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Biochemical composition of *Lucifer hanseni* from the Cochin estuary

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ABSTRACT

Biochemical composition and the elemental chemical constituents of the planktonic sergestid shrimp, *Lucifer hanseni* Nobili were estimated during October 1991 - May 1992 from a selected station off Vypin island in the Cochin estuary. 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. An inverse relation was evident between the moisture content of the shrimp and its lipid level. Carbohydrate content of the organism was found complementary to its lipid content. Decrease in carbohydrate content was recorded during periods of low salinity. Values of chitin and ash were less variable. There was marked seasonal variation in the moisture content. Calorific content of *L. hanseni* estimated as 4.527 k cal/g ash free weight was found comparable with that of other cadidate species selected as live feed. The average values of carbon, nitrogen and hydrogen were 39.84%, 8.73% and 6.09% respectively of dry weight.

Introduction

The epiplanktonic shrimps of the genus *Lucifer* have a significant role in the food web of warm waters as indicators of pelagic fishing grounds as well as nursery grounds of fishes and prawns (Huang and Fang, 1987). A rapid turnover of generations, each with a short adult life span of 30-40 days and maturing within 19 days at 30°C, sequential spawnings and carrying of eggs until hatching characterize the life strategy of this small shrimp (Lee *et al.*, 1992). Moreover, *Lucifer* sp. is reported to be a hardy laboratory animal responding well to a variety of food types, container sizes and rough handling (Zimmerman, 1973). Therefore with the view to assess the suitability of these shrimps as potential live feed for larvae of fishes and prawns, the present work was undertaken to estimate the nutritional value of *L. hanseni*, the most commonly occurring pelagic shrimp in the estuarine waters.

Materials and methods

Zooplankton samples were collected fortnightly during October 1991 - May 1992 from a selected station off Vypin islands in the Cochin estuary (Lat. 09° 58' N., Long. 76°16' E). Owing to the distinct seasonal fluctuation in their abundance, the present

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investigation on *L. hanseni* was restricted to October - May, when they were available in sufficient quantities. Adults of *L. hanseni* were sorted out and the estimations done on fresh samples in triplicate. Moisture content, total protein, carbohydrate, chitin and ash were estimated following standard methods proposed by Raymont *et al.* (1964). Total lipid was estimated by the Sulphophosphovanillin method (Barnes and Blackstock, 1973). Simultaneous dry weight measurements (Lovegrove, 1966) were made. Calculated values are expressed as percentage of wet and dry weights. Carbon, nitrogen and hydrogen were determined using a CHN analyser (Heraeus - CHN). Caloric content was calculated using the results of CHN analyses as per the methodology given by Gnaiger and Bitterlich (1984). The organic carbon fraction in ash-free biomass, w_c is calculated as:

$$w_c = \frac{tot\ ^{w}c\text{-}ash^{w}\ c \times w_{ash}}{1 - w_{ash}}$$

where, $tot^{w}c$ is total carbon mass in the total dry biomass ((g total C) / (g_dw)), $ash^{w}c$ is the inorganic carbon fraction in the ash ((g inorganic C)/(g ash)), and w_{ash} is the mass fraction of ash in the dry weight ((g ash)/(gd^{w})). The energy content in the ash free biomass $\Delta_c h$ (kJ/$g_{af}{}^{W}$)) is calculated using the formula $\Delta_c h = 11.5 \times (1 - {}^{w}H_2O) - 66.27 \times w_c$

where ${}^{w}H_2O$ is the generally estimated residual water fraction of 0.06 (Gnaiger and Bitterlich, 1984.).

Results

Protein was found to be the major component varying from 57.03% in February to 69.76% in November, averaging 63.35% of the dry body weight (Table 1). Lipid varied from 9.69% in October to 15.87% in February with a mean value of 12.57% of the dry body weight. Carbohydrate was low averaging 3.61% of the dry body weight. Though variations occurred, the amount of carbohydrate was always small; minimum being 3.00% of dry weight in October and maximum 4.59% of dry weight in April. Chitin and ash contents together was 19.27% of the dry body weight in February and 17.06% in October. During October, the ash content was 12.9% and chitin 4.1% of the dry body weight. Moisture content was found to vary from 80.35% in May to 87.00% in October with an average value of 84.55%. Seasonal variation in the moisture content was evident in the present study. The mean moisture content during the premonsoon season was 81.76% and during the postmonsoon season it was 86.95%.

An inverse relation was observed between the water content and the lipid level. During the low saline month of October when the moisture content of the shrimp was the highest (87.00%), the lipid content registered was the lowest (9.69% dry weight). The lipid content increased to as much as 15.87% of dry weight in February when the moisture content was found reduced to 85.57%. From March to May when the moisture content was lower (80.35-83.6%), the lipid component remained higher (14.06 - 14.91%). A similar inverse relation was also observed between the moisture and the carbohydrate contents. The mean value of carbohydrate was 4.14% of dry weight during the premonsoon season when the mean moisture content was 83.3% while the mean value of carbohydrate during the postmonsoon season was 3.30% dry weight when the mean moisture content was 86.56%.

The lipid and protein contents were also found to bear a reciprocal relationship. In February, when the lipid content was the highest, the protein content was the lowest recorded (57.03% of dry weight). In October when the lipid content was the lowest, the protein content recorded the high-

TABLE 1 . *The biochemical components of* Lucifer hanseni *from the Cochin estuary*

	Percent of dry weight	Water content %	Percent wet weight			Percent dry weight		
			Protein	Carbohydrate	Lipid	Protein	Carbo-hydrate	Lipid
January	13.36	86.64 ± 0.535	8.51 ± 0.367	0.49 ± 0.0462	1.49 ± 0.338	63.70	3.67	11.15
February	14.43	85.57 ± 0.090	8.23 ± 0.155	0.54 ± 0.104	2.29 ± 0.273	57.03	3.74	15.87
March	16.40	83.60 ± 0.482	9.66 ± 0.482	0.66 ± 0.156	2.35 ± 0.353	58.90	4.02	14.33
April	17.00	83.00 ± 0.889	10.32 ± 0.747	0.78 ± 0.085	2.39 ± 0.587	60.71	4.59	14.06
May	19.65	80.35 ± 0.994	10.88 ± 0.785	0.83 ± 0.052	2.93 ± 0.308	59.98	4.22	14.91
October	13.00	87.00 ± 0.73	9.07 ± 0.402	0.39 ± 0.085	1.26 ± 0.095	69.76	3.00	9.69
November	13.40	86.60 ± 0.797	9.35 ± 0.474	0.41 ± 0.057	1.31 ± 0.071	69.78	3.05	9.78
December	14.00	86.00 ± 0.819	9.37 ± 0.488	0.49 ± 0.078	1.51 ± 0.12	66.92	3.50	10.78

TABLE 2 . *Chemical composition of* Lucifer hanseni *from the Cochin estuary*

	Percent dry weight			
	C	N	H	C:N Ratio
January	37.23	8.296	5.693	4.49
October	41.56	9.461	6.292	4.39
November	42.91	9.170	6.426	4.68
December	37.67	8.362	6.021	4.52

est value (68.84% of dry weight). During the period from November to May, comparatively lower protein and higher lipid contents were observed.

Of the elemental components in *L. hanseni,* carbon was the major component with a mean value of 39.84% of dry weight which varied from 37.23% in January to 42.91% in November. In contrast to carbon, the nitrogen content (average 8.73% of dry weight) was rather stable and varied from 8.30% in January to 9.46% in October. The average hydrogen content was 6.108% of dry weight, ranging from 5.693% in January to 6.426% in November. The values of C:N ratio were fairly constant and varied from 4.39% to 4.68%. The caloric content of *L. hanseni* estimated in October was 4.527 k cal/g ash free weight.

Discussion

The high moisture content of *L.hanseni* is comparable to those reported by Madhupratap *et al.,* (1979) for *L.hanseni* from Cochin backwaters (86.5%) and Omori (1969) for *Lucifer* sp. from the North Pacific Ocean (86.7%). High moisture content is reported to be characteristic of planktonic decapods. According to Balachandran (1980) the water content in the larvae of *Penaeus* spp. vary from 80.1 to 86.4%. Results indicated a seasonal fluctuation in the moisture content of *L.hanseni.* Higher values were observed in samples collected during the postmonsoon season when compared to those obtained during the premonsoon season. The weight and chemical composition of zooplankton are known to vary markedly with internal and external conditions. Some zooplanktonic animals absorb water when their organic dry weight is reduced (Raymont *et al.,* 1971b). Low nutrition has been suggested as a factor for higher water absorption in zooplankton (Gopalakrishnan *et al.,* 1977). Variation in water content has also been attributed to variation in the habitat salinity as proven experimentally in juveniles of *Penaeus indicus* (Kalyanaraman, 1983). An inverse relationship between the water content and the lipid level was evident in the present study. During the postmonsoon season when salinity was comparatively low in the estuary and water retention high in the organism, the carbohydrate content was lower than that estimated during the high saline premonsoon season. Utilization of carbohydrate reserves during periods of stress such as low salinity has been reported in a variety of estuarine animals (Reethamma, 1991). Balachandran (1980) is of the opinion that variations in the relative abundance between the water content and the lipid and carbohydrate contents may be due to variations in the retention of metabolic water since oxidation of different nutrient components may release varying quantities of metabolic water.

Of the biochemical constituents estimated for *L.hanseni*, protein formed the major fraction with the value of 68.35% in terms of dry weight. Madhupratap *et al.*, (1979) reported protein content of 65.22% of dry weight (8.77% of wet wt.) for *L.hanseni* and 75.67% of dry weight (14.485% of wet wt.) for *Acetes cochinensis* from the Cochin backwaters. Nair *et al.*, (1975) and Gopalakrishnan *et al.*, (1977) recorded protein values ranging from 47 to 63.9% of dry weights for several groups of zooplankton from the Cochin estuary. Information from various other localities in the seas around India revealed that protein formed the major constituent of the organic matter in the different species of zooplankton contributing to the main metabolic reserve substrate in tropical zooplankton (Austin, 1970; Goswami *et al.*, 1981). Mobilisation and utilisation of protein were demonstrated under starved conditions in the chaetognath, *Sagitta hispida* (Reeve *et al.*, 1970) and during environmental stress such as low and fluctuating salinity.

The variation observed in the amounts of total protein and lipid in this study might be due to the change over from an essentially carnivorous diet during the premonsoon season when zooplankton biomass in the estuary was at its peak to a predominantly herbivorous diet during the postmonsoon season when phytoplankton blooms were prevalent. (Silas and Pillai,1975). During the premonsoon season from February to May, the relative amount of protein was found to be suppressed by a much higher build up of lipid reserves. The inverse relation was also evident during the postmonsoon season when the protein content was higher than the lipid content. Similar reciprocal relationship between the two fractions has been noted in the euphausid *Meganyctiphanes norvegica* (Raymont *et al.*, 1969) and in the amphipod, *Jassa falcata* (Nair and Anger, 1980) in which protein was negatively and lipid positively correlated with the amount of suspended food in the water.

Lipid is regarded as an important metabolic substrate in zooplankton which may be oxidized directly when needed or stored as the principal food reserve. Size, spawning, maturity, season, geographical location and diet are all reported to affect the lipid content of a species (Fisher, 1961). A review of the work on the analyses of the lipid content indicates very high values for zooplankton from high latitudes at times. The variation is believed to reflect storage and at times extensive utilization. In contrast, zooplankton in tropical and subtropical waters having a more constant supply of food do not contain large energy reserves (Raymont *et al.*, 1969).

The lipid observed in the present study agrees with the value (9.23% dry weight) reported by Madhupratap *et al.*, (1979) for *L.hanseni* from Cochin backwaters. According to Nair *et al.*, (1975) the lipid component of the major groups of zooplankton from the Cochin backwaters vary during January - March and it was 12.4% for decapod larva, 19.4% for mysids and 16.5%

for the sergestid, *Acetes* sp., all values estimated as percent dry weight. The lipid values were low for the zooplankton from the Andaman Sea with a mean of 11.9% of dry weight (Goswami *et al.*, 1981).

However the biochemical analyses of mixed zooplankton from different localities in the north eastern and central Arabian Sea (Nandakumar *et al.*, 1988; Krishnakumari and Achuthankutty, 1989; Bhat and Wagh, 1992) and from the north west Bay of Bengal (Krishnakumari and Goswami, 1993) all show a low lipid content varying from 2.51 to 12.1% of their dry weights. Protein was found to be the principal component varying from 16.85 to 44.87% and carbohydrate, the lowest component varying from 1.4 to 4.33% of weights. Fisher (1961) was of the opinion that the lipid concentrations from different sea areas reflect the productivity of the area.

The carbohydrate content of *L. hanseni* in the present study was low when compared to other zooplankters from a variety of habitats and geographical localities. The mean value of carbohydrate estimated in the present study (3.51% of dry wt.) agrees with that reported for *L. hanseni* (3.03%) from the Cochin backwaters (Madhupratap *et al.*, 1979). Work on some dominant zooplankton groups from Indian waters showed low values in all the organisms investigated and a range of 1.4-3.21% was reported for mixed zooplankton from the north eastern Arabian Sea (Krishnakumari and Achuthankutty, 1989). Such low values could be due to the fact that glycogen does not form a substantial part of the body reserves in zooplankton.

The ash content of *L. hanseni* estimated in this study is similar to that reported for *Lucifer* sp. (11.9% of dry weight) by Omori (1969). Chitin content is also well within the range reported for planktonic decapods (3-6% dry weight) by Raymont *et al.* (1967) and for the genus *Acetes* (4% of dry weight) by Nair *et al.* (1975). According to Lee *et al.* (1992) *L. faxoni* produces 4 to 5 broods within about 14 days, moulting in between subsequent ovipositions. Such frequent moultings could probably lead to smaller quantities of chitin.

The carbon, nitrogen and hydrogen values and the C:N ratio of *L. hanseni* determined in this study compare well with those reported for *Lucifer* sp. (carbon 41.1%, nitrogen 9.3%, hydrogen 6.7% and C:N ratio 4.4) from the North Pacific Ocean (Omori, 1969). Expression of zooplankton productivity by carbon equivalent is considered to be a reliable method. Fluctuations of the carbon content have been attributed to age and physiological state of the species (Gupta, 1977). Omori and Ikeda (1984) after determining the C, H and N contents in geographically different locations found that the carbon content in the tropical zooplankton was always lower than 45%, while that of the boreal species could be as high as 65% reflecting large accumulation of lipid in the body. In contrast to carbon, the nitrogen content was rather stable and usually around 10% of the dry weight or less (Omori and Ikeda, 1984). The average hydrogen content in zooplankton was about 6 to 10% of the dry weight (Omori, 1969). In general, species with high carbon content are reported to have high hydrogen content. Some relation exists between the elemental components and the proximate composition. The C:N ratio of the animals increased with lipid:protein ratio; the ratio of the tropical species fairly constant and was found low throughout the year.

The calorific content of *L. hanseni* from the Cochin estuary estimated in this study as 4.527 kcal/g ash-free weight is comparable with that reported for the adults of *Lucifer chacei* from Kaneohe Bay, Hawaii 4.818 kcal dry weight and 5.770 kcal/g ash free dry weight (Zimmerman, 1973).

Gopalakrishnan *et al.* (1977) recorded the calorific content of *Acetes* sp. as 5.740 kcal/g dry weight. A review of the energy value estimated for the mixed zooplankton from various localities in the Indian waters indicate the range from 2.59 to 5.74 kcal/g dry weight (Qasim *et al.*, 1978; Matondkar *et al.*, 1995). The energy value of *L.hanseni* as obtained in the present study is comparable to that reported for the brine shrimp, *Artemia salina* (5.152 kcal/g dry weight) which is widely used in aquaculture practices (Zimmerman, 1973).

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