Article

Biochemical composition and calorific value of zooplankton from the coastal waters of South Andaman

M. Arun Kumar, **G. Padmavati**, **I. Anandavelu**
Department of Ocean Studies and Marine Biology, Pondicherry University, Brookshabad Campus, Port Blair-744 112, Andaman and Nicobar Islands, India
Email**:** padma190@rediffmail.com

Received 24 April 2013; Accepted 28 May 2013; Published online 1 September 2013

Abstract
Estimation of biochemical composition of zooplankton is important in understanding their metabolism, nutritive value and energy transfer which are relevant to the marine ecosystem. Zooplankton biomass and their biochemical composition were estimated from the coastal waters of South Andaman during October 2011 to September 2012. The dry weight biomass and chlorophyll *a* discerned a positive correlation ($p<0.05$; one-way ANOVA) in two stations. Protein formed the major fraction of the organic constituents. Seasonal variation in the protein content of zooplankton was observed. Carbohydrate was the minor component and ranged from 1.1-12.2% ($\bar{x}$ = 3.4±1.1) in terms of dry weight. Neither lipid nor carbohydrate appeared to be significant source of energy for these organisms. Caloric value obtained in this study ranged from 1.35 to 2.72 kcal/g dry weight ($\bar{x}$ =1.8±0.2). Relatively higher values were attributed to the dominance of calanoid copepods in the zooplankton population almost throughout the year. Zooplankton did not show an 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 variations in biochemical composition of zooplankton are influenced by species composition and feeding activities of zooplankton, which is in accordance with the previous studies. This study is the first report on Biochemical Composition and Calorific Value of Zooplankton from the coastal waters of Port Blair, South Andaman.

Keywords Andaman; biochemical composition; biomass; calorific content; zooplankton.

Proceedings of the International Academy of Ecology and Environmental Sciences
ISSN 2220-8860
URL: http://www.iaees.org/publications/journals/piaees/online-version.asp
RSS: http://www.iaees.org/publications/journals/piaees/rss.xml
E-mail: piaees@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 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 enzymes, all of which play an important role in digestion and the metamorphosis of larvae (Støttrup, 2000; Molejon and Alvarez-Lajonchere, 2003; Rajkumar and Vasagam, 2006; Rajkumar et al., 2008). Estimation of biochemical composition of zooplankton is important in understanding their metabolism, nutritive value and energy transfer. Information about the biochemical constituents of zooplankton from Indian Ocean is limited (Madhupratap et al., 1979; Dalal and Parulekar, 1986; Krishnakumari, 1988; Nandakumar et al., 1988; Goswami et al., 2000; Nageswara Rao and Ratnakumari, 2002). Further, information on chemical composition of zooplankton from the Andaman Sea is fragmentary (Goswami et al., 1981; Nageswara Rao and Krupanidhi, 2001).The present study deals with the annual variations in biomass, biochemical composition and calorific content of zooplankton collected from the coastal waters of South Andaman.

2 Materials and Methods

2.1 Study site

The present study was carried out from 4 stations namely Chatham Jetty, Junglighat Bay, Carbyn Creek and Burmanallah (11°29' N-92°36'E) from the coastal waters of South Andaman Sea during October 2011 to September 2012 (Fig. 1). The station 1 (S1) Chatham is the major harbor area, station 2 (S2) Junglighat bay is one of the major fish landing center in Andaman Islands. This bay receives large amount of sewage discharge from the adjacent areas. The station 3 (S3) Burmanallah is a good ecosystem known for the seagrass, coral reefs and mangroves. This area is directly connected to the Andaman Sea and has been affected by high incursion of seawater during tsunami, December 2004. The station 4 (S4) Carbyn's Cove is a bay shaped area is a mangrove area and relatively polluted due to high human interference, and drainage.

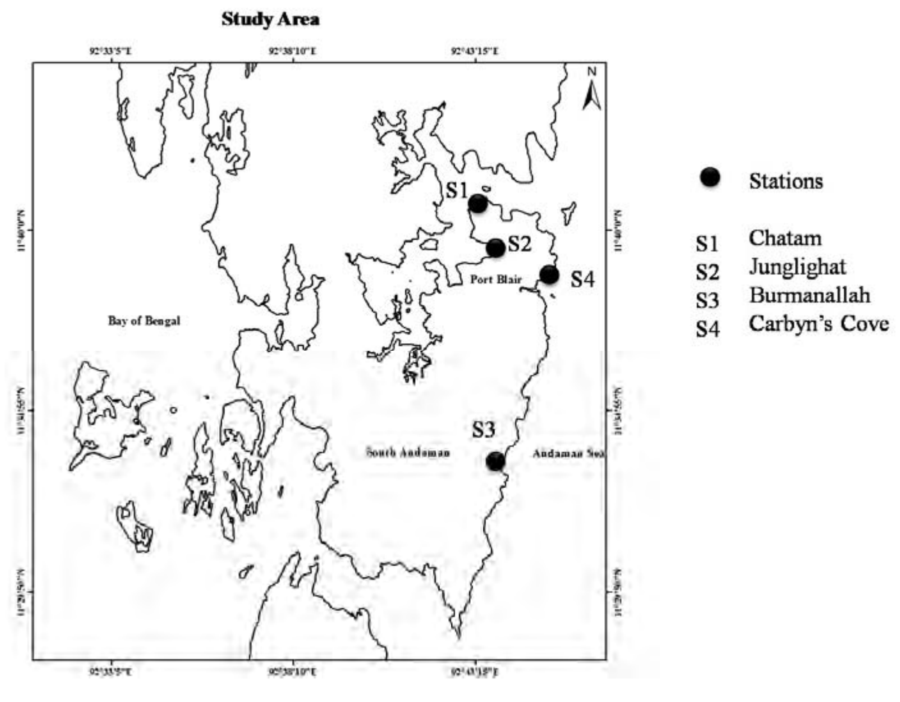

Fig. 1 Location of station.

2.2 Sample collection and analysis

Zooplankton samples were collected at monthly intervals from the 4 stations during October 2011 to September 2012 through 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 (Kasturirangan, 1963; Conway et al., 2003) 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 biochemical constituents. Wet weight was measured to the nearest milligram after removing the excess moisture by using blotting paper (Omori and Ikeda, 1984). The samples were dried at 60ºC until constant weight was observed. Protein was measured spectrometrically by the Biuret method (Raymont et al., 1964); Carbohydrate was measured by Dubois et al., 1956; Lipid content was estimated by Folch et al. (1957).

3 Results

Zooplankton standing stock in terms of dry weight is a reliable approach. The dry weight biomass varied from 0.19- 2.96 g/m^3 ($\bar{x}$= 1.1±0.6). Maximum biomass (2.96 g/m^3) was recorded during September at S4 due to low salinity (20 ‰) and high Chlorophyll *a* (0.24 μg/l) followed by 2.82 g/m^3 during June at S4 (Table 1).

Low biomass (0.19 g/m^3 at S2) and (0.27 g/m^3 at S1) during November when high salinity (31‰) and low chlorophyll *a* was recorded (0.03 μg/l). The dry weight biomass and chlorophyll *a* discerned a positive correlation ($p<0.05$; one-way ANOVA) at almost all the stations. Average dry weight biomass values are shown in Fig. 2A.

Table 1 Monthly variations of dry weight biomass (g/m^3) of zooplankton.

Months	S1	S2	S3	S4
Oct-11	0.31	0.44	0.99	0.96
Nov-11	0.27	0.19	1.7	0.89
Dec-11	0.36	1.26	0.88	1.98
Jan-12	0.48	0.44	1.95	1.58
Feb-12	0.58	0.31	2.15	0.76
Mar-12	0.95	1.75	2.05	1.33
Apr-12	0.84	0.44	1.62	1.6
May-12	0.86	2.5	1.16	2.4
Jun-12	0.76	1.87	0.63	2.82
Jul-12	0.94	1.99	0.74	0.66
Aug-12	1.02	1.1	0.88	1.12
Sep-12	1.13	2.09	0.98	2.96

Protein, lipid and carbohydrate of zooplankton calculated as a percentage of dry weight were presented. Protein constituted the major biochemical component and ranged from 16.74-50.76 mg/g ($\bar{x}$= 29.1±6.8). Protein values were generally high when higher number of calanoid copepods, tintinnids, decapods larvae, bivalve larvae and chaetognaths forms contributed mostly to the total zooplankton. High protein value (50.76% dry weight) for the zooplankton was recorded at S3 during June followed by 47.88% at S4 during March (Table 2). The lowest value (16.74 mg/g) at S3 during November and S2 during January (19.1 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 S1, S3 and S4 compared to S2 in the study area (Fig. 2B). Abundance of some gelatinous forms such as Hydromedusae, Siphonophores at S2 might have attributed to low protein content in zooplankton in this area.

Table 2 Monthly variations of protein content (% dry weight) of zooplankton.

Months	S1	S2	S3	S4
Oct-11	22.49	20.14	19.62	22.23
Nov-11	20.5	22.306	16.74	22.99
Dec-11	36.18	28.4	41.58	19.76
Jan-12	26.67	19.19	19.44	27.55
Feb-12	25.87	22.8	18.72	23.56
Mar-12	39.34	33.97	38.52	47.88
Apr-12	23.08	24.7	28.8	40.47
May-12	37.61	28.41	29.7	32.68
Jun-12	35.86	25.08	50.76	29.83
Jul-12	27.26	29.57	29.7	24.51
Aug-12	37.01	26.94	36.36	46.74
Sep-12	36.56	31.92	45.36	37.24

Table 3 Monthly variations of lipid content (% dry weight) of zooplankton

Months	S1	S2	S3	S4
Oct-11	9.8	10	13.95	13.78
Nov-11	9.6	11.13	14.4	12.74
Dec-11	8.89	10.02	12.15	11.18
Jan-12	9.3	9.18	15.9	10.08
Feb-12	9.1	9.34	15.6	9.75
Mar-12	12.64	9.8	18.45	10.73
Apr-12	8.4	10.2	16.35	14.17
May-12	10.5	12.4	17.85	17.12
Jun-12	11	10.6	16.95	16.58
Jul-12	10.8	9.0	15.3	16.25
Aug-12	12.98	13.43	19.14	16.85
Sep-12	9.0	12.81	18.75	8.13

Lipid was the second major components in zooplankton and ranged from 8.13- 19.14% ($\bar{x}$= 12.5±1.4% dry weight). The lipid content was more in zooplankton collected during April-September in S3 and S4stations (Table 3). Average lipid content was higher at S3 ($p<0.5$; one-way ANOVA) compared to other regions could be due to the occurrence of high lipid containing groups such as copepods, tintinnids, sergestids, bivalve larvae and oil globules of Invertebrate and Fish eggs and larvae (Fig. 2C) from this area. The lipid content was low (8.1-9.3%) at S4 and S1 during September- January when the water temperature was high (28ºC) which inhibits lipid position in zooplankton (Krishnakumari and Nair, 1988).

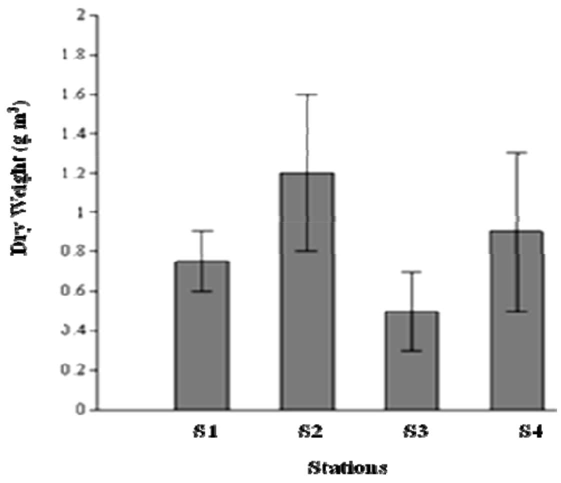

Fig. 2(A) Zooplankton dry weight biomass at different stations in the study area.

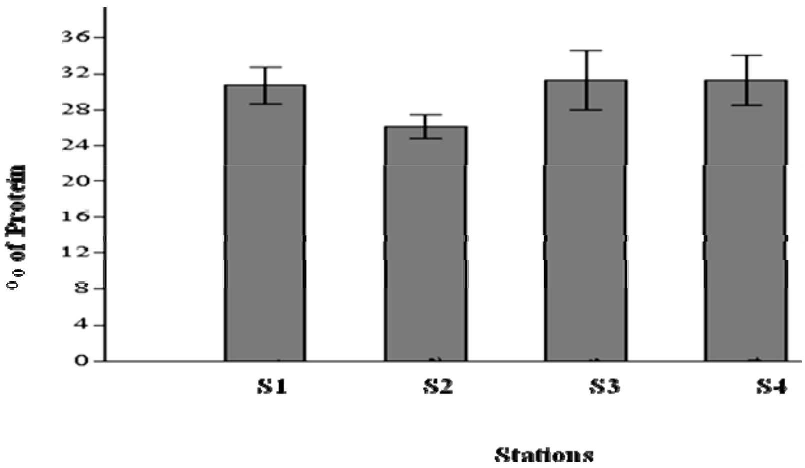

Fig. 2(B) Protein content of zooplankton at different stations in the study area.

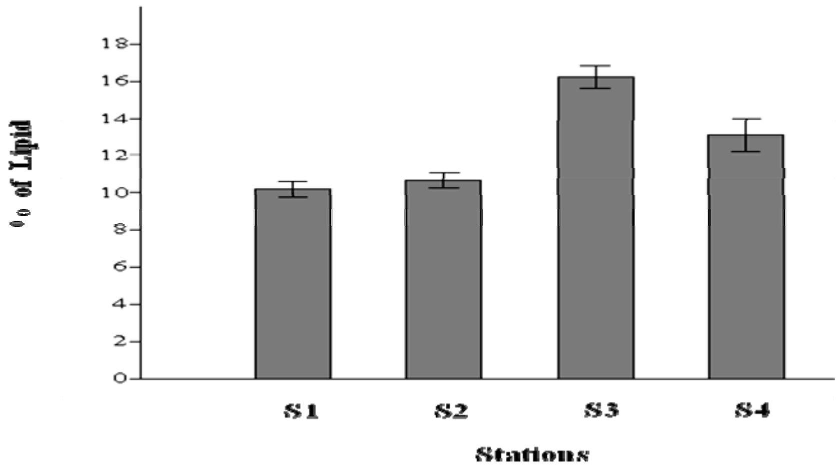

Fig. 2(C) Lipid content of zooplankton at different stations in the study area.

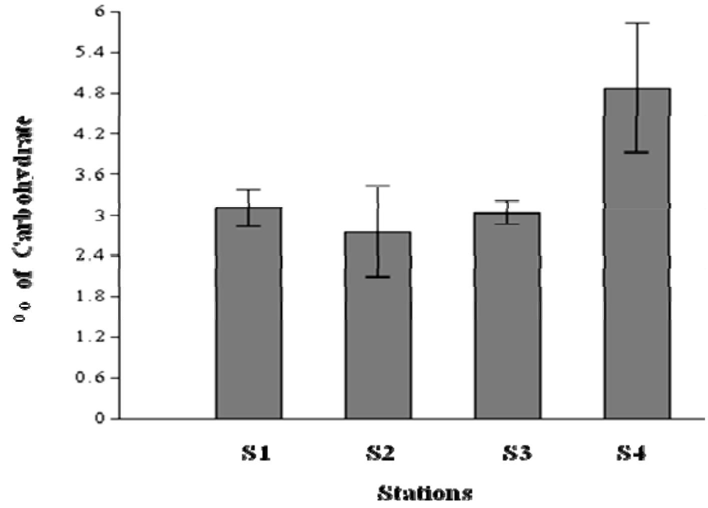

Fig. 2(D) Carbohydrate content of zooplankton at different stations in the study area.

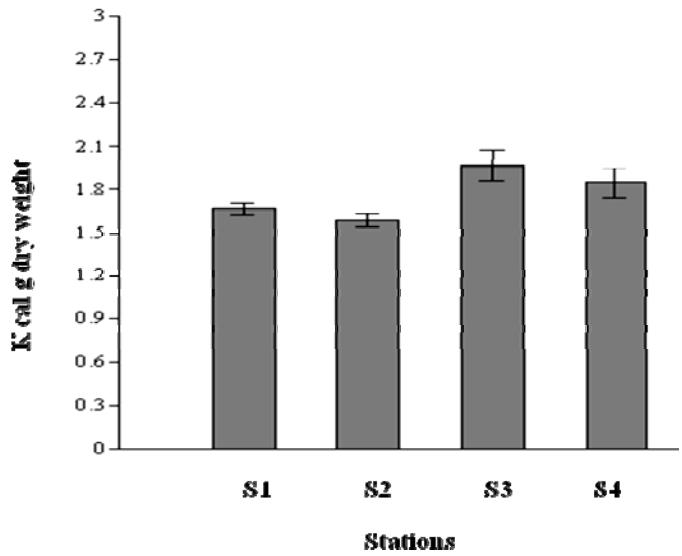

Fig. 2(E) Calorific content of zooplankton at different stations in the study area.

Carbohydrate was the minor component and ranged from 1.1-12.2% ($\bar{x}$= 3.4±1.1) in terms of dry weight. High values observed in April and September at S4 and low during October- November at S1 and S2 could be due to occurrence of non-crustacean groups such as Oikopleura, Siphonophora and Hydromedusae during these periods (Table 4). Spatial variation was pronounced in the carbohydrate content of zooplankton. Maximum carbohydrate percentage was recorded at S4 (9.68%) could be due the higher abundance of Copepods, Chaetognatha and Decapoda in the collected samples. Overall mean carbohydrate values were higher (*t*-test; p <0.05) at S4 compared to other study area (Fig. 2D).

Caloric value obtained in this study ranged from 1.35 to 2.72 kcal/g dry weight ($\bar{x}$ =1.8±0.2). In this study, calorific values significantly correlated with protein (r=0.2) and carbohydrate (r= 0.1). High calorific content (>2.0 kcal/g dry weight) was recorded during May-August S3 and S4station (Table 5). The lowest value obtained during September at S2 and S3. Maximum values (2.72 kcal/g dry weight) at S3 followed by (2.39

kcal/g dry weight) at S4 during August could be due to the dominance of Calanoid copepods and Decapod larvae (Fig. 2E). The lowest calorific content (1.3 kcal/g dry weight) was observed at S2 due to the presence of non crustacean forms such as Medusa, *Pleurobrachia globossa*, *Diphyes* sp.

Table 4 Monthly variations of carbohydrate content (% dry weight) of zooplankton.

Months	S1	S2	S3	S4
Oct-11	2.1	1.8	2.9	2.7
Nov-11	1.75	2.3	2.7	2.3
Dec-11	2.89	1.07	1.91	2.75
Jan-12	3.0	1.13	2.94	1.72
Feb-12	2.5	1.3	2.77	1.44
Mar-12	3.68	6.83	3.47	9.5
Apr-12	2.5	2.05	2.83	9.68
May-12	3.5	1.75	3.3	3.96
Jun-12	4.75	5.5	3.1	8.3
Jul-12	3.25	1.25	2.71	3.25
Aug-12	2.8	1.1	4.0	3.4
Sep-12	4.54	6.98	3.8	9.5

Table 5 Monthly variations of calorific content (kcal/g dry weight) of zooplankton.

Months	S1	S2	S3	S4
Oct-11	1.62	1.59	1.62	1.8
Nov-11	1.53	1.78	1.67	1.64
Dec-11	1.61	1.49	1.41	1.62
Jan-12	1.72	1.47	1.91	1.56
Feb-12	1.66	1.59	1.76	1.45
Mar-12	1.59	1.73	2.29	1.64
Apr-12	1.52	1.75	1.86	2.01
May-12	1.94	1.66	2.19	2.08
Jun-12	1.84	1.82	2.04	2.33
Jul-12	1.88	1.46	1.77	2.32
Aug-12	1.52	1.36	2.72	2.39
Sep-12	1.55	1.35	2.4	1.31

4 Discussion

Low biomass of zooplankton ($\bar{x}$ = 1.1±0.6) obtained in this study compared to that reported from the oceanic realm of this area (Goswami et al., 1981) could be due to the ecological distribution type of these organisms. However, the dry weight values are comparable to the values reported earlier from harbor waters of Visakhapatnam (Nageswara Rao and Ratnakumari, 2002) and Bay of Bengal (Sreepada et al., 1992). Zooplankton biomass of a particular environment depends upon the primary productivity and variation in the habitat temperature and salinity during that period.

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 (Nageswara Rao and Ratnakumar, 2002). However, protein content in zooplankton observed in this study is somewhat lower than an earlier report from this area (Goswami et al., 1981). The values recorded in this study are comparable to the earlier reports from Arabian Sea (Jagadeesan et al., 2010) and Bay of Bengal (Sreepada et al., 1992). 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 (Sreepada et al., 1992).

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 (Goswami et al., 1981), Arabian Sea (Nandakumar et al., 1988) and Bay of Bengal (Sreepada et al., 1992) but higher than Cochin backwaters (Madhupratap and Haridas, 1975). 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 (Goswami et al., 1981).

Carbohydrate content was poor ($\bar{x}$= 3.4±1.1) and lower compared to earlier reports from this area (Goswami et al., 1981), Arabian Sea (Nandakumar et al., 1988) and Bay of Bengal (Sreepada et al., 1992) which suggest that glycogen, the usual storage carbohydrate in zooplankters might not contribute substantially towards the body reserve (Goswami et al., 1981). 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 (Nageswara Rao and Ratnakumari, 2002).

The average calorific value (1.8±0.2) recorded in this study is lower compared to earlier study from this area (Goswami et al., 1981), Arabian Sea (Krishnakumari and Nair, 1988) and Bay of Bengal (Sreepada et al., 1992) but higher than that reported from harbor waters of Visakhapatnam (Nageswara Rao and Ratnakumari, 2002). Low calorific content in this study could be due the absence of some forms with high calorific content such as *Euphuasiadio meddeae* (3.72 kcal/g dry weight), *Pontellina plumata* (4.07 kcal/g dry weight), *Pontella* sp. (3.98 kcal/g dry weight) and Fish larvae (4.23 kcal/g dry weight) in zooplankton samples, that have been reported from the oceanic region of Andaman Sea (Goswami et al., 1981). 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.

5 Conclusions

This study is the first report on biochemical composition and calorific value of zooplankton from the coastal waters of Port Blair, South Andaman. 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 evident that zooplankton can be utilized as nutritional live feed for aquaculture. The variations in biochemical composition of zooplankton are influenced mainly by species composition and feeding activities of zooplankton. This is in accordance with the previous studies conducted elsewhere.

Acknowledgements

The authors are grateful to the authorities of Pondicherry University for providing the requisite facilities for the study. We are indebted to all the fishermen without their help this work would not have been possible. We are also thankful to Mr. A. Saravanan, Department of Disaster Management, Pondicherry University, for preparing the map of the study area.

References

Conway DVP, White RG, Hugues-Dit-Ciles J, Gallienne CP, Robins DB. Guide to the Coastal and Surface Zooplankton of the South-Western Indian Ocean. Occasional Publications. Marine Biological Association of the United Kingdom, Plymouth, UK, 2003

Dalal SD, Parulekar AH. 1986. Validity of zooplankton on biomass estimates and energy equivalent in the Indian Ocean. Indian Journal of Marine Science, 15: 264-266

Dubois M, Gills KA, Hamilton JK, et al. 1956. Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28(3): 350-356

Folch JM, Lees M, Sloane Stanley GH. 1956. A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry, 226: 497-509

Goswami SC, Krishnakumari L, Shrivastava Y. 2000. Diel variations in zooplankton and their biochemical composition from Vengurla to Ratnagiri, West coast of India. Indian Journal of Marine Science, 29: 277-280

Goswami SC, Rao TS, Matondkar GP. 1981. Biochemical composition of zooplankton from the Andaman Sea. Indian Journal of Marine Science, 10: 296-300

Hernandez Molejon OG, Alvarez-Lajonchere L. 2003. Culture experiments with *Oithona aculata* Farran, 1913 (Copepoda: Cyclopoida) and its advantages as food for marine fish larvae. Aquaculture, 219: 471-483

Jagadeesan L, Arivuselvan N, Thirumaran G, Anantharaman P, Balasubramanian T. 2010. Biomass and biochemical composition of zooplankton along the Arabian Sea, West Coast of India. Advance Journal of Food Science and Technology, 2(2): 96-99

Kasturirangan LR. 1963. A Key for the Identification of the More Common Planktonic Copepoda of Indian Coastal Waters. Council of Scientific and Industrial Research, New Delhi, India

Krishnakumari L. 1988. Biomass, organic carbon and calorific content of zooplankton from the Arabian Sea off Central West Coast of India. Indian Journal of Marine Science, 17: 78-80

Krishnakumari L, Nair VR. 1988. Biomass, organic carbon and calorific content of zooplankton from the Arabian Sea off Central West coast of India. Indian Journal of Marine Science, 17: 78-80

Madhupratap M, Haridas P. 1975. Composition and variation in zooplankton abundance in the Cochin backwaters from Cochin to Aleppy. Indian Journal of Marine Science, 4: 77-85

Madhupratap M, Venugopal P, Haridas P. 1979. Biochemical studies on some tropical estuarine zooplankton species. Indian Journal of Marine Science, 8: 155-158

Nageswara Rao I, Krupanidhi G. 2001. Biochemical composition of zooplankton from the Andaman Sea. Journal of Marine Biological Association of India, 43: 49- 56

Nageswara Rao I, RatnaKumari R. 2002. Biochemical composition of zooplankton from Visakhapatnam harbor waters, east coast of India. Indian Journal of Marine Science, 31: 125-129

Nandakumar K, Bhat LK, Wagh AB. 1988. Biochemical composition and calorific value of zooplankton from Northern Part of Central Arabian Sea. Indian Journal of Marine Science, 17: 48-50

Omori M, Ikeda T. Methods in Marine Zooplankton Ecology. John Wiley and Sons, New York, USA, 1984

Rajkumar M, Kumaraguru Vasagam KP, 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture, 261: 649-658

Rajkumar M, Kumaraguru Vasagam KP, Perumal P. 2008. Biochemical Composition of Wild Copepods, *Acartia erythraea* Giesbrecht and *Oithona brevicornis* Giesbrecht, from Coleroon Coastal Waters, Southeast Coast of India. In: Advances in Aquatic Ecology Vol-2. (Sakhare VB, ed). Daya Publishing House, New Delhi, India

Raymont JEG, Austin J, Linford E. 1964. Biochemical studies on marine zooplankton l. The biochemical composition of *Neomysis integr*. Journal du Conseil/Conseil Permanent International pour l'Exploration de la Mer, 28: 354-363

Sreepada RA, Rivonkar CU, Parulekar, AH. 1992. Biochemical composition and calorific potential of zooplankton from Bay of Bengal. Indian Journal of Marine Science, 21: 70-73

Støttrup JG. 2000. The elusive copepods: Their production and suitability in marine aquaculture. Aquaculture Research, 31: 703-711