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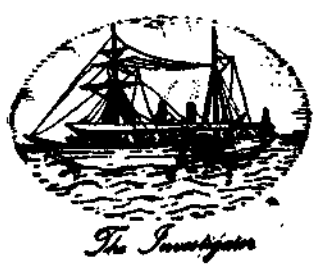

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RELATIVE EFFICIENCIES OF PELLETIZED FEEDS COMPOUNDED WITH DIFFERENT ANIMAL PROTEINS AND THE EFFECT OF PROTEIN LEVEL ON THE GROWTH OF THE PRAWN *PENAEUS INDICUS*

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ABSTRACT

Laboratory experiments with four pelletized feeds, compounded separately with the animal proteins from prawn waste meal, mantis shrimp protein, clam meat powder and fish meal in combination with the plant protein from groundnut cake, were conducted to study the relative efficiency by feeding juvenile *Penaeus indicus*. The animal and the vegetable proteins in each feed were approximately adjusted in the ratio 1 : 1. Tapioca powder was used as the source of carbohydrate as well as the binding agent. The control experiment was carried out with the feed prepared solely from fresh clam meat. Feeds with mantis shrimp protein and clam meat powder gave high increase in live weight and good food conversion values followed by the feeds with fresh clam meat, prawn waste meal and fish meal.

Feeding experiments with pelletized feeds, consisting of mantis shrimp protein, groundnut cake and tapioca powder with crude protein content ranging from 20.5% to 46.5% were conducted on the juvenile *P. indicus*. Progressive increase in the live weight gain was recorded with the increase in the crude protein level upto 42.9% and declined thereafter, while the protein efficiency ratio was the highest at 20.5% crude protein level.

INTRODUCTION

THE white prawn *Penaeus indicus* has been identified as one of the most suitable species for intensive culture in coastal aquaculture practices. The development of a suitable feed is an important pre-requisite for the successful culture operations. For that the basic knowledge on the nutritional requirements of the prawn is essential. Commendable work has been done in this direction (New, 1978) and a number of feeds have been patented in various countries of the world. Very often these feed formulations cannot be directly utilized due to either the non-availability of the raw materials or their prohibitive cost.

Protein forms the most important constituent in prawn nutrition. Several workers have conducted studies on the protein requirement of different species (Deshimaru and Shigeno, 1972 : Sick *et al.*, 1972; Venkataramaiah *et al.*, 1975 ; Balazs and Ross, 1975 ; Colvin, 1976).

In the present study, an attempt has been made to study the relative efficiencies of some of the locally available animal protein materials to be included in prawn diets and the protein requirement in the feeds in terms of the raw materials for the culture of *P. indicus*.

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Materials and Methods

Raw materials

The prawn waste includes head and exoskeleton obtained from the peeling sheds. Mantis shrimp protein was prepared from *Oratosquilla nepa*. The wet material was boiled in water and the coagulated protein was separated and dried (Garg *et al.*, 1977). This material was obtained from the Central Institute of Fisheries Technology, Cochin. The clam (*Vellorita cyprenoidea*) meat was separated from the shells by heating and the whole meat was dried. Fish meal was obtained from the Kerala Fisheries Corporation, Azhikode. Groundnut cake and Tapioca (*Manihot utilissima*) were procured from the local market. All the raw materials were dried in an oven at 70-80°C and ground in an electrical grinder and sieved through 60 mesh sieve. Fresh clam meat (*Sunneta scripta*, 82% moisture), stored in the deep freeze, was given as the control diet.

The crude protein contents of the raw materials, determined by the micro Kjeldahl method, are given in Table 1.

Preparation of the experimental feeds

In each feed the animal and the plant proteins were approximately adjusted in the ratio 1:1. Groundnut cake was the common plant protein source in all the feeds. Tapioca powder was used as the main source of carbohydrate as well as the binding agent. Calcium lactate and potassium dihydrogen phosphate and multivitamins were included in all feeds.

Tapioca powder was first cooked with 40-50% of water for 10-15 minutes until the starch gelatinised. The other premixed ingredients were added to the paste and thoroughly mixed into a dough. The dough was passed through a 3 mm diameter die in a screw press. The pellets were dried at 70-80°C and found to be quite water stable.

Rearing

The juveniles of *Penaeus indicus*, used in the feeding experiments were collected from the backwater canals around the Vypeen Island. The animals were acclimatized for 5-7 days and starved for one day before the start of the experiment.

Feeding experiments were conducted in 50 litre capacity circular plastic troughs. Ten animals were stocked in each trough. The troughs were covered with velon screens to prevent the animals from jumping out. The sediments were removed regularly and the water was changed once in three days. Aeration was provided with an air compressor.

Feeding was done at the rate of 10-15% of the live body weight once in a day in the evening hours in petri dishes kept at the bottom in the middle of the trough. The food left

Table 1. *Crude protein values of the raw materials*

Ingredients	Prawn waste meal	Mantis shrimp protein	Clam meat powder	Fish meal	Groundnut cake	Tapioca
Crude protein content. % on dry basis ..	35.2	59.2	48.1	60.7	48.5	2.0

over was recovered every day before feeding. Weight and measurements were taken every ten days. No attempts were made to control the environmental conditions.

Feeding experiment I

Four experimental feeds 1, 2, 3 and 4 were compounded separately with the animal proteins from prawn waste meal, mantis shrimp protein, clam meat powder and fish meal in combination with the common plant protein from groundnut cake. The ingredients in each feed were adjusted to give the same crude protein content of 35%. The percentage composition of the feeds is given in Table 2.

Prawns with an average body weight of 100 mg were separately fed with feeds 1-4 and fresh clam meat for 30 days. For each feed two sets of experiments were run concurrently.

The salinity of the water increased from 1.8‰ to 7.5‰. The temperature ranged between 28.5°C to 32.5°C and the pH between 8.0 and 8.7.

The results of the feeding experiments are given in Table 3.

TABLE 2. *Percentage composition and crude protein values of the experimental feeds* 1-4

Ingredients %	Experimental feeds			
	1	2	3	4
Groundnut cake	35.0	38.0	40.0	35.0
Tapioca powder	17.0	31.0	19.0	37.0
Prawn waste meal	45.0	—	—	—
Mantis shrimp protein	—	28.0	—	—
Clam meat powder	—	—	38.0	—
Fish meal	—	—	—	25.0
Mineral mix*	2.0	2.0	2.0	2.0
Vitamin mix**	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0
Crude protein %	34.4	35.0	33.3	33.9

* Mineral mix : Each kg of the feed contains Calcium lactate 14 g ; Potassium dihyrogen phosphate 8g ; Ferrous sulphate 106 mg, Magnesium phosphate 480 mg.

** Vitamin mix Each kg of the feed contains vitamin A 40000 I.U., Thiamin mononitrate 100 mg, Riboflavin 20 mg, Nicotinamide 100 mg, Cynocobalamine 10 mg, Ascorbic acid 50 mg, Calciferol 4000 I.U., vitamin E 15 mg, Biotin 0.5 mg.

TABLE 3. *Results of the feeding experiment* 1 *fed with the feeds* 1-4 *and fresh clam meat for* 30 *days*

Description	Experimental feeds				
	1	2	3	4	Fresh clam meat
Initial average body weight (mg) ..	100	100	100	100	100
Final average body weight (mg) ..	380	513	497	250	400
Increase in average body weight (mg) ..	280	413	397	150	300
Percentage increase in average body weight ..	280	413	397	150	300
Average growth (mg/day) ..	9.30	13.80	13.20	5.00	10.00
Total food consumed (g) ..	6.38	5.16	5.79	5.62	—
Average food ingestion (mg/animal/day) ..	21.30	23.60	19.30	21.00	—
Food conversion* ..	2.27	1.71	1.46	4.20	—
Survival % ..	100	80	100	70	30

* Food conversion : $\frac{\text{Average rate of food ingestion}}{\text{Average growth rate.}}$

Feeding experiment 2

Experimental feeds 5, 6, 7, 8 and 9 were prepared consisting of mantis shrimp protein, groundnut cake and tapioca powder with the crude protein contents of 20.6, 28.5, 35.0, 42.9 and 46.5% respectively. The percentage composition of the feeds 5-9 is presented in Table 4.

TABLE 4. *Percentage composition and crude protein values of the experimental feeds* 5-9

Ingredients	Experimental feeds				
	5	6	7	8	9
Mantis shrimp protein	14.0	21.0	28.0	35.0	42.0
Ground nut cake	19.0	28.5	38.0	47.5	57.0
Tapioca powder	64.0	47.5	31.0	14.5	10.0
Mineral mix	2.0	2.0	2.0	2.0	2.0
Vitamin mix	1.0	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0	112.0
Crude protein %	20.6	28.5	35.0	42.9	46.5

The animals with an average body weight of 200-230 mg were fed separately with feeds 5-9 for 30 days. For each feed three sets of experiments were run concurrently.

The salinity of the water used in the experiment ranged from 17.3‰ to 20.3‰, temperature varied between 30.8 to 32.5°C and pH between 7.9 and 8.0. The results are presented in Table 5.

RESULTS

In the first experiment, feeds 2 and 3 with mantis shrimp protein and clam powder topped among the protein materials tested, by producing an average weight increase of 313% and 297% and an average growth of 13.8 and 13.2 mg/day respectively (Table 3). These were followed by fresh clam meat (200% and 10 mg/day), feed 1 with prawn waste (181% and 9.3 mg/day) and feed 4 with fish meal (50% and 5 mg/day). Clam powder gave the best food conversion (1.46) followed by mantis shrimp protein (1.71), prawn waste (2.27) and fish meal (4.2). The food conversion in the case of fresh clam meat was not determined, as there was heavy mortality.

The average rate of food ingestion was the highest in the case of mantis shrimp protein (23.6 mg/day/animal) and the lowest in the

TABLE 5. *Results of the feeding experiment* 2 *fed with the feeds* 5-9 *for* 30 *days*

Description	Experimental feeds				
	5	6	7	8	9
Initial average body weight (mg)	210	200	230	200	200
Final average body weight (mg)	590	590	700	890	800
Increase in average body weight (mg)	380	390	470	690	600
Percentage increase in average body Weight	181	195	204	345	300
Average growth (mg/day)	12.70	13.00	15.70	23.00	20.00
Total food consumed (g)	8.66	7.05	8.97	8.88	8.77
Average rate of food ingestion (mg/animal/day)	28.90	23.50	29.90	29.60	29.20
Food conversion	2.28	1.80	1.90	1.29	1.46
Protein efficiency ratio*	2.10	1.96	1.50	1.50	1.18
Survival %	100	100	100	100	100

* Protein efficiency ratio : Live weight gain per gram of protein consumed.

case of claim powder (19.3 mg/day/animal), while for prawn waste and fish meal the food intake was 21.3 and 21.0 mg/day/animal respectively.

Weight gain increased with time (Fig. 1) in general. The increase in weight was the highest in the last ten days and lowest in the

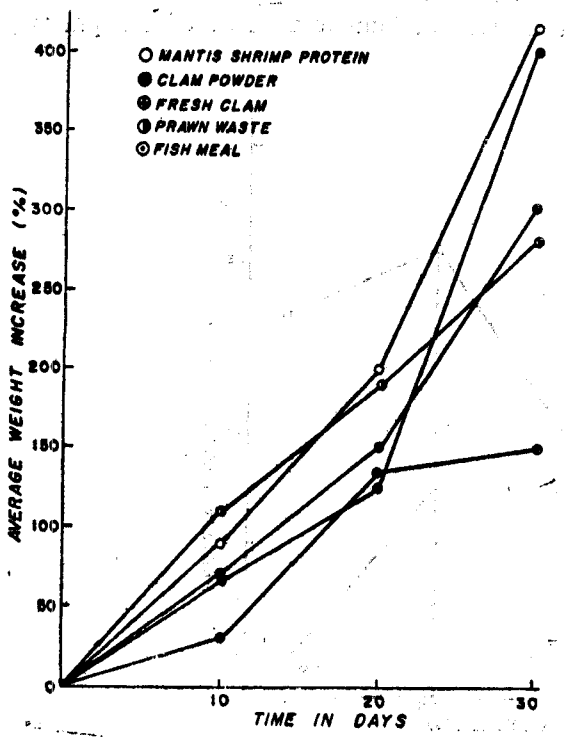

Fig. 1. Growth curves of the prawn *P. indicus* fed on he feeds compounded separately with prawn waste, mantis hrimp protein, clam meat powder, fish meal and fresh lam meat.

first ten days in the case of feeds 2, 3 and fresh clam meat, whereas in the case of feeds 1 to 4 it was vice versa. In the case of fresh clam meat frequent moulting, heavy mortality and cannibalism were observed.

In general the animals were immediately attracted to all the foods. However, the preference was observed for prawn waste, mantis shrimp protein, fresh clam meat, clam powder and fish meal in the decreasing order.

The gain in live-weight increased with the increase in crude protein level in the diet upto 42.9% (Table 5) and declined thereafter in the second experiment. The feed with 42.9% crude protein gave the highest increase in live weight gain (345% and 23 mg/day) and best food conversion (1.29). The protein efficiency ratio declined gradually with successive increase in the dietary protein level.

There was a sharp increase in weight between 35.0 and 42.9% crude protein levels, while the increase in weight from 20.6 to 35.0% protein levels was gradual (Fig. 2, curve A) and again there was a gradual decline between 42.9 and 46.5% protein. The protein utilisation gradually declined from 20.6 to 35.0 crude protein level (Fig. 2, curve B); it was steady between 35.0 and 42.9% and it sharply declined between 42.9 and 46.5%.

Discussion

Mantis shrimp protein and clam powder gave almost identical growth rates, while clam powder gave better food conversion. But both are superior to fresh clam meat. The growth obtained by prawn waste is comparable to that of the fresh clam meat. Venkataramaiah *et al.* (1978) observed that *Penaeus 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 in the diets for *Macrobrachium rosenbergii*. Similar results were obtained by Forster and Beard (1973) for *Palemon serratus*. Prawn waste protein is reported to be having several essential amino acids (Foster, 1975). Fresh clam meat failed to give superior growth results compared to that of the compounded diets with mantis shrimp protein and clam powder. Kanazawa

et al. (1970) reported that the fresh diet of short-necked clam (*Tapes philippinarum*) gave superior growth compared to the compounded diets for *Penaeus japonicus*. Similar results were obtained by Forster and Beard (1973) for *Palaemon serratus*. But Venkataramaiah *et al.* (1975) found that although the live foods such as *Artemia* nauplii and shrimp meat gave superior growth in brown shrimp, a high rate of chitinoclastic bacterial infection, leading to heavy mortality was observed in these experiments. The relatively poor performance obtained by the fresh clam meat in the present study may be due to similar reasons.

Frequent moulting was observed during feeding experiments with fresh clam meat suggesting that this contains a factor which induces moulting. The probable factor may be the iodine rich thyro-proteins in the fresh clam (Personal discussion with Kai W. Chow, Aquaculture Department and Co-ordination Prog., FAO).

Fish meal gave comparatively poor results as reported earlier by Deshimaru and Shigeno (1972) and Colvin (1976). The former workers found that the amino acid composition of fish meal was not similar to that of the prawn *P. japonicus*. The latter suggested that the relative deficiency of the amino acids, tyrosine and phenylalanine in the fish meal may be the reason for its relatively poor performance.

Prawns were observed to prefer prawn waste. The odour it possesses may be attracting the animals and making the feed more palatable,

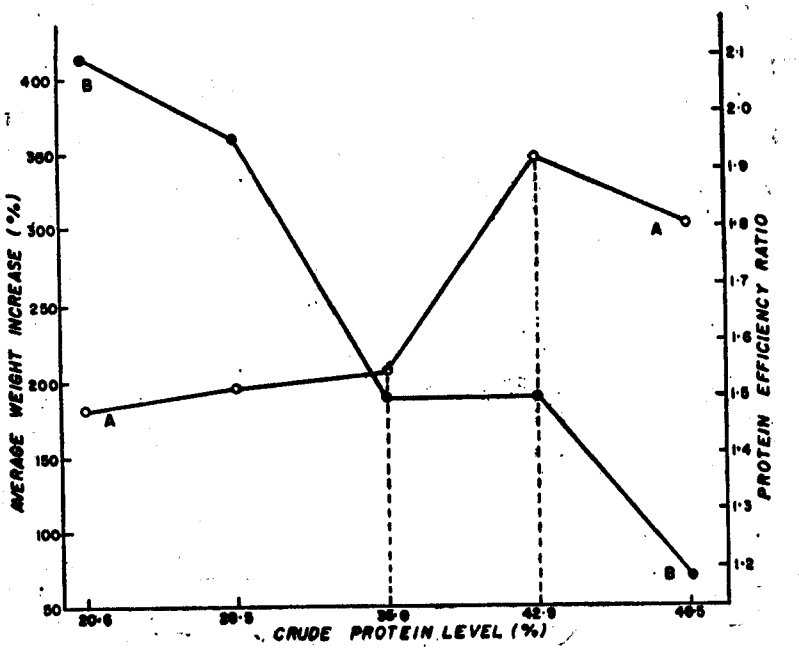

Fig. 2. Growth, dietary protein level and protein efficiency ratio curves of the prawn *P. indicus*: A. Relationship between the dietary protein level and live-weight increase and B. Relationship between dietary protein level and protein efficiency ratio.

The protein quality of the prawn waste may be further improved by blending it with other high quality protein materials such as mantis shrimp, in suitable proportions.

Deshimaru and Shigeno (1972) observed that the growth of *P. japonicus* was found to correlate with the amount of crude protein in the diet. A similar trend was observed by Balazs and Ross (1976) that high protein content produced larger prawns (*M. rosenbergii*). Venkataramaiah *et al.*, (1975) found best growth with the food containining 40% protein (*P. aztecus*) and Colvin (1976) recorded highest live-weight gain with a 43% protein diet (*P. indicus*). The findings of experiments carried out in the present study conform to the above results. The growth values recorded in the present study (23 mg/day with initial weight 0.2 g) are comparable to that of Colvin (1976, 44 mg/day with initial weight 0.95) taking into consideration the initial mean weights of the prawns. The food conversion values obtained are comparatively superior.

The optimum protein level in the diets for penaeid prawns appears to be between 35 and 40%. This is indicated by the steep rise in weight increase (Fig. 2, curve A) between 35.0 and 42.9%, while the increase in weight was gradual in the lower protein levels. This is further supported by the fact that the protein utilisation is steady (Fig. 2, curve B) between the two protein levels. Results from other workers confirm that protein levels compatible with maximum or near-maximum growth were between 30 and 40% for penaeid prawns (Sick *et al.*, 1978 ; Forster and Beard, 1973 ; Venkataramaiah *et al.*, 1975). In general it is observed that the high protein levels in the diet beyond the optimum level do not produce significant increase in growth or the growth is not proportional to the increase in protein level. The probable explanation for this may be that the increase in protein decreases the quantity of other energy giving nutrients such as fat and carbohydrate in the diet, from which the animals normally derive most of the energy required for their metabolic activities. In that case the protein in excess of the optimum level is mostly utilised for the metabolic energy required and not for tissue growth. This is indirectly supported by the fact that the protein utilisation, in terms of live-weight gain, declines with the increase in the dietary protein level. However, this needs further study to establish the fact.

The results of the present study indicate that the quality of the protein in the diets depends upon its source and influences the growth. This is in accordance with the findings of Forster (1975). Therefore for the practical utilization, it will be more realistic to select the suitable raw materials available in the region concerned and find the nutritional requirements in terms of the raw materials, instead of purified protein materials, such as casein. For the growth and food conversion obtained by the diets containing casein at a particular protein level may be entirely different from that of the diets containing the selected raw materials depending upon their protein quality.

The results of the present study show that the mantis shrimp protein is one of the high quality animal protein sources for diets. Little Information is available in the literature about the use of mantis shrimp in prawn diets. Considerable quantities of mantis shrimp are landed along with the prawns. But most of it is not properly utilised. The utilisation of mantis shrimp as one of the prawn feed ingredients may be a promising proposition.

Conclusion

Mantis shrimp protein and dry clam powder may be considered high quality animal protein sources to be used in the prawn diets. Prawn waste provides desirable flavour and palatability in the diets for prawns. Fresh clam meat contains a factor which induces moulting in the

juvenile prawns. Fish meal alone may be a relatively poor animal protein source for prawns. Maximum growth rate is obtained with diets containing 42.9% crude protein and the optimum protein level in the diets for penaeid prawns lies between 35-40%.

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