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RESEARCH ARTICLE

Effect of stocking density, feed ration on performance and environmental nutrient loading from culture of Tiger shrimp (*Penaeus monodon*) fed by check tray method

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Abstract

In the present study stocking density, feed ration on performance and environmental nutrient loading from culture of tiger shrimp (*penaeus monodon*) fed by check tray method was assessed by 120 days outdoor culture experiment. During the experiment two commercially available shrimp diets CD1 and CD2 were evaluated by three different stocking densities 15, 30, and 45 nos/m^2 with two feeding ratio 10 and 15% body weight. Maximum growth, FCR and SGR were obtained in tanks stocked with 15 nos/m^2 with 10% body weight feed ration in CD1 diet fed groups. The performance parameters of CD2 diet also more or less similar to CD1 diet. On the analysis of nitrogen and phosphorus retention and loss in outdoor culture experiment nitrogen, phosphorus consumption and retention was more in culture tanks stocked with maximum stocking density 45 nos/m^2 likewise total nitrogen and phosphorus loss also maximum in 45 nos/m^2 stocked tanks. More or similar trend noticed in 15% feed ration. Commercial feed CD2 also, a similar variation in nitrogen and phosphorus consumption, gain, retention and loss as percentage of feed were recorded for both 10 and 15% body weight. But the overall values were high for commercial feed CD1 when compared to CD2 diet.

INTRODUCTION

Aquaculture is the fastest growing food-production sector in the world and is viewed as a viable solution to global nutritional deficiencies and poverty (Stefan, *et al.,* 2009). It has been practiced for centuries in China and some other Asian countries and serves as primary source of cheap animal protein to many low-income communities mainly through fish production (Popma and Michael, 1999).

In Aquaculture, shrimp culture is rearing of post larval stage of shrimp up to a marketable size in an enclosed system of water (Pillay, 1992). The farming of shrimp has rapidly expanded over the last two decades with the total world cultured shrimp production reaching 3.4 million tones,valued at over 14 billion USD in 2008 (FAO,2010; Thuyet *et al*., 2012). In India also *P. monodon* is the most popular one, reared in hatcheries and it is a very important species in commercial culture practice (Kurian and Sebastian, 1993).

The nutrients needed for shrimp feed in shrimp culture practices are protein, lipid, vitamins and minerals and all these nutrients must be found in balanced proportion in the diets offered to the cultured animals for their effective utilization (Raj, 1993). In the past, formulation of diets in intensive aquaculture has often been aimed at meeting requirements for maximum growth, but recently, formulations are being designed to meet other desired production goals. One such goal is to increase the sustainability of various aquaculture enterprises by reducing the environmental impacts they may have on surrounding ecosystems.

The stocking density is one of the rearing factors that have to be considered for successful aquaculture. Increasing stocking density of fish and crustaceans in pond usually exacerbates problems with increased accumulation of feed related solid and soluble wastes in pond water and sediment also increases the susceptibility of prawns to diseases (Hanson and Goodwin, 1997). In addition, increasing the density raises pressure on natural food resources and as food conversion efficiency is often reduced (Sandifer *et al.*, 1987), the total feed cost raises (New, 1987). Feed accounted for 47% and 55% of added nitrogen and phosphorus, in semi intensive shrimp ponds when using a 30% protein diet, and harvested shrimp accounted for 37% of applied nitrogen and 20% of applied phosphorus (Green *et al.*, 1997). Thus a portion of the nutrients in the feed consumed by shrimp is converted to shrimp flesh, but a greater proportion is wasted in the water column. It was estimated that the nutrients originating from the production of 1 kg of live weight of the culture species in ponds can lead to the production of 2 to 3 kg dry weight of phytoplankton (Boyd, 1985).

An attempt to the themes listed above for shrimp may center upon identifying the optimum feeding strategy, nutrient sources, stocking density to assure high growth rate, at the same time limiting the amount of waste released into the water. Another approach would be to evaluate the widely used commercial shrimp feeds for the discharge of solid and soluble wastes. Hence quantification of stocking density dependent nutrient waste accumulation in shrimp culture practice is of the hourly need. Therefore the present study was carried out to evaluate the effect of stocking density, feed ration on performance and environmental nutrient loading from culture of Tiger shrimp (*P.monodon*) fed by check tray method.

2. MATERIALS AND METHODS

Collection of shrimp

For the present study, post larvae (PL20) of *P. monodon* were procured from a private shrimp hatcheries (Kanai), Kulasekarapattinam, Thoothukudy District, Tamilnadu, India. The post larvae were transported in oxygenated bags with least disturbance and acclimatized to the laboratory condition in one tonne capacity Fibre Reinforced Plastic (FRP) tanks provided with filtered seawater with adequate aeration for a period of 3 days. During the period of acclimatization, the shrimps were fed with formulated control diet at *ad libitum* thrice a day.

Outdoor culture experimentation

In outdoor culture experiments, the effect of feeding strategies feed ration and stocking density on retention and loss of nitrogen and phosphorus was studied in *P. monodon* by rearing them in 1 tonne capacity FRP tanks fed commercial diets (CD1 and CD2) for a period of 120 days. During this experimentation, growth responses, were also assessed.

Experimental diets

Two commercial shrimp diets CD1 and CD2 procured from the market were used. In these commercial diets, grower, starter and finisher feeds were used. The biochemical constituents such as protein, carbohydrate, lipid, nitrogen and total phosphorus contents of all the types of experimental diets were measured individually and the pooled average values were used for the further evaluation study.

Estimation of Biochemical Constituents:

The biochemical constituents of fish such as protein, carbohydrate, lipid, nitrogen in all experimental samples will be carried out according to the procedure indicated in AOAC (1990).

Feeding experiment by check tray method

This experiment was also carried out in the outdoor culture environment by using one tonne capacity FRP tanks. The experimental tanks were provided with pond sediment as substratum to the level of 20 cm height and filled with filter and diluted seawater having 20 ppt salinity. In total thirteen FRP tanks were maintained and one tank out of thirteen was used as the control without shrimp but with substratum and seawater including aeration. In the remaining twelve tanks the PL25 stage *P. monodon* 20.0 ± 0.60 mg were stocked at the stocking density of 15, 30 and 45 nos/m^2. The first two sets were offered with commercial diet 1(CD1) at 10 and 15% body weight by check tray method. Likewise, the second sets were offered with commercial diet 2 (CD2) at 10 and 15% body weight by the same check tray method. In this method, in all the four sets of tanks 1st 40 days starter feed, 2nd 60 days grower feed and 3rd 20 days finisher feed were given at the rate of four times per day by using check trays. The trays with feeds were immersed with least disturbance and were remained for the stipulated time schedule and then the trays were removed and unfed remains were collected. The collected unfed were then dried, weighed and stored at -20^{0}C. In each culture tank a check tray with the diameter of 35 cm was used to offer the feed. During this experimental period growth was measured once in 10 days till the termination of the experiment and 50% water exchange was give once in 5 days for maintaining optimum proper water quality parameters. At the end of the experiment, all the shrimps were collected, weighed individually and sacrificed for further biochemical analysis (Maynord and Loosli, 1962).

Growth Responses

The growth performance parameters such as Biomass (g), Specific Growth Rate (SGR%) and Feed Conversion Ratio (FCR) were estimated using the formula described by Ridha (2006 and Hardy (2003).

Nitrogen and Phosphorus estimation

The methods for analysis of phosphorus and nitrogen in the diets, carcass and their consumption, loss retention rates were estimated using the formula described by Takeuchi *et al* .(1989)

Data Analysis

The data obtained in this study were subjected to relevant statistical analysis following the method described by Zar (1999). Individual weight was analysed using one-way ANOVA and Student-Newman-Keuls multiple range test (SNK). The parameters like, growth performance, biomass, SGR (%), FCR, retention and loading of nitrogen and phosphorus were analysed in one-way ANOVA to determine if significant difference exist among the different diets and stocking density groups. Results were considered statistically significant at the level of $P<0.05$.

RESULTS

Evaluation of commercial feeds CD1 and CD2 in outdoor culture system

3.2.1. Effect of stocking density and feed ration (10% and 15% live body weight) by check tray method

To investigate the interacting effect of feed ration (10 and 15% live body weight) and stocking density (15, 30 and 45 nos/m^2), four sets of experiments were carried out on two commonly used commercial diets in one tonne capacity FRP tanks in outdoor environment. In all four sets of experiments, the shrimps were cultured at 15, 30 and 45 nos/m^2 and fed with commercial diets CD1 and CD2 at 10 and 15% body weight for a period of 120 days. During the experimentation 20% water was changed once in alternate days and aeration was also provided. The growth, FCR and SGR were calculated following the standard method at regular intervals and recorded.

Commercial feed 1 (CD1): (10 and 15% Ration Vs stocking densities (15, 30 and 45 nos/m^2)

The growth response of *P. monodon* stocked at 15, 30 and 45 nos/m^2 fed on CD1 diet were shown in Tables 1. The performance parameters such as production and consumption of *P. monodon* were high in culture tank stocked with 15 nos/m^2 and low in tanks stocked with 30 and 45 nos/m^2. Accordingly the better FCR and SGR values of 1.84 and 3.91% were recorded in culture tank stocked with 15 nos/m^2.

3.2.1b. Commercial feed 2 (CD2): (10 and 15% Ration Vs stocking densities (15, 30 and 45 nos/m^2)

Data on growth responses of *P. monodon* cultured at 15, 30 and 45 nos/m^2 and fed with CD2 diet provided in Table 2. At this feeding ratio (10 and 15% body weight) the performance parameters showed a declining trend with increase in stocking density from 15 to 45 nos/m^2. In this experiment, the better FCR and SGR values of 1.59 and 3.80% were recorded in culture tank stocked at the lowest density of 15 nos/m^2 against the low values recorded in culture tanks stocked with 30 and 45 nos/m^2. Here the overall FCR and SGR of *P. monodon* received feed at 15% body weight were low when compared to the FCR and SGR values recorded for those shrimps received 10% body weight.

3.5. Prediction analysis on phosphorus and nitrogen retention and loss in outdoor culture system

Considering the laboratory estimate of nitrogen and phosphorus retention with that of feed utilized, biomass produced and FCR value of *P. monodon* cultured in the outdoor culture systems the nitrogen and phosphorus retention and loss in outdoor culture system were calculated and the results are given in Tables 3 to 10.

Nitrogen and phosphorus retention and loss in outdoor culture system

Interacting effect of feed ration and stocking density by check tray method – (CD1) / (CD2)

In the experiment on commercial feed CD1 at 10% body weight, the nitrogen and phosphorus consumption and retention (%) of *P. monodon* was more in culture tanks stocked with maximum density of 45 nos/m^2. Likewise total nitrogen and phosphorus loss was also maximum in 45 nos/m^2. Obviously the nitrogen and phosphorus retention as percentage of feed was more in *P. monodon* stocked at 15 nos/m^2 (Tables 3 to 6).

The trend noticed for the phosphorus and nitrogen consumption, gain and loss as percentage of feed in *P. monodon* fed 15% ration were more or less similar to that of noticed in 10% ration fed groups. But the retention values were relatively less, when compared to those received diets at 10% body weight (Tables 3 – 6). At this ration, the loading of total phosphorus and nitrogen were more in 45 nos/m^2 stocked system.

In experimentation on commercial feed CD2 also, a similar variation in nitrogen and phosphorus consumption, gain retention and loss as percentage of feed were recorded for both 10 and 15% body weight. But the overall values were high for commercial feed CD1 when compared to CD2 diet (Tables 7 – 10).

Table 1. Commercial diet 1 (CD1): 10 and 15% Ration Vs stocking densities (15, 30 and 45 nos/m^2)

Growth parameter	10%			15%		
	15	30	45	15	30	45
Initial weight (g)	0.15±0.02	0.18±0.02	0.16±0.01	0.15±0.01	0.17±0.02	0.18±0.01
Final weight (g)	16.38± 0.27	14.60±0.13	12.18±0.09	16.42±0.08	15.10±0.05	12.80±0.11
Consumption (g)	29.92 ± 0.22	28.79±0.10	27.04±0.05	29.92±0.05	33.62±0.06	33.97±0.03
FCR	1.84±0.05	2.25±0.04	1.84±0.06	1.84±0.06	2.25±0.03	2.69±0.05
SGR%	3.91±0.03	3.66±0.06	3.90±0.03	3.90±0.03	3.74±0.02	3.55±0.03

Each value is a mean (X±SD) of triplicate samples.

Table 2. Commercial diet 2 (CD2): 10 and 15% Ration Vs stocking densities (15, 30 and 45 nos/m^2)

Growth parameter	10%			15%		
	15	30	45	15	30	45
Initial weight (g)	0.16±0.01	0.17±0.01	0.16±0.01	0.18±0.01	0.17±0.01	0.16±0.02
Final weight	15.20± 0.42	13.87±0.	11.46±0.	15.94±0.	14.27±0.	11.87±0.

(g)		59	54	31	38	40
Consumption (g)	24.02 ± 0.12	27.02±0.13	24.03±0.09	24.99±0.18	28.42±0.21	28.62±0.52
FCR	1.60±0.03	1.97±0.03	2.13±0.07	1.59±0.05	2.02±0.04	2.44±0.13
SGR%	3.80±0.15	3.67±0.14	3.56±0.08	3.74±0.17	3.69±0.24	3.59±0.10

Each value is a mean (X±SD) of triplicate samples.

Table 3. Nitrogen metabolism of *P. monodon* fed with commercial feed CD1 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feedration/stocking density	Shrimp nitrogen (% wet wt)	Nitrogen gain/retention (g)	Nitrogen consumption		
			Amount of feed (g)	Feed nitrogen (mg/100mg)	Nitrogen consumed (g)
10%/15 Nos/m^2	7.054±0.04	34.66±0.03^e	904.18	6.28	56.78±0.21
10%/30 Nos/m^2	6.832±0.06	59.85±0.09^d	1909.68	6.28	119.93±0.38
10%/45 Nos/m^2	6.675±0.03	73.17±0.01^b	2455.50	6.28	154.21±0.08
15%/15 Nos/m^2	6.824±0.08	34.64±0.11^e	903.53	6.28	56.74±0.08
15%/30 Nos/m^2	6.750±0.10	61.16±0.09^c	2002.26	6.28	125.74±0.07
15%/45 Nos/m^2	6.602±0.08	76.06±0.06^a	3098.88	6.28	194.61±0.03

Each value is a mean (X±SD) of triplicate samples.
Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Table 4. Phosphorus metabolism of *P. monodon* fed with commercial feed CD1 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feedration/stocking density	Shrimp phosphorus (% wet wt)	Phosphorus gain/retention (g)	Phosphorus consumption		
			Amount of feed (g)	Feed phosphorus (mg/100mg)	Phosphorus consumed (g)
10%/15 Nos/m^2	5.244±0.02	2.577±0.12^e	904.18	8.210	7.423±0.06
10%/30 Nos/m^2	5.290±0.05	4.594±0.09^d	1909.68	8.210	15.678±0.16
10%/45 Nos/m^2	5.180±0.05	5.748±0.05^b	2455.50	8.210	20.160±0.07
15%/15 Nos/m^2	5.267±0.05	2.662±0.08^e	903.53	8.210	7.418±0.10
15%/30 Nos/m^2	5.286±0.03	4.751±0.05^c	2002.26	8.210	16.439±0.10
15%/45 Nos/m^2	5.235±0.01	6.041±0.04^a	3098.88	8.210	25.442±0.05

Each value is a mean (X±SD) of triplicate samples.
Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Table 5. Nitrogen retention/loss of *P. monodon* fed with commercial feed CD1 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feedration/stocking density	**Nitrogen retention as % of feed**	**Total nitrogen loss(g)**	**Nitrogen loss/g of shrimp produced (mg/g)**	**Nitrogen loss/g of feed consumed (mg/g)**
10%/15 Nos/m^2	61.45±0.13^a	22.12±0.15^e	45.01±0.09^e	24.46±0.05^e
10%/30 Nos/m^2	49.67±0.17^c	60.08±0.06^d	68.58±0.26^d	31.46±0.05^d
10%/45 Nos/m^2	48.34±0.13^e	81.04±0.11^b	73.93±0.10^b	33.00±0.08^b
15%/15 Nos/m^2	60.83±0.15^b	22.1±0.09^e	43.53±0.07^f	24.46±0.10^e
15%/30 Nos/m^2	48.99±0.04^d	64.58±0.17^c	71.28±0.06^c	32.19±0.06^c
15%/45 Nos/m^2	39.07±0.09^f	118.55±0.16^a	102.91 ±0.06^a	38.26±0.04^a

Each value is a mean (X±SD) of triplicate samples.

Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Table 6. Phosphorus retention/loss of *P. monodon* fed with commercial feed CD1 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feedration/stocking density	phosphorus retention as % of feed	Total phosphorus loss (g)	phosphorus loss/g of shrimp produced (mg/g)	phosphorus loss/g of feed consumed (mg/g)
10%/15 Nos/m^2	33.09±0.10[b]	4.846±0.05[e]	9.862±0.06[e]	5.360±0.01[c]
10%/30 Nos/m^2	27.87±0.14[c]	11.084±0.10[d]	12.653±0.07[d]	5.804±0.07[b]
10%/45 Nos/m^2	27.18±0.11[d]	14.412±0.18[b]	13.147±0.13[b]	5.869±0.08[b]
15%/15 Nos/m^2	34.20±0.20[a]	4.756±0.13[e]	9.370±0.15[f]	5.264±0.03[c]
15%/30 Nos/m^2	27.50±0.21[d]	11.688±0.06[c]	12.901±0.05[c]	5.837±0.17[b]
15%/45 Nos/m^2	22.60±0.13[e]	19.401±0.10[a]	16.841 ±0.08[a]	6.261±0.10[a]

Each value is a mean (X±SD) of triplicate samples.
Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Table 7. Nitrogen metabolism of *P. monodon* fed with commercial feed CD2 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feed ration/stocking density	Shrimp nitrogen (% wet wt)	Nitrogen gain/retention (g)	Nitrogen consumption		
			Amount of feed (g)	Feed nitrogen (mg/100mg)	Nitrogen consumed (g)
10%/15 Nos/m^2	6.541±0.02	29.83±0.12[e]	729.60	6.26	45.67±0.14
10%/30 Nos/m^2	6.408±0.06	53.33±0.04[d]	1639.43	6.26	102.63±0.18
10%/45 Nos/m^2	6.251±0.01	64.47±0.05[b]	2196.88	6.26	137.52±0.22
15%/15 Nos/m^2	6.557±0.04	15.684±0.03[f]	380.169	6.26	23.80±0.21
15%/30 Nos/m^2	6.341±0.03	54.29±0.05[c]	1729.524	6.26	108.27±0.24
15%/45 Nos/m^2	6.184±0.01	66.06±0.05[a]	2606.65	6.26	163.18±0.10

Each value is a mean (X±SD) of triplicate samples.
Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Table 8. Phosphorus metabolism of *P. monodon* fed with commercial feed CD2 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feed ration/stocking density	Shrimp Phosphorus(% wet wt)	Phosphorus gain/retention (g)	Phosphorus consumption		
			Amount of feed (g)	Feed Phosphorus (mg/100mg)	Phosphorus consumed (g)
10%/15 Nos/m^2	4.816±0.10	2.196±0.01[e]	729.60	7.163	5.226±0.01
10%/30 Nos/m^2	4.850±0.03	4.008±0.10[d]	1639.43	7.163	11.743±0.06
10%/45 Nos/m^2	4.701±0.21	4.967±0.11[b]	2196.88	7.163	15.736±0.19
15%/15 Nos/m^2	4.845±0.02	1.152±0.11[f]	380.169	7.163	2.723±0.12
15%/30 Nos/m^2	4.816±0.04	4.123±0.16[c]	1729.524	7.163	12.389±0.11
15%/45 Nos/m^2	4.817±0.02	5.145±0.12[a]	2606.65	7.163	18.671±0.09

Each value is a mean (X±SD) of triplicate samples.
Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Table 9. Nitrogen retention/loss of *P. monodon* fed with commercial feed CD2 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feedration/stocking density	Nitrogen retention as % of feed	Total nitrogen loss(g)	Nitrogen loss/g of shrimp produced (mg/g)	Nitrogen loss/g of feed consumed (mg/g)
10%/15 Nos/m^2	64.88±0.43[b]	15.84±0.48[e]	34.74±0.30[e]	21.71±0.38[e]
10%/30 Nos/m^2	51.89±0.56[c]	49.30±0.87[d]	59.24±0.39[d]	30.07±0.45[d]
10%/45 Nos/m^2	47.25±0.30[e]	73.05±0.20[b]	70.83±0.73[b]	33.25±0.28[b]

15%/15 Nos/m^2	66.30±0.50^a	8.12±0.38^f	33.96±0.46^f	21.36±0.45^e
15%/30 Nos/m^2	49.82±0.31^d	53.98±0.39^c	63.05±0.35^c	31.21±0.29^c
15%/45 Nos/m^2	40.59±0.43^f	97.12±0.30^a	90.91 ±0.18^a	37.26±0.50^a

Each value is a mean (X±SD) of triplicate samples.
Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Table 10. Phosphorus retention/loss of *P. monodon* fed with commercial feed CD2 at 10% and 15% body weight by check tray method in outdoor culture tanks as a function of stocking density

Feedration/stocking density	Phosphorus retention as % of feed	Total Phosphorus loss(g)	Phosphorus loss/g of shrimp produced (mg/g)	Phosphorus loss/g of feed consumed (mg/g)
10%/15 Nos/m^2	43.44±0.47^b	3.03±0.32^e	6.645±0.46^d	4.153±0.26^c
10%/30 Nos/m^2	35.43±0.42^c	7.735±0.12^d	9.295±0.30^c	4.718±0.11^b
10%/45 Nos/m^2	32.77±0.24^e	10.769±0.21^b	10.769±0.21^b	4.902±0.15^{ab}
15%/15 Nos/m^2	43.90±0.20^a	1.571±0.33^f	1.571±0.33^d	4.132±0.25^c
15%/30 Nos/m^2	34.55±0.35^d	8.266±0.21^c	8.266±0.21^c	4.779±0.21^b
15%/45 Nos/m^2	28.61±0.23^f	13.526±0.30^a	13.526 ±0.30^a	5.189±0.25^a

Each value is a mean (X±SD) of triplicate samples.
Note: values with same alphabets are not significantly different (P<0.05; SNK test)

Discussion

Marian *et al* (1982) have reported that multiple feeding at the optimum ration result in more efficient utilization of feed than a single feeding. When feed is offered at the optimum ration, larger amount of feed is usually consumed by the fish and display the higher yield with maximum food conversion. It was also established that a change in food supply might refelect on a number of dependent variables like growth, moulting, biosynthesis of chemical constituents and egg production. In the present study the influence of feed ration (10 and 15% body weight) feeding strategies (check tray method) and stocking densities (15, 30 and 45 nos/m^2)on feed related waste accumulation was also performed on *P.monodon* in outdoor culture system by using commonly used two commercial diets (CD1 and CD2). The results indicated that irrespective of the type of commercial feed used and density stocked, the performance parameters of *P.monodon* fed with 10% and 15% body weight did not vary much. Yet in check tray method, the performance parameters suchas FCR and SGR of *P.monodon* fed commercial diets CD1 and CD2 at 10and 15% body weight did not deviate much and the deviation between them was not statistically significant (P>0.05; ANOVA test) in all the tested stocking densities. This result clearly indicates that, a feed ration of 10% body weight was found to be optimum meal size for enhancing the performance parameters of *P.monodon* stocked at 15 to 30nos/m2 in the outdoor culture system. It was also established that consumption of feed above the optimum feed ration resulted in decrease of production, because the organisms has to spent excess energy on the metabolism of the over fed nutrients and also to the associated eliminating process. this may be the reason for the displacement of poor gross production efficiency by *P.monodon* reared at high feed ration of 15% body weight.

Ayyappan (2002) reported that feeding accelerated the food consumption in *Panulirus homarus* and it was very low for those group fed with low feed ration (10%) and it was more or less same for those lobsters fed with sub-optimum feed rations (20 and 30% ration) and was maximum in optimum feed ration of 40%. Further he also reported that an increase in feed ration beyond the optimum level of 40% exerted negative impact on FCR and SGR of *P.homarus*. For successful culture of cultivable species, the size of the daily meal to be offered must be established to prevent over feeding and restricted growth through sub-optimum ration. However, enhancing the feed ration or frequency of feeding beyond the optimum level not only hike the feed cost but also pollute the environment by the accumulation of uneaten food.

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