48
2.	August	20	1.27	27.47	17.56	1.15	1.35
3.	September	26	2.08	34.97	10.12	6.98	1.41
4.	October	17	0.43	20.16	13.77	1.91	1.60
5.	November	16	0.17	23.1	12.74	2.5	1.79
6.	December	19	1.28	28.3	11.19	1.09	1.5
7.	January 2017	24	0.45	19.15	11.09	1.17	1.64
8.	February	35	0.36	22.98	10.76	1.9	1.62
9.	March	54	1.79	33.73	10.54	6.87	1.75
10.	April	41	0.44	25.61	15.17	2.12	1.79
11.	May	75	2.9	28.44	17.19	1.65	1.68
12.	June	22	1.89	25.9	17.24	5.8	1.83

Table-I: Monthly variation in biomass, chemical components and dry weight percentages of zooplankton species from Vettar estuarine (Station – I)

S. No.	Months	Zooplankton Biomass ml.100 m^{-3}	Percent of dry weight (mg)	Percent dry weight			Caloric value k cal/g dry wt
				protein	lipid	Carbohydrate	
1.	July 2016	27	0.76	27.23	16.75	4.01	2.36
2.	August	19	0.88	37.09	19.15	4.34	2.40
3.	September	21	0.98	37.54	18.79	8.31	1.98
4.	October	15	0.97	22.59	13.89	2.8	1.85
5.	November	11	1.91	20.9	14.34	2.5	1.78
6.	December	15	0.89	36.71	12.13	2.97	1.9
7.	January 2017	21	1.97	27.66	16.1	1.78	1.86
8.	February	32	2.18	28.43	16.9	1.65	1.57
9.	March	43	2.07	40.34	19.43	9.7	1.68
10.	April	35	1.65	24.05	16.89	9.67	2.09
11.	May	67	1.19	37.82	17.84	5.3	2.1
12.	June	26	0.64	36.11	16.59	9.73	2.34

Table – II: Monthly variation in biomass, chemical components and dry weight percentages of zooplankton species from Nagore marine (Station – II)

Carbohydrate was the minor component and ranged from 1.09-9.73% ($\bar{X}$= 2.86±2.18) and ($\bar{X}$=5.23±3.09 % of dry weight) in the estuarine and marine waters respectively. High values observed in summer at Station – II and low during Monsoon at Station - I and Station -II could be due to occurrence of non-crustacean groups such as Oikopleura, Siphonophora and Hydromedusae during these periods (Table 1 and 2). Spatial variation was pronounced in the carbohydrate content of zooplankton. Maximum carbohydrate percentage was recorded at Station - II (9.73%)

could be due the higher abundance of Calanoid Copepods, Chaetognatha and Decapoda in the collected samples. Overall mean carbohydrate values were higher at Station - II compared to Station - I study area (Figure 6).

Caloric value obtained in this study ranged from 1.35 to 2.40 kcal/g dry weight ($\bar{X}$=1.62±0.15) and ($\bar{X}$=1.99±0.25) in the estuarine and marine waters respectively. High calorific content was recorded during summer Station - II (Table 1 and 2). The lowest value obtained during monsoon at Station - I. Maximum values (2.40 k cal/g dry weight) at Station - II during summer could be due to the dominance of Calanoid Copepods and Decapod larvae (Figure 7). The lowest calorific content (1.09 kcal/g dry weights) was observed at Station - I due to the presence of non crustacean forms such as Medusa, Pleurobrachia globossa, Diphyes sp. The differences in caloric content observed here are attributable to seasonal differences in the food content, the time of collection and varying species composition and maturity stages of zooplankton.

Considerable seasonal variation in the chemical fractions of zooplankton from higher latitudes as well as warm waters has been reported. But in the Nagore coastal, occurrence of various species is by itself seasonal, the high saline species investigated occur only during the pre-monsoon period when the estuary becomes saline. However, in tropical waters zooplankton have comparatively shorter life span than cold water species. Hence several generations can occur within short periods

and variations in Chemical components between generations would need further investigation. It is fairly well established that protein forms the major fraction in terms of dry weight in zooplankton. Low biomass of zooplankton ($\bar{X}$= 13.66±1.88) obtained in this study compared to that reported from the marine realm of this area [16] could be due to the ecological distribution type of these organisms. However, the dry weight values are comparable to the values reported earlier from coastal waters of Nagore, southeast coast of Tamilnadu [5]. Zooplankton biomass of a particular environment depends upon the primary productivity and variation in the habitat temperature and salinity during that period. Assessment of chemical composition, such as protein, lipid and carbohydrate in zooplanktons is important for better understanding of the organic production and cycling of biogeochemical elements in the marine and estuarine biotopes (Table 3). The present study indicates that protein is the major chemical component in zooplanktons and the values are higher than those of the earlier reports of [17] in Nagore coastal area. The protein contents of zooplanktons were higher in sea when compared to those from estuaries which indicate that salinity of the water might influence the protein content of the zooplanktons [2]. The presently recorded variations in protein contents are comparable to those reported for mixed zooplankton from higher latitudes [4].

Table - III: Mean values of chemical components in zooplankton at Nagore coastal during the period from July 2016 to June 2017 (station I & II)

Parameters	Stations	Pre monsoon	Monsoon	Post monsoon	Summer
Zooplankton biomass	I	28.33±7.93	17.33±1.24	37.66±12.39	46±21.92
	II	22.33±3.39	13.66±1.88	32±8.98	42.66±17.59
Dry weight	I	1.77±0.71	0.62±0.47	0.86±0.65	1.74±1.009
	II	0.87±0.08	1.25±0.46	2.07±0.08	1.16±0.41
Protein	I	29.79±1.82	23.85±3.36	25.28±6.17	26.65±1.27
	II	33.95±4.75	26.7±7.08	32.14±5.80	32.6±6.12
Lipid	I	14.67±3.25	12.56±1.06	10.79±0.22	16.53±0.96
	II	18.23±1.05	13.45±0.95	17.47±1.41	17.10±0.53
carbohydrate	I	3.13±2.72	1.83±0.57	3.31±2.53	3.19±1.85
	II	6.02±2.62	2.75±0.19	4.37±3.76	7.76±1.82
calorific values	I	1.41±0.05	1.63±0.12	1.67±0.05	1.76±0.06
	II	2.24±0.18	1.84±0.04	1.70±0.11	2.17±0.11

Protein constituted the major fraction in terms of dry weight indicating itself as the major energy reserve for the tropical zooplankton that they utilize as energy source at times of environmental stress [2]. However, protein content in zooplankton observed in this study is somewhat lower than an earlier report from this area [16]. The values recorded in this study are comparable to the earlier reports from vettar estuarine [18]. Variation of protein content in zooplankton could be attributed to difference in ecological distribution, temporal difference and salinity variation and productivity of the area and species contribution to the total zooplankton standing stock [19]. Lipid fraction was low with the abundance of organisms with high water content (Hydromedusae, Oikopleura and Siphonophores) as observed in this study are almost similar to an earlier report from this area Vettar estuarine [19] but higher than Nagore marine water [20]. Further, in tropical environment, the rate of primary productivity far exceeds than the rate of consumption by zooplankton which might have contributed to the higher lipid content in these organisms [16]. The protein fractions of species in the present study also fall within the above ranges except for the ctenophore, Pleurobrachia and the species belonging to hydromedusae. Comparable studies for these groups of organisms seem to be lacking. Reciprocal relationship has been observed between protein and lipid fractions but such a relationship was generally not apparent in the present study.

The lipid content was slightly higher than that of carbohydrate and lower than that of protein. In tropical environments, the rate of primary production far exceeds the rate of consumption of zooplankton food would render lipid reserve unnecessary, which may be the reason for the low lipid content in zooplanktons [2]. The lipid content of tropical zooplankton, when compared to temperate zooplankton is significantly low which may be due to the hydrological conditions and the type of availability of food organisms in environment as shown by the findings of Ashok Prabu [21] Nageswara Rao and Krupanidhi [17] showed that variations in the lipid content can be attributed to its storage and utilization during periods when it serves as an effective energy reserve. The function of protein as an important energy reserve may be of importance for zooplankton having low lipid content. The low lipid content observed in the present investigation supports the view that these are all surface water zooplanktons and moreover the protein may form a major metabolic reserve substrate in zooplanktons [22]. The low lipid content observed in the species in the present study supports the view that protein may form a major metabolic reserve substrate in tropical zooplankton. It is also possible that the rich food supply available to the herbivores in the estuary and carnivores like ctenophora, hydromedusae and chaetogtha during the saline period when zooplankton abound in the estuary would render large lipid storage unnecessary for them.

Carbohydrate content was poor ($\bar{X}$= 1.83±0.57) and lower compared to earlier reports from this area Nagore marine [19] which suggest that glycogen, the usual storage carbohydrate in zooplankters might not contribute substantially towards the body reserve [16]. Variation in carbohydrate content in zooplankton also depends upon species composition and increase or decrease of gelatinous organisms as observed in this study. Low carbohydrate content in this study reflects the short-term variation in glycogen storage of zooplankton which depends upon their feeding activities [5]. Carbohydrate content of the planktonic forms is usually low and does not appear to represent a significant nutritional reserve. In general, carbohydrate content was very low in the zooplankton as compared to protein and lipid. Lower values of carbohydrate of wild-zooplanktons have been reported earlier by many workers [2]. The present observation of low carbohydrate content may be attributed to the fact that glycogen is the usual storage carbohydrate in many animals. Besides, the utilization of carbohydrate glucosamine during the chitin synthesis in crustaceans may prone to the decrease of carbohydrate level in zooplanktons [21]. Goswami [4] reported that carbohydrate content of zooplankton community is dependent upon its composition, declining in gelatinous forms than those with calcareous shells and increasing with zooplanktons. The fluctuations in glycogen content of animals generally depend upon their feeding activities [17]. The low carbohydrate content and high levels of protein in zooplankton suggest that protein, in addition to lipid, may function as a food reserve [21]. Maruthanayagam and Subramanian [22] felt that the carbohydrate from the food might be oxidized directly by zooplankton and that fats might be oxidized on need or stored as principal reserve food. In general low carbohydrate content in zooplankton led to contemplations on the functional role of other chemical fractions in their metabolism.

The average calorific value ($\bar{X}$=1.62±0.15) and ($\bar{X}$=1.99±0.25) in the estuarine and marine waters recorded in this study is lower compared to earlier study from this area but higher than that reported from marine waters of Nagore [5]. Variation in calorific content could be due to the species composition and physiological state of zooplankton as found in the present study and it has been reported earlier from elsewhere. Differences in calorific values in the Coastal zooplankton may be attributed to the species composition, time of collection and physiological state of zooplankton. High calorific values in the present study were associated with zooplankton dominated by Calanoid copepods, tintinnids, decapods and chaetognaths in the total zooplankton. The differences in caloric content observed here are attributable to seasonal differences in the food content, the time of collection, varying species composition and maturity stages of zooplankton

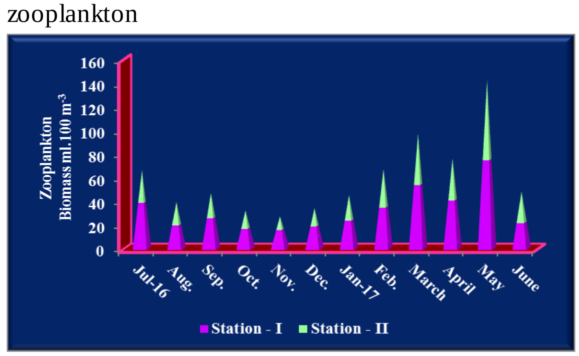

Figure 2: Monthly values of zooplankton biomass at different stations in the study area

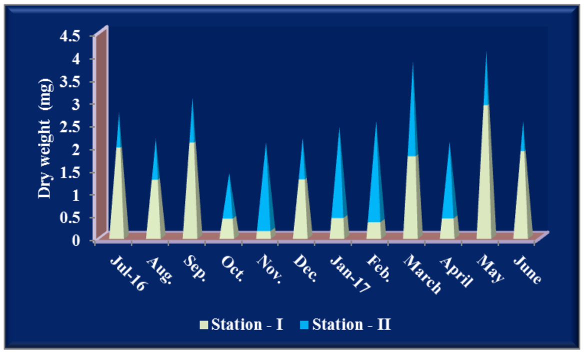

Figure 3: Monthly values of zooplankton dry weight biomass at different stations in the study area

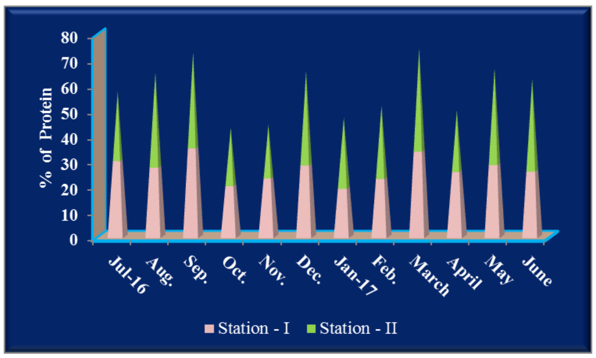

Figure 4: Monthly values of protein content of zooplankton at different stations in the study area

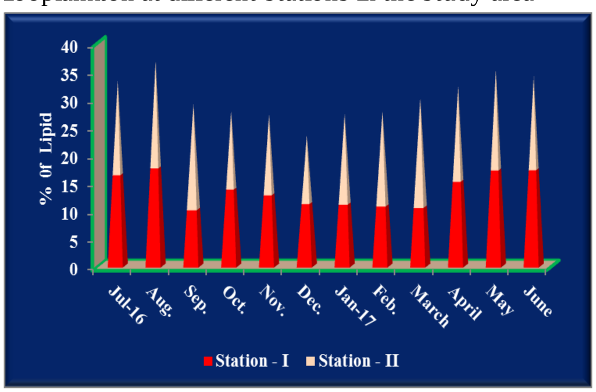

Figure 5: Monthly values of lipid content of zooplankton at different stations in the study area

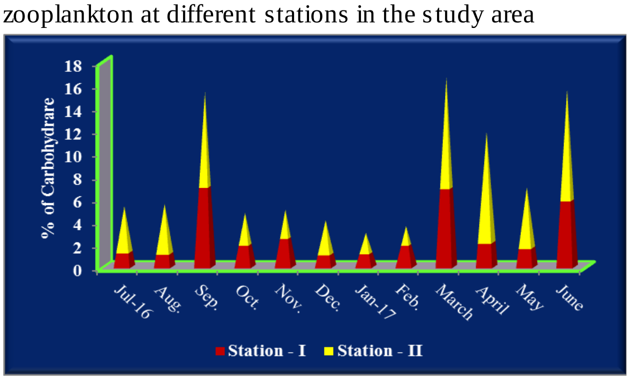

Figure 6: Monthly values of carbohydrate content of zooplankton at different stations in the study area

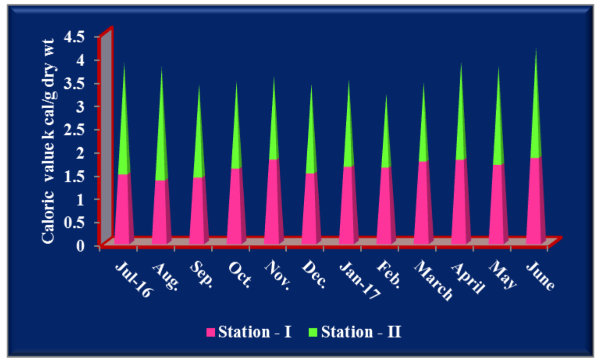

Figure 7: Monthly values of calorific content of zooplankton at different stations in the study area

IV. CONCLUSIONS

In this study reported on chemical components and calorific value of zooplankton from the coastal waters of Nagore, Southeast coast of Tamilnadu. Protein constituted the major fraction in terms of dry weight indicating that protein is the main energy reserve for the zooplankton for utilization at times of stress. It is therefore apparent that zooplankton can be utilized as nutritional live feed for aquaculture. Furthermore, it has been documented that protein content varies with season, the zooplankton organisms at the time of collection and environmental conditions. The lipid content was slightly higher than that of carbohydrate and lower than that of protein. In tropical environments, the rate of primary production far exceeds the rate of consumption of zooplankton food would render lipid reserve unnecessary, which may be the reason for the low lipid content in zooplanktons. Differences in calorific values in the Coastal zooplankton may be attributed to the species composition, time of collection and physiological state of zooplankton. Variation in carbohydrate content in zooplankton also depends upon species composition and increase or decrease of gelatinous organisms as observed in this study. The low carbohydrate content and high levels of protein in zooplankton suggest that protein in addition to lipid may function as a food reserve. High calorific values in the present study were associated with zooplankton dominated by Calanoid copepods, tintinnids, decapods and chaetognaths in the total zooplankton. The variations in chemical components of zooplankton are influenced mainly by species composition and feeding activities of zooplankton.

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