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VARIATION IN BIOCHEMICAL COMPOSITION OF THE GREEN MUSSEL *PERNA VIRIDIS* LINNAEUS FROM NORTHERN ARABIAN SEA

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The annual cycle in total protein, lipid, glycogen caloric values, ash and tissue weight of the green mussel *Perna viridis* were studied during the year 1981. The percentage composition of these parameters was described along with the weight composition of a standard size mussel (65 mm). The protein and lipid content paralleled the changes in tissue weight which showed a decline during the spawning period (July to October). There is an inverse relationship between glycogen and protein and tissue weight. The glycogen content reached its minimum in June and thereafter rose gradually to reach its peak in October-November. The glycogen level was very low compared to other mussel species. Changes in biochemical contents were also reflected in calorific value which exhibits a seasonal cycle dropping to lowest values during the spawning season. The mean caloric values of dry tissue weight were 4.63 Kcal/g ash-inclusive and 5.21 Kcal/g ash-free.

INTRODUCTION

Studies on biochemical changes in mussels are mostly centered on the species of *Mytilus*. The work on energy substrates and biochemical composition of species of *Mytilus* has been extensively reviewed by Giese [1-3] and Gabbot [4]. Comparable studies on species of *Perna*, an allied genus of *Mytilus*, are very few [5, 6], from Thailand and India, respectively.

The green mussel, *Perna viridis* Linn. occurs lower in the intertidal zone of the rocky beach at Manora facing direct surf action, at Native Jetty and Sandspit where they are exposed only at very low tides. In addition they occur in considerably large numbers attached to buoys, ship hulls and other floating objects in the Manora channel. This species was reported to be found in relatively large number at Gwadar on the Baluchistan coast [7]. The ecology and gonadal changes of *Perna viridis* from the Karachi coast have been described by Barkati and Ahmed [8].

The present study forms part of a series of investigations designed to document the seasonal variation in energy metabolism of marine invertebrates, especially the economically important bivalve species of northern Arabian sea [9, 10].

MATERIAL AND METHODS

Individuals of *Perna viridis* were collected for a period of one year from January 1981 to December 1981 from the Manora channel where they attach to buoys, ship hulls and other floating objects. These mussels therefore stimulate in characteristics to cultured mussels which grow from floating structures. Their shells were cleaned of the encrusting organisms and kept overnight in clean filtered seawater for defaecation. The mussels were then cut open and wet tissue weight obtained on an electric balance. The tissues were dried in an oven at 80° for 48 hr and weighed.

Biochemical determinations were carried out on oven dried tissues. Nitrogen was determined by microkjeldahl method [11] and was multiplied by 6.25 to get protein concentration, and lipid was extracted following the method of Folch *et al.*, [12]. To determine the glycogen content, method described by Caroll *et al.*, [13] was employed. Ashing was done in a muffle furnace at 550° for 6 hr. Caloric values of the mussel tissue was determined by utilizing two methods: (a) by combustion of dried tissue in Parr-adiabatic oxygen bomb calorimeter, (b) by converting the biochemical components to caloric values using the following caloric equivalents: Protein 5.65 (calculated as N x 6.25), lipid 9.45, and glycogen 4.2 Kcal/g, as carbohydrates of bivalves are mainly composed of glycogen [14].

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RESULTS

Dry tissue weight. Seasonal variations in percent dry tissue weight of mussels are illustrated in Fig. 1. The tissue weight increased rapidly from 20.4% in January to reach the maximum of the year (25.6%) in April. A continuous and gradual decline in tissue weight occurred during late summer and autumn. The lowest values were recorded in November. A minor increase in September was associated with improved feeding conditions such as phytoplankton abundance at that time of the year.

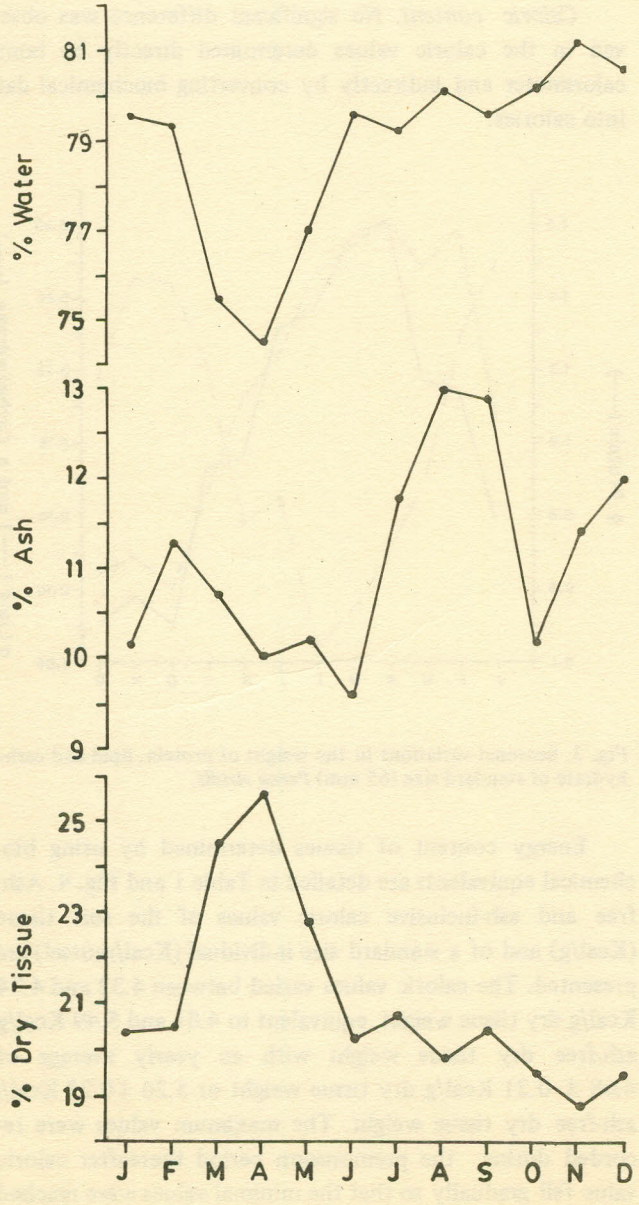

Fig. 1. Seasonal variations in percentage biochemical composition of tissues of *Perna viridis*.

Seasonal changes in tissue weight (g/mussel) of a standard mussel (65 mm shell length) show a distinct annual cycle (Fig. 4). The tissue weight decreased from 2.25 g per mussel in April to 1.05g in October representing a loss of 53% in tissue weight. Higher values of tissue weight were observed during the first half of the year whereas the next half was characterised by the lower values of the tissue.

Water content. The percentage water content of the tissues is summarised in Fig. 1. Minimal values for water content were observed during the period March to May indicating the ripe gonad. A rise in water content was noted in June, thereafter it fluctuated around about 20% until October. The period of maximum water content in the tissues corresponded with the minimum tissue weight of the mussels.

Biochemical composition. Fig. 2-3 summarise the variations in percentages of protein, glycogen, lipid and ash on dry weight basis and for a standard mussel, respectively. It is evident that all components exhibit marked seasonal changes. The protein fraction rose from a value of 64.7% in January to reach the maximal value of the year (74%) in June and then fell steadily from July to September to a lowest value (56.7%) in October. The percentage carbohydrate showed a trend which is just opposite to that of protein, i.e. the minimal values were found in June and the maximal in October. Glycogen ranged from 3.56 to 25.6% of the total dry tissue weight. There was a rapid increase in the glycogen percentage during July to October which is a period of active spawning; the increase was terminated in October. Changes in the lipid content were less conspicuous and followed closely the pattern described for protein. The percentage lipid varied from 7.8% in October to 14% in May.

Since the percentage values may not provide the information regarding the fluctuations in a particular variable, it was stressed in the literature [14, 15] to consider also the absolute values of the components. The composition of a standard mussel was then calculated by combining the data of dry tissue weight (Fig. 3) and percentage composition of the mussel tissue (Fig. 1-2). The three main components, protein, glycogen and lipid, expressed as mg/mussel, showed a pronounced seasonal cycle. The weight of protein ranged from 600 to 1610 mg/mussel. The protein was at a maximum in April before declining gradually through the monsoon period (May to September) to reach a minimum in October representing a loss of 99 mg. The changes in lipid followed closely the pattern mentioned for protein. The lipid weight showed fluctuations between 80 and 300 mg with a minimum in October after spawning. The minimum of protein and lipid corresponded with the maximal

values of glycogen. On comparing the variations in weights of protein and lipid with that of percentage variations of the same components, it is evident that both showed similar fluctuations save that peak values are shifted a little. During the year the glycogen weight ranged from 70 to 278 mg ($\bar{x}$ = 185 ± 0.07). The glycogen content of standard size individual was high in post monsoon which then declined gradually so that a minimum was reached in June. The weight of glycogen then rose gradually to attain the major peak of the year in October-November. The lowest value of glycogen therefore corresponded with the maximal values of protein. The present observations therefore evidently demonstrate a reciprocal relationship between glycogen and protein which is very similar to the percentage composition of the two components described earlier.

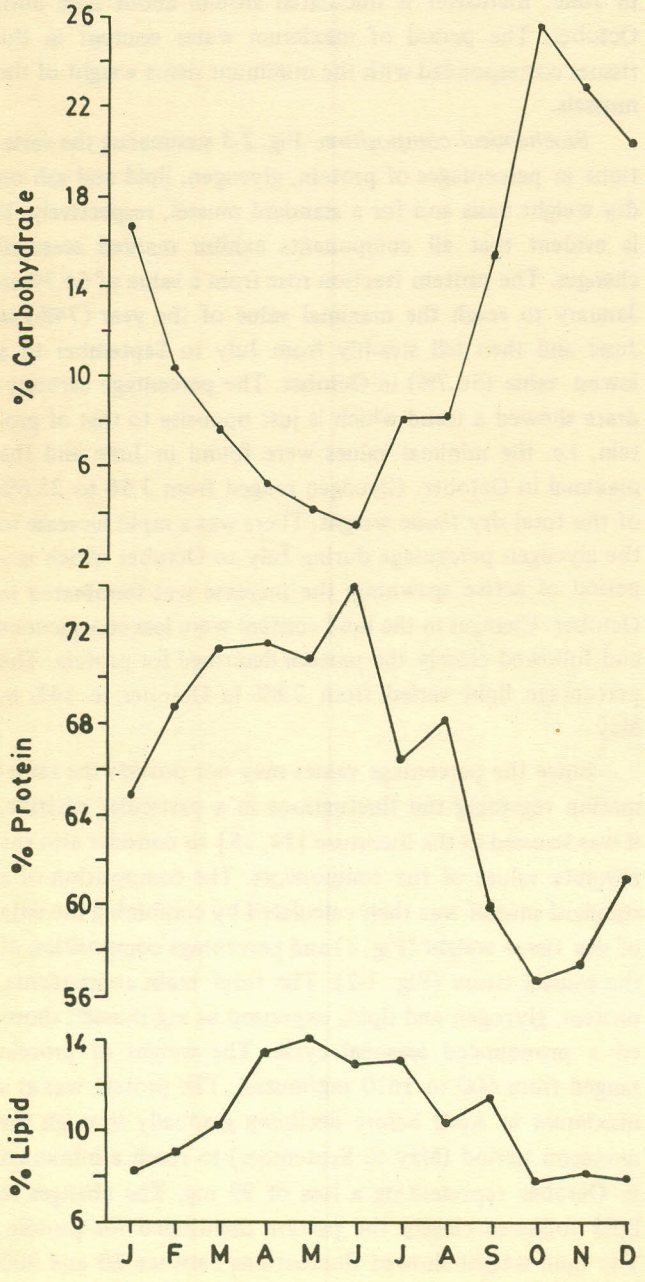

Fig. 2. Seasonal variations in percentage biochemical composition of tissues of *Perna viridis*.

Ash. The percentage ash declined steadily from February to June (Fig. 1). This was followed by an increase during the monsoon period. August and September were the months of maximum ash content (13.0 and 12.9%, respectively). A sudden fall in ash content occurred in October which coincided with the major spawning peak of mussels.

Caloric content. No significant difference was observed in the caloric values determined directly by bomb calorimeter and indirectly by converting biochemical data into calories.

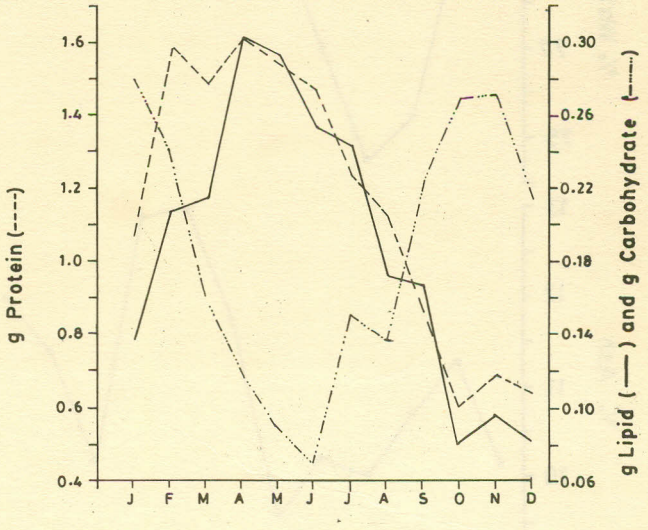

Fig. 3. Seasonal variations in the weight of protein, lipid and carbohydrate of standard size (65 mm) *Perna viridis*.

Energy content of tissues determined by using biochemical equivalents are detailed in Table 1 and Fig. 4. Ash-free and ash-inclusive caloric values of the soft tissue (Kcal/g) and of a standard size individual (Kcal/mussel) are presented. The caloric values varied between 4.32 and 4.94 Kcal/g dry tissue weight, equivalent to 4.81 and 5.49 Kcal/g ash-free dry tissue weight with an yearly average of 4.68 ± 0.21 Kcal/g dry tissue weight or 5.26 ±0.23 Kcal/g ash-free dry tissue weight. The maximum values were recorded during the premonsoon period thereafter caloric value fell gradually so that the minimal values were reached in October just after spawning. The total caloric values of a standard individual, in Kcal per mussel, varied from 5.28

Table 1. Monthly caloric values of the dry tissues of a standard size (65 mm) *Perna viridis*

Date	Kcal/g dry tissue		Kcal/65 mm mussel	
	Ash-inclusive	Ash-free	Ash inclusive	Ash-free
January	4.33	4.81	8.52	7.65
February	4.77	5.38	11.94	10.56
March	4.88	5.47	11.12	9.93
April	4.91	5.46	12.44	11.19
May	4.86	5.41	11.82	10.62
June	4.94	5.47	10.98	9.93
July	4.79	5.43	9.92	8.75
August	4.78	5.49	8.52	7.41
September	4.49	5.16	7.51	6.54
October	4.57	5.08	5.28	4.75
November	4.40	4.97	5.92	5.25
December	4.50	5.12	5.30	4.67
Average ±SD	4.68 ±0.21	5.26 ±0.23	9.11 ±2.65	8.12±2.37

to 12.44 with an average of 9.11 ± 2.65 Kcal/dry tissue weight or 8.12 ± 2.37 Kcal/ash-free dry tissue weight. The caloric value showed a gradual decline from the highest value (12.44) in April to the lowest value (5.28) in October. This decline in caloric value was affected mainly by the lipid and protein components, both of which showed a remarkable drop.

DISCUSSION

Ever since Daniel [16-18] published his work on the biochemical composition of the mussel *Mytilus edulis* from England, much data have accumulated on a number of bivalve species. Most notable of these studies are related to the bivalves from the Clyde Sea area carried out by Ansell and co-workers [15, 19,-22].

A significant relationship between chemical contents and reproductive cycle have been demonstrated [14, 16, 17, 23-26]. The tissue weight of *P. viridis* was at a maximum in April which declined gradually and reached its minimum in October. The seasonal changes in protein and lipid followed the pattern similar to the tissue weight. In contrast, seasonal changes in carbohydrate observed a different course. A decrease in carbohydate (glycogen) occurred when protein and lipid were at a maximum. In general, seasonal changes in carbohydrate differ greatly from those of protein and lipid. A reciprocal relationship between percentage protein and carbohydrate was described in *Mytilus edulis* [14, 27]; the weight composition of the two components, however, shows similar trend. The results of the present study on *Perna viridis* are at variance from those discussed above as an inverse relationship between carbohydrate and protein exists both in percentage and weight composition. This has resulted from the relatively high percentage of lipid in *P. viridis* which ranged from 7.8 to 14% in contrast to 4 to 10% in *M. edulis* [14]. The high content of lipid is relfected in the long spawning season of green mussel, which is a characteristic of warm water species.

Results of biochemical composition showed that protein was the main component of mussel tissue representing an average of 65% with carbohydrate and lipid constituting 12 and 10%, respectively, of the tissue weight. The carbohydrate level in *P. viridis* is relatively low than observed for other species of mussels; for instance, carbohydrate forms 22.5% of the dry tissue weight in *M. edulis* from England [14] and 10-35% glycogen in *M. edulis* from Wadden Sea [28]. Working on pearl oyster *Pinctada martensi,* Tanaka and Hatano [29] recorded a continuous decrease in glycogen contrary to increase in tissue weight; they attributed the reduction in glycogen to the production of gametes. A decrease in carbohydrate during gametogenesis was noted in *M. edulis* by Pieters *et al* [30]. They further stated that the production of byssus against the violence of storms could also decline the glycogen. It is known see Ansell. [20] that the carbohydrate of bivalve tissue serves two main purposes: (a) accumulation of reserves for utilization at the time of food scarcity or adverse environment conditions and (b) production of gametes through conversion into lipids. Hence a distinct and direct relationship between carbohydrate and spawning similar to protein and lipid cannot be expected.

A decline in protein and lipid during the spawning period is reflected in the reduction of tissue weight which followed changes similar to protein and lipid. It is notable that a rise in carbohydrate during July to October was not reflected in the rise in tissue weight. The accumulation of carbohydrate during this period may simultaneously be used to meet the high energy demand for gametogenesis. A rapid accumulation after spawning was noted by a number of workers [14, 31].

The caloric content of tissue weight varied seasonally and closely paralleled the changes in tissue weight. A general, decline occurred in caloric content during the July to October period which according to Barkati and Ahmed [2] constitutes the main spawning season of *Perna viridis.* There are very few reports available on the caloric values of mussels. The caloric content of *P. viridis* from Karachi averages 5.21 Kcal per g ash-free dry tissue weight during

the year, which compares favourably with that of *Mytilus edulis* from England [14] and Norway [32], which averages 5.57 and 5.47 Kcal. per g ash-free tissue weight, respectively.

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