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**Different Feed Ingredients on Growth, Survival, Production and Feed
Conversion Ratio of Cage Reared White Shrimp,
Penaeus indicus at Vellar Estuary**

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Abstract: To assess the effect of various feed ingredients on growth, survival, production and feed conversion ratio of *Penaeus indicus*. Four uniform size rectangular cages (10×5×1.5 m) were erected on the bottom soil substrate. All these cages were uniformly stocked at the rate of 50 m⁻² with juveniles of size ranging from 3.3 to 4.1 g. The shrimps of the first cages were fed with fish meal based diet, the second with clam meal based diet, the third with soyaben based diet and fourth with mixed diet of fish meal, clam meal and soyabeen. As the culture was carried out for 100 days, all the cages were changed at regular interval of 34 days. The higher growth 22.9 g, survival rate 97%, production rate 1110.65 g m⁻² and better feed conversion ratio 1:1.8 were observed for the shrimps fed with the mixed diet.

Key words: *Penaeus monodon*, rectangular cages, fish meal, clam meal, soyaben meal, Vellar estuary

INTRODUCTION

The formulation of cheap diets is very important to the commercial culture of shrimps. This can be achieved by utilizing and experimenting upon a variety of locally available low priced raw materials (Usha Goswami and Goswami, 1982). Intensification of culture practices and large-scale stocking may lead to depletion of natural protein available in the environment and this affect fish growth (Hepher and Ghervinski, 1965). Artificial feeding is the only solution to overcome this problem (Raman *et al.*, 1982). Eventhough many studies are available on the effect of artificial feeds on the shrimps (Forster and Beard, 1973; Verghese and Singh, 1979; Ahamad Ali, 1982a, b; 1986; Ponraj *et al.*, 1990; Tidwell *et al.*, 1995), studies on nutritional requirements of the cage-cultured shrimps are scanty. In view of this, an attempt was made in the present study to formulate supplementary feeds using cheap and locally available feed ingredients to assess the effect on growth, survival and production and feed conversion ratio of cage reared shrimp, *P. indicus* at Vellar estuary.

MATERIALS AND METHODS

Cage Erection

In the present study, four uniform size rectangular (10×5×1.5 m) cages were erected on the bottom soil substrate and all of these cages were provided with hide-outs. Among these four cages, the shrimps of the first cage were fed with fish meal based diet, second with clam meal based diet, third with soyabeen based diet and fourth with mixed diet of fish meal, clam meal and soyabeen based diet.

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Seed Transportation

The seed purchased from hatchery was transported to culture site in Vellar estuary by oxygenated polythene bag and were kept in styroform boxes. Before transportation, the qualities of seeds were examined by taking the seeds in a plastic container to ensure uniform size and good health. Postlarvae of penaeid shrimps are small, fragile and are sensitive to change in water conditions. So the postlarvae purchased from the hatchery were acclimatized to estuarine condition before stocking to avoid heavy mortality. In order to increase the survival rate and prevent the escape from the cage, the acclimatized seeds were released into already erected small hapa of 2×1×1 m size in the estuary and the seeds were reared for 10 days.

Stocking

After 10 days of culture in the hapa their average length and weight of the postlarvae were recorded. All the cages were uniformly stocked at the rate 50 m⁻² with the juveniles of *P. indicus* size ranging from 3.3 to 4.1 g and the culture period was 100 days. All of four cages were changed at the regular interval of 34 days instead of 30 days.

Preparation of Artificial Diets

Fish meal, clam meal, soyabean, beef meal, ground nut oil cake, shrimp waste, rice bran, tapiaco flour and maida flour were used for the preparation of the artificial diets. Vitamins and minerals were also added for preparing the diets. The compositions of different feeds were showed in Table 1a and b.

Table 1a: Feed composition (%) of different artificial feeds

Ingredients	Feed types			
	Fish meal based diet	Clam meal based diet	Soya bean based diet	Mixed diet
Fish meal	51	--	--	17
Clam meal	--	51	--	17
Soya bean	--	--	51	17
Beaf meal	10	10	10	10
Ground nut oil cake	10	10	10	10
Prawn waste	5	5	5	5
Rice bran	9	9	9	9
Tapiaco flour	5	5	5	5
Maida flour	10	10	10	10

**Vitamin and mineral mix

Table 1b: Composition of vitamin and mineral mix (per kg pellet)

Vitamin and mineral mix**	Concentration
Vitamin A.I.S. (as Acetate)	25000.00 I.U.
Thiamine mononitrate I.P. (Vit. B ₁)	2.00 mg
Riboflavin I.P. (Vit. B ₂)	3.00 mg
Nicotinamide I.P.	25.00 mg
Pyridoxine hydrochloride I.P. (Vit. B ₆)	1.50 mg
Calcium pantothenate U.S.P.	5.00 mg
Cyanocobalamine I.P. (Vit. B ₁₂)	1.00 mg
Ascorbic acid I.P. (Vit. C)	50.00 mg
Cholecalciferol U.S.P. (Vit. D ₃)	200.00 I.U.
Vitamin E.N.F. (as D1 Alpha-tocopheryl acetate)	10.00 mg
Biotin (Vit. H)	0.05 mg
Minerals	
Calcium phosphate	0.208 g
Dried ferrous sulphate	10.62 g
Magnesium phosphate dibasic	48.00 mg
Manganese hypophosphate	0.60 mg
Total phosphorus in the preparation	44.60 mg

Fish meal, clam meal and shrimp waste were procured locally from the Parangipettai and Pudupettai fish landing centers and were dried, powdered individually by using mini-pulverizer and sieved through 200 μ sieve. Beaf meal was purchased from the nearby slaughter house and was also dried, powdered by using the same mini-pulverizer. Ground nut oil cake, rice bran, tapiaco flour and maida flour were also purchased from the local market. For each feed type required ingredients were uniformly mixed with hot water in order to make it dough. After this vitamins and minerals were added. The dough of each feed item was individually extruded in the form of noodles using a mini-pelletizer. Pellets thus obtained were sun dried initially and later in an oven at 40°C for 12 h. The dry pellets of each feed types individually packed in the air tight polythene bags.

Biochemical Analysis

Biochemical analysis was done on all feed type in order to evaluate their nutritive value. The estimation of protein, carbohydrate and lipid were carried out following the standard methods of Raymont *et al.* (1964), Dubois *et al.* (1956) and Folch *et al.* (1956), respectively.

The moisture content was estimated individually for each feed type by drying two grams of the pellet in a hot air oven at 60°C for 48 h and then weighed. The difference in weight gives the moisture content.

For the analysis of the ash content, 1 g of powdered pellet was taken in a porcelain crucible and kept in muffle furnace at 600°C for 4 h. The ash was then weighed and percentage was calculated as in the case of moisture content.

Physical Evaluation

Water Stability of Pellets

Pellets of known size were taken and gently dropped into rectangular fibreglass tanks (size 50×30×30 cm) with a water level of 30 cm. The time taken for its disintegration was taken as the stability period of the feed pellet and was expressed in hours.

Sinking Rate of Pellets

The sinking rate of each test feed was determined in a measuring jar of 1 L capacity. Five uniform size pellets were gently dropped into water individually and the time taken by each to travel the known depth of water was noted using a stop watch. The average time by each test diet was calculated separately and the values are expressed in cm sec⁻¹.

Feeding Schedule

The shrimps of upto 6 g of all the cages were uniformly provided with 1×1.5 mm pellets, 2×3 mm pellets were provided up to 10 g and 2.5×4 mm pellets were fed up to harvest (Table 2).

Table 2: Feeding schedule

Pelleted feeds	Feed types	Size (mm)	Average body weight (g)	Amount of feed per day	Feeding frequency per day
Fish meal based diet	Pellet-I	1.0×1.5	Upto 6	9-10	4
	Pellet-II	2.0×3.0	6-10	6-9	4
	Pellet-III	2.5×4.0	10-21.3	3.5-6	4
Clam meal based diet	Pellet-I	1.0×1.5	Upto 6	9-10	4
	Pellet-II	2.0×3.0	6-10	6-9	4
	Pellet-III	2.5×4.0	10-21.7	3.5-6	4
Soya bean based diet	Pellet-I	1.0×1.5	Upto 6	9-10	4
	Pellet-II	2.0×3.0	6-10	6-9	4
	Pellet-III	2.5×4.0	10-21.4	3.5-6	4
Mixed diet	Pellet-I	1.0×1.5	Upto 6	9-10	4
	Pellet-II	2.0×3.0	6-10	6-9	4
	Pellet-III	2.5×4.0	10-22.9	3.5-6	4

Ten percent of feeds were provided initially to shrimps and based on intake the level was gradually reduced to 3.5% during later periods. Feeding was done daily in four instalments, in the morning h (06.00-07.00), noon h (01.00-02.00 pm), evening h (05.00-06.00 pm) and night h (09.30-0.30 pm). The feed was kept in specially designed feed trays.

Feed Conversion Ratio (FCR)

Feed conversion ratio also calculated separately for each and every feed.

Sampling

At every ten days interval, 15 individuals of *P. indicus* were collected by using a hand net and their length and weight were recorded. The length was measured from the tip of rostrum to the tip of the telson. After recording the length and weight, the shrimps were immediately returned into the cage without any stress.

Assessment of Environmental Parameters

The environmental parameters were monitored at every morning around 6 am during entire culture period. The salinity, dissolved oxygen, pH and temperature were measured by using water analysing Kit model CK-711.

Survival Rate

The percentage of survival was calculated at every ten days interval.

Harvest

At the end of culture period (100 days) the cages were removed from the culture site and brought to near land. The shrimps were harvested by hand picking and the individual length, weight and total weight of harvested shrimps were recorded separately for each type of cages.

RESULTS

Biochemical Composition of the Different Feeds

Among the four pelleted feeds, fish meal based diet showed higher crude protein content of 43%, followed in the order of clam meal based diet (42%), mixed diet (40%) and soya bean based diet (36%). The higher carbohydrate content of 30% was observed in soya bean based diet and the lower carbohydrate content of 22% was observed in both fish meal based diet and clam meal based diet (Table 3). Carbohydrate content of mixed diet was 28%. The higher and lower crude lipid contents of 12 and 8% were recorded in fish meal based diet and clam meal based diet, respectively. The crude lipids content of 11 and 10% were recorded in the soya bean based diet (10%).

Physical Evaluation of the Feeds

Based on the size of the pellets, 1×1.5 mm pellets of all the feed types were designated as P-I (Pellets-I), 2×3 mm pellets were designated as P-II (Pellet-II) and 2.5×4 mm pellets were designated as P-III (Pellet-III). In general the water stability of the P-I of all the diets was lower than the P-II and P-III (Table 4). For example the water stability of P-I of fish meal based diet was 4.2 h, which was lower than the water stability of P-II (4.55 h) and P-III (5.3 h) of the same fish meal based diet. The sinking rate of P-I of all the diets was found to be higher than the P-II and P-III. For example the sinking rate of P-I of mixed diet was 10 cm sec⁻¹, which was higher than the P-II (9 cm sec⁻¹) and P-III (8 cm sec⁻¹) of the same mixed diet (Table 4).

Table 3: Bio-chemical composition of different feed items

Biochemical composition (%)	Feed types			
	Fish meal based diet	Clam meal based diet	Soya bean based diet	Mixed diet
Crude protein	43	42	36	40
Crude carbohydrate	22	22	30	28
Crude lipid	12	8	11	10
Moisture	8	12	11	10
Ash	12	12	10	11

Table 4: Physical evaluation of different pelleted feeds

Feed type		Physical evaluation	
		Water stability (h)	Sinking rate (cm sec ⁻¹)
Fish meal based diet	P-I	4.20	9
	P-II	4.55	8
	P-III	5.30	7
Clam meal based diet	P-I	4.12	10
	P-II	4.30	9
	P-III	5.10	8
Soya bean based diet	P-I	3.80	11
	P-II	4.15	10
	P-III	4.80	9
Mixed diet	P-I	4.15	10
	P-II	4.40	9
	P-III	5.20	8

P-I = Pellet-I; P-II = Pellet-II; P-III = Pellet-III

Table 5: Summary on the production of cage reared *P. indicus*

Particulars	Feed types			
	Fish meal based diet	Clam meal based diet	Soyabean based diet	Mixed diet
Water spread area (m ²)	50	50	50	50
Dimension (m)	10×5×1.5	10×5×1.5	10×5×1.5	10×5×1.5
Number stocked	2500	2500	2500	2500
Stocking density (No. m ⁻²)	50	50	50	50
Days of culture	100	100	100	100
Initial weight (g)				
a) Average	3.6	3.7	3.6	3.6
b) Range	3.4-4.0	3.4-4.1	3.4-4.1	3.3-4.1
Initial length (mm)				
a) Average	62	62	62	62
b) Range	61-63	61-64	61-64	61-63
Final average weight (g)	21.3	21.7	21.4	22.9
Final average length (mm)	125	126	126	126
Growth increment (g day ⁻¹)	0.177	0.18	0.178	0.193
Survival rate (%)	82.2	91.8	85.4	97
Number harvested	2055	2295	2135	2425
Total production (kg 50 m ⁻²)	43.77	49.80	45.689	55.53
Production rate (kg ha ⁻¹)	8754.3	9960.3	9137.8	11106.5
Production rate (g m ⁻²)	875.43	996.03	913.78	1110.65
Feed Conversion Ratio (FCR)	1:2.1	1:1.8	1:1.9	1:1.8
Total weight of autoentrants (g 50 m ⁻²)	354	482	412	678

Growth

Among the four cages, shrimps fed with mixed diet showed higher growth of 22.9 g. The lower growth of 21.3 g was observed for the shrimps fed with fish meal based diet. The growth of clam meal based diet and soyabean based diets were 21.7 and 21.4 g, respectively (Table 5).

Table 6: Environmental parameters (range) of the culture period

Salinity (ppt)	Dissolved oxygen (mg L ⁻¹)	pH	Temperature (°C)
21-28	4.6-5.3	8.3-8.5	28-31
23-30	4.5-5.3	8.3-8.5	28-32
22-30	4.5-5.2	8.4-8.5	28-31
21-30	4.2-5.1	8.4-8.6	29-31
21-32	4.4-5.0	8.3-8.5	29-32
23-33	4.3-5.1	8.4-8.5	28-32
25-33	4.5-4.9	8.3-8.6	28-31
28-32	4.1-4.8	8.3-8.6	29-33
28-33	4.5-4.9	8.4-8.6	30-32
27-33	4.4-5.0	8.4-8.7	30-32

Survival Rate

In general, the survival rate of all the cages was found to be good (Table 5). However, the higher survival rate of 97% was obtained shrimps fed with mixed diet, followed in the order of clam meal based diet (91.8%), soya bean based diet (85.4%) and fish meal based diet (82.2%).

Production Rate

Maximum production rate of 1110.65 g m⁻² was recorded for the shrimps fed with mixed diet and minimum production rate of 875.43 g m⁻² was obtained for shrimps fed with fish meal based diet (Table 5). The production rates of 996.03 and 913.78 g m⁻² were observed for the shrimps fed with clam meal based diet and soya bean based diet, respectively.

Feed Conversion Ratio

Feed conversion ratio of the mixed diet and clam meal based diet were 1:1.8, which was found to be better than the other two formulated feeds. The PCR of the fish meal based diet and soya bean based were 1:2.1 and 1:1.9, respectively (Table 5).

Environmental Parameters

Salinity was observed between 21 and 33 ppt, dissolved oxygen was between 4.1 and 5.3 mg L⁻¹, pH ranged from 8.3 to 8.7 and temperature varied from 28 to 33°C (Table 6).

DISCUSSION

The importance of supplementary feed in the shrimp culture is emphasized by many workers (Subramanian, 1981; Ahamad Ali, 1982a, b). Collins (1999) observed better results in the enclosures when the fresh water prawn *Macrobrachium borelli* fed with artificial feeds than unfed prawns. In the present investigation also all the four cages were fed with different type of pelleted feeds. Among these the higher production rate of 1110.65 g m⁻² was achieved for the shrimps fed with mixed diet, followed in the order of clam based diet (996.03 g m⁻²), soya bean based diet (913.78 g m⁻²) and fish meal based diet (875.43 m⁻²). It is clearly indicates that the production rate of shrimps was influenced by types of ingredients used in the artificial feeds. Similar observation was reported by several workers. Rajyalakshmi *et al.* (1979) reported that the cuttle fish meal and soya meal yielded best growth performance both in laboratory and field studies. According to Netke (1989), the complete feed is the one which would supply all the nutrients needed by shrimp and it is essential for maximizing the production of shrimp. Parallel to his statement in the present study, the mixed diet is ideal for the cage-reared shrimp *P. indicus* as it reported maximum production than other feeds.

In the present study the production rate of shrimps fed with fish meal based was comparatively poor. Parallel results were observed by many workers. Deshimaru and Shigeno (1972), Colvin (1976) and Ahamad Ali (1982a) observed lower production for the shrimps fed with fish meal based diet.

Deshimaru and Shigeno (1972) found that the amino acid composition of fish meal was not similar to that of the shrimp *P. japonicus*. The relative deficiency of the amino acids tyrosine and phenylalanine in the fish meal may be the reason for its relatively poor performance (Colvin, 1976).

The production rate of shrimps fed with clam meal based diet showed better results over the shrimps fed with soya bean based diet and fish meal based diet. Similarly Kanazawa *et al.* (1970) reported that the fresh diet of short necked clam (*Tapes philippinarum*) provided superior growth compared to the compounded diets for *P. japonicus*. Similar results were reported by Forster and Beard (1973) for *Palaemon serratus*. Ahamad Ali (1982a) also showed good results for clam powder based diet for *P. indicus* with better food conversion. Next to clam meal based diet, soya bean based diet showed better production than the fish meal based diet. Deshimaru and Shigeno (1972) observed that the plant product, soya bean is known to have amino acid profile more similar to that of the shrimp, *P. japonicus*, than that of an animal such as *Artemia salina*. Similar observations were reported by Kanazawa *et al.* (1970), Blazs *et al.* (1973) and Sick and Andrews (1973) with soya meal based diet.

In the present study, shrimp waste was used as one of the ingredient in all the four types of compounded diets. Shrimps waste protein is reported to be having several essential amino acids (Forster, 1975). Venkataramaiah *et al.* (1978) observed that *P. aztecus* fed with shrimp waste pellets gave good results. Sandifer and Joseph (1976) found waste shrimp heads (*P. setiferus*) were a good source of fatty acids and pigments for the diet of *M. rosenbergii*. Similar results were obtained by Forster and Beard (1973) for *P. serratus*. Ahamad Ali (1982a) also showed good results with mantis shrimps protein for *P. indicus*. Similarly, various sources of shrimp waste have been used in many studies yielded good results (Balazs *et al.*, 1973; Sick *et al.*, 1972). Shrimp meal as protein source is said to increase the efficiency of the diets, in fact even 25 to 35% protein levels have given good results with *P. japonicus* when shrimp meal is fed (Balazs *et al.*, 1973). As in the present study 5% shrimp meal was used by Collins (1999). In the present study, ground nut oil cake, rice bran, tapiaco flour and maida flour were also used for preparing compounded diets for shrimps (Siddharaju and Menon, 1982).

The protein level of the fish based diet, clam meal based diet, soya based diet and mixed diet used in the present study were 43, 42, 36 and 40%, respectively. Results from other studies confirm that maximum or near-maximum growth was observed for the feed containing protein level between 30 and 40% for penaeid shrimps (Sick *et al.*, 1972; Forster and Beard, 1973; Venkataramaiah *et al.*, 1975). Ponraj *et al.* (1990) reported maximum growth for *P. monodon* fed with diet containing the protein level of 42%. The feed containing 45% protein gave the maximum growth rates and survival rates of *P. indicus* (Annie Mathew and Jeyaprakas, 1990). However Sambasivam *et al.* (1982) obtained good results for the higher protein level of 60% than the other lower level of 40 and 50% for *P. indicus*. Similarly, Deshimaru and Shigeno (1972) also observed higher growth rate for *P. japonicus* fed with test diets having more than 60% protein. A similar trend was observed by Balazs and Ross (1976) that high protein content enhanced the growth of *M. resenbergi*.

According to Ahamad Ali (1982a), in general it is observed that the high protein level in the diets beyond the optimum level do not produced significant increase in growth or growth is not proportional of the increase in protein level. The probable explanation for this may be that the increased in protein decrease the quantity of other energy giving nutrients such as fat and carbohydrate in the diet, from which the animal normally derived most of the energy required for their metabolic activities. In fact, the protein in excess of the optimum level is mostly utilized for the metabolic energy required and not for tissue growth. This is indirectly supported by the fact that the protein utilization, in terms of live weight gain, declines with the increase in the dietary protein level. The results of the present study are in agreement with that of Ahamad Ali (1982a). Eventhough the protein level of the different compounded diets of the present study were found to be between 36 and 43%, the shrimps fed with mixed diet of 40% protein level showed maximum growth rate.

As with the other aspects of nutritional requirements, information on optimum level of dietary energy sourced for shrimp is limited. In the case of lipids the formulated feeds on which best growth had been obtained with relatively low levels. Deshimaru and Shigeno (1972), showed a level of 8.8% crude fat in their best diet and it seems unlikely that there is much to be gained by providing higher level. Shudo *et al.* (1971) reported that the addition of 4% squid liver oil added to their slandered ration improved the growth of *P. jarponicus*. But Forster and Beard (1973) and Andrews *et al.* (1972) reported inhibition of growth at lipid level of 15 and 10% supplementation respectively. In purified diets Sick and Andrewa (1973) observed 10% lipid gave better growth while Deshimaru and Kuroki (1974) reported lipid level of 6% provided better growth than 12%.

Although the data is limited, it would appear that shrimps do not require high level of dietary lipid and the optimum level is probably between 5 and 10% (Forster, 1975). In the present study both mixed diet and clam meal based diet showed better results which contains 10 and 8% lipid levels respectively. Similarly Chandge and Paulraj (1990) observed better survival and growth in larvae and post larvae of *P. indicus* fed with 10% lipid level. Further, Ranganath (1989) reported that the recommended lipid levels of commercial shrimp feeds should not exceed 10% as increased levels are associated with mortalities and stunted growth. This is well reflected in the present study results that the maximum survival rates of 97% for shrimps fed with mixed diet and 91.8% for clam meal based rates of attributed to the lipid level of 10 and 8%, respectively. Minimum survival rates of 85.4% for soya bean based diet and 82.2% in fish meal based diet are attributed to the lipid levels of 11 and 12%, respectively.

According to Ranganath (1989), carbohydrate is not a dietary essential for shrimp's feeds, in the absence of adequate carbohydrates shrimps will utilize protein to meet their energy levels. The carbohydrate level of the mixed diet (28%) used in the present study appears to be optimum level as it showed better growth rate (22.9 g), survival rate (97%) and production rate (1110.65 g m⁻²) than other feed types. Due to intermittent feeding behaviour of the shrimps, good water stability of the compounded diet is a highly desirable factor (New, 1976). From the findings of the present study, it is clear that the water stability and sinking rate of the mixed diet was found to be optimum for the cage cultured shrimps.

Data on growth rate and food conversion ratio on various species of penaeid shrimps had earlier published by authors like Andrews *et al.* (1972), Venkataramaiah *et al.* (1975) and Royan *et al.* (1977). Royan *et al.* (1977) reported FCR values ranging between 0.94-3.50 for *M. monoceros* which was feed upon different level of protein. In the present study, the feed conversion ratio was recorded within the ranges of 1.8 to 2.1 was found to be better than earlier works. Feed conversion efficiency of *P. indicus* by using M/s. Ruminant feed was found to be 1:3:7 (Shanmugam *et al.*, 1998). Collins (1999) reported the food conversion ration of 2.84 for the culture of *M. borellii* in enclosures.

Minor variations in the environmental parameters of the present study were optimal for cage culture. From the finding of the present study, it is clear that the shrimps fed with mixed diet showed better growth, survival and production and feed conversion ratio.

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