

## Biochemical Studies on Some Tropical Estuarine Zooplankton Species

M MADHUPRATAP, P VENUGOPAL\* & P HARIDAS\*

National Institute of Oceanography, Dona Paula, Goa 403 004

Received 27 January 1979; revised received 22 March 1979

Percentages of protein, carbohydrate and lipid which form the major biochemical constituents of 10 species of zooplankton from Cochin backwaters were estimated. Protein invariably formed the major constituent in terms of dry weight. Carbohydrate content was in general very poor. Both protein and lipid were low for organisms with higher water content and did not show any reciprocal relationship. The results in general supported the view that protein may function as a metabolic reserve in zooplankton and that the availability of a constant supply of food may render large amount of lipid storage unnecessary in tropical zooplankton.

Information on biochemical composition of tropical zooplankton especially from Indian waters is meagre. Estimation of biochemical constituents of zooplankton is important in understanding their physiological functions, metabolism and nutritive value which are relevant to the marine ecosystem, in its energy transfer and secondary production. In this paper major biochemical constituents of 10 zooplankton species from Cochin backwaters, are presented.

### Materials and Methods

Zooplankton was collected from the mouth of the estuary using a square net and was brought immediately to the laboratory live. Most of the species which are high saline (optimum range—20 to 30‰) were collected during March-April 1978 when the estuary attained its climax community. Two copepod species *Pseudodiaptomus annandalei* and *Acartia plumosa* which are medium saline (15-25‰) and the sergestid *Acetes cochinchensis* which tolerates wide salinity fluctuation were collected, during May.

All species except copepods were identified live and estimations made within a few hours of capture. Copepods were deep frozen, thawed later and rapidly sorted in cold water for estimations. All estimations for a species were made from animals of the same haul except for copepods. Estimation of protein was made by biuret method<sup>1</sup>, carbohydrate by the method of Dubois *et al.*<sup>2</sup>, as modified and described by Raymont *et al.*<sup>1</sup>, total lipid by the gravimetric method of Folch *et al.*<sup>3</sup> and total organic carbon by E1 Wakeel and Riley<sup>4</sup> method. Dry weight percentages of individual species was obtained after drying them to constant weight at 60°C<sup>5</sup>.

### Results

The results are presented in Table 1.

Protein formed the major constituent in all species investigated. Protein content was comparatively low in organisms with high water content such as ctenophora and hydromedusae and ranged between 30 and 40% in terms of dry weight. In other species it ranged between 50.9% (in *Acartia centrura*) and 77% (in *Acartia plumosa*).

Carbohydrate content was extremely low and ranged between 0.39 and 4.18% in terms of dry weight. The value 4.18 obtained for *Acartia plumosa* should be treated with some bias since the specimens of this species had some algal particles sticking to their appendages which could not be completely removed inspite of repeated washings and the high carbohydrate content could be an artifact due to this. Lipid content was very low for the more watery organisms (ctenophora, hydromedusae and chaetognatha) and ranged from 6.02 to 8.91% in terms of dry weight. It was also on the low side for other species (9.23 to 14.12%) compared to reported values for zooplankton from higher latitudes. Total organic carbon was estimated for mixed zooplankton (gelatinous and non gelatinous separately) and the average of 4 estimates was 5.1% for the former and 33.1% for the latter in terms of dry weight.

### Discussion

Considerable seasonal variation in the biochemical fractions of zooplankton from higher latitudes as well as warm waters have been reported<sup>6-10</sup>. But in the Cochin backwaters, occurrence of various species is by itself seasonal, the high saline species investigated occur only during the premonsoon period (December-April) when the estuary becomes saline<sup>11</sup>. However, in

\*Present address: Regional Centre of NIO, Cochin 682018

Table 1—Protein, Carbohydrate and Lipid Content and Dry Weight Percentages of 10 Zooplankton Species from Cochin Backwaters  
[Values are expressed as per cent wet weight (WW) or dry weight (DW)]

	Protein		Carbohydrate		Lipid		Percentage of dry weight
	WW	DW	WW	DW	WW	DW	
Ctenophora							
<i>Pleurobrachia globosa</i>	1.63	39.77	0.03	0.64	0.25	6.02	4.09
Hydromedusae							
<i>Eirene ceylonensis</i>	0.81	30.34	0.01	0.39	0.27	8.11	3.44
<i>Eutima commensalis</i>	0.86	35.69	0.04	1.96	0.34	8.91	2.43
<i>Blackfordia virginica</i>	0.98	32.11	0.02	0.58	0.27	8.72	3.07
Chaetognatha							
<i>Sagitta enflata</i>	8.33	75.83	0.16	1.47	0.69	6.32	10.99
Copepoda							
<i>Pseudodiaptomus annandalei</i>	11.12	74.79	0.29	1.94	1.71	11.53	14.88
<i>Acartia centrura</i>	8.57	50.93	0.17	1.02	2.21	14.12	16.83
<i>A. plumosa</i>	10.60	77.00	0.63	4.18	No data		13.32
Sergestidae							
<i>Lucifer hanseni</i>	8.77	65.22	0.41	3.03	1.12	9.23	13.44
<i>Acetes cochinensis</i>	14.45	75.67	0.43	2.14	2.48	12.37	20.15

tropical waters zooplankton have comparatively shorter life span than cold water species. Hence several generations can occur within short periods and variations in biochemical composition between generations would need further investigation.

It is fairly well established that protein forms the major fraction in terms of dry weight in zooplankton. Mean values in terms of dry weight given by Raymont *et al.*<sup>1,8,12</sup> are 57% in the euphasid *Meganyctiphanes norvegica*, 58% in several decapods, 60% in several oceanic decapod plankton and 70.9% in the mysid *Neomysis intiger*. Reeve *et al.*<sup>10</sup> have given the mean protein content of the chaetognath *Sagitta hispida* as 52.9% and Mayzaud and Martin<sup>13</sup> have reported 54.2% for the chaetognath *S. elegans* and 44.5% for the copepod *Calanus finmarchicus*. Nakai<sup>14</sup> has given the range of protein from 34.8% for the copepod *Calanus plumchrus* to 82.6 in *Acartia clausi*. Ferguson and Raymont<sup>9</sup> have reported protein values for the euphasid *Euphasia superba* ranging from 37 to 56.3%. From Cochin backwaters Nair *et al.*<sup>15</sup> have reported 64.4% for the chaetognath *Sagitta bedoti* and a range of 52.4 to 63.9% for some other groups of zooplankton. The protein fractions of species in the present study also fall within the above ranges except for the ctenophora *Pleurobrachia globosa* 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<sup>7,14</sup> but such a relationship was generally not apparent in the present study. Total lipid content was generally low compared to reported mean values from colder waters, but was usually close to the lower values of the ranges (10 to 29—*Meganyctiphanes norvegica*, 16 to 34—*Euphasia superba*, 9 to 15—*Neomysis intiger*). Raymont *et al.*<sup>12</sup> reported the lipid content of *Sergestes* sp. as 29% and Reeve *et al.*<sup>10</sup> gave the lipid range of *Sagitta hispida* as 9 to 27 with 17 as the mean percentage. Absence of a reciprocal relationship between protein and lipid was especially noticeable in ctenophora and hydromedusae in which both protein and lipid content was very low. Lee<sup>16</sup> also observed comparatively low lipid content for the ctenophores *Pleurobrachia pileus* (9%) and *Beroe cucumis* (14%) compared to copepod species which had a high lipid content (*Calanus finmarchicus*—47%). Conover and Corner<sup>17</sup> observed the lipid changes of the cold water oceanic copepod *Calanus hyperboreus* to vary from 15 to 50% of dry weight and Conover<sup>18,19</sup> found that the lipid content of this species may increase to as much as 60%. Lee and Hirota<sup>20</sup> suggested a geographical pattern in the distribution of lipid among copepods and an increase

in lipid content with deep water and high latitude species compared with species in near surface waters or low latitudes.

The general low carbohydrate content in zooplankton led to contemplations on the functional role of other biochemical fractions in their metabolism. Raymont and Conover<sup>21</sup> felt that the carbohydrate from the food may be oxidised directly by zooplankton or that fats may be oxidised on need or stored as principal reserve food. Later evidences indicated that the neutral lipids available for metabolic purposes would not amount to more than a fraction of the total lipids and hence the animals would have to feed more or less continuously to fulfill their immediate needs<sup>22</sup>. Considering these, it was felt that although lipid would function as an important food reserve, protein may also be utilised and function as a reserve food<sup>7,10,17,19,23-25</sup>.

Studies on the mysid *Neomysis integer*<sup>26</sup> indicated that on starvation amino acids from protein appear to be mobilised and subsequently deaminated with a rapid rise in ammonia excretion. Loss of protein in zooplankton under starved conditions indicating its utilisation have been demonstrated<sup>10,24,25</sup>. Mobilising protein for metabolic requirements would be especially true for tropical zooplankton like the species in the present study which have lower lipid content.

Lee<sup>16</sup> observed that ctenophores and *Sagitta* which had low fat content could be starved only for 48 hr after which they died, but copepods with high lipid content could be starved up to a month. He found that in both ctenophores and *Sagitta* triglycerides and wax esters (neutral lipids) were very low and that phospholipids (structural lipids) showed little variation in zooplankton species regardless of the changes in quantity or type of food. Copepods and *Lucifer* from Cochin backwaters survived in starved conditions in the laboratory only for 3 to 5 days<sup>27</sup>. Exceptionally high values of fat (60%) were reported for the isopod *Cirrolana fluviatilis* from Cochin backwaters<sup>28</sup> and it is of interest that this species is not a continuous feeder<sup>29</sup>. Mayzaud and Martin<sup>13</sup> suggested that small neritic copepods because of their body size present a high level of turnover of their biomass apparently as an alternative of high storage and, therefore, do not contain large amount of lipid material. Lee and Hirota<sup>20</sup> pointed out that zooplankton of tropical region have more constant supply of food than in higher latitudes so that an elaborate structure for lipid storage is unnecessary for them. Lee *et al.*<sup>30</sup> found sharp variations in lipid content between surface living copepods (*Candacia curta*—3%) and deep water copepods (*Bathycalanus* sp—59%, *Heterorhabdus* sp—61%) and concluded that the function of protein as an important energy reserve may be true for zooplankton

having low lipid content, but less important for the lower mesopelagic and bathypelagic copepods rich in lipid. 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<sup>31</sup> and carnivores like ctenophora, hydromedusae and chaetogtha during the saline period when zooplankton abound in the estuary<sup>11</sup> would render large lipid storage unnecessary for them.

The average organic carbon content of non gelatinous zooplankton compare well with the value of 30% reported for *Neomysis integer*<sup>6</sup>. Low organic carbon content has been reported<sup>32</sup> for organisms (ctenophora—6.4%, salps—9.4%, cnidarians—13.8% to 31.4%) with high fresh to dry weight ratios as observed for gelatinous organisms.

The total recovery rates were low especially for gelatinous organisms which contain little chitin. Raymont *et al.*<sup>23</sup> have found that the non protein nitrogenous (NPN) fraction of *Neomysis integer* varies with environmental salinity. Reeve *et al.*<sup>10</sup> attributed the low totalised figures they obtained for *Sagitta hispida* to the presence of NPN compounds which was highly variable (mean—37% of total nitrogen content) and concluded that variability of NPN was correlated with environmental salinity changes. The estuarine species in the present study withstood considerable salinity variations<sup>11</sup> and may have a ready high NPN content to cope with the wide fluctuations that occur in the estuary.

#### Acknowledgement

The authors are indebted to Dr S.Z. Qasim, Director, and Dr T.S.S. Rao for their kind suggestions on the study and the manuscript.

#### References

- 1 Raymont J E G, Austin J & Linford E, *J Cons perm int Explor Mer*, **28** (1964) 354.
- 2 Dubois M, Gilles K A, Hamilton J K, Rebers P A & Smith F, *Analyt Chem*, **28** (1956) 350.
- 3 Folch J, Lee M & Solane Stanley G H, *J biol Chem*, **226** (1956) 497.
- 4 El Wakeel & Riley J P, *J Cons perm int Explor Mer*, **22** (1957) 180.
- 5 Lovegrove T, in *Some contemporary studies in marine science* edited by H Barnes (George, Allen & Unwin Ltd, London) 1966, 429.
- 6 Raymont J E G, Austin J & Linford E, in *Some contemporary studies in marine science* edited by H Barnes (George, Allen and Unwin Ltd, London) 1966, 597.
- 7 Raymont J E G, Sreenivasagam R T & Raymont J K B, *Deep Sea Res*, **16** (1969) 141.
- 8 Raymont J E G, Sreenivasagam R T & Raymont J K B, *Deep Sea Res*, **18** (1971) 1167.

- 9 Ferguson C P & Raymont J K B, *J mar biol Ass, UK*, **54** (1974) 719.
- 10 Reeve M R, Raymont J E G & Raymont J K B, *Mar Biol*, **6** (1970) 357.
- 11 Madhupratap M & Haridas P, *Indian J mar Sci*, **4** (1975) 77.
- 12 Raymont J E G, Austin K & Linford E, *Deep Sea Res*, **14** (1967) 113.
- 13 Mayzaud P & Martin J L M, *J exp mar Biol Ecol*, **17** (1975) 297.
- 14 Nakai Z, *Spls Publs Tokai Fish Res Lab*, **5** (1955) 12.
- 15 Nair R V, Saraswathy M, Saraladevi K & Gopalakrishnan T C, *Mahasagar- Bull natn Inst Oceanogr*, **8** (1975) 109.
- 16 Lee F R, *J Fish Res Bd Can*, **31** (1974) 1577.
- 17 Conover R J & Corner E D S, *J mar biol Ass, UK*, **48** (1968) 49.
- 18 Conover R J, *Rapp Cons Explor Mer*, **153** (1962) 190.
- 19 Conover R J, in *Food Relation and nutrition of zooplankton* (Univ Rhode Island) 1964, 81.
- 20 Lee F R & Hirota K, *Limnol Oceanogr*, **18** (1973) 227.
- 21 Raymont J E G & Conover R J, *Limnol Oceanogr*, **6** (1961) 154.
- 22 Raymont J E G, *Some investigations on biochemical composition of marine zooplankton* In *Essays in Hydrobiology* (Univ of Exeter) 1972, 683.
- 23 Raymont J E G, Austin J & Linford E, *J mar biol Ass, UK*, **48** (1968) 735.
- 24 Cowey C B & Corner E D S, *J mar biol Ass, UK*, **43** (1963) 495.
- 25 Linford E, *J Cons perm int Explor Mer*, **30** (1965) 16.
- 26 Raymont J E G & Krishnaswamy S, *Int Revue ges Hydrobiol Hydrogr*, **53** (1968) 563.
- 27 Madhupratap M, Venugopal P & Haridas P, Unpublished data.
- 28 Gopalakrishnan T C, Nair K K C, George Peter, M Sankaranarayanan V N & Rao T S S, *Indian J mar Sci*, **6** (1977) 151.
- 29 Gopalakrishnan T C, Personal communication.
- 30 Lee F R, Hirota J & Barnett M R, *Deep Sea Res*, **18** (1971) 1147.
- 31 Qasim S Z, in *Marine food chains* edited by J H Steele (Oliver & Boyd, Edinburg) 1970, 45.
- 32 Curl H, *Rapp Cons Explor Mer*, **153** (1962) 183.