CHAPTER V I

BIOCHEMICAL COMPOSITION OF MUSSELS
INTRODUCTION

Today, much of our attention, has been focussed on seafoods as they are one among the major source of protein. Seafoods are known to have high nutritive value and also can earn considerable amount of foreign exchange. Among molluscs, particularly mussels are known to thrive well in estuarine subtidal ecosystem without much maintenance and yields high rate of returns (Qasim et al., 1977).

Earlier studies (Gerritsen and Van Pelt, 1945; Koringa, 1956; Baird, 1966; Giese, 1966; 1969; Williams, 1969; Gabbot and Bayne, 1973; Dare and Edwards, 1975; Pieters, 1979; 1980) suggest that seasonal variations in biochemical composition follow different patterns depending on latitudes and geographic areas and are strongly influenced by temperature and phytoplankton. Zandee et al. (1980) described in detail the seasonal variations in biochemical composition of Mytilus edulis with reference to energy metabolism and gametogenesis. Changes in some of the biochemical constituents are known to associate with different phases of annual cycle of reproduction.

In the present study, an investigation on the proximate biochemical composition of the raft-grown green mussel P. viridis in relation to culture biology with changing growth phases and its variations in relation to reproductive cycle, are discussed. An effort is also made to have better understanding about the impact of some of the important hydrobiological parameters such as temperature and phytoplankton abundance on the biochemical
constituents of the body tissue, when grown in an estuarine environment, under continuous submergence.

RESULTS

Annual changes in proximate biochemical composition during the period of study in the raftgrown green mussel _Perna viridis_ L. are shown in Figs. 34 to 40. From the estimated biochemical constituents, the caloric potential was calculated using the conversion factors 5.7, 9.3 and 4.0 Kcal./g for protein, lipid and carbohydrate respectively (Elliot and Davison, 1975). Percentage frequency of animals with different conditions of gonad are depicted in Fig. 41. Regression analysis to establish different relationships among these biochemical constituents were conducted and results are given in Table 9.

WATER:

Changes in water content in tissue (as percentage) during the period of study in the raft-grown green mussel are shown in Fig. 34. In the present investigation, the water content in the mussel tissue varied from 66.86 to 90.12%. Maximum water content was observed in first fortnight of July and minimum in the second fortnight of March. The water content values from the beginning of the study period were low upto first fortnight of February with further decrease till April. The water content during this time ranged from 66.86 to 73.78%. The magnitude of variation being only to the tune of 6.56%. Thereafter, from April, the percentage water content steadily increased upto second fortnight of May, attaining a peak value of 85.15%, followed by a declining
Fig. 34. Fortnightly variations in the water content in the raft-grown *P. viridis* L.
trend upto second fortnight of June. Since then, a sudden increase in the percentage of water content was observed, which continued to remain high throughout the monsoon season till August. The high percentage of water content was observed to coincide with low saline waters during south west monsoon period. The higher percentage of water content in mussel tissue coincided with low values of protein, lipid, carbohydrate and ash content.

PROTEIN:

Protein content variation in the raft-grown green mussel *P. viridis* L. are depicted in Fig. 35. In the present study, the protein concentrations were observed to be generally high, except in the second half of monsoon season, just prior to the termination of the experiment. In small sized mussels, the protein values were low, which suddenly increased in November and then onwards a gradual increase in protein content was noticed upto January. The range of variation from the beginning of study to January was from 600.76 to 609.8 mg/g dry wt. During pre-monsoon season, the protein values were higher and the rate of increase in protein content was also high during the period from February to March. During the above mentioned period, the protein values ranged from 620.72 to 685.84 mg/g dry wt. Since then, upto May, the values remained stable. The maximum value of protein content was observed in first fortnight of March (685.84 mg/g dry wt.). During southwest monsoon, i.e. from June onwards, a decreasing trend in protein content was noticed registering its lowest value in September (457.46 mg/g dry wt.). A slightly
Fig. 35. Fortnightly variations in protein concentration in the raft-grown *P. viridis* L.
higher value was reported in second fortnight of July (532.55 mg/g dry wt.).

The contribution of protein for total energy (cal/g dry wt) varied from 2584.649 to 3874.996 cal/g dry wt. during the period of study, coinciding with minimum and maximum values of protein in the respective months. The percentage contribution of protein above for total energy production of the raft-grown green mussels varied from 77.45 to 79.09%.

An increase in protein content from February to May was observed to coincide with maturation of gonad. From June onwards the protein level decreased, indicating that much of the energy contributed by protein was used for maturation and spawning. The average value of protein from February to May was 66.73% and during peak spawning period i.e. June-August, it was 51.42% as evidenced from spent gonad conditions. From the examination of gonad condition of the mussels it appears that gametogenesis gets initiated in January and the maturation of gonads lasts till May. In the raft-grown mussels, first gametogenesis occurs at a size group of 15 mm and above. From the observation on gonad, it appears that the spawning was continuous from June onwards to the end of the experimental period i.e. September 1988. From February onwards, three stages of gonadal conditions viz. maturing, mature and spent were found. The reoccurrence of maturing stages of gonad during July to September could mainly be due to intermittent spawning of these mussels. In the present study, the peak period of spawning was observed to be from May to July, although spawning continued at reduced rate in the
following months. Thus in an estuarine environment, the mussels not only thrive well, but, also reproduce, over prolonged breeding season.

LIPID:

Variations in lipid content of the raft-grown green mussel, *P. viridis* during the period of study are shown in Fig. 36. In the early phases of growth, the lipid content observed was high which steadily decreased till the second fortnight of December. The variation in lipid value was in the range of 61.62 to 74.23 mg/g dry wt.. Thereafter, upto June, low value of lipid content was observed. From January to July, the variations in lipid content was not high, but it showed an alternate increase of low magnitude. The lipid content values were in the range of 41.31 and 55.59 mg/g dry wt.. This clearly shows that variation in lipid content during the above mentioned period was not marked. The lower values of lipid content were found to be inversely related to the protein content values. In June, during first fortnight, slightly higher value (62.86 mg/g dry wt.) was observed, which decreased during following fortnight. Thereafter, from July onwards a gradual decrease in lipid content values were observed upto the end of study period. The maximum and the minimum values of the lipid content were observed in October 1987 (74.23 mg/g dry wt) and September 1988 (25.76 mg/g dry wt.) respectively. The difference in minima and maxima during the total period of study being 48.47 mg/g dry wt.. It was also observed that higher values of protein were followed by
Fig. 36. Fortnightly variations in the lipid concentration in the raftgrown P. viridis L.
the higher values of lipid in the successive months.

The contribution of lipid content to the total energy varied from 243.432 to 701.475 cal/g. Percentagewise, contribution from lipid to the total energy potential in terms of calories was from 7.2 to 15.6.

Average lipid content from October to December was 6.63%. Thereafter, during maturation (> 15mm) the lipid content was low as compared to early stages of life (60 to 70 mm size group) with an average value of 4.81%. The lipid content was reported to be comparatively high during pre-spawning period. Soon after spawning, the lipid content declined and the average value from July to September was 3.83%.

CARBOHYDRATE:

Changes in carbohydrate content in the raft-grown green mussel are depicted in Fig. 37. The carbohydrate content registered its maximum value (198.62 mg/g dry wt.) in the initial stages of culture period. As the growth enhanced, a gradual decrease was observed upto second fortnight of February registering its minimum value of 113.82 mg/g dry wt.. The carbohydrate content increased steeply upto second fortnight of April and remained steady till the first fortnight of May. During second fortnight of May, a slightly low value followed by a decreasing trend was observed upto second fortnight of June. In July, although low, but a slight increase in carbohydrate level was observed which remained constant till the termination of the experiment. At the time of low carbohydrate
Fig. 37. Fortnightly variations in carbohydrate content in the raft-grown P. viridis L.
concentration, the values ranged from 123.89 to 133.86 mg/g dry wt. with little variations. Overall analysis indicate that there is no marked variation in carbohydrate content in green mussel during the complete period of study except a slightly higher value in May. During monsoon season, the lower values of carbohydrates coincided with low values of protein content. It was observed that when the protein content was high the corresponding carbohydrate content was generally low, but, just prior to the monsoon period slightly higher values of carbohydrate were recorded. To the total energy potential, the contribution from carbohydrate was upto the tune of 446.662 to 814.322 cal/g during the months of February and October respectively. The percentage contribution from this biochemical constituent was from 9.9 to 18.2 to the total energy production in the raft-grown green mussels.

During pre-monsoon period, just prior to peak spawning period, high carbohydrate content (161.8 mg/g dry wt.) was observed which coincided with higher protein content. However, during spawning period, the carbohydrate content values were low. In general, carbohydrate values observed were higher in immature mussels which declined in mature mussels.

ASH:

Trends in ash content variations during the period of study in these raft-grown green mussels are depicted in Fig. 38. The ash content varied from 51.86 to 218.37 mg/g dry wt.. During the early stages of growth, the ash content showed higher values
Fig. 38. Fortnightly variations in the ash content in the raft-grown *P. viridis* L.
(218.32 mg/g dry wt.), which declined sharply registering a value of 83.94 mg/g dry wt. in November. In the succeeding months, an increase was observed in December followed by a decrease till first fortnight of February. A high value (182.39 mg/g dry wt.) was observed in second fortnight of February. In April, a sudden rise was noticed which declined in May. Since May, the ash content values in general were low which showed gradual increase till July followed by decreasing trend upto the end of study period. During July-September period, the values varied from 51.86 to 118.52 mg/g dry wt.. Lower values of ash content during this time were found to coincide with low values of lipids and proteins, whereas higher values of ash content coincided with higher values of carbohydrates during the early stages of growth.

**ORGANIC CARBON:**

The changes in organic carbon content in the raft-grown green mussel during the period of study are shown in Fig. 39. The peak value of 369.7 mg/g was observed in August and the minimum value of 182.4 mg/g dry wt. in March. The annual magnitude of variation was 187.3 mg/g dry wt.. The organic carbon content in the raft-grown green mussel was low in the early stages of growth which increased gradually till second fortnight of December. Thereafter, upto second fortnight of February the organic carbon content was stable in the range of 246.5 - 297.2 mg/g dry wt., which declined in the first fortnight of March registering lowest value (182.4 mg/g dry wt.). In May, the organic carbon value increased and remained stable upto July,
Fig. 39. Fortnightly variations in the organic carbon in the raft-grown P. viridis L.
Fig. 19. Growth in meat weight of the raft-grown *Perna viridis* L.
Fig. 20. Growth in shell weight of the raft-grown *Perna viridis* L.
followed by an increasing trend upto August, thereafter followed by decreasing trend till September. Higher values were inversely related to protein, lipid, carbohydrate and ash content.

**CALORIFIC POTENTIAL:**

Variations in total calorific values are shown in Fig. 40. From the energy contribution made by major biochemical components, it is evident that in early stages of growth, the energy reserves were generally high. Since the beginning of study period to January, no marked changes in calorific potential were observed. The calorific value during this period was in the range of 4.397 - 4.602 Kcal/g. From January onwards the pattern of variation displayed an increasing trend upto March, and then showed low value in the first fortnight of April. During the period from February to May, the calorific values were high and varied from 4.661 to 4.986 Kcal/g. Thereafter, the energy content underwent a steady decline, registering lowest value in September (3.336 kcal/g) with an exception in second fortnight of July, when a slightly high value was observed. The maximum energy content during the study period was recorded (4.986 kcal/g) in the second fortnight of April. The maximum values of total energy were found to coincide with higher values of protein, indicating significant contribution made by protein to the total energy content.

To know, whether there exists any relationship among the above biochemical parameters, regression analysis were conducted. The relationship and the levels of significance are given in
Fig. 40. Fortnightly variations in the caloric content in the raft-grown *P. viridis* L.
Fig. 41. Reproduction cycle in raft-grown green mussel *Perna viridis* L.
Table 9. From the statistical analysis made, it appears that water content and protein are inversely related with high degree of significance. The contribution of protein to total caloric potential showed a positive correlation with high degree of significance \((r = 0.924; p<0.001)\). Carbohydrate content showed a significant positive relationship with lipid, whereas the water content and lipid concentration showed a negative relationship, although not significant. The relationship between organic carbon and carbohydrates displayed negative correlation and was significant at 90% level. The share of carbohydrate content for the total energy contribution was significant as seen from correlation coefficient value. However, contribution by lipids to the total energy content was not appreciable as revealed by low value of correlation coefficient. Organic carbon and water content displayed an inverse and significant relation with total energy content at varying level of significance.

**DISCUSSION**

Studies on variation in biochemical composition in *Mytilus* sp. have been conducted earlier in the temperate waters (Alvarez, 1968; Giese, 1969; Williams, 1969b; Gilles, 1972a; Dare, 1973a; Gabbot and Bayne, 1973). These studies show that the changes in body weight are mainly due to changes in carbohydrate content. The seasonal cycle for storage and utilization of glycogen reserves reflect the complex interaction between food supply and temperature; and between the growth and the annual reproductive cycle (Gabbot, 1976). Available literature on the biochemical composition of green mussel from tropical waters (Suryanarayanan
Table 9. Regression coefficients of various biochemical parameters showing the relationship alongwith correlation coefficient value (r) and level of significance.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Relationship</th>
<th>a ± SE</th>
<th>b ± SE</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lipid/protein</td>
<td>13.869 ± 1.3</td>
<td>-0.002 ± 0.125</td>
<td>-0.006 NS</td>
</tr>
<tr>
<td>2.</td>
<td>Carbohydrate/protein</td>
<td>3.621 ± 0.83</td>
<td>0.024 ± 0.08</td>
<td>0.136 NS</td>
</tr>
<tr>
<td>3.</td>
<td>Organic carbon/protein</td>
<td>42.455 ± 3.434</td>
<td>-0.294 ± 0.331</td>
<td>-0.375 NS **</td>
</tr>
<tr>
<td>4.</td>
<td>Water/protein</td>
<td>117.82 ± 3.94</td>
<td>-0.71 ± 0.38</td>
<td>-0.646</td>
</tr>
<tr>
<td>5.</td>
<td>Energy content/protein</td>
<td>0.89 ± 0.115</td>
<td>0.059 ± 0.011</td>
<td>0.924 ***</td>
</tr>
<tr>
<td>6.</td>
<td>Carbohydrate/lipid</td>
<td>0.85 ± 1.06</td>
<td>0.32 ± 0.254</td>
<td>0.496</td>
</tr>
<tr>
<td>7.</td>
<td>Organic carbon/lipid</td>
<td>32.03 ± 5.32</td>
<td>-0.51 ± 1.27</td>
<td>-0.18 NS</td>
</tr>
<tr>
<td>8.</td>
<td>Water/lipid</td>
<td>83.19 ± 7.47</td>
<td>-0.536 ± 1.788</td>
<td>-0.135 NS</td>
</tr>
<tr>
<td>9.</td>
<td>Energy content/lipid</td>
<td>3.46 ± 0.42</td>
<td>0.068 ± 1.01</td>
<td>0.292 NS</td>
</tr>
<tr>
<td>10.</td>
<td>Organic carbon/carbohydrate</td>
<td>34.59 ± 6.65</td>
<td>-1.906 ± 1.82</td>
<td>-0.43</td>
</tr>
<tr>
<td>11.</td>
<td>Water/carbohydrate</td>
<td>87.196 ± 6.7</td>
<td>-2.255 ± 2.611</td>
<td>-0.385 NS</td>
</tr>
<tr>
<td>12.</td>
<td>Energy content/carbohydrate</td>
<td>3.53 ± 0.37</td>
<td>0.17 ± 1.44</td>
<td>0.473</td>
</tr>
<tr>
<td>13.</td>
<td>Water/organic carbon</td>
<td>84.97 ± 4.5</td>
<td>0.434 ± 0.602</td>
<td>0.311 NS</td>
</tr>
<tr>
<td>14.</td>
<td>Energy content/organic carbon</td>
<td>5.368 ± 0.239</td>
<td>0.039 ± 0.032</td>
<td>-0.484</td>
</tr>
<tr>
<td>15.</td>
<td>Energy content/water</td>
<td>7.48 ± 0.22</td>
<td>-0.041 ± 0.019</td>
<td>-0.700</td>
</tr>
</tbody>
</table>

n = 23

NS - not significant
* - significant at 10%
** - significant at 5%
*** - significant at 1%
and Alexander, 1972; Nagabhushanam and Mane, 1975; Wafar et al., 1976; Qasim, et al., 1977; Nagabhushanam and Mane, 1978; Shafee, 1978; Parulekar et al., 1982; Mohan and Kalyani, 1989) suggest that information on biochemical composition is essential as it reflects directly on the nutritive value, thereby enabling to establish an ideal time of harvest. Further, it reveals that the changes in biochemical constituents depend on the phases of reproductive cycle.

Nagabhushanam and Mane (1978) discussed seasonal variations in the biochemical composition of *Mytilus viridis* L. from Ratnagiri, west coast of India, whereas, from Ennore estuary, Madras along the east coast of India, variations in biochemical composition of the green mussel *Perna viridis* L. have been studied by Shafee (1978). In coastal waters of Goa, the growth of raft-grown green mussel *Perna viridis* L. was very rapid (Parulekar et al., 1982) due to the abundance of food material and ideal environmental conditions and the mussels adapt biochemically to wide ranging external conditions and also respond appropriately to rapid and irregular variations in these conditions.

Many bivalves are known to increase or decrease the level of tissue water content with respect to change in salinity of the surrounding medium. Galtsoff (1964) reported that during low saline conditions, the water level in oysters rose to 92.5%. In the present study, a noticeable increase in water content during monsoon season i.e. at the time of fall in salinity was observed.
In monsoon, the water content in the raft-grown mussels was up to 90%. Nagabhushanam and Mane (1978) reported the highest percentage of water content (81.17%) during monsoon and the lowest (79.35%) in summer. These authors in their earlier study also found high level of water content in monsoon and low level during the summer months. Present observations corroborate the same. The possible cause of higher percentage of the water content in monsoon may be, that the mussels might have gained water and lost salts as stated earlier by Galtsoff (1964). Parulekar et al. (1982) also observed similar type of relationship between salinity and water content in the raft-grown green mussel and stated that these mussels develop an iso-osmotic internal medium to compensate for considerable lowering of salinity during monsoon season. Furthermore, it was reported that this compensation is achieved by dilution of body fluids, resulting in higher water content in tissues. Minimum water content was observed in March (summer). Such low values of water content in summer were earlier observed by Deshmukh (1972) and Parulekar et al. (1982). Parulekar et al. (1982) stated that these mussels develop an appropriate compensatory mechanism to counteract the increasing salt content in the environment during summer season.

The protein values in the present study indicate that from March to May, the values were higher as compared to other period which coincided with increased food availability and just prior to active spawning period. Such higher concentration of protein during pre-spawning period was earlier observed by Wafar et al.
(1976) and Nagabhushanam and Mane (1978). The increased protein content during pre-spawning season could be a mechanism of storage of reserves to meet spawning requirements. The protein content immediately after peak spawning period was observed to be low in the present study. Galtsoff (1964), Quayle (1969), Nagabhushanam and Mane (1975; 1978) and Wafar et al. (1976) reported decrease in protein content during post-spawning period. Gabbot and Bayne (1973) reported a decrease in total energy during spawning and found that protein accounted for about 75% of the loss and also noticed that fall in protein content of the body tissue was accompanied by an increase in the rate of ammonia-N excretion. This implies that much of the energy spent during active spawning period in the present case was mainly contributed by protein. Further the Mytilus edulis can utilise protein as an energy source during winter, when glycogen, the normal reserve, is at minimum level.

The influence of reproductive cycle on biochemical composition depends on timing of gonad proliferation and gametogenesis (Lubet, 1959; De Zwann and Zandee, 1972; Gabbot, 1976). The gonad development in Perna viridis causes a reciprocal decline in stored reserves in body tissue and protein from adductor muscle (Comely, 1974). Taylor and Venn (1979) stated that the gametogenesis is supported by reserves of glycogen and protein in temperate waters. However, the extent to which the energy demands are met from stored reserves depend on the level of feeding and energy conversion efficiency.
As the mussel increased in length, during the initial period of growth the protein content was noticed to be increasing at uniform rate. This increase in protein content could mainly be due to increased feeding efficiency associated with food availability. The proper assimilation of ingested food could have resulted in increase in protein content during this time. The increased protein content may also be attributed to better metabolic conditions which prevailed in a subtidal ecosystem (Qasim et al., 1977), thereby increasing assimilation efficiency, directly influencing protein content. Thus it indicates that protein as a source of energy reserves in bivalve, play an important role as compared to glycogen and other intermediary carbohydrate metabolism.

The lipid content, in the raft-grown green mussels, was found to be in the range of 61.62 - 74.23 mg/g dry wt. till December. The high values of lipid content in the initial stages of growth were mainly attributed to increased feeding efficiency. Venkataraman and Chari (1951) correlated high lipid level with intensive feeding and storage of fat before spawning. Earlier workers (Lubet and Longcamp, 1969; Williams, 1969; Telembici and Dimoftach, 1972; Pieters et al., 1979) noticed a peak value in winter and low value in summer. However, in contrast, a reverse pattern reporting higher value of lipid in summer and lower value in winter, is also on record (Renzomi, 1963; Fraga, 1958; Gabbot and Bayne, 1973; Dare and Edwards, 1975).

During January to May, the lipid content values were lower as compared to those in the early stages of life. During this
time, the lipid content was somewhat stable with slight variations alternately. The lipid content during this period was in the range of 41.31 and 52.78 mg/g dry wt. The low values of lipid were mainly due to utilization of accumulated lipid for building up of tissue material. The low lipid content values were accompanied by faster growth rate of the mussels. Low lipid content values were correlated with faster growth rate in oysters earlier by Venkataraman and Chari (1951). The probable cause for low fat content could also be due to initiation of gametogenesis and utilization of energy reserves for development of gametes. Similar observations were earlier made by Qasim et al. (1977) and Zandee et al. (1980).

In the present study, the lower values of fat content could be correlated to low content of chlorophyll a and phytoplankton biomass at the site of raft culture. Widdows and Bayne (1971), Bayne (1973) and Lucas et al. (1978) stated that presence of large amount of phytoplankton allows the accumulation of lipid and carbohydrate reserves.

During the remaining part of the study i.e. from June till termination of the experiment in September, the lipid content declined. This decline in lipid content was observed to coincide with monsoon season. At this time, the water content in these mussels was observed to be high thus indicating an inverse relationship between lipid and water content. This period of low lipid content coincided with post-spawning season in these mussels. Such a fall in lipid content during post-spawning
period has also been reported earlier (Qasim et al., 1977; Shafee, 1978; Parulekar et al., 1982). Low values of lipid content during post-spawning could be attributed to exhausting of energy resources for spawning activities (Qasim et al., 1977). The reduction in fat content during monsoon period could also be due to low water temperature and other unfavourable biotic conditions prevailing at that time. The effect of temperature and nutritive stress can be interpreted as a compensatory change in the seasonal steady state values for metabolic rate resulting in a decline from routine to standard metabolism (Bayne, 1973).

Carbohydrate content in raft-grown green mussel *Perna viridis* L. showed cyclic variations. In the initial stages of growth, carbohydrate content was found to be very high (198.62 mg/g dry wt.). High carbohydrate content in immature mussels, have earlier been observed by Nagabhushnam and Mane (1975). Lec and Pepper (1956) also reported increased carbohydrate content in immature animals and a drop in gravid animals. Parulekar et al. (1982) reported low values of carbohydrate content in small sized mussels. In the present study carbohydrate values remained low during winter period i.e. from December to February. Such low values of carbohydrate during winter season were also reported by Baird (1958; 1966), Gabbot and Bayne (1973), Shafee (1981); Galassi et al. (1982) and Parulekar et al. (1982). In general the carbohydrate values were stable throughout the period of study, suggesting that during spawning season, energy requirements are met by protein and lipid to a greater extent as compared to carbohydrate contents. Earlier studies (Wafar et
al., 1976; Qasim et al., 1977; Shafee, 1981) also demonstrated that during pre-spawning and post-spawning season, protein and lipid increases and decreases respectively thus indicating that these biochemical constituents play a dominant role in gametogenesis.

No conspicuous decrease was observed in carbohydrate content during the period from December to February. The chlorophyll $a$ and phytoplankton biomass at this time was observed to be high. This indicates that no decrease in carbohydrate could result as its metabolic energy demands were met by phytoplanktonic biomass (Brunetti et al., 1983). The carbohydrate content showed gradual increase from March to May registering its second maxima in May, prior to peak spawning season. The increase in carbohydrate content prior to spawning period was earlier observed by Parulekar et al. (1982). However, Nagabhushnam and Mane (1978) reported a fall in carbohydrate content during pre-spawning period. Taylor and Venn (1979) stated that, in green scallop, Chlamys opercularis, gametogenesis is supported by reserves of glycogen and proteins. During remaining period of study i.e. from June to September (monsoon season) the carbohydrate content declined and remained steady (125.54 - 133.86 mg/g dry wt.). Such a decline in carbohydrate content during monsoon months was earlier reported by Mohan and Kalyani (1989) and during post-spawning period low values were reported by Galassi et al. (1982). The decrease in carbohydrate content during monsoon season could be due to low temperature and unfavourable conditions causing stress to raft-grown mussels. Gabbot and
Bayne (1973) reported that, stress in these animals results in utilization of carbohydrate reserves and a decline in the rate of excretion of ammonia-N. Carbohydrate serves as an index of high glycogen metabolism during the period of high environmental stress in monsoon season (Parulekar et al., 1982).

The changes in ash content in the raft-grown green mussels did not show any definite pattern. The ash content was generally high (204.34 mg/g dry wt.) in small sized mussels, inspite of large fluctuations. In large sized mussels, ash content was low (51.86 mg/g dry wt.). Dare and Edwards (1975) measured ash contents in Mytilus edulis and reported to be between 9 and 15%. Paoli and Heral (1988) reported the ash content to vary from 4.4 to 41.2% in the oyster, Crassostrea gigas. Organic carbon content in the present study varied from 182.4 to 369.7 mg/g dry wt.. The higher values of organic carbon were observed during monsoon season, which were found to be inversely related to major biochemical constituents like protein, carbohydrate and lipid. The higher values of organic carbon during monsoon season in the raft-grown green mussel were also earlier reported by Parulekar et al. (1982).

The energy content in the raft-grown green mussels during the beginning of growth stages was high (4.39 - 4.98 Kcal/g) upto May. Higher energy content in mussels was mainly due to higher content of proteins and lipids which directly influenced the total energy content. Shafee (1978) reported energy content in mussels to vary from 5.25 to 5.42 Kcal/g on ash free dry wt. basis, which was higher as compared to energy values observed in
the present study. Since May, till the end of the period of study i.e. September, a decreasing trend in energy content was noticed, which was mainly due to low values of major biochemical constituents. It was also noticed that soon after spawning, the energy content were in low range (3.33 - 4.01 Kcal/g). Shafee (1981) reported that energy reserves do not appear to play a significant role in subsequent maturation of gonads.

Present study indicates that major biochemical constituents in raft-grown green mussel, *Perna viridis* L. are greatly influenced by quality and quantity of food available, exogenous parameters such as temperature which influence metabolic level and reproductive cycle of cultivated mussels. The environmental conditions appear to influence certain biological processes within a population so that the reproductive cycle usually becomes acutely tuned to local seasonal conditions (Walter, 1982). It was also observed that the most appropriate time of harvesting these mussels was at a size group of 65-70 mm, when the major biochemical constituents were at the maximum level, thus yielding higher food value. The present study, has also revealed that, the reproductive cycle to a large extent was associated with the proximate biochemical composition and thus affected the seasonal cycle.