A PRELIMINARY STUDY OF THE EFFECT OF MANTIS SHRIMP AS AN INGREDIENT IN *PENAEUS INDICUS* POSTLARVAL DIETS

MANPAL SRIDHAR, P. VIJAYAGOPAL and R. PAUL RAJ

Physiology, Nutrition and Pathology Division, Central Marine Fisheries Research Institute, Kochi–682014, Kerala, India

ABSTRACT

The apparent digestibility (Da) of five diets, incorporated with mantis shrimp at levels of 10, 15, 20, 25 and 30% was determined for *Penaeus indicus* postlarvae (initial weight ranging from 0.087–0.106 g). Da for crude protein ranged from 61.97 to 92.76% showing a significant increase with increase in the level of mantis shrimp upto 25% in the diet and was higher than the control value of 66.09 ($P > 0.05$). Crude fat digestibility ranged from 52.26 to 89.57% also showing an increase upto 25% incorporation of mantis shrimp.

The same diets were fed to *P. indicus* postlarvae (average initial weight 0.118 g) for a period of 30 days. Weight gain, specific growth rate (SGR), feed conversion ratio (FCR) and survival did not differ significantly among treatments. However, weight gain and SGR were lowest and FCR poorest in the control diet. Carcass protein though similar in all the treatments was higher than that of the control ($P > 0.05$) and carcass fat ranged from 3.8–6.0% with no consistent trend. The study indicates the potential of mantis shrimp meal as an effective substitute of shrimp/prawn meal in *P. indicus* postlarval diets.

Key words: Digestibility, mantis shrimp, postlarvae, *P. indicus*

The formulation of a successful practical shrimp diet is dependent on an understanding not only of the chemical and physical characteristics of the individual feedstuffs being used, but also of their relative digestibility to the shrimp. Commercial shrimp feeds usually contain 30–40% crude protein, composed mostly of marine animal protein products such as fish, shrimp and squid meals. These feed materials have high nutritive value and palatability but are expensive and not readily available (Lim and Persyn, 1989). Thus it is imperative to identify alternate protein sources for shrimp feed development. *Oratosquilla nepa* is a stomatopod caught in abundance in the southwest coast of India. It has been identified as an ingredient for shrimp feeds (Ali and Mohamed, 1985). It contains a fairly high percentage of protein, calcium, phosphorus and chitin (Muzzareli, 1977), which are very important in prawn nutrition.

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Currently there is little information available on the nutritive value of mantis shrimp for postlarval shrimp. The objectives of the present study were to evaluate the apparent digestibility of mantis shrimp, at different levels of incorporation, in the diet of *Penaeus indicus* and to determine the efficacy of these diets in promoting growth. The results of this study would be of use in deciding the levels at which mantis shrimp can safely be incorporated in feeds of *P.indicus* postlarvae.

MATERIALS AND METHODS

Diet formulation and preparation

Fresh mantis shrimp, collected from the Cochin Fisheries Harbour, was cleared off extraneous material, washed thoroughly in running tap water, sun dried, pulverized and sieved through a number 60 standard test sieve (less than 250 µm). All other ingredients viz. fresh meal, soyabean meal etc. were procured from the local market. Before formulation the selected ingredients were subjected to proximate composition analysis (Table 1). Five diets were formulated (Table 2) by incorporating mantis shrimp meal at concentrations of 10, 15, 20, 25 and 30%. A diet devoid of mantis shrimp served as the control. All the diets contained 1% Cr_2O_3. The powdered and weighed ingredients excepting tapioca flour were mixed together. Cholesterol was mixed with oil before adding to the dry feed mixture. Tapioca gelatinized in water was added last and served as binder. The resulting dough was extruded through a 1mm die.

The pellets were sun dried to <10% moisture, manually broken into strands of 3–5 mm length and stored in labelled plastic containers at room temperature for further use.

Table 1. Proximate composition of the ingredients used in diet formulation (% dry matter)

Ingredients	Dry matter	Crude protein	Crude lipid	Ash	Crude fibre	NFE[1]
Mantis shrimp	92.68	48.12	9.10	26.12	16.37	0.29
Prawn meal	90.32	44.42	4.12	29.68	18.61	6.27
Fish meal	91.62	63.98	8.33	22.94	1.33	3.42
Soyabean meal	89.00	50.82	1.55	7.34	6.97	33.32
Ground nut oil cake	92.12	40.42	1.58	6.32	9.48	42.20
Tapioca powder	89.36	2.69	0.91	3.26	5.18	87.96

[1]Nitrogen free extractives = 100–% (Crude protein + crude lipid + ash + crude fibre)

Water stability of the diets

Water stability of the diets was determined by the method of Jayaram and Shetty (1981) with minor modifications. Fifteen grams of each diet was weighed, in three replicates, and transferred to 4" × 4" pouches made of bolting silk (No.42).

Table 2. Percentage composition of the control and experimental diets used for the digestibility and growth trials

Ingredient	Diets (g/100 g dry diet)					
	C	D_1	D_2	D_3	D_4	D_5
Mantis shrimp	0	10	15	20	25	30
Prawn meal	25	15	10	05	–	–
Fish meal	20	20	20	20	20	15
Soyabean meal	20	20	20	20	20	20
Ground nut oil cake	15	15	15	15	15	15
Tapioca powder	10.5	10.5	10.5	10.5	10.5	10.5
Oil[1]	6	6	6	6	6	6
Vitamin mix[2]	1	1	1	1	1	1
Mineral mix[3]	1	1	1	1	1	1
Cholesterol	0.5	0.5	0.5	0.5	0.5	0.5
Cr_2O_3	1	1	1	1	1	1

1. Oil-mixture of (1:1) cod liver and corn oil
2. Vitamin mixture (mg/100 g dry diet)—para-aminobenzoic acid 5.55; biotin 0.22; inositol 222.06; nicotinic acid 22.21: Ca pantothenate 33.31; pyridoxine-HCL 6.66; riboflavin 4.44; thiamine-HCL 2.22; menadione 2.22; betacarotene 5.55; tocopherol 11.10; calciferol 6.66; Na-ascorbate 110.3
3. Mineral mix (g/kg dry diet) —K_2HPO_4 1.008; $Na_2HPO_4 7H_2O$ 2.167; $CaCO_3$ 0.978; Ca-lactate 1.663; KCl 0.282; $MgSO_4$ $7H_2O$ 0.048; $MnSO_4$; $6H_2O$ 0.0108; $CuCl_2$, 0.0015; KI 0.0023; $CoCl_2$ $6H_2O$ 0.0141: Celufil 0.0216

These were immersed in four litres of sea water (35 ppt salinity and 29.5°C water temperature) in plastic tubs provided with mild aeration. Pouches were removed from water at 1, 2, 3, 4, 5 and 6 hours respectively and rinsed well in distilled water to remove the adhering salts. The contents were transferred to pre-weighed Petridishes and dried in an hot air oven at 80°C and the resultant loss in dry matter calculated.

Experimental set-up

P. indicus postlarvae of total length 20–34 mm and weight 0.087–0.106 g were divided into groups of twenty numbers so that triplicates were available for each of the five treatments and the control. Prior to the 20 day experiment the prawns were acclimatized to laboratory conditions for 4 days and fed the control diet.

Shrimp were stocked in 50 l plastic tubs containing 40 l of seawater. The tubs were arranged vertically on racks and each tub was provided with aeration. The salinity of the water used was maintained at 30 ± 1‰, temperature, 28.0 ± 0.6°C and dissolved oxygen 5 ± 0.3 ml/l for the entire experimental duration. One third water exchange was carried out daily, while complete water change was done every third day. Experimental diets were fed at the rate of 20% of the body weight in two divided doses at 9.00 and 18.00 h daily. Tanks were cleaned before each feeding and from day 6 to day 20 faecal matter and left over feed from each tub was collected twice daily with the help of a thin plastic tubing, immediately rinsed with distilled water to remove traces of adhering salts and after oven drying at 80°C for 12 h pooled for analysis.

For the growth study, postlarvae, with an initial average weight of 0.118 ± 0.023 g, were stocked in perspex tanks and fed the control diet for three days. They were segregated and stocked in 50 l plastic tubs containing 40 l of sea water at 20 postlarvae per tub with triplicates for each treatment and reared on the same diets used in the digestibility trial. Shrimp were fed at 10.00 and 18.00 h daily at 20% of their body weight. Temperature, salinity and dissolved oxygen were monitored regularly and ranged for 28.4–29.0°C; 32–33 ppt and 4.8–5.2 ml/l respectively for the entire growth trial. One third water exchange was carried out daily, while complete water change was done every third day. Mortality was recorded regularly and amount of feed adjusted. After 30 days the experiment was terminated and shrimp in each tub weighed. The carcasses were dried and proximate composition analysis carried out on them.

Analytical methods

Proximate analysis of feed ingredients, diets and faeces samples was performed according to AOAC (1990). Chromic oxide was estimated by the west digestion method of Furukawa and Tsukahara (1966). Apparent digestibility values were calculated using the following formula (Maynard and Loosli, 1969):

Apparent nutrient digestibility (%) =

$$100 - 100\left(\frac{\%\ \text{marker in diet}}{\%\ \text{marker in faeces}} \times \frac{\%\ \text{nutrient in faeces}}{\%\ \text{nutrient in feed}}\right)$$

Statistical analysis

Difference in apparent digestibility coefficients were tested for significance ($P < 0.05$) by Duncans multiple range test (Duncan, 1955).

RESULTS

Table 3 gives the proximate chemical analysis of the control and experimental feeds, containing 10 to 30% of mantis shrimp meal. The diets had protein in the range of 45.2 to 47.5%, and fat 10.3 to 13.3%. Crude fibre and acid insoluble ash levels were higher (2.13% and 3.60% respectively) in the control diet. In the experimental diets crude fibre ranged from 1.34 to 1.74% and acid insoluble ash from 0.52 to 1.84%. Metabolizable energy of the diets ranged from 1938 to 1975 kJ/g. Table 4 shows the water stability of the control and experimental diets. Initial dry matter (DM) content of all the feeds was above 95% and a 2–4% decrease was observed within one hour. From 2–6 hours all the feeds exhibited an additional loss of 8% in the DM at the rate of approximately 2% per hour. No cracking and physical disintegration of the feed pellets was observed. However, desirable softening of the pellets could be seen in all feeds and the postlarvae readily accepted the green pellets.

Table 3. Proximate chemical composition of the control and experimental diets used for digestibility and growth trials (% dry matter basis)

Nutrient	Diets					
	C	D_1	D_2	D_3	D_4	D_5
Dry matter	92.22	91.63	91.83	92.61	90.68	91.21
Crude protein	46.81	46.00	47.51	45.17	47.47	45.41
Ether extract	10.78	11.35	10.33	11.16	13.28	12.85
Crude fibre	2.13	1.34	1.39	1.43	1.70	1.74
NFE[1]	23.93	17.92	18.84	18.25	26.01	15.21
Organic matter	75.87	57.69	58.23	56.76	77.64	74.21
Ash	16.35	16.02	16.76	17.60	17.22	17.00
Acid insoluble ash	3.60	1.71	1.84	1.68	0.52	0.75
Estimated DE[2]	351.69	350.61	350.07	349.53	348.99	348.89

[1]Nitrogen free extractive calculated as 100-% (crude protein + crude lipid + ash + crude fibre)
[2]Digestible energy (Kcal/g diet)

Table 4. Nutrient leaching and water stability of the control and experimental diets

Hours elapsed	% Dry matter remaining in the diets					
	C	D_1	D_2	D_3	D_4	D_5
0	95.37	95.03	95.42	95.78	95.04	95.82
1	91.51	92.13	91.42	91.37	92.38	92.33
2	87.39	85.37	90.37	90.34	91.57	91.38
3	85.25	85.48	86.71	85.27	85.36	85.11
4	84.95	84.92	85.32	33.48	83.72	83.01
5	81.32	81.90	82.13	82.48	82.12	82.65
6	80.30	80.38	81.28	81.42	81.72	80.11

The apparent nutrient digestibility coefficients for crude protein and crude fat are given in Table 5. Apparent nutrient digestibility for protein increased with increase in level of mantis shrimp in the diet from 61.97% at 10% incorporation to 82.94% at 30% incorporation. However, no statistically significant variation ($P < 0.05$) could be detected in the apparent digestibility of protein with increasing levels of mantis shrimp in the diet. Apparent nutrient digestibility for fat showed a similar trend with 30% mantis shrimp giving a digestibility coefficient ($P > 0.05$) of 98%.

The results obtained after feeding diets containing 10 to 30% of mantis shrimp to postlarvae of *P. indicus* for a period of 30 days are elaborated in Table 6. No significant variation was observed in the present study with regard to weight gain, specific growth rate (SGR) and feed conversion ratio (FCR) at the different levels of mantis shrimp incorporation in the feed. Mantis shrimp incorporation in diets at 15 and 20% resulted in complete survival of postlarvae followed by 95% survival at 30% incorporation. At both 10 and 25% levels of incorporation 80% survival was obtained.

Table 5. Digestibility coefficients (%) for crude protein and crude fat of the experimental and control diets fed to *P. indicus* postlarvae

Diet No.	Level of mantis shrimp in diet	Crude protein	Digestibility coefficient crude fat
C	0	66.09[a]	60.1[a]
D_1	10	61.97[a]	52.26[a]
D_2	15	82.59[a]	69.41[a]
D_3	20	90.53[a]	77.81[a]
D_4	25	92.76[a]	89.57[a]
D_5	30	72.94[a]	70.00[a]

[1]Column means with the same superscript are not significantly different (P > 0.05)
P value for protein = between treatments = 0.0536; between replicates = 0.5891
P value for fat = between treatments = 0.0521; between replicates = 0.8874

Table 6. Mean body weight, weight gain, Specific Growth Rate (SGR) Feed Conversion Ratio (FCR) and survival of *Penaeus indicus* postlarvae after 30 days of feeding

Diet No.	Level of mantis shrimp in diet (%)	Mean body initial (g)	Weight final (g)	Increase in weight (g)	Weight gain (%)	SGR*	FCR*	Survival (%)
C	0	0.109	0.544	0.435	399	1.45	5.41	85
D_1	10	0.115	0.577	0.463	404	1.54	4.67	80
D_2	15	0.111	0.585	0.475	429	1.58	4.01	100
D_3	20	0.106	0.534	0.428	404	1.43	4.56	100
D_4	25	0.116	0.603	0.487	420	1.62	5.02	80
D_5	30	0.151	0.632	0.481	319	1.60	4.77	95

*SGR = 100 (Final mean weight/no. of days)
*FCR = Weight of feed consumed (g)/prawn wet weight gain (g)

No significant effect of dietary mantis shrimp level on carcass protein or lipid was detected. Carcass protein of the treatment groups was higher (ranging from 72% to 78%) than that of the control group (Table 7). Carcass fat ranged from 3.8% to 4.2% on all the diets excepting the diet containing 30% mantis shrimp meal wherein it was 6%.

DISCUSSION

Digestibility is an important parameter considered in determining the utilization of a feed. Though digestibility of a feedstuff is best evaluated solely to eliminate the possibility of an associative effect, shrimp are fed compounded complete feeds containing many ingredients which are affected differently by the associative effects of the constituents of the diet. Therefore mantis shrimp was incorporated at varying concentrations in feed and the digestibility in association with other ingredients determined. Goldblatt *et al.* (1980) reported on the

Table 7. Level of crude protein and fat in carcass of shrimp (dry matter basis)

Diet No.	Level of mantis shrimp in diet (%)	% crude protein	% crude fat
C	0	68.91	4.2
D_1	10	72.19	4.6
D_2	15	75.47	3.8
D_3	20	72.19	3.8
D_4	25	78.75	4.2
D_5	30	75.47	6.0

potential leaching of nutrients from feed prior to ingestion and from the faeces prior to collection to be a problem associated with the determination of apparent digestibility in aquatic environments. However, Fenucci (1981) and Coelho (1984) found leaching to have no significant effect in shrimp nutrition studies when the feed or faeces was exposed to seawater for less than 2 hr. In the present study all the six diets prepared utilizing gelatinised tapioca as a binder showed good water stability even upto 6 hours of immersion in sea water and were well accepted by the postlarvae throughout the experimental duration.

The higher values of Da of both protein and fat for most of the test diets containing 15% to 30% mantis shrimp meal than those for the control diet devoid of mantis shrimp indicates a good digestibility for mantis shrimp in *P. indicus* postlarvae at these levels of incorporation. Ali (1989) reported comparatively low digestibility for mantis shrimp protein incorporated at 68.5% in the diet of juvenile *P. indicus* and attributed this mainly to the chitinous shell material of mantis shrimp. Akiyama *et al.* (1989) reported negative apparent digestibility values for chitin fed to *P. vannamei* but their test diet contained 88% chitin and the shrimp were given a limited acclimation period.

Garg *et al.* (1977) extracted protein from mantis shrimp. Using this extracted protein excellent results were obtained (Ali, 1982) in the juveniles of *P. indicus* with the diet having 35% protein. The performance of mantis shrimp protein in their study was on par with that of clam meat powder and superior to that of fish meal.

Mantis shrimp incorporation above 35% in compounded feeds was reported to lower growth performance in juvenile *P. indicus* (Ali and Mohamed, 1985). In our study, however, the significant improvement observed in the digestibility of nutrients in diets incorporated with 15% to 30% mantis shrimp was not reflected in the weight gain, SGR, FCR or survival rates of *P. indicus* postlarvae maintained on these diets. These differences in results may be attributed to differences in size of shrimp, environmental and experimental conditions, and the diet perse (complete or incomplete) as digestibility of a feedstuff is the associative effects of other ingredients in feed (Schneider and Flatt, 1975).

However, the results of the current study prove that mantis shrimp incorporation below 30% appears to be rational and promising for enhancing the production of low cost feeds for postlarval shrimp, and could substitute prawn/shrimp meal in shrimp diets.

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