

Elemental (C, H, N) composition of zooplankton from north Arabian Sea

S G P Matondka, K L Bhat, Z A Ansari & A H Parulekar
National Institute of Oceanography, Dona Paula, Goa-403 004, India

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Zooplankton samples collected from north Arabian Sea during March 1992 were analysed for elemental (C, H, N) composition. Estimated carbon, hydrogen and nitrogen concentrations displayed variations among different groups but their ratios were nearly stable in various samples. Carbon content as percentage of dry weight, varied from 8.2% (thaliacea, ostracoda and amphipoda as major groups) to 44.6% (copepoda and ostracoda as major groups). Similarly nitrogen content varied from 1.7% in thaliacean dominated hauls to 6.3% in copepods and ostracods dominated hauls. Hydrogen concentration was highest (7.3%) in copepoda and ostracoda and lowest (2.5%) in thaliacea and amphipoda. Mean values of carbon and nitrogen conversion factors. Such factors are now essentially needed for accounting role of zooplankton in sediment trap collections in Arabian Sea region.

Arabian Sea is a region of high biological productivity, influenced by monsoon and upwelling¹. Extensive phytoplankton blooms are noted during June-September period followed by zooplankton swarms from some sections of the Arabian Sea² where the dead and decaying planktonic organisms contribute significantly to downward flux of particles. Although, zooplankton diversity of Arabian Sea is extensively studied, information on elemental composition (C, H, N) of zooplankton is little known. Hence an attempt is made to study the CHN composition of coastal and offshore zooplankton from the Arabian Sea.

Materials and Methods

Zooplankton samples were collected by bongo net (mesh size 300 μm , mouth area 0.28 m^2) from 21 stations in the north Arabian Sea (Fig. 1) during 87th cruise of *FORV Sagar Sampada* (March 1992). Vertical hauls were made from 200 m to surface in offshore stations. Procedures involved for sample preparation, drying and proximate composition were as reported earlier³. Total C, H, N content were determined with a CHN autoanalyser (Perkin Elmer-PE 2400) using 1-2 mg of dry zooplankton powder weighed on a microbalance. Two replicates were analysed for each sample to account variability in analysis if any. Acetanalamide standard and blank were analysed after every 10 replicates.

Results and Discussion

The faunistic composition of Arabian Sea zooplankton during March 1992 is presented in Table 1.

The biomass of zooplankton across transect was highly variable, ranging from 3-500 ml.100 m^{-3} of water. Copepod formed the dominant group constituting 65.5 to 90% of total composition. Other forms like medusae, ostracodes, chaetognaths and thaliaceans were also common at some stations. Such a variability in the occurrence and abundance of different groups has been reported earlier for Arabian Sea⁴.

There were marked variations in the moisture content of zooplankton (Table 2). The dry weight as percentage of wet weight was 4.5 to 16.6% ($\bar{X} = 9.16\% \pm 3.79$). Since all major taxonomic groups were represented in the present study, an average 9.16% of wet weight may be considered as dry weight for Arabian Sea zooplankton for normalising sediment trap flux biomass for zooplankton contribution.

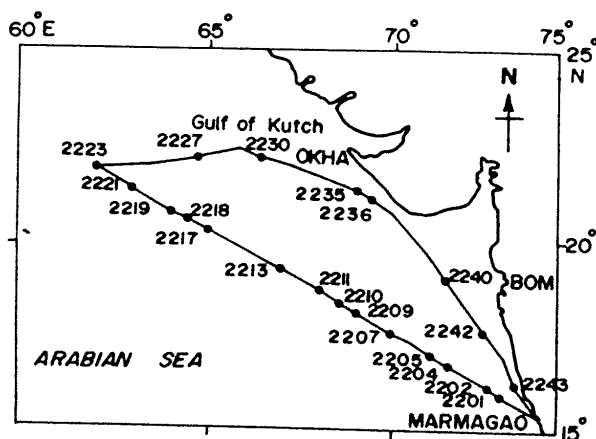


Fig. 1—Location of sampling stations

The C, H, N data are presented in Tables 2-4. A marked spatial variation was seen in carbon and nitrogen composition (Table 2). The carbon values varied from 8.2 to 44.6% and that of nitrogen from 1.7 to

7.9% on dry weight basis. Significant differences were noted between gelatinous samples and nongelatinous samples. In case of gelatinous samples, average carbon was $21.2 \pm 8.6\%$ and nitrogen was $4.1 \pm 1.9\%$ whereas in nongelatinous samples the corresponding values were $31.7 \pm 7.1\%$ and $5.71 \pm 1.3\%$ respectively (Table 3). In general for 21 stations studied carbon was $25.63 \pm 9.42\%$ and nitrogen was $4.79 \pm 1.81\%$ (Table 3). The differences were negligible between coastal (C = 27.2% and N = 4.9%) and offshore (C = 24.7% and N = 4.8%) stations. This may possibly be due to short time lag between the collection of samples of the two regions. In earlier studies low carbon (1-10%) and low nitrogen (1-5%) were recorded in gelatinous forms^{5,6}. Similarly high carbon (20-60%) and high nitrogen (6-15%) in crustacean zooplankton were also reported⁷⁻⁹.

It is evident from the analysis that at a given point of time, composition of different taxonomic groups prevailing in zooplankton samples is important in determining elemental composition (Tables 1, 2). The lowest recorded values corresponded to the samples mainly composed of gelatinous forms like medusae and thaliacians. High values were recorded in samples

Table 1--Percentage composition of zooplankton in Arabian Sea during March

Groups	Composition (%)
Medusae	0.02-2.34
Siphonophora	0.25-1.05
Polychaeta	0.12-1.05
Cladocera	1.00-1.47
Ostracoda	0.03-1.05
Copepoda	65.50-90.01
Amphipoda	0.06-0.35
Decapoda	0.3-1.06
Gastropod. larvae	0.52-1.84
Appendicularia	1.62-16.72
Fish eggs & larvae	0.20-0.52
Chaetognatha	2.38-6.44
Bivalve larvae	0.51-1.39
Pteropod	0.02-0.25
Thaliacea	0.01-10.00

Table 2--Elemental composition and dominant groups of zooplankton from Arabian Sea

St no (depth in m)	Dry wt as % wet wt	% Dry weight			Dominant groups**
		C	H	N	
*2201 (75)	12.5	33.8	5.2	5.3	Cop. Chae. Thali
*2202 (75)	4.5	32.9	4.9	6.3	Thali, Medu, Cope
*2204 (80)	16.1	27.8	4.1	5.1	Cope, Medu
2205 (200)	12.9	44.6	7.3	6.3	Cope, Ostra
2207 (200)	9.1	31.1	4.9	6.5	Cope, Ostra
2209 (200)	11.1	13.4	2.9	2.6	Thali, Ostra, Medu
2210 (200)	5.9	19.3	3.3	3.7	Medu, Ostra
2211 (200)	11.8	15.5	3.4	3.1	Medu, Amphi
2213 (200)	4.9	11.4	2.8	2.3	Medu, Ostra, fish egg
2217 (200)	4.4	23.3	3.2	3.5	Thali, Medu, Ostra
2218 (200)	5.6	37.3	5.6	8.5	Thali, Ostra
2219 (200)	6.2	8.2	2.5	1.7	Thali, Ostra, Amphi
2221 (200)	5.2	20.9	3.8	4.3	Thali, Ostra, Cope
2223 (200)	11.3	27.3	4.4	5.3	Thali, Medu, Siph
2227 (200)	16.6	35.9	5.5	7.9	Cope, Thali
2230 (200)	9.8	30.8	4.7	5.7	Amphi, Deca
*2235 (80)	9.6	23.3	4.1	4.6	Thali, Ostra
*2236 (70)	6.0	20.6	3.4	3.4	Thali, Amphi
*2240 (70)	8.2	22.3	3.6	3.8	Cope, Ostra, Chae
*2242 (60)	7.4	31.9	4.7	6.5	Cope, Ostra
*2243 (50)	13.6	24.9	3.9	4.2	Cope, Ostra
n = 21					
\bar{X}	9.16 ± 3.79	25.63 ± 9.42	4.2 ± 1.15	4.79 ± 1.81	

*Coastal stations, Gelatinous taxa dominated stations, **Cop = Copepoda, Chae = Chaetognatha, Thali = Thaliacea, Medu = Medusae, Ostra = Ostracoda, Amphi = Amphipoda

Table 3—Composition of coastal, offshore, gelatinous, nongelatinous, zooplankton from Arabian Sea

Parameter	Coastal	Offshore	Total	Gelatinous	Nongelatinous
Dry wt. (%)	9.8±4.0	8.8±3.7	9.2±3.8	7.2±2.9	11.8±3.4
C (%)	2712±5.2	24.7±11.4	25.7±9.4	21.2±8.6	31.7±7.1
H (%)	4.3±0.7	4.2±1.4	4.2±1.2	3.7±0.9	4.9±1.1
N (%)	4.9±1.1	4.8±2.2	4.8±1.8	4.1±1.9	5.7±1.3
C:N	6.6±0.6	6.1±0.9	6.3±0.9	6.1±0.7	6.6±1.1
C:H	6.4±0.5	5.7±1.2	6.0±1.1	5.6±1.2	6.5±0.3
C+H+N (%)	36.3±6.9	33.6±14.7	34.6±12.1	28.8±11.2	41.4±9.5
T organic (%)	40.2±7.3	46.6±12.7	44.2±11.2	44.4±11.5	45.4±11.0
Cal (kcal.g ⁻¹)	2.55±0.5	2.6±0.8	2.8±0.7	2.8±0.8	2.9±0.7
SP*	9.8±5.5	4.4±3.1	6.7±5.50	4.9±3.3	8.2±5.6
n	8	13	21	12	9

*SP=Secondary production (mg.m⁻³)

Table 4—Elemental ratio and organic content of zooplankton from Arabian Sea

St no	C:N	C:H	C+H+N (%)	Total organics* (% dry wt)	Caloric value (kcal.g ⁻¹)
2201	7.40	6.5	44.4	50.8	3.2
2202	6.1	4.7	44.1	40.1	2.6
2203	6.4	6.88	337.0	47.4	2.9
2205	8.9	6.4	60.2	58.7	3.6
2207	5.7	3.6	42.6	60.9	3.8
2207	5.6	6.3	42.6	60.9	3.8
2209	5.9	4.7	18.8	24.7	1.6
2210	6.0	5.8	26.3	34.2	2.1
2211	5.9	4.6	21.9	67.4	4.2
2213	5.7	4.2	16.5	52.9	3.5
2217	7.7	7.4	29.9	39.1	2.4
2218	5.1	6.7	51.1	52.8	23.4
2219	5.9	3.3	12.3	33.2	2.2
2221	5.7	5.5	29.1	50.8	3.8
2223	5.9	6.3	36.9	49.6	3.2
2227	5.3	6.5	49.4	34.0	2.3
2230	6.3	6.6	41.3	49.0	3.1
2235	6.0	5.7	31.9	37.9	2.4
2236	7.2	6.2	27.3	37.9	2.6
2240	6.8	6.2	29.7	26.5	1.7
2242	5.8	7.2	43.1	42.4	2.7
2243	6.9	6.3	33.0	38.9	2.5
X	6.29	5.96	34.6	44.2	2.8
	±0.87	±1.1	±12.1	±11.16	±0.7

*Total organics = protein + carbohydrate + lipids

with high percentage of crustaceans, particularly copepods at st. 2205. High values in crustaceans may be due to their direct feeding on C, N rich phytoplankton than other zooplankton groups.

In addition to above mentioned variations, seasonal and regional variations have also been reported in elemental composition of zooplankton from world oceans^{9,10} where carbon values were as high as 66% in

copepods and as low as 0.82% in ctenophores on dry weight basis. Beer⁸ observed 41.6% C and 9.26% N in copepods and 36.9% C and 7.83% N in other crustaceans sampled off Bermuda. These higher values were attributed to metabolic stage, species and age of specimen. Razuals¹¹ observed higher elemental carbon concentration for copepodites as compared to copepods. In another study¹² among 4 species of copepods, carbon and nitrogen concentrations ranged from 32.4-43.4% C and 9.3-11.5% N. In general, the variation due to composition of different taxonomic groups is larger in magnitude and not comparable with metabolic stages, season etc.

From present set of data it is observed that carbon is 25.63% on dry weight basis and nitrogen is 4.79% (Table 2). The routinely used mean values for zooplankton carbon for particle flux conversion¹³ is 35-40% which is much higher than Arabian Sea factor derived from present investigation (Tables 2-4). The higher value may be used in conditions like zooplankton swarms, aggregation of fecal pellets or similar conditions¹⁴. Earlier it has been observed that carbon can be 1.5 times higher in zooplankton after the phytoplankton blooms⁹.

Hydrogen values were 2.52% at st. 2219 to 7.28% at st. 2205. The hydrogen concentration of Arabian Sea zooplankton is slightly lower as compared to world ocean data where hydrogen concentrations were 6-11% for euphausiids and chaetognaths and 1-4% for pteropods⁹. In the Southern Ocean study⁶ higher hydrogen content in zooplankton was attributed to moisture that was retained by gelatinous tissues due to the limitation of traditional drying technique used. Considering 20% carbon as hydrogen¹⁵, the Arabian Sea zooplankton hydrogen values are comparable with those reported elsewhere from world oceans. From foregoing account it may be inferred that

gelatinous groups like salps, frequently observed in Arabian Sea do not interfere in estimation of elemental composition of gross zooplankton as seen earlier for the Southern Ocean⁶.

The C:N ratio is frequently referred as gross measure of zooplankton condition. Its apparent connection to lipid-protein make C:N a better indicator of environment in which zooplankton prevails. C:N values, in present study, remained almost stable (6.29 ± 0.87) at all stations (Table 4). This stability in C:N ratio was partly due to similar type of zooplankton composition prevailing in coastal and offshore samples (Table 2). C:N in the zooplankton varied in different geographic regimes. In case of Pacific Ocean⁷ C:N was 5.87 ± 3.1 and for Sargasso Sea⁸, it was 3.76 ± 0.66 . In another study of north-west Mediterranean¹⁶ the C:N ratio ranged from 2.5-7.9 the average being 4.2. With reference to world ocean data the particulate material derived from zooplankton in Arabian Sea should have C:N 5-6. Recently from sediment trap collections in the Arabian Sea it has been reported that the C:N ratio of settled material at 80 m was much higher (> 10) mainly due to algal matter rather than of zooplankton origin¹⁷. In sediment trap collections decomposed particles can be differentiated as phytoplankton or zooplankton based on average C:N values.

C:H ratio of the zooplankton samples was more or less stable (6 ± 1) at 21 stations. However, sum of C, H and N was highly variable (34.6 ± 12.1) in various samples examined. This variability was reflected particularly in gelatinous forms (28.8 ± 11) and crustaceans (41 ± 9). Hence, besides C:N, sum of elemental composition of sedimented particle may reveal the origin of particles to a particular trophic level, and domination of group of organisms in productivity processes.

Particle flux produced in the Arabian Sea is many a time dominated by phytoplankton (bloom) or and zooplankton (swarm). Phytoplankton are rich in elements and carbohydrates as biochemical constituent, whereas zooplankton are rich in protein-lipid and are poor in carbohydrate. During the present study proximate composition of zooplankton has been analysed. The sum of the organics derived from proximate composition of zooplankton (Table 4), was variable in nature at different stations studied. This was partly due to abiotic factors as well as environment and zooplankton composition. Total organics from Arabian Sea samples was $44 \pm 11\%$ of which protein was major constituent. By taking $N \times 5.78$ as protein⁶ it appears that protein in Arabian Sea samples accounted for major nitrogen content and non-protein nitrogen was negligible. Similarly, it was also observed that organic carbon was major part of total carbon

content³. These basic aspects of mineral composition of the zooplankton in Arabian Sea will be useful in differentiating origin of short term particle flux especially during upwelling period.

Zooplankton being secondary producers are ecologically important as linking organisms between first and third trophic level. Around 15 groups of zooplankton were recorded during present study (Tables 1, 2). Crustaceans were more abundant in coastal waters and gelatinous forms were prominent in offshore waters (Table 2). The secondary production (SP) of zooplankton was high in crustaceans ($\bar{X} = 8.2 \pm 5.6$) and hence coastal stations ($\bar{X} = 9.8 \pm 5.5$) (Table 3). The SP was low in gelatinous group ($\bar{X} = 4.9 \pm 3.3$) and hence in offshore stations ($\bar{X} = 4.4 \pm 3.1$) as presented in Table 3. The calorific content ($\bar{X} = 2 \pm 0.7$) was almost stable at all stations studied (Table 3). The mineral and organic content of gelatinous samples were reasonably high considering high water content in gelatinous tissue (Tables 2-4). This study suggests that gelatinous forms are equally energetic and may form the important component of particle flux in the Arabian Sea, during salp blooms⁴.

The world ocean picture on zooplankton CHN is also found to be interesting. The C varied from 0.6 to 69.81% ($\bar{X} = 25\%$) which is in the range of Arabian Sea data. Similarly N varied from 0.2 to 13.91 ($\bar{X} = 5\%$) which is also in close agreement with Arabian Sea data. The C:N ratio of Arabian Sea zooplankton (> 6) is much higher than world ocean average (≈ 5). Generally C:N ratio of zooplankton should remain stable of organisms from second trophic level as Redfield ratio. Since chemical processes in Arabian Sea are complex in nature and seasonally varying, the CHN composition of zooplankton during other season may be of further interest.

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