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Growth and production of *Penaeus monodon* in semi-intensive culture systems of Kerala fed with different diets

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Abstract

Growth and production of *P.monodon* was studied in semi-intensive culture systems of Kerala where three types of feeds have been applied, *viz.* clam meat, clam meat and dough ball and farm made pelleted feeds. The average final length and weight were 15.10cm and 30.73g respectively. Mean biomass increase was 95.38g/m^2 for 120 days at the rate of 0.795/m^2/day at an average stocking density of 6.31 PL/m^2. The average growth rate was 0.252g/day per animal. The production and the biomass increase per day were not significantly influenced by the feed types. However, the mean final weight of shrimp achieved with the feed types differed significantly. The pelleted feed was superior to the other two feed types in realizing significantly higher mean final weight of shrimp. The higher growth rate and the better overall performance of tiger shrimp noted in the present study are attributed to the combined effect of supplementary feed and fertilizer applied to the system.

Introduction

The tiger shrimp, *Penaeus monodon* Fabricius is the most suitable and commercially important species for intensive monoculture. It is the largest and fastest growing farm raised shrimp species and is cultured widely in the world particularly in the tropical south east Asian countries. Adequate information is available on the biology and fishery of this species, however literature on the growth, survival and production especially in the semi-intensive culture systems of India is very limited.

Some of the recent reports on the monoculture of this species in Indian conditions are those of Guru *et at.*,(1993), Karthikeyan (1994), Saha *et al.*,(1999) and Athithan *et al.*, (2001). The information on the growth and production of this species in feed and fertilizer applied semi-intensive systems of Kerala state are very meager. The present study on the growth, survival and production of this species in semi-intensive culture systems of Kerala along with the evaluation of the efficiency of certain local feeds would help to evolve better management measures for similar culture practices of *P.monodon* in India.

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Material and methods

For the study three regions were selected from the two central districts of Kerala, Alleppey and Ernakulam; Pallithode in Alleppey and Chellanam and Kannamaly in Ernakulam. From each region three ponds which had similar management practices were chosen. In the selected three regions sufficient salinity (range = 9 to 24 ppt) prevailed for 8-10 months enabling two culture operations per year. The study was conducted for a period of two years and altogether 36 culture operations each extending for a period of 120 days were studied. The area of the pond selected ranged from 0.5 ha to 1 ha. Drying the pond bottom, eradication of pest and predators, liming (100-600Kg/ha) and fertilization with cattle manure (200-500Kg/ha) and inorganic fertilizers (Super phosphate, ammonium sulphate or urea either solitarily or in combination 20-75Kg/ha) and water management were carried out in all the ponds. Only hatchery reared seed (PL20), mostly transported from other states, were used for stocking. In all the three regions seed was directly introduced into the grow out ponds. Three types of supplementary feeds were used by the farmers: clam meat (in all the three regions), clam meat with dough ball (in Chellanam and Kannamally) and farm made pelleted feeds (in Pallithode alone). Water exchange rate was about 5-10% per day which was increased to about 20% towards the end of the culture period.

On the 30th day of stocking and thereafter every 15 days 100 specimens were collected from the ponds with small meshed cast net at random and the length and weight were measured and after measurements the specimens were returned to the ponds. The initial length and weight were taken by collecting 120 PL- 20 seeds of *P.monodon* from the hatchery. The average daily length and weight gain were calculated. Other parameters determined are Instantaneous growth (G) (Hopkins1992), Biomass increase per day ($g/m^2/day$) (New, 1976), Feed Conversion Ratio (F.C.R), Feed Conversion Efficiency (F.C.E) and Survival rate (Rubright *et al.*, 1981)

Types of feeds

The feed one (F1) was the fresh meat of the brackish water clam, *Villorita cyprinoides* var.*cochinensis*. The second type feed (F2) was feed1+ dough ball. The composition of the dough ball is ground nut oil cake (45%), wheat flour (25%), rice bran (20%), and tapioca flour(10%). The third type of feed (F3) used was a pelleted feed which consists of , squilla powder (54%), rice bran (10%), shrimp head waste (10%), ground nut oil cake (10%), wheat flour(10%), tapioca flour(5%), vitamin-mineral mix(1%), cod liver oil (2ml/kg) and palm oil(2ml/kg). For the preparation of dough ball all the ingredients, except fish oil were mixed thoroughly and

cooked well in an aluminum container. After cooking fish oil was added and mixed well. For the preparation of pelleted feed all the ingredients except oils and vitamin mix were ground and mixed in a mixer/mincer machine and steam cooked. After cooling, oils and vitamin mix were added and mixed well. The mixture was pelleted with a hand pelletizer. The pellets were sun dried to less than 10% moisture.

The clam meat was fed at 8-10% body weight per day. In feed 2 the clam meat and dough ball were mixed in proportions ranging from about 1:1 and 8:1 and fed at 5-6% body weight/day. Feed 3 (Pelleted feed) was given at 3-4% body weight/day. Feeding was done twice daily from the third day of stocking onwards till the end of the culture period. Nearly 40% was given in the morning (6 am) and the rest 60% in the evening(6pm). The protein, fat and carbohydrate contents of the feeds were estimated based on the methods of A. O. A. C (1975). From these results the gross energy and the protein to energy ration were computed following the procedure suggested by the A. D. C. P (1983).

Feed distribution details are given in Table 1.

Results

The mean values of water quality, growth and production of the 36 culture operations extending for 120 days are consolidated in table 3. The stocking density ranged from 4 to 10 PL/m^2 (means 6.31 PL/m^2). The average survival rate was 50.21% (range 38-58%). The shrimp registered a mean final length of 15.1cm and a weight of 30.2g. The mean length gain per day was 0.128cm and the mean daily weight gain, 0.252g. The biomass increase per day registered a mean of 0.795g/m^2/day (range 0.478-1.275g/m^2/day). The total production in the 36 ponds ranged from 560 to 1536 kg/ha with an average of 959kg/ha.

The survival rate and the average final weight were not correlated with stocking density. But, biomass increase per day ($r=0.889$; $p<0.001$) and total production ($r=0.459$;$p<0.001$) registered significant positive correlation with stocking density. The average final weight of the shrimps was not correlated with survival rate. Similarly, total production also was not correlated with survival rate.

The protein, fat and carbohydrate contents and the nutritional indices of the three feed types are shown in table 4. FCR for feed 1 ranged from 1.49 to 2.55

Table 1. *Details of feed distribution*

Days of culture	Distribution of feed in check tray	Distribution of feed by broadcasting
3-60	6%	94%
61-90	4%	96%
91-120	2%	98%

(mean =1.70) in the 20 culture operations in which it was used. FCR of feed 2 ranged from 1.29 to 2.62 (mean=1.59) and of feed 3 ranged from 1.52 to 1.56 (mean=1.55). The FCR of the three feed types did not differ significantly. The growth rates of shrimps achieved with the three feed types are represented in Fig.1. As noticeable from the results the growth was faster with pelleted feed.

The mean total production with the three feed types did not differ significantly. Biomass increase /day were not significantly influenced by the feed types. However, the final average weight of shrimps for the three feed types differed significantly ($f=3.817$; $p<0.05$). The results of SNK multiple range test (modified for unequal group sizes; Zar, 1974) to test the differences between mean final weight of shrimps with the three feed types are presented in Table 2.

The results show that with pelleted feed (F3) a higher mean final weight of shrimp is possible or that pelleted feed is superior to both fresh clam meat (F1) and clam meat + dough ball (F2) in promoting growth of shrimps.

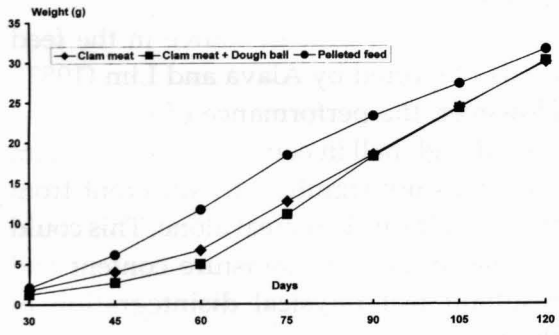

Fig. 1. Growth rate of P. monodon fed with different types of feeds

Discussion

It is well documented that *P.monodon* can be cultured at high densities (Liao.,1977; Liu and Mancebo, 1983). As observed in the present study, an average harvest weight between 30-32g in 120 days culture with supplemental feeding, for this species is reported by several workers (Liao., 1977; Tiro *et at.*,1986). In the present study the growth rate was slow initially and after 60 days the rate was fast till 120 days. This observation is in agreement with those of AQUACOP (1984) and Chen *et al.*, (1989). Even though some studies suggest that shrimp growth is inversely related to stocking density, there was no evidence in the present study to corroborate this, as also reported by AQUACOP(1984) and Wyban *et al.* (1987). The high growth rate obtained in the present study may be because of the combined effect of feed and fertilizer applied to the culture system as reported by Buck *et al.* (1981), Rubright *et al.*, (1981), Wohlfarth *et al.*, (1985) and Anderson *et al.*, (1987).

The mean biomass increase was 95.33g/ m^2 for 120 days at the rate of 0.795g/ m^2/ day at an average stocking density of 6.31 animals /m^2 and a survival rate of 50.2% which is in agreement with that of other species of shrimp reported by other workers (Sick *et al.*, 1972) and Sick and Andrews (1973). A significant positive correlation ($r = 0.884$, $p<0.001$) between stocking density and biomass increase per

Table 2. *Results of SNK multiple range test with mean final weight of shrimps with three feed types.*

Feed Type	F1	F2	F3
Mean final body weight (g)	30.00	30.18	31.60
Rank of means	1	2	3

Comparison	Difference in mean	SE	Q	p	$q_{0.0521p}$	Conclusion
3 vs. 1	1.60	0.4117	3.886	3	3.566	$\mu_3 ? \mu_1$
3 vs. 2	1.42	0.4367	3.252	2	2.942	$\mu_3 ? \mu_2$
2 vs. 1	0.18	0.3255	3.553	2	2.942	$\mu_{2=}\mu_1$

day was observed in this study. Similar results are reported for *P. vannamei* by Lee *et al.*, (1986), Sandifer *et al.*, (1987) and Wyban *et al.*, (1987) .The survival rate of shrimps varied between 38% and 58% and this value is a comparatively low, is consistent with figures reported in commercial shrimp culture. The low survival in the present study may be due to high mortality in post larval stages. Transportation stress and stress induced by sudden transfer of post larvae into grow out ponds might have contributed to the low survival rate. Though survival rate in culture system is inversely related to stocking density, in the present study with moderate survival at all stocking densities, such a correlation was not found. Chen and Wang (1990) for *P. monodon* and Wyban *et al.*, (1987), Goxe *et al.*, (1988) and Hernandez-Llmas *et al.*, (1992) for other penaeid species, also did not find any significant correlation between stocking density and survival rate.

The highest value of FCR is for clam meat and the lowest value for pelleted feed, and the FCR for the three feeds were not significantly different. The FCR for clam meat was 1.70 which is lower than that reported by many earlier workers. (Ali, 1988, Kungvankij *et al.*,1990). In the present study, the moist dough ball used had a protein content of 27.71%. In combination with clam meat, the ratio of clam meat to dough ball varying from 1:1 to 8:1 in the combined feed, the protein content ranged from 40.15% to 49.79%. This combined feed had a low FCR than the clam meat. This low value than that of clam meat FCR could be due to the presence of more than one protein source in the feed as also reported by Alava and Lim (1983). However, the performance of shrimp fed with dough ball in combination with clam meat was not significantly different from those fed fresh clam meat alone. This could be due to the high moisture content and resultant fast physical disintegration of the feed.

The lowest FCR as well as the highest

Table.3. *Average water quality, growth and production parameters of the culture system*

Parameters	Pallithode	Chellanam	Kannamaly
Salinity (ppt)	16.30 +/- 5.82	14.41 +/- 4.91	13.29 +/- 3.78
pH	7.28 +/- 0.11	7.86 +/- 0.27	7.58 +/- 0.28
Dissolved Oxygen (ppm)	6.05 +/- 0.52	6.06 +/- 0.23	5.84 +/- 0.34
Alkalinity (ppm)	60.12 +/- 17.54	96.67 +/- 11.78	72.54 +/- 8.50
Secchi Disc visibility (cm)	40.53 +/- 6.11	35.56 +/- 3.15	36.36 +/- 3.2
Average final length (cm)	15.550	14.840	14.900
Average final weight (g)	30.180	30.000	30.520
Average daily weight gain (g)	0.251	0.250	0.254
Instantaneous growth (g)	0.052	0.052	0.052
Stocking density (no./ m^2)	6.690	5.730	0.520
Survival rate (%)	47.580	50.620	52.430
Biomass increase (g/ m^2)	93.990	87.940	104.220
Biomass increase per day (g)	0.783	0.733	0.868
Production (Kg/ ha)	947.580	886.580	1043.420

growth rate were achieved with the pelleted feed used in the study. The pelleted feed was superior to the other two in realizing better average final weight on the growth rate of *P.monodon*. This may be because of the better amino acid balance of the pelleted feed by virtue of the four different protein sources incorporated in the feed. Alava and Lim (1983) reported that diets containing two or more proteins are better utilized by shrimp by those containing a single protein source. This could be the reason for the higher mean final weight realized with pelleted feed in the present study.

The second feed type (clam meat + dough ball) also contained more than one protein source. However, the results obtained with this feed were significantly inferior to that of pelleted feed. The poor

Table.4. *Proximate composition and nutritional indices of three feed types.*

Composition / indices	Feed types		
	Clam meat	Clam meat + Dough ball	Pelleted feed.
Crude protein (%)	52.6	40.15 — 49.79	35.27
Fat (%)	10.63	8.6 —10.17	6.79
Carbohydrate (%)	28.46	25.47 — 27.77	9.79
Gross energy (Kcal / 100g feed)	502.72	403.69 — 480.24	295.91
P / E ratio (mg protein / Kcal)	104.63	99.48 — 103.68	119.24
FCR	1.7	1.59	1.5
FCE	59.4	64.94	64.51

performance of F2 compared to F3 is attributable to the lack of any other marine protein source other than clam meat, in F2. The pelleted feed contained two sources of marine protein: shrimp head waste and squilla powder. Further, it is now proven that penaeid shrimps have a dietary requirement of native chitin (Fix, 1993). Shrimp head meal is not only a good source of chitin, but also of protein, carotenoid pigments, fatty acids and fibre (Meyers, 1986). Deshimaru and Shigueno (1972) reported that the amino acid composition of the rations that give the best growth performance of shrimp, most closely approximate the amino acid composition of the shrimp. Shrimp meal in the pelleted feed, therefore, would have ensured a desirable amino acid balance in the formulation. Besides, shrimp meal would meet the substrate requirement of chitin and provides the requisite amount of calcium needed for rapid growth and can be used at fairly high levels to sustain good growth rate as reported by Cuzon *et al.* (1994).

Another reason for better growth for pelleted feed may be due to the presence of both w-3 and w-6 PUFA through the supply of cod liver oil and palm oil incorporated. The presence of these PUFA helps in the synthesis of essential fatty acids that are needed for rapid growth and normal moulting of penaeids (Colvin, 1976 and Guary *et al.*, 1976). The protein/ energy ratio was the highest for pelleted feed (119.24mg protein/ kcal). This value is in agreement with that reported by Hajra *et al.* (1988) and Shaiu and Chou (1991) for the feeds they used for *P.monodon*. Rajyalakshmi *et al.* (1982) reported that a protein level in the range of 20-40% in the diets is sufficient to ensure good growth in penaeid shrimps, especially in tropical waters. The present results corroborate the above mentioned observation. The best growth for *P.monodon* was realized with pelleted feed containing about 35% protein. In this study, the overall performance of shrimp weighs strongly in favour of the use pelleted feed.

In terms of economics also the same holds good. The total production cost, 36.04% and 34.31% were accounted respectively for the cost of clam meat and the clam meat + dough ball whereas only 30.37% of the total production cost were accountable for pelleted feed. The performance of the pelleted feed in terms of growth and economy was mainly because of its quality and nutritional value. Shrimps being slow feeders require water stable pellets. Further, uniformity in the particles compacted into a pellets, the nutrient density in the feeds in terms of macronutrients and micronutrients add to the qualities of the pelleted feed. Further, this feed was made in the farm itself adopting an appropriate feed technology with maximum utilization of locally available conventional and non-conventional ingredients. It was all these factors, which New (1992) also emphasized, that added up to advocate on farm feed making for the small scale, semi intensive, monoculture systems of fish and shrimps.

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