Contribution of natural biota in the initial growth of black tiger shrimp *P. monodon*, in modified extensive shrimp farming practices on South-West coast of India.

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Abstract
Understanding natural biota in aquaculture practices is important so as to reduce the artificial feed and reduce the feed coasts. During present study the food preference of shrimp was studied from aerated and non-aerated shrimp culture ponds. The aerated ponds were managed with HOBAS aeration devices developed by HOBAS Norway. Natural diet preference from these ponds was evaluated, by observing the presence of natural biota, in the shrimp gut. Artificial feed utilization was evaluated by observing formulated feed uptake. It was found that, when natural biota was abundant, shrimp ceased feeding on artificial diet. From 40 to 60 Day of Culture (DoC) onwards shrimp preferred artificial diet. During the experiment, gut content showed higher total biota count in the gut over the period decreased after 40 to 60 DoC. After 40 to 60 DoC, average micro-benthic density was found to be higher since they were not utilized as food by the shrimp. It was observed that, effects of natural food utilization were reflected in the FCRs being low during both the experimental cycles studied during EC-1 and EC-2. During EC-1 FCRs were higher than EC-2. It was found that, though stocking rates in aerated and non-aerated ponds, were different physico-chemical properties of water and soil as well as shrimp growth did not differ significantly (p> 0.05).

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Key words: Natural biota, artificial feed, FCR, shrimp growth, aeration.

Introduction
Achieving growth in stipulated time limit is the most important aspect in shrimp farming. From traditional to intensive shrimp farming practices this task turns out to be important, as profitability becomes vital. In this regard attaining best feed conversion ratio (FCR) is considered to be effective management tool to reduce the feeding costs. According to Mohanty (2001) artificial formulated feed constitute about 55% of total operational cost in the aquaculture practices. In case of aquaculture systems, practices which are not intensified are categorized mainly as extensive, modified extensive to semi-intensive practices which are most common in India, as the land holding per farmer is less (Krishnan & Brithal, 2002). Hence most of the farmers practice modified extensive to semi-intensive type shrimp culture practices in India. These farms have moderate stocking densities ranging from 8 to 12 PL.m⁻², hence they follow low input feed strategy (Krishnan & Brithal, 2002), while allowing shrimp to utilize the available natural biota. Much has been studied since early 1960’s especially in point of view of commercial production of aquatic species by understanding their feeding habits, and behavior (Goddard, 1992). During present research the role of natural food was studied in shrimp nutrition in comparison with the artificial feed in modified extensive type of shrimp culture practices with aeration in consideration which has been lack in earlier studies.

Shrimp growth is mainly believed to be affected by the environmental factors (exogenous) and biological factors (endogenous). The exogenous factors includes salinity, light regime, dissolved oxygen and temperature, wherein endogenous factors include elevated activity level, body size and availability of food organisms either at the bottom or overlying water consisting of phytoplankton. These entities certainly affect the shrimp behavior towards feed selection and consumption as well (Goddard 1996). There is also contemplation that, apart from these...
endogenous and exogenous factors feed detection by shrimp is found to be hampered due to physical constrict like feed dispersion from bunds, which may not distribute the feed uniformly, hence it is difficult for shrimp to detect the feed. According to Martin et al. (1998) conditions at water and sediment interface may turn deleterious during low oxygen conditions due to oxidation of fecal pellets and organic matter decomposition at the bottom of water, leading to deleterious odors originating from sulfite reduction during anoxic conditions. This can impart stress on the shrimp and can bring about changes in the selection of food. Hence it was understood that shrimp is either unable to reach towards the feed due to improper dispersal of feed or due to offensive odors originated in the reducing environments. This may starve the animal in case natural fauna is not available as feed for the shrimp in the pond. In this erudition it was hypothesized that, in such conditions when shrimp is unable to detect the artificial feed, an alternate and obvious food comes from the natural biota present at the bottom and in the overlying waters. Absentia of the natural food organisms due to practices of drying pond bottom, liming practices, water exchanges, as well as predation by culture species may bring depletion of natural fauna. These situations may turn lethal for shrimp concerning the availability of food and may bring them under stress resulting in stunted or uneven growth.

From the present study it was observed that, shrimp depend on the natural food in the form of microphytobenthos not only in the initial stages but also contribute significantly at the later growth phase of shrimp. In the later stage they feed upon secondary productivity which mainly includes benthic invertebrate macrofauna, meiofauna and microbenthos along with artificial feed. They are fed upon by shrimp either actively in former two cases or passively in the later case. Hence it was understood that, it is also necessary to understand the primary productivity of the culture system which can help in reducing the dependability of shrimp on artificial commercial diet and for avoiding situations of starvation due to unavailability of the feed. In this regard, during this study shrimp gut contents were quantified for the presence of natural biota, and simultaneously feeding of shrimp on artificial commercial feed and resultant growth was studied. Physico-chemical parameters such as temperature, salinity, pH, DO, nutrient, chlorophyll a were observed throughout the culture period during EC-1 and EC-2. These parameters were monitored from aerated and control pond so as to observe if there are any difference between water quality as well as primary productivity measured in terms of chlorophyll a, and secondary productivity in terms of benthic invertebrates such as macrofauna, meiofauna and microbenthos (Holme, and McIntyre 1984).

Materials and Methods

Description of Study area.

A shrimp farm was selected at Alvekodi, near Kunta town North Kanara District, in Karnataka state on the south west coast of India (Figure 1). Shrimp farming activities on the west coast are concentrated in this area along the banks of Kali and Agnashini creeks in karwar and Kunta sections respectively. Ponds were ideally located

Figure 1: Map of the study area

about 10-12 kms from the local hatchery (Skyline Hatcheries Pvt Ltd.) providing constant supply of *P. monodon* larvae of 20 day old which were screened for WSSV.

Experimental Ponds and arrangement of aerators

The farm has total water spread area of ~6.0 ha of which, two ponds, namely Aerated Pond (Experimental Pond) and Non-aerated Pond (Control Pond) having an area of 0.65 and 0.60 ha. and average depth of 1.20 m was selected. (Figure 2). The creek adjacent to the experimental ponds, was tidal fed and ran about 3 to 5 km from the sea harboring about 40 ponds with an approximate water spread area of 0.5 to 0.6 ha. Two culture cycles were studied, named Experimental Cycle -1 (EC-1), carried out over the period of June 2004–September 2004 and Experimental Cycle-2 (EC-2) carried out over the period April 2005- August 2005.

Figure 2: Layout of Farm and sampling ponds showing sampling locations
Arrangement of aerators in experimental ponds was done by considering the wind flow directions and currents generated through wind driven water circulation to achieve better circulation, mixing and to accumulate sludge at the centre of the pond. Four aerators developed by HOBAS-Norway of 1 HP capacity each were fixed at four corners of experimental ponds as showed below (Figure 3).

**Physico-chemical parameters**

All physico-chemical parameters were measured to evaluate water quality. Temperature was measured with the help of Hg-thermometer (GH-Zeal-London). pH of the water and sediment were measured with a pH meter (PHAN and Orion- combo pH electrode). Salinity was measured following Mohr-Knudsen argentometric method and dissolved oxygen concentration was determined by using Winkler’s titrimetric methods as described by Strickland and Parsons (1972). For BOD analysis, water samples were collected in BOD bottles, and were analyzed after keeping samples in dark for 5 days at 20 °C in BOD incubator. Nutrient analysis for NO\textsubscript{3}-N, NO\textsubscript{2}-N, NH\textsubscript{3}-N and PO\textsubscript{4}-P was also carried out by spectrophotometric determination as described by Strickland and Parsons (1972).

In view, that shrimp is an indiscriminate feeder it was important to consider its other scavenging or subsidiary food items. These are taken up passively or actively in case of absence of other food source as per hypothesis. Hence chlorophyll a, from water and sediment were studied. For the estimation of Chlorophyll a spectrophotometric method described by Strickland and Parsons (1972) was followed. A 1000 ml of water sample was filtered though GF/F glass fiber filter paper (47 mm diameter; 1.2 μm pore size) and extracted in 90% acetone overnight.

**Shrimp feeding and growth studies**

Commercial supplementary feed having stability of 4 hrs in water were fed to the shrimp. Feed was administered manually from the periphery of the pond, four times a day at regular interval of 00.00, 6.00, 12.00, and 18.00 hrs. Aeration was stopped before and after 1 hr. while administrating the feed. This practice allows shrimp to access the feed dispersed at the fringe of the ponds. Utilization of the feed was monitored with the help of check trays in respective ponds, and daily dosages were adjusted, according to the check tray monitoring and shrimp body weight.

Data on shrimp length and weight and feeding were collected at fortnightly intervals by taking the length and weight of shrimps as described by Goddard (1996). The absolute growth rate was calculated for shrimp by using formula , Absolute growth rate= \( \frac{W_{2}-W_{1}}{T} \), where, \( W_{2} \) Final weight, \( W_{1} \) Initial weight of the shrimp, \( T \) time in days of culture. The Feed conversion ratio (FCR) was calculated using formula, FCR= [Total food fed/ Total weight of shrimp in kg](3).

**Shrimp Gut content Analysis**

Gut content analysis was carried out by percent occurrence method as described by Hyslop (1980) for establishing the role of natural biota from an experimental and control pond. Shrimps were collected randomly by using cast net. From four to five hauls 10 shrimps were selected with full guts at 10.00 hrs and 22.00 hrs that is, 2 hrs prior to standard feeding practices at 6.00 and 24.00 Hrs. Shrimp were anesthetized in ice chilled water and were dissected immediately. Gut was removed carefully and then transferred to a clean Petri dish. Gut was then cut opened with the help of scalpel, and entire content were transferred in to the vials containing 5% Formalin and Lugol’s solution. They were analyzed for the presence of microbenthos. Entire gut content fauna were identified to nearest group level. Identification was carried out using Olympus BX 51 compound microscope and Olympus binocular stereoscopic zoom microscope. Sedgwick Rafter was used for identification of remains of microbenthos.

**Data Processing/ Statistical Analysis**

Data processing was done with the help of statistical software packages like Statistica 5.0, SPSS 7.5 for windows and MS-Excel. Correlation analysis was carried out using Statistica 5.0 to study the linear relationship between multiple parameters. Correlations thus obtained are expressed at \( p \leq 0.05 \). Multiple regression analysis was carried out using SPSS 7.5 for studying the linear relationship between one dependent variable and several independent variables for water quality, benthos, gut content analysis and are described on the basis of their significant relationships at \( p<0.05 \) and \( p<0.001 \).

**Results**

As mentioned earlier, two earthen ponds namely aerated pond with HOBAS aeration systems-Norway and non aerated pond showed following results during study period over two culture cycles EC-1 and EC-2. Physico-chemical parameters such as temperature, salinity, DO (Decampo et.al., 2003, Chen and Lai, 1993), pH of the water and sediment (Boyd, 1995, Wikins.1984), NH\textsubscript{3}-N and NO\textsubscript{3}-N (Rosas et.al. 1999) are known to affect shrimps, these parameters were at their optimal also exert similar effect on penaeus monodon in the culture systems. During present study however, these parameters were found to be at their optimum (Table 3). The one way ANOVA carried out for mentioned physico-chemical parameters showed no significant differences (\( p>0.05 \)) in between aerated and control ponds during EC-1 and EC-2. The effect of individual water quality parameter was studied on shrimp growth did not show any significant effect (\( p>0.05 \)). As physico-chemical parameters were at their optimal best, and showed no significant differences in aerated and control pond, the focus was to see, if, artificial feed and gut biota in the form of microphytobenthos. Microphytobenthos mainly consisted of diatoms such as Coscinodiscus sp., Pleurosigma sp., Navicula sp. Overall over two culture cycles it was observed that Coscinodiscus sp. contributed 44%, Navicula sp. contributed 38% and Pleurosigma sp. 18% in aerated pond and Pleurosigma sp. contributed 47%, followed by Coscinodiscus sp. with38% and Navicula sp. contributed 10%. As these diatoms form an important source of food for the shrimp they were studied to see their relationship with that of shrimp growth. Hence stepwise and backward multiple regression analysis was carried out to study the role of microphytobenthos in shrimp growth. Overall it was found that there were significant differences (\( p>0.05 \)) between species percent...
contribution in aerated and non aerated pond over two culture cycles EC-1 and EC-2. Further during the experiment, gut content showed higher total biota during Experimental Cycle-2 (EC-2) consisting of mostly diatomaceous food and was significantly correlated with higher chlorophyll a values in the sediment. This was in contrast to the observations during Experimental Cycle (EC-1) where lower sediment chlorophyll a values were observed. Further average artificial feed consumption was also subjected to regression analysis using SPSS 7.3 to study the role of artificial feed verses natural feed in earthen ponds. Given below is an account of regression analysis carried out by taking shrimp weight as dependent parameter and natural food in terms of chlorophyll a and artificial feed as independent parameters.

1.1 Experimental cycle (EC-1)

Fortnightly average shrimp weight for aerated and non-aerated pond has been depicted in the Figure 4 and fortnightly average feed consumption for aerated and non-aerated pond has been depicted in the Figure 5 during the EC-1. Interestingly non aeration pond showed slightly higher overall weight with maximum weight peaking up from 45th Day of Culture (DoC) being 12.50 gm to 25.52 gm on 120th DoC (Figure 4) despite lower average feed consumption of 3.13 kg (Figure 5). It is evident from Figure 8 that, chlorophyll a showed lower values in the sediment. Further comparing Figure 10 and Figure 11 it can be seen that microbenthos showed lower densities per unit area and at the same time gut biota was higher. This indicates that in non aeration pond natural fauna uptake was higher than the artificial feed uptake.

1.1.1 Regression analysis Aerated Pond

The absolute growth rate in terms of weight of the cultured shrimps from aerated pond was found to be 0.23 g.day$^{-1}$. In aerated pond FCR was found to be 1.30 during EC-1, (Table 1). On the basis of these observations, to check the linearity between shrimp growth, natural diet and supplementary feed, backward regression analysis was carried out, which explained (91.3%) variance in shrimp weight due to artificial feed, (B=3.62;p=0.001) and chlorophyll a (B=0.75;p=0.041) in the sediment at (F$^2$,6=42.8,p=0.001). This indicates that artificial feed had more significant effect on the growth of the shrimp than the natural diet in aerated pond.

1.1.2 Regression analysis Non-aerated Pond

For non aerated pond stepwise multiple regression analysis explained, 90.7% changes in shrimp weight due to artificial feed (B=6.79;p=0.001) and chlorophyll a (B=1.17;p=0.022) in the sediment with overall significant relationship at (F$^2$,6=40.20;p=0.001). In non-aerated pond beta values suggested that, artificial feed played more significant role in the shrimp growth. The significant contribution of microphytobenthos in shrimp diet was also evident from the presence of lower chlorophyll a in the sediment and the higher diatom counts in shrimp diet.

1.2 Experimental cycle (EC-2)

Fortnightly average shrimp weights for aerated and non-aerated pond are depicted in the Figure 6 and, fortnightly average feed consumption for aerated and non aerated pond are depicted in Figure 7. Trend of higher weight of the shrimp in non aerated pond was observed (Figure 6) with lower feed uptake (Figure 7) during EC-2.
This is evident again from Figure 9 that chlorophyll $a$ showed slightly higher values in the water than in the sediment. Also it can be seen from figure 12 and 13 for aerated and non-aerated pond that up to 60 DoC when micro-benthos density per unit area was less the gut biota showed higher occurrence of the micro-benthos which mainly consisted of diatomaceous food. The said figure 12 and figure 13 also shows that, whenever gut biota densities for natural biota were higher the feed uptake was lower and vice versa.

1.2.1 Regression analysis Aerated Pond

In aerated pond stepwise multiple regression analysis explained 96.1% shrimp growth due to artificial feed and chlorophyll $a$ in the sediment with overall significant relationship at $F_{2,5}=86.16; p=0.001$. Artificial feed ($B=4.49; p=0.001$) and chlorophyll $a$ in the sediment
The trends for growth and contribution of...understood from this study that, the natural...found to be almost similar to that of EC-1, during EC-1 and EC-2 respectively. There was significant negative co-relationship p<0.05, between the natural feed evaluated in terms of gut fauna and artificial feed uptake by the shrimp, during both the culture periods. During EC-1 and non-aerated pond during EC-2 indicates that approximately about 22% growth was due to the natural food biota available in the pond although artificial food was less utilized. The absolute growth rate of the shrimp during EC-2 was found to be almost similar to that of EC-1. For aerated pond, it was 0.23 g.day\(^{-1}\) and for non-aerated ponds it was 0.24 g.day\(^{-1}\).

### Discussion

**Shrimp Growth and Feeding**

It is understood from this study that, the natural fauna uptake was decreased with progressing culture period especially after 60\(^{th}\) DoC (Figure 10, 11, 12 and 13) during EC-1 and EC-2 for both the ponds. Artificial feed showed increasing trend, and is depicted in Figure 2 & Figure 4 for EC-1 and EC-2 respectively. There was significant negative co-relationship p<0.05, between the natural feed evaluated in terms of gut fauna and artificial feed uptake by the shrimp, during both the culture periods. During EC-1 for aerated pond overall gut biota averaged 239 organisms.individual\(^{-1}\) and 128 organisms.individual\(^{-1}\) respectively for non-aerated pond, while, for EC-2 the overall average was almost double being 469 organisms.individual\(^{-1}\) for aerated pond and 404 organisms.

### Table 1: Production and FCR during EC-1

<table>
<thead>
<tr>
<th>Pond Type</th>
<th>Area (ha.)</th>
<th>PL. Stocked No.m(^{-2})</th>
<th>Production (Kg.)</th>
<th>% Survival</th>
<th>Mean Length (cm.)</th>
<th>Mean weight (gm)</th>
<th>Total feed used (Kg.)</th>
<th>FCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerated Pond</td>
<td>0.65</td>
<td>12</td>
<td>1607</td>
<td>54.63</td>
<td>15.74 ± 1.19</td>
<td>29.27 ± 7.16</td>
<td>2084.01</td>
<td>1.30</td>
</tr>
<tr>
<td>Non-aerated Pond</td>
<td>0.6</td>
<td>6</td>
<td>715</td>
<td>63.26</td>
<td>16.30 ± 1.04</td>
<td>33.78 ± 6.96</td>
<td>1118.67</td>
<td>1.56</td>
</tr>
</tbody>
</table>

### Table 2: Production and FCR during EC-2

<table>
<thead>
<tr>
<th>Pond Type</th>
<th>Area (ha.)</th>
<th>PL. Stocked No.m(^{-2})</th>
<th>Production (Kg.)</th>
<th>% Survival</th>
<th>Mean Length (cm.)</th>
<th>Mean weight (gm)</th>
<th>Total feed used (Kg.)</th>
<th>FCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerated Pond</td>
<td>0.65</td>
<td>10</td>
<td>1121</td>
<td>74.24</td>
<td>15.74 ± 1.19</td>
<td>29.27 ± 7.15</td>
<td>1070.8</td>
<td>1.04</td>
</tr>
<tr>
<td>Non-aerated Pond</td>
<td>0.6</td>
<td>5</td>
<td>536</td>
<td>68.35</td>
<td>14.78 ± 1.78</td>
<td>25.52 ± 6.33</td>
<td>621.56</td>
<td>0.86</td>
</tr>
</tbody>
</table>

### Table 3: Important physico-chemical parameter values for aerated and non-aerated pond during EC-1 and EC-2.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>EC-1</th>
<th></th>
<th>EC-2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aerated Pond</td>
<td>Non-Aerated Pond</td>
<td>Aerated Pond</td>
<td>Non-Aerated Pond</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>27.90</td>
<td>35.40</td>
<td>27.80</td>
<td>35.30</td>
</tr>
<tr>
<td>pH Water</td>
<td>7.09</td>
<td>8.32</td>
<td>7.16</td>
<td>8.50</td>
</tr>
<tr>
<td>pH Sediment</td>
<td>5.58</td>
<td>7.62</td>
<td>3.75</td>
<td>7.47</td>
</tr>
<tr>
<td>Salinity</td>
<td>7.20</td>
<td>43.18</td>
<td>8.10</td>
<td>41.89</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg.l(^{-1}))</td>
<td>2.93</td>
<td>4.06</td>
<td>2.86</td>
<td>4.81</td>
</tr>
<tr>
<td>BOD (mg.l(^{-1}))</td>
<td>0.26</td>
<td>3.05</td>
<td>1.16</td>
<td>3.73</td>
</tr>
<tr>
<td>NO(_3)-N (µmol.l(^{-1}))</td>
<td>0.30</td>
<td>2.72</td>
<td>0.33</td>
<td>0.98</td>
</tr>
<tr>
<td>NO(_2)-N (µmol.l(^{-1}))</td>
<td>0.06</td>
<td>0.53</td>
<td>0.08</td>
<td>3.42</td>
</tr>
<tr>
<td>NH(_3)-N (µmol.l(^{-1}))</td>
<td>0.10</td>
<td>1.93</td>
<td>0.31</td>
<td>4.76</td>
</tr>
<tr>
<td>PO(_4)-P (µmol.l(^{-1}))</td>
<td>0.11</td>
<td>4.65</td>
<td>0.41</td>
<td>3.58</td>
</tr>
<tr>
<td>Chlorophyll a in water (mg.m(^{-2}))</td>
<td>1.42</td>
<td>6.41</td>
<td>1.14</td>
<td>5.93</td>
</tr>
<tr>
<td>Chlorophyll a in Sediment (mg.g(^{-1}))</td>
<td>1.38</td>
<td>14.24</td>
<td>2.06</td>
<td>10.68</td>
</tr>
</tbody>
</table>
individual for non-aerated pond.

Thus from results and total gut biota values (Figure 10,11,12 and 13) it can be said that, during EC-1, due to less availability of natural biota in pond, there was higher uptake of the feed, by the shrimp. During EC-2 however overall average of total gut biota was comparatively double and feed uptake by shrimp was thus lower. This is evident from the FCR values, being higher during EC-1 and was 1.30 and 1.56 for aerated and non-aerated pond respectively (Table 1). FCR values were comparatively lower during EC-2, being 1.04 and 0.86 for aerated and non-aerated pond respectively. During both the culture periods, though the decrease in the amount of natural gut biota was gradual, it was characteristic in a view that, its presence in the gut decreased drastically from 75 DoC onwards, till the end of the culture period.

According to one of the established facts, as well as from numerous studies on juvenile shrimp nutritional analysis indicates that, the larval stages of shrimp like naupli exclusively feed on the algal diet such as Chaetoceros and Skeletonema, a well known feeding practices at the shrimp hatcheries. The role of these microalgae in shrimp nutrition has been studied earlier by Nunez et al. (2002), Kumlu, (1998), and Su et al. (1997). In the grow-out ponds, however, once the post larvae are released in the water, the general practice is that, shrimp are not fed on for first few days, or are fed only twice, instead of four times a day. Such practices are prevalent in view that, the post larvae utilize the available phytoplankton in the water column. The adult prawn however is known to be benthic indiscriminate feeder, and is known to feed on diverse food items in the natural as well as artificial environment. Unlike natural environment, the availability of the natural fauna in the artificially constructed pond is certainly low due to confined nature of the ponds, wherein in the creek fauna gets replenished due to the tidal incursion and excursion.

It can be seen from the total gut biota for aerated and non aerated pond that the decrease for aerated and non aerated pond during EC-1 was from 60th DoC (Figure 10 ) and 90th DoC (Figure 11). Gut biota though decreased thereafter, the counts were marginally higher in aerated pond than control pond during EC-1. The counts for aerated and control pond during EC-2 were found to decrease from 60th DoC (Figure 12 and Figure 13). In contrast, during EC-1, non-aerated pond showed slightly higher gut counts than the aerated pond (Figure11). Further, from the growth and feeding data, the growth rate determination revealed interesting and comparable results with respect to contribution of natural feed. It was observed that, the absolute growth rates from 75 to 120 DoC were higher being 0.34 g.day \(^{-1}\), over 0.18 g.day \(^{-1}\) for non-aerated pond during EC-1.

The chlorophyll a during study can be attributed to have originated from the diatomaceous population, which included mostly the pinnate diatoms like Navicula, Nitzschia, Pleurosigma and centric diatoms such as Coscinodiscus. During EC-1 in non-aerated pond the microbenthos showed decreasing trend (Figure 11), while in aerated pond it showed increasing trend (Figure 10). The FCR remained high during EC-1. The FCR was found to be 1.30 and 1.56 for aerated and control pond respectively during EC-1 (Table 1). This further confirms the reliance on the natural fauna in view that, feed was not utilized effectively by shrimp, especially in the non-aerated pond. Thus, shrimp showed higher average weights during EC-1(Figure 4) than the EC-2 (Figure 6).

During EC-2, the FCR of 1.04 and 0.86 for aerated pond and non-aerated pond indicates very good utilization of artificial feed. However, there was slight underachievement of shrimp weight (Figure 6). It was observed that, the growth rate of shrimp differed for non-aerated pond, being 0.28 g.day \(^{-1}\) till 60 days and bettered over, the next 45 day growth rate, being 0.16g. \(^{-1}\). In aerated pond however, the difference in growth rates was comparatively negligible being 0.23 and 0.21 g.day \(^{-1}\) for first 60 and last 45 days respectively. The underachievement in weight during EC-2 can be attributed to the lack of better utilization of available micro-benthic fauna or the changes in the quality of artificial feed, due to disintegration seems to be the possible reason especially during EC-2 for both the ponds.

As mentioned earlier Mohanty et al. (2001) showed that, scientific shrimp farming depends largely upon the commercial formulated feed, which constitutes nearly 55% of the total operational costs. These supplemental feeds are provided especially in the commercial shrimp farming due to the insufficient availability of the natural food. Cordova et.al.(2002) has shown to have promoted biota by application of organic fertilizers. Further it has been sited by Cordava et.al.(2002) that in the farming of Litopenaeus stylirostris natural food organisms contribute about 75% of the requirement of the farmed organisms. During present study though, shrimp has shown reliance on the artificial feed (Figure 5 and Figure 7) for EC-1 and EC-2 respectively up to 22 % uptake of natural fauna is evident. Further decrease of uptake of fauna towards the end of the culture period is also evident (Figure 10 and Figure 11) for EC-1 and (Figure 12 and Figure 13) for EC-2. From FCR (Table1 and Table 2) it was understood that, natural feed by shrimp was consumed approximatedly, 22-25% of total food requirements of the cultured shrimp.

Conclusion
During study the diversity and abundance of natural benthic biota especially microphytobenthos were found to be the most significantly consumed component of benthos and was also abundant in the shrimp pond as well. Hence, the results obtained here show the dependence of shrimp on the natural fauna, particularly on microphytobenthic diatoms up to first 60 DoC during the culture period along with the artificial feed being the main component especially after 60 DoC. However along with the abundance of natural fauna, its quantification in terms of the calorific value it provides to shrimp over artificial feed needs further detail evaluation.

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**Abbreviations**
EC-1: Experimental Cycle-1
EC-2: Experimental Cycle-2

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17. Statistica (1994) Statistica for windows, Statsoft Inc. USA.

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