INTRODUCTION

In freshwater, the amount of a gas dissolved (ml/liter) is given by the product of solubility coefficient (a) and the percentage of an atmosphere of the gas in equilibrium with the water. The amount of oxygen or carbon dioxide in water may be expressed as a concentration (ml O_2/liter, mg O_2/liter, or mM O_2/liter), or as the partial pressure (mmHg) of the gas phase in equilibrium with the water. In natural freshwaters, the oxygen concentration may vary considerably according to temperature, degree of thermocline with air, photosynthesis, and oxygen depletion by consumption by organisms. Below thermocline there is a little mixing and the oxygen concentration may be much lower than at the surface. In warm surface waters, both in fresh water and in the sea, where there is much photosynthesis, the oxygen concentration may exceed air saturation. Very low oxygen concentration may be encountered in muds where non-biological oxidation occurs. Oxygen which enters an animal across a respiratory surface or into cells must diffuse via an aqueous solution, and the availability of oxygen depends
on its concentration immediately outside the organism (Prosser, 1973). In bivalve molluscs, though the pallium plays some role in the respiration, gills are the main organs for respiration. The structure of the gill in these animals is well-suited to function in gas exchange, by virtue of its considerable surface area and rich supply of blood. Large volumes are passed through the mantle cavity, ensuring a supply of oxygen, and the diffusion distance for oxygen from water to blood is small. The constant movement of large number of cilia present in the gills cause a water current. This water current is useful for external respiration, feeding and the removal of metabolic wastes.

Biological literature records many values of oxygen consumption by various aquatic invertebrates under various environmental conditions such as temperature, salinity, pH, carbon dioxide, oxygen tension, etc. (Davis, 1975). Rate of respiration in these animals is also influenced by activity, body size, stage in life cycle and time of day, as well by previous oxygen experience, and genetic background (Prosser, 1973). Indeed, a considerable knowledge is available on the interaction of oxygen availability, oxygen uptake and ventilation rates for many freshwater, marine, and estuarine organisms. Most aquatic organisms can utilize several metabolic pathways as a means of obtaining
several metabolic pathways as a means of obtaining energy. These processes can be aerobic or anaerobic. Anaerobic processes yield energy in the absence of oxygen. An excellent discussion on the various metabolic pathways, their evolution and relationship to oxygen availability can be found in the description given by Hochachka and Somero (1973). Davis (1973) reviewed minimal dissolved oxygen requirement of aquatic life. Bodies of freshwaters often show large variations in the dissolved oxygen, both seasonally and geographically.

Variations in oxygen consumption with external conditions have been worked out by many investigators, such as temperature (Rao and Bullock, 1954; Barnes and Barnes, 1969; Newell and Pye, 1971), nutritional conditions (Newell et al., 1972; Marsden et al., 1973; Newell, 1973), and whether measurements are made in air or in water (Toulmond, 1967 a,b). Temperature is recognised as one of the major environmental determinants of the rate of metabolism and the level of activity of poikilothermic organisms. However, bivalve molluscs, like many other littoral invertebrates, although apparently unable to regulate their rate of heat loss or gain from the environment, are able to vary their respiratory and feeding rates in such a way to maintain themselves relatively independent of the environmental temperature.
The subject of thermal compensation in poikilotherms has been reviewed by Bullock (1935), Prosser (1955), Gunter (1957), Fry (1958), Precht (1958), Prosser and Brown (1961), Segal (1961), Vernberg (1962), Kinne (1963, 1964, 1970), Newell (1970, 1973), Vernberg and Vernberg (1972) and Wieser (1973). The general concept of thermal adaptation includes both genetic and non-genetic aspects. Genetic adaptation takes place over many generation and sets the upper and lower limits of thermal tolerance. Non-genetic adaptation is influenced directly by the environment and can be divided into two categories on the basis of the time course of the physiological compensation. The subject has been nicely explained by Prosser and Brown (1961) and Bayne (1976). Metabolism in poikilotherms usually increases with increasing temperature, and acclimation to seasonal temperature variation, seasonal changes in food availability and reproductive status may all influence respiration (Krogh, 1941; Bullock, 1955; Newell, 1969).

Studies on the respiration of several bivalve molluscs have been made by a number of investigators (Collip, 1921; Bruce, 1926; Nozawa, 1929; Baltsoff and Whipple, 1930; Bouxin, 1931; Ishida, 1935; Krough, 1939; VanDam 1935,1954; Lane and Tierney, 1951). Several
environmental factors are known to influence the respiration of bivalve molluscs. The rates of oxygen uptake under various environmental conditions are well documented by many investigators in marine and estuarine bivalves. Mussels and oysters were the main targets of the earlier studies (Schlieper, 1957; Collier 1959; Read, 1962; Helm and Trueman, 1967; Moon and Pritchard, 1970). Respiration of many other bivalve species was also studied under various environmental conditions (Newell and Pye, 1970; Bayne, 1971, 1973; Vahl, 1972; Boyden, 1972a,b; Kennedy and Mihursky, 1972).

Amongst the marine bivalves of Indian coasts, the respiration of Martesia fragilis (Srinivasan, 1965), Martesia striata (Nagabhushanam, 1966), Meretrix meretrix (Deshmukh, 1972), Katelysia opima (Mane, 1975), Donax cuneatus (Mane and Talikhedkar, 1976) and Paphia lateralisulca (Dhamne and Mane, 1976) has been studied so far.

Few studies on freshwater molluscs give rigorous consideration to seasonal respiratory variations and acclimation (Berg et al., 1958; Burky, 1971; McMohan, 1973). The studies of Burky (1969, 1970, 1971) and McMohan (1973, 1975) on bivalves and Burky (1973, 1974), Burky and Burky (1976) and Burky et al. (1972) on gastropods give extensive information on the energetics of population growth and fecundity in
relation to respiration. For these studies the adaptation of respiratory response takes on a real significance in relation to the animal and their physical environment.

There are many reports on respiration in freshwater bivalves as stated above, however, most of these deal directly with responses to temperature, anaerobiosis and drying under controlled laboratory conditions. Other studies provide information on respiratory variations for field adapted bivalves during one season and estimates of other seasonal levels of metabolism from limited data. Most of these reports provide valuable but limited estimates because the status of growth, reproduction, or life cycle are often ignored or unknown. The studies of Burky and Burky (1976) on Pisidium walkeri, Hornbach (1980) and Hornbach et al. (1983) on Sphaerium striatunum, Way et al. (1981) and Buchwalder (1983) on Musculium partumelium, and Alexander (1982) and Alexander and Burky (1982) on Musculium lacustre provide comprehensive information on life cycle and habitat characteristic coupled with respiratory physiology. Apart from these studies several other investigators have worked out the aspects of respiration on many other freshwater species (Weinland, 1919; Culbreth, 1941; Hiscock, 1953; Dance,

Amongst the Indian freshwater bivalves, the respiration of Parreysia corrugata (Lomte and Nagabhusnan, 1971), Lamellidens corrianus (Lohgaonkar, 1974), Corbicula regularis (Mudkhede, 1974), and Indonaia caeruleus (Khatib, 1975) have been studied to understand the effect of several environmental factors. While studying the effect of various pollutants, including the pesticides and heavy metals, Akarte (1985) and Muley (1985) made an attempt to understand the seasonal variations in the respiration of three freshwater bivalves, Lamellidens corrianus, Lamellidens marginalis and Indonaia caeruleus, exposed and unexposed to pollutants. Similarly, Kulkarni (1987) on Indonaia caeruleus and Rao (1988) on Lamellidens marginalis, while studying the effect of cerebralactomy on some aspects of physiology and reproduction of these bivalves made an attempt to understand the seasonal variations in
the respiration of these animals. The studies carried out by Akarte (1985), Muley (1985), Kulkarni (1987) and Rao (1988) on the respiration of the freshwater bivalves were restricted to certain months of the seasons from the Godavari river flowing through Paithan. For example, these workers restricted the data on respiration in April-May for summer season, while in July-August for monsoon and in December-January for winter. Such studies, however, cannot give the exact seasonal variation in the respiration of freshwater bivalves to correlate with the aspects like nutrition, impact of environmental parameters and reproduction through every month. Hence, the present study has been directed in understanding the fortnightly variations in the respiration of the adult Lamellidens corrianus for a period of one year.

MATERIALS AND METHODS

The animals, Lamellidens corrianus, residing along the left bank of the Godavari river 42 km away from Aurangabad at Kaygaon (Fig. 1) were chosen for the study. After collection of these animals, they were immediately brought to the laboratory. The shells were brushed to remove the fouling biomass and mud. The
animals of 60-65 mm in shell length were selected and
stocked in a large aquarium containing reservoir water
in laboratory conditions for a period of three hours.
Constant aeration was given to the aquarium. During this
three hours period the animals could remove the waste
material from the viscera, thus clearing the gills and
the mantle cavity. One of the primary endogenous factors
affecting oxygen uptake in bivalves is shell valve
movement and any factor which affects the degree to
which the shell valves are, or remain open will affect
water flow and necessarily affect the oxygen consumption
rates (Shumway, 1982). Hence, in the present study the
animals after collection were maintained for three hours
in laboratory conditions to facilitate normal opening as
suggested by Galtsoff (1964). These animals could
maintain the shell valve opening to regulate the
ventilation during this period. After this period the
rate of respiration of individual animal was determined
in a specially prepared respiratory glass jar, coloured
black, containing one liter capacity of water, and
fitted with rubber cork having inlet and outlet
connected with rubber tubes. Each animal was kept in
this jar and reservoir water was allowed to flow for 2-3
minutes through inlet and the tube was pinched tightly
without leaving any air bubble in the jar. Soon after
opening the valves, the time was counted till one hour.
Fig. 1: Map showing collection site (A) of the bivalve species, *Lamellidens corrianus* along the bank of Godavari River at Kaygaon.
After one hour, the water from the respiratory jar was carefully siphoned out in the stoppered bottle and oxygen was determined according to Golterman (1969). The flesh of the bivalve was then taken out from the shells and carefully blotted to remove excess of water. This flesh was then weighed to obtain the wet weight of each animal. The oxygen consumed by the animal is expressed as $\frac{0 \text{ mg/gm/h/l}}{2}$. In this way the respiration of ten animals was determined and the average values were taken out with standard deviations. The body wet weights of individuals used in each set of experiment was pulled to obtain the fortnightly variations in their weights. The entire experiment was repeated on the days dated 11th and 26th of each month from May, 1986 to April, 1987. Every time freshly collected animals were treated in similar way as described above to determine the rate of respiration. The rate of respiration was determined during 12 noon to 2 pm on each date mentioned above. During August first fortnight it was observed that the river flooded and the animal bed got covered with water which made difficult to collect the animals. Hence, the rate of respiration for this first fortnight of August was not measured.

The records of air and water temperatures and of oxygen content of the river water from the banks of
Godavari River along the animal bed were made once in a day during afternoon (between 14.00 and 15.00 hours). The data on rainfall and humidity for every day were obtained from the Chikalthana Air Port near Aurangabad. The minimum and maximum values of air and water temperatures, rainfall, humidity and oxygen content were then established.

RESULTS

The data on air and water temperatures and of oxygen content of the Godavari River water, along with the rainfall and humidity are given Table 1. The values represent minimum and maximum measured in every month for the period May, 1986 to April, 1987. The air temperature increased to maximum during April and May ($37.4$ to $39.8 \degree C$, respectively), and decreased to minimum from December to February ($11.3$ to $13.1 \degree C$, respectively). On the other hand, the water temperature increased during the second fortnight of March ($29.5 \degree C$)
Table 1. Minimum and maximum air temperature, humidity and rainfall from the vicinity of Kaygaon near Aurangabad along with Godavari River water temperature and oxygen content for the period of May 1986 to April 1987.

<table>
<thead>
<tr>
<th>Months &amp; years</th>
<th>Temperature (°C)</th>
<th>Rainfall (mm)</th>
<th>Humidity (%)</th>
<th>Oxygen content (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air</td>
<td>Water</td>
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<td>**</td>
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</tr>
<tr>
<td>1986</td>
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</tr>
<tr>
<td>May</td>
<td>23.7-39.8</td>
<td>28.7-31.5</td>
<td>--</td>
<td>15-63</td>
</tr>
<tr>
<td>June</td>
<td>22.5-33.7</td>
<td>26.0-28.8</td>
<td>0.0-87.4</td>
<td>60-95</td>
</tr>
<tr>
<td>July</td>
<td>21.9-30.2</td>
<td>24.1-26.5</td>
<td>0.0-64.0</td>
<td>67-98</td>
</tr>
<tr>
<td>August</td>
<td>20.8-28.8</td>
<td>23.8-26.0</td>
<td>0.0-45.8</td>
<td>73-97</td>
</tr>
<tr>
<td>September</td>
<td>21.1-32.4</td>
<td>24.3-26.7</td>
<td>0.0-34.0</td>
<td>60-93</td>
</tr>
<tr>
<td>October</td>
<td>18.6-34.5</td>
<td>23.0-26.5</td>
<td>0.0-13.1</td>
<td>28-76</td>
</tr>
<tr>
<td>November</td>
<td>14.9-31.3</td>
<td>22.9-24.7</td>
<td>0.0-7.8</td>
<td>32-90</td>
</tr>
<tr>
<td>December</td>
<td>11.3-28.1</td>
<td>17.6-22.5</td>
<td>0.0-18.6</td>
<td>34-95</td>
</tr>
<tr>
<td>1987</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>13.4-29.5</td>
<td>16.7-21.5</td>
<td>0.0-2.4</td>
<td>41-89</td>
</tr>
<tr>
<td>February</td>
<td>13.1-29.8</td>
<td>18.2-24.6</td>
<td>0.0-4.90</td>
<td>29-77</td>
</tr>
<tr>
<td>March</td>
<td>17.8-34.7</td>
<td>24.4-29.5</td>
<td>0.0-3.4</td>
<td>20-61</td>
</tr>
<tr>
<td>April</td>
<td>21.9-37.4</td>
<td>26.0-29.5</td>
<td>0.0-0.5</td>
<td>11-66</td>
</tr>
</tbody>
</table>

* -> Second fortnight  ** -> First fortnight
and first fortnight of June (28.8°C), and decreased during second fortnight of December (17.6°C) and first fortnight of February (18.2°C). During July first fortnight and November second fortnight the water temperature fluctuated from 22.9°C (in second fortnight of November) to 26.7°C (in first fortnight of September). The oxygen content decreased to minimum during second fortnight of April to second fortnight of May (4.54 to 4.22 mg/l, respectively). During first fortnight of June to first fortnight of March the oxygen content fluctuated little from 5.68 mg/l in first first fortnight of October to 7.30 mg/l in first fortnight of January. The data on rainfall revealed that first rainfall took place on second June and reached to the maximum of 87.4 mm in the same month. The rainfall continued till April 17th (0.55 mm) with a gradual decline. In monsoon (during early June to late September) the rainfall declined from 87.4 mm to 34.0 mm. The data on humidity showed that minimum percentage occurred in second fortnight of April (11%) and first fortnight of May (15 %). Maximum humidity occurred in July second fortnight (98%) and later fluctuated till second fortnight of March (20%).

The fortnight variations in the wet weights of soft body (gms) of Lamellidens corrianus is given in Table 2. It can be seen that maximum wet weight
<table>
<thead>
<tr>
<th>Month &amp; year</th>
<th>Soft body weight (gms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td>1986</td>
<td></td>
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<tr>
<td>May</td>
<td></td>
</tr>
<tr>
<td>1st FN</td>
<td>10.94 ± 0.75</td>
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<tr>
<td>2nd FN</td>
<td>11.31 ± 1.46</td>
</tr>
<tr>
<td>June</td>
<td></td>
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<tr>
<td>1st FN</td>
<td>10.79 ± 0.84</td>
</tr>
<tr>
<td>2nd FN</td>
<td>10.93 ± 1.22</td>
</tr>
<tr>
<td>July</td>
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<tr>
<td>1st FN</td>
<td>11.48 ± 0.64</td>
</tr>
<tr>
<td>2nd FN</td>
<td>12.69 ± 0.80</td>
</tr>
<tr>
<td>August</td>
<td></td>
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<tr>
<td>2nd FN</td>
<td>10.23 ± 1.65</td>
</tr>
<tr>
<td>September</td>
<td></td>
</tr>
<tr>
<td>1st FN</td>
<td>8.58 ± 0.73</td>
</tr>
<tr>
<td>2nd FN</td>
<td>10.26 ± 0.91</td>
</tr>
<tr>
<td>October</td>
<td></td>
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<tr>
<td>1st FN</td>
<td>10.89 ± 1.55</td>
</tr>
<tr>
<td>2nd FN</td>
<td>12.14 ± 0.94</td>
</tr>
<tr>
<td>November</td>
<td></td>
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<tr>
<td>1st FN</td>
<td>12.37 ± 1.16</td>
</tr>
<tr>
<td>2nd FN</td>
<td>12.06 ± 1.84</td>
</tr>
<tr>
<td>December</td>
<td></td>
</tr>
<tr>
<td>1st FN</td>
<td>12.35 ± 1.89</td>
</tr>
<tr>
<td>2nd FN</td>
<td>8.36 ± 1.80</td>
</tr>
<tr>
<td>1987</td>
<td></td>
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<tr>
<td>January</td>
<td></td>
</tr>
<tr>
<td>1st FN</td>
<td>10.19 ± 0.96</td>
</tr>
<tr>
<td>2nd FN</td>
<td>11.20 ± 0.42</td>
</tr>
<tr>
<td>February</td>
<td></td>
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<tr>
<td>1st FN</td>
<td>12.64 ± 0.52</td>
</tr>
<tr>
<td>2nd FN</td>
<td>11.98 ± 0.35</td>
</tr>
<tr>
<td>March</td>
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<tr>
<td>1st FN</td>
<td>9.07 ± 0.89</td>
</tr>
<tr>
<td>2nd FN</td>
<td>11.98 ± 0.35</td>
</tr>
<tr>
<td>April</td>
<td></td>
</tr>
<tr>
<td>1st FN</td>
<td>11.33 ± 0.52</td>
</tr>
<tr>
<td>2nd FN</td>
<td>10.34 ± 0.62</td>
</tr>
</tbody>
</table>
occurred in July second fortnight (12.69 ± 0.80), October second fortnight (12.14 ± 0.94), November first fortnight (12.37 ± 1.16) and second fortnight (12.06 ± 1.84), December first fortnight (12.35 ± 1.89), and February first fortnight (12.64 ± 0.52). Minimum wet weight occurred in September first fortnight (8.58 ± 0.73), December second fortnight (8.36 ± 1.90) and March first fortnight (9.07 ± 0.89). For rest of the period body weight almost remained within the range of 10.19 ± 0.96 - 11.98 ± 0.35. Thus, the data in general showed that from August second fortnight to September second fortnight, from December second fortnight to January second fortnight, and from March first fortnight to April second fortnight the body weight decreased but increased during July second fortnight and February first and second fortnights, and also from October second fortnight to December first fortnight.

The rate of respiration of *Lamellidens corrianus* measured during each fortnight for the period May to April revealed considerable variations (Fig. 2) according to the fluctuations in the environmental parameters as given in Table 1. The values expressed in bracket, henceforth represent the rate of respiration in mg O₂/gm/h. The rate of respiration increased from first fortnight of May (0.2198±0.0246) to first
fortnight of June (0.3662±0.0356). From second fortnight of June (0.3127±0.0399) to second fortnight of July (0.2049±0.0180) the rate of respiration decreased. In August second fortnight the rate of respiration increased (0.3625±0.0254). In September first fortnight the rate of respiration decreased (0.3202±0.0235) and in second fortnight it further decreased, reaching to the minimum value obtained through out the year (0.0790±0.0131). In October first fortnight the rate of respiration considerably increased (0.3083±0.0504) and in second fortnight it further increased (0.3222±0.0232). In November first fortnight the rate of respiration decreased (0.2316±0.0503). In second fortnight the rate of respiration increased (0.3170±0.0408). In December first and second fortnights the rate of respiration decreased (0.2525±0.0376 and 0.1697±0.0176, respectively). In first fortnight of January the rate of respiration increased (0.2567±0.0377) but in second fortnight it decreased (0.1906±0.0096). In February also the rate of respiration increased in first fortnight (0.2892±0.0177) but it decreased in the second fortnight (0.1503±0.0212). Similarly in March the rate of respiration increased in the first fortnight (0.3281±0.02008) but in the second fortnight it decreased (0.1435±0.0189). In April the rate of
Fig. 2: The rate of respiration of *Lamellidens corrianus* measured during each fortnight.
respiration increased in both first and second fortnights (0.2715±0.0248 and 0.3348±0.0320, respectively).

Thus, the study revealed that the rate of respiration reached the maximum values during first fortnight of June and second fortnight of August. The rate of respiration reached the minimum value during second fortnight of September. The study further revealed that the rate of respiration fluctuated during October to March. The decrease in the rate of respiration was observed in the first fortnight of November and in the second fortnights of December, January, February and March. The variations accounted for 78.43% of the total seasonal variation in the rate of respiration.

It has been further observed that the rate of respiration significantly increased from first fortnight of May to first fortnight of June (P<0.01). From June second fortnight to July second fortnight the rate of respiration significantly decreased (P<0.01). From July second fortnight to August second fortnight the rate of respiration significantly increased (P<0.001). From September first fortnight to second fortnight the rate of respiration significantly decreased (P<0.001). In October first and second fortnights the rate of
respiration significantly increased (P<0.001), however, in November first fortnight it significantly decreased (P<0.05). In second fortnight of November the rate of respiration increased non-significantly. In December first and second fortnights the rate of respiration significantly decreased (P<0.01), however, in January first fortnight it significantly increased (P<0.05). In second fortnight of January the rate of respiration significantly decreased (P<0.05). In February first fortnight the rate of respiration significantly increased (P<0.01) but in second fortnight it significantly decreased (P<0.001). In March first fortnight the rate of respiration increased significantly (P<0.001) but in second fortnight it significantly decreased (P<0.001). In April first and second fortnights the rate of respiration significantly increased (P<0.001).

DISCUSSION

Freshwater molluscs as a whole seem to possess a considerably greater physiological adaptability than, for example marine molluscs (Berg et al., 1958). It is important to know the respiratroy function of these animals for understanding the physiological adaptation of species, since many features of aerobic metabolism
can be studied indirectly by measurement of the rate of oxygen consumption by intact animals. Seasonal variation in respiration is, therefore, a quality which must be considered in intra- and inter-specific comparison of the physiology of animal. The oxygen sensitivity and oxygen uptake rate of many freshwater organisms appear to reflect the habitat in which they live (Fox et al., 1937; Von Brand et al., 1950) and various responses of these organisms to low or declining oxygen level have been described. A few workers have stressed the importance of fluctuation of oxygen tension in regulation of oxygen consumption in bivalve molluscs. The bivalves in general, have been shown to be capable of some regulation of these rates of oxygen consumption under hypoxic conditions (Bayne, 1971; Mangum and Vanwinkle, 1973; Taylor, 1974; Mangum and Burnett, 1975). In the present study with Lamellidens corrianus it has been observed that the oxygen content of water declined during April second fortnight and May first fortnight, but for the rest of the period oxygen content remained almost at a steady level. Since Lamellidens corrianus belongs to the lotic environment along the banks of Godavari river at Kaygaon the oxygen saturation remains almost constant, except during summer (April to May) and hence this animal is deprived of facing low oxygen stress. However, the response given by this
animal in respiration during the summer months, i.e., during April to June, can also be attributed to the animals experiencing the elevated water temperature of the stratified banks of the Godavari River.

Bayne (1976) stated that in the light of the many varied effects of environmental changes on respiration rate, it is not surprising to find a regular seasonal pattern in the rate of oxygen consumption by some species. However, even when the effects of temperature, for example, or body size, are excluded experimentally for determination of oxygen consumption, a residual seasonal pattern often remains.

In Mytilus edulis, Bruce (1926) found a seasonal pattern of respiration with high values in winter and spring, and low values in summer. On the other hand, the same species maintained at a constant temperature at 15°C showed high rate of respiration in the spring, declining to minimum rate after spawning in the summer, and increasing again during the autumn (Krüger, 1960). Both the authors correlated this seasonal pattern with the cycle of gametogenesis, and the storage and utilization of nutrient reserves. Bruce (1926) concluded that the increasing proportion of gonad material in the body through the late summer and autumn increased the oxygen demand of the mussels. Inspite of
these marked seasonal changes in oxygen demand, which are at least in part, independent of temperature, Bruce (1926) estimated that in the natural populations temperature would be more important in controlling the rate of oxygen consumption than innate physiological changes. However, temperature acclimation factor was ignored by Bruce. In the present study the rise in temperature during the summer months affected the rate of respiration of *Lamellidens corianus* revealing the increased rate during summer months, i.e. April, May and June. This is probably due to maintenance of the body metabolism. Similar effects of temperature rise in maintenance metabolism of bivalves has been discussed by Bayne (1976). Apart from this maintenance metabolism, day length in different months of the year also play significant role in bringing about the cyclic changes in the oxygen consumption (Chanchel et al., 1979). In the present study, the increase in the rate of respiration of *Lamellidens corianus* during summer months can also be due to the increase in the day length. However, such a parameter's measurement with respiration in the field population requires special attention.

There are some reports dealing with the seasonal changes in respiration of intertidal gastropod molluscs. Davies (1966) while working on *Patella vulgata* and *Patella aspera* found that in July but not in
January, *Patella vulgata* from high shore levels have reduced metabolic rates when compared with either *Patella vulgata* from low levels or *Patella aspera*. The author further stated that seasonal variations in respiratory rate are to be followed in order to discover when this interpopulation differences appear. In addition, the respiratory rate was studied in limpets which have become adapted to different combinations of the environmental factors on the seasonal basis. Davis (1967) suggested that the low respiration rate of high level limpets might result from either acclimation to higher temperature or the lower nutritional condition of the habitat. In prosobranch gastropod, *Thias lamellosa*, respiration has been correlated with temperature, nutritional conditions and reproduction by Stickle (1973). In this gastropod the oxygen consumption rate of males was highest during October, December and March. Males were normally actively copulating in December and had just began feeding when collected in March. The oxygen consumption rates of females appeared to be more closely related to changes in water temperature than was the oxygen consumption rates of males. In case of freshwater bivalve molluscs, studies show that high temperature and lower nutritional conditions during summer months can significantly bring about alterations
in the rate of oxygen consumption (Akarte, 1985; Kulkarni, 1987; Rao, 1988). In the present study also is likely that the higher temperature along with low nutritional conditions of the habitat, particularly during summer months increases the rate of respiration of Lamellidens corrianus from May first fortnight to first fortnight of June.

Davis (1967) also found differences in respiratory rate of high- and low- level of Patella vulgata during the summer (as expressed on fresh body weight basis). If high level limpets contain a significantly higher proportion of storage products or body water for the same weight, the low level limpets contain significantly more respiring tissue resulting in greater total rate of respiration. Even on the basis of dry weight and total nitrogen the author found significant difference in the rate of respiration between low- and high- level limpets. In Patella vulgata, the difference in the rate between high- and low- level animals disappear as in November when the respiratory rate of the low-level limpets decreases. The author found that this coincides with the immediate post-spawning period in the reproductive cycle (Orton et al., 1956). The respiratory rate of low level limpets is lower than that of high level limpets during November and January when measured at 5 C. Between January and
March the respiratory rate of low level limpets increases, whilst the rate of high level limpets remains relatively unchanged. Thus, the differences between the two populations of *Patella vulgata* are established in the early spring and maintained until the post-spawning period in November. In *Patella aspera* similar seasonal trend to the low-level *Patella vulgata* exists. The metabolic rate in this limpet decreases during winter and the return to the high summer level commences in the period between January and March. The author while comparing the effects of nutritional conditions on the respiratory rates of the limpets found that in both March and July, at both high shore-level and mid-shore level, the population of limpets living in close proximity to algae show greater rate of respiration; intermediate between those of high- and low-level populations. The difference in the rate of respiration first appears in the spring when the metabolic rate of both *Patella aspera* and low-level *Patella vulgata* begins to increase (Davis, 1967). This can be correlated with a resumption of somatic growth following the cessation of growth during the winter months (Orton, 1928 a,b). Towards the end of the summer, somatic growth declines but growth of gonad tissue continues until spawning which takes place in late September in *Patella aspera*.
and in October in *Patella vulgata* (Orton et al., 1956). The sharp decrease in the rate of respiration in November is therefore correlated with the immediate post spawning period. This pattern of event follows very closely to that described by Barnes et al. (1963) for two species of *Balanus*. In these animals, oxygen consumption is at a low-level during the winter months but during the early spring the respiration rate, total body weight, reserve materials and total content of RNA all increase sharply. Similar changes in *Acarthia* were observed by Conover (1959) with the spring diatoms increase and the presence of abundant food. In *Patella* the concentration of blood sugars and stored glycogen in the tissue rise during the spring (Barry and Munday, 1959) in a similar manner to the respiration rate. This has been correlated with the onset of active feeding following winter quiescence. However, Davis (1967) found that *Patella* continues to feed during the winter months. Somatic growth of limpets in this population is also resumed in the spring but the anticipated increase in the metabolic rate, associated with increased energy requirement for protein synthesis do not occur. This strongly suggest, therefore, that low-level population of *Patella vulgata* is to be regarded as the 'normal' population and that the low metabolic level of the high-level population is a response to the environmental
factor of the high shore-level habitat. In the freshwater limpet, Ancylus fluviatilis respiration rate was at a minimum in March and May which was correlated with the onset of reproduction (Berg et al., 1958). The authors stated that there may be a direct functional relationship between these processes. Calow (1975) showed a rise in the respiratory metabolism of Ancylus fluviatilis prior to egg deposition. This may suggest some preparatory process in this species perhaps associated with the production of large yolky eggs (Calow, 1972). In the present study with Lamellidens corriianus, it has been also observed that the rate of respiration increases during November second fortnight at the time of increase in the glycogen content from hepatopancreas, gonad and foot (for detail refer Chapter 3). During this period the total body weight also increases revealing somatic growth. Many gametes are released from the gonad in this period. The sharp decrease in the respiration during second fortnight of September correlates with decrease in the total body weight due to the release of many gametes (refer Chapter 4). Similar situation also exists during December second fortnight. This can also be confirmed from the data on decrease in gonad wet weight in both the second fortnights of September and December. In April second
fortnight it is interesting to note that the rate of respiration increases at the time of fully shed gametes and during this time protein content increases from hepatopancreas, gonad and mantle. This is also correlated with the increase in the temperature during the summer months.

From the above description, the importance of nutritional condition in determining the level of the metabolic rate can be suggested. There appears to be very little information available on the relationship between the nutritional level and metabolic rate in other animals. However, Bodine (1921) demonstrated different metabolic rates correlated with different feeding levels in the insects, *Malanoplus differentialis*. Their metabolic rates were determined by the amount of oxygen required to oxidise the assimilated food products. It is not fully known whether in bivalves, including freshwater species, a low metabolic rate is a direct result of, or active compensation for low nutritional conditions. In the present study with *Lamellidens corriaus* the probable effect of high nutritional level in increasing the oxygen consumption can be recorded during the second fortnight of August. This maximum increase in the rate of respiration in second fortnight of August is correlated with the build-up of reserve materials like glycogen, protein and lipid
in the tissues—hepatopancreas, gonad, mantle and foot (except protein in the later tissue, wherein it decreased). However, the subsequent fluctuation in the rate of respiration of this animal requires special attention from the point of reproduction and biochemical divergence. In the mussel _Mytilus edulis_, Thompson and Bayne (1972) found that food stimulus increases the rates of ventilation, filtration and oxygen consumption above routine values. The authors found that heart rate is not affected by feeding, the ventilation/relative perfusion ratio is increased, resulting in a drop in the efficiency of oxygen withdrawal. Thus, the authors concluded that the changes are regarded as an active metabolism associated with feeding. It was further found that the increase in the ventilation rate of _Mytilus edulis_ during feeding enables the animals to bring more food to the gills in unit time, which may be adaptive in a discontinuous distribution of planktonic food sources. In _Lamellidens corriianus_ increase in the gill ciliary activity during the post-monsoon period can also be attributed to decreased amount of food material available (refer Chapter 2) (Kulkarni, 1987; Rao 1988) and the animals try to bring more food to the gills by increasing the gill ciliary activity. The quantity of oxygen consumed
by an animal is related to such metabolic processes as growth, repair of tissue, excretion, digestion and osmoregulation (Collier, 1959). Besides these processes, the author stated that any act which results in the performance of mechanical work increases oxygen consumption.

While studying the seasonal variations of oxygen consumption of the freshwater limpet, Ancylus fluviatilis, Berg et al. (1958) found that the higher rate of respiration from April to the end of July is caused by the reproductive activity, hence the period of reproduction occurs just at that time. The author further noted that the rate of respiration is distinctly higher in early summer. The early summer maximum of oxygen consumption is about twice that the consumption found in autumn and winter at same experimental temperature. From a comparison between the curves of growth rate and the rate of respiration drawn by the authors it must be concluded that the increased rate of respiration during spring and early summer can not be accounted for by an increased growth rate since this, on the contrary, decreases at that time. But (a) the time of the change of the growth rate (March, adults) and (b) the time of the increase in the rate of respiration (March/April), compared with (c) the beginning of reproduction period of both pupulations (April),
warrants the conclusion that reproduction is responsible for both the changes in growth rate and the rise in the rate of respiration. In the present study also it is possible that the strange fluctuation in the rate of respiration from second fortnight of July to second fortnight of March in case of *Lamellidens corrianus* is due to variations in the timing of completion of the reproductive process and the growth of the animal itself. It has been reported that the growth of the freshwater bivalves, like *Indonaja caeruleus*, from Godavari river is not uniform throughout the year. The period of rapid growth is found from March to August which coincides with high temperature and the period of slow growth from September to February with the lowering of temperature (Godbole, 1977). However, before correlating the data on respiration with the growth of a species requires special consideration through its life cycle. In the present study it is further observed that the spawning in *Lamellidens corrianus* starts from monsoon and continues to early summer, and there occurs interruption in spawning during this entire period. This results in the fluctuation in the rate of respiration of these mussels during post monsoon to early summer. The rate of respiration has been correlated with the seasonal changes in the reproduction
of the estuarine mussel, *Mytilus edulis* by Bayne (1973). Measurements of routine rate of respiration by *Mytilus edulis* of North sea population showed a marked seasonal cycle, with high rates in winter and low rates in summer. These changes are apparently related to the seasonal gametogenic cycle, high rates of oxygen consumption coinciding with active gametogenesis, and low rates occurring after spawning in summer. These seasonal changes may not be as marked in more northerly population where very low temperature inhibits gametogenesis which may occur over a large portion of a year. Thus, three components of aerobic metabolism may be recognized—maintenance metabolism, which may be estimated as a standard rate of oxygen consumption; metabolic processes associated with ventilation, movement of feeding; and gametogenesis. The last two of these contribute to the routine rate of oxygen consumption. Gametogenesis, feeding activity and the processes of maintenance contribute towards the observed rate of oxygen uptake. Temperature acts directly on these processes as a "disturbance" (Wieser, 1973) and also on a "control unit", or temperature transducer as a "stimulus". Gametogenesis, feeding activity and maintenance are influenced by reference inputs such as season, body size and age; these act on activity via the control unit. According to Burky and
Burky (1976) in freshwater bivalve *Pisidium walkeri* the low $Q^{10}_S$ during the colder months can likely dampen the effects of any short-term temperature fluctuations which might occur and act to stabilize metabolism during July–September which can act to allow these clams to take advantage of 'optimal' feeding conditions at times of increased temperature during period of maximum growth and reproduction. Generally high $Q^{10}_S$ would appear to be adaptive, but at the same time it is possible that the resulting high metabolic rate could significantly decrease the amount of energy available for growth and reproduction. This could be critical at times of low primary production when the pond stratifies during the summer. In *Lamellidens corrianus* it has been observed that the high metabolic rate during summer months are correlated to low primary productivity. This period also corresponds to decrease in the amount of energy available for maturation of gametes and probably for rapid growth due to stratification along the banks of Godavari river. It has also been observed that the humidity remains high during monsoon, i.e. during June to September and also during post monsoon to early winter, i.e. during October to February. This can be correlated with the gradual decrease in the air and water temperatures as well as the rainfall. However,
during March, April and May, the low values of temperature, rainfall, oxygen content of the water and humidity all in combination perhaps affect the productivity and food availability to *Lamellidens corrianus* along the banks of Godavari River during summer months resulting in the high rate of respiration.

Burky and Burky (1976) further stated that elevated metabolism in *Pisidium walker* in January--March above April--June and also in July--November above all other values is selected for a more efficient exploitation of available energy for the prevailing conditions (biological and physical). The authors further stated that the reduced metabolism during April--June is selection for a more efficient utilization of available energy by allocating a greater percentage and absolute amount of the total assimilation to the non-respired polls of growth and respiration output. The seasonal shifts in the levels of respiration when correlated with the reproduction and biochemical constituents from different body parts of *Lamellidens corrianus* under present study show that levels of respiration are probably balanced with the timing of utilization of body reserves and reproduction so that there is a selection for more efficient utilization of available energy by allocating to growth and spawning during post monsoon to early summer. Further data on
reproductive period is given Chapter 4. Hornbach et al. (1983) found that in *Sphaerium striatum* larger clams have a both greater absolute metabolism and higher rates metabolism in the winter. In *Musculium lacustre*, the 'b' value and metabolism related to body sizes decline before birth period suggesting that smaller clams may be growing faster; the 'b' values increase during birth period, indicating that the presence of large embryos in the brood sacs may have influence (Alexander, 1982; Alexander and Burky, 1982). Huebner (1982) while studying seasonal variations in the respiration of two species of unionid clams, *Anodonta grandis* and *Lampsilis radiata* found no difference in the response of animals of different sizes to changes in temperature of season. Also, inspite of variable of proportion of female dry weight made up of glochidia at different times of the year (Huebner, 1980), there was no difference in respiratory rate of male and females. In the present study it has been observed that *Lamellidens corriganus* is a hermaphroditic species and broods glochidia in the outer demibranch from August to March (refer Chapter 4). The significant differences in the respiration of these animals during each fortnight can be attributed to a proportion of respiration made up of glochidia at different times of the year, particularly during
spawning period.

In *Mytilus edulis* the routine rate of oxygen consumption is seasonally variable, with high values in winter and low values in summer (Bayne, 1973). The standard rate also varied seasonally in this mussel. The exponent that relates routine oxygen consumption to body size varies from high values in the summer to a low value in the winter. In winter and spring, when carbohydrate reserves are low, stress results in reduced O : N values. In the summer and autumn when carbohydrate reserves are high the O : N ratio increases during stress. The author further found that in summer and autumn when the routine rate is low, decline to the standard rate may occur within ten days. In winter, when gametogenesis is active and the routine rate is high, decline to the standard rate may require 25-30 days (Gabbott and Bayne, 1973). In spring, however, when gametogenesis virtually completes and the energy reserves of body reach a minimum, starvation results in a very rapid decline to the standard rate. This standard rate of oxygen consumption could also be called a 'starvation rate', since it is empirically defined as a result of starvation. The decline from routine to standard is due, in part, to reduced activity, and is also equated with the reduction of body reserves and other conditions characteristic of starvation. In
the present study the minimum values of the rate of respiration of *Lamellidens corrianus* obtained during second fortnight of July, second fortnight of September, first fortnight of November, second fortnight of December, second fortnight of January, second fortnight of February and second fortnight of March are correlated with the low values of the glycogen and protein contents from gonad, hepatopancreas and mantle (refer chapter 6). This can be attributed to the result of starvation in the field population. This decrease in the rate of respiration in *Lamellidens corrianus* could indicate a lowered metabolic rate or it could indicate a switch in the emphasis from a carbohydrate-oriented metabolism to a lipid or protein oriented metabolism. It is likely that the observed lowered oxygen consumption in *Lamellidens corrianus* is an adaptation enabling the mussels to conserve food stores. Such conservation of food stores have been reported in case of pulmonates by Von Brand et al. (1948). The increase from standard to active rate of oxygen consumption, resulting from the offer of food to animals previously starved has been described by Thompson and Bayne (1972) and Widdows (1973). Such an increase is almost instantaneous and is associated with a greatly enhanced level of activity. The increase in the rate of respiration subsequently
following starvation periods as stated earlier for *Lamellidens corrianus* during second fortnight of August, second fortnight of October, second fortnight of November, first fortnight of January, first fortnight of February and first fortnight of March is probably due to active feeding associated with a greatly enhanced level of activity. Thompson and Bayne (1974) stated that if feeding at high ration level is continued after starvation the rate of oxygen consumption may decline or it may remain close to the active rate. At low ration levels, only slightly in excess of maintenance, the rate of oxygen consumption increases rapidly with any increase in the concentration of food particles reaching an asymptotic value which is then maintained over a considerable range of further rapid increase. In the present study with *Lamellidens corrianus*, the high level of oxygen consumption during the second fortnight of August and first fortnight of September can be correlated with the possibility of high feeding activity in the presence of increased concentration of food particles during monsoon season. However, the decline in oxygen consumption during subsequent period from second fortnight of September to second fortnight of March is probably due to the fluctuating concentration of food particles along the banks of the Godavari River. The rainfall considerably decreases from October onwards and
the concentration of available food material to _Lamellidens corrianus_ also decreases. This is particularly noticed during the period of March second fortnight to second fortnight of May when these animals migrate down the river as the bank of Godavari River stratifies (based on the field observations). Based on changes in ration Thompson and Bayne (1972) and Byane (1973) defined three different levels of oxygen consumption rate by _Mytilus edulis_. When the animals are fed, filtration rate increases to maximum (Widdows, 1973) coincidently with the marked increase in the rate of oxygen consumption to the active rate. Thus, the present study and the earlier reports by other workers could reveal that the relationship between respiration rate and ration are complex, involving the metabolic demand, not only for activity (primarily the action of gill cilia in bringing about the movement of water and the filtration of particles in the mantle cavity as referred in Chapter 2) but also of processes related to the assimilation of food (the metabolic costs of digestion, excretion and growth). The action of gill cilia comprise the 'mechanical costs' associated with feeding, and the assimilation of food comprise 'physiological cost'. These various metabolic demands in _Mytilus californianus_ were estimated by Bayne _et al._
(1975) by relating the oxygen consumption to ventilation rate. The physiological costs of feeding includes energy utilized in digestion and assimilation, and non-utilized energy freed through deamination and other processes (Warren and Davis, 1967). Bayne (1976) stated that the decline in oxygen consumption after feeding in *Mytilus edulis* could be assigned to two components one of which was associated with the decline in feeding activity and the other associated with digestion and assimilation. This latter component coincided in time with a pulse of increase in nitrogen excretion, and accounted to between 5 and 30% of the total increment in oxygen uptake following feeding. The similarity of the respiration rate-temperature curves for both winter and summer unionid clams, *Anodonta grandis* and *Lampsilis radiata* (cold and warm acclimated, respectively) indicates that neither species shows respiratory compensation although not the usual case non acclimation has been found in other molluscs (Newell et al., 1977; Brown et al., 1978). Both the unionid species are sedentary and obtain food by filtering water flowing passed them. Since rates of most physiological functions which decrease as temperature declines and since it is probable that no increased activity is needed to obtain adequate food for maintenance, there is perhaps more reason to expect non-acclimation, possibly as an energy
conserving mechanism during winter gonad development (Huebner, 1930), than acclimation in these mussels (see Burky and Burky, 1976 for further discussion of respiratory compensation of freshwater bivalves). Thus, from the data on the present study on respiration, biochemical changes and reproduction of *Lamellicidens corrianus*, it can be stated that the variation in the respiration is probably due to changes in the physiological costs of metabolism and in particular to (a) the gametogenic cycle, (b) seasonal changes in the use of different substrates for energy metabolisms, and (c) seasonal changes in the balance between metabolically active and inactive materials in the mantle, gonad and non-gonad tissues.

Many authors also studied the tissue respiration of bivalve molluscs and correlated the seasonal changes with the aspects of reproduction and environmental parameters. Seasonal changes in the metabolic rate of isolated tissues have been demonstrated by Percy *et al.* (1971) working with the oyster, *Crassostrea virginica*. They found that the oxygen consumption rates of gill and mantle tissues (but not adductors muscles) were depressed in winter, when the rate temperature curves showed evidence of 'inverse acclimation'. There was a negative correlation between a
condition index (which they suggest was a measure of glycogen content) and the respiration rate of mantle tissue. However, Hopkins (1946) who studied Mercenaria mercenaria found tissue respiration to be higher in winter than in summer, that is, there was a positive seasonal acclimation. These differences may be a function of different gametogenic cycles of the species (Percy et al., 1971). Mercenaria, like Mytilus, has active gametogenesis in the early winter and retains ripe gametes throughout the winter to the spring. Crassostrea, on the other hand, has a gametogenic 'resting stage' in the winter. These studies might suggest therefore that the gametogenic cycle, which is under hormonal control is determinant, directly or indirectly, of the seasonal metabolic pattern. Innate physiological demands, resulting from gametogenesis and nutrient cycles possibly determines the seasonal pattern of oxygen consumption but further research is needed to identify and characterise 'innate physiological demand'.

The endocrine control of developmental and physiological processes in invertebrates has been amply demonstrated by the results of various kinds of experiments in different phyla (Highnam and Hill, 1978). Many of the effects of physical factors on metabolism are mediated by hormones. The unifying features of endocrine controlled processes in invertebrates is
almost the ubiquitous involvement of neurosecretory mechanisms. Where a developmental process varies with the environmental situation and can be shown to be under neurosecretory control, it is often assumed that the neurosecretory mechanism is influenced by the environment. Hormonal involvement in controlling the oxygen consumption has been now well established in crustaceans (Silverthorn, 1973a, b; Nagabhushanam and Kulkarni, 1978a; Hanumante et al., 1980). The implication of hormonal factors in the regulation of oxygen consumption has been reported for annelids (Kale and Rao, 1973; Nagabhushanam and Hanumante, 1977; Kulkarni et al., 1978; Nagabhushanam and Kulkarni, 1978b, 1983) and in gastropods (Geraerts, 1975; Hanumante et al., 1980). In case of bivalve molluscs it has been shown that the cerebral ganglia are likely to be the centers in regulating the respiration, where as the visceral ganglia are the centers for enhancing the rate of respiration (personal communication from Mane, U.H.). The cerebral ganglia control the tonus of adductors and their activity seems to be antagonistic to that of visceral ganglia (Barnes, 1955; Horridge, 1958; Salanki, 1961). In the present study with Lamellidens corinus it has been observed that the cerebral and visceral neurosecretion varies seasonally (refer chapter 5) and
it is possible that this variation brings about the fluctuation in the rate of respiration. The exact role of neurosecretion from these ganglia requires special attention from the experimental point of view.

Few authors working on fishes showed involvement of gonadal steroids in respiration. Chanchal et al. (1979) while working on Anabas testudineus found two peaks in respiration - first spawning in June/July which corresponds to its breeding or spawning period, and second in October. The high value for oxygen consumption during spawning period may be because of two facts - 1) during spawning period the animals become more active and for the act of reproduction more energy is required, and 2) increased production of gonadal steroids. Hoar (1958) observed gonadal steroids stimulating the metabolic rate in goldfish. Though the exact mechanism involved in the action of gonadal steroids on oxidative metabolism is however, not clear Hoar (1958) exploded two possibilities - 1) the steroids may increase in some way the reactivity of neuromuscular mechanism, thus promoting the locomotor activity which indirectly results an increased demand for oxygen, and 2) these steroids might act generally throughout the body stimulating oxidative metabolism in a variety of tissues. Presence of steroid hormones (like 17$\beta$-HSDH, 3$\alpha$-HSDH) in bivalve molluscs has been reported by few
investigators (Hathaway, 1965; Mori et al., 1965, 1966, 1969; Longcamp et al., 1974). It can be presumed that these steroids also occur in the freshwater bivalves also. If it is true, it can be said that they affect the activity of the bivalves and thereby the respiratory rate as observed in the present study with *Lamellidens corrianus*. This aspect of steroid hormonal impact on respiration in bivalves requires special experimental evaluation.

The wide occurrence of neurotransmitters like ACh, 5-HT and catacholamines (predominantly dopamine) in the nervous system of various bivalve molluscs is well established (Sweeney, 1960; Hill and Welsh, 1964; Cotrell and Laverack, 1969). This distribution is not surprising since these compounds are common biochemicals as are the enzymes involved in their metabolism. Movement of gill cilia and heart beat in bivalves are affected by these neurotransmitters (Nistratova, 1969; Aiello, 1960, 1970; Malanga, 1971, 1974, 1975; Paparo et al., 1976). Paparo et al. (1976) have given a detailed description on the nerves releasing 5-HT and dopamine from cerebro-visceral connective and branchial nerve to the gill. Considering the effect of neurotransmitters on the respiratory organ in bivalve molluscs, the effect of these transmitters in altering the rate or respiration
of *Lamellidens corrianus* under present study during different fortnights of the year, particularly during July second fortnight to March second fortnight cannot be ruled out, because release of large quantities of serotonin and catecholamines from the ganglia of bivalve molluscs has been well documented (Lubet, 1965, 1970).
SUMMARY

1) The rate of respiration of *Lamellidens corrianus* from the banks of Godavari River at Kaygaon near Aurangabad measured during each fortnight for the period May to April revealed considerable variations. The rate of respiration reached the maximum values during first fortnight of June and second fortnight of August, and reached to the minimum value during second fortnight of September.

2) The rate of respiration fluctuated during October to March. The decrease in the rate of respiration during this period was observed in first fortnight of November, second fortnight of December to March.

3) The total variation over the entire study accounted for 78.43 %. The rate of respiration significantly changed from one fortnight to another in all the months, however, in second fortnight of November the rate increased non-significantly than first fortnight of November.

4) Increase in the rate of respiration during April, May and June has been correlated with the rise in temperature during summer months having increase in the day length.
5] Increase in the rate of respiration during second fortnight of August and first fortnight of September may probably be due to the high nutritional levels along the banks of the river.

6] The fluctuation in the rate of respiration from second fortnight of July to second fortnight of March can be correlated with the timing of completion of reproductive events and the growth the animal itself.

7] Decreased rate of respiration during first fortnight of July, second fortnight of September, first fortnight of November, second fortnight of December, second fortnight of January, second fortnight of February and second fortnight of March is correlated with the low values of glycogen and protein contents from gonad, hepatopancreas and mantle. This could indicate a lowered metabolic rate, or it could indicate a switch in the emphasis from a carbohydrate-oriented metabolism to a lipid or protein-oriented metabolism.

8] The results are also discussed in the light of probable involvement of horomones, neurotransmitters and gonadal steroids.
BIBLIOGRAPHY


Bleck, V. and Heitkamp, U. (1980). Okophysiological
Untersuchungen an *Pisidium personatum* Malm, 1855
and *Pisidium obtusae* (Lamarck, 1818) (Bivalvia,

Bodine, J.H. (1921). Factors influencing the water
content and the rate of metabolism of certain

Bouzin, H. (1931). Influence des variations rapides de la
salinité sur la consommation d’oxygène chez *Mytilus
Monaco.*, 569:1.

Boyden, C.R. (1972a). The behaviour, survival and
respiration of the cockles *Cerastoderma edule* and

Boyden, C.R. (1972b). Aerial respiration of the cockle,
*Cerastoderma edule* in relation to temperature.

consumption by *Bullia* (Dorsinum) *melancoides*
(Deshayes) and *Bullia digitalis* (Meuschen)
(Gastropoda, Nassariidae) - an example of non-

Bruce, J.R. (1926). The respiratory exchange of the

the metabolism and activity of poikilotherms. *Biol.*


Comp. Endocrinol., 5:504-508.


Holopainen, I.J. and Ranta, E. (1977a). Carbon dioxide output in the respiration of three Pisidium

Holopainen, I.J. and Ranta, E. (1977b). Respiration of 
*Pissidium amnicum* (Bivalvia) measured by infrared 

Hopkins, H.S. (1946). The influence of season, 
concentration of seawater and environmental 
temperature upon the oxygen consumption of tissues 

Hornbach, D.J. (1980). Population energetics of the 
freshwater clam, *Sphaerium striatium*, with special 
reference to seasonal patterns of growth, 
reproduction, filter feeding and metabolism. Ph.D. 
Dissertation, Miami University, Oxford, Ohio. 
(Diss. Abst. 41: 25140-2515B, Order No. 8108485).

Seasonal variation in the metabolic rates and Q10 
values of the fingernail clam, *Sphaerium striatunm*

the gill of *Mya* (Lamellibranchiata). *J. Physiol.*, 

Huebner, J.D. (1980). Seasonal variation in two species 
of unionid clams from Manitoba, Canada: biomass. 
Huebner, (1982). Seasonal variation in two species of unionid clams from Manitoba, Canada: respiration. 


Kulkarni, G.K., Nagabhushanam, R. and Hanumante (1978). Implication of a hormonal principle in thermal acclimation of the Indian freshwater leech,


Philadelphia. 688.


Schlieper, C. (1957). Comparative study of *Asterias rubens* and *Mytilus edulis* from the North sea (30 per 1000s) and the Western Baltic sea (15 per 1000s). *Annes biol.*, 33: 117-127.


Thompson, R.J. and Bayne, B.L. (1972). Active metabolism associated with feeding in the mussel *Mytilus*.


Berlin.


