J. mar. biol. Ass. India, **45** (2) : 186 - 194, July - Dec., 2003

Optimum ration size and feeding frequency for postlarval *Penaeus indicus* (H. Milne Edwards)

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Abstract

Post larval *Penaeus indicus* (initial length 2.98±0.21 cm and initial weight of 0.1313±0.01 g) were maintained on a commercial compounded feed. The effects of four ration sizes viz.2 %, 12 %, 22 % and 32 % bwt d^{-1} and four feeding frequencies were tested for influences on growth. The feeding frequencies tested were one time night feeding, one time, two times, three times and four times day feeding. Survival was found to be statistically significant ($P<0.05$) with regard to change in ration size, though feeding frequency failed to elicit any significant difference ($P >0.05$). Optimum ration was calculated at 12 % of the wet body weight per day. Rations below 8 % were termed maintenance rations and those above 24 % as maximum rations.

Introduction

The costs of formulated feed and labour associated with feeding are the major components of the cost of cultured shrimp production. (Lawrence and Lee, 1997). Feed management is a critical factor in determining the profitability of a shrimp farm. Overfeeding results in wastage of feed, water pollution increased operating costs and the shrimp farming industry is facing increasing pressure to lower its environmental impact. (Naylor *et al.* 1998).

Ration is considered to be a driving force and any restriction to it results in a lower metabolic rate (Brett, 1979; Jose and Jose, 1993, 1996). A precise knowledge of the relationship between food requirement and body weight for a particular species and diet would be essential to avoid overfeeding and restricted growth through sub maximum rations. In order to achieve an efficient feeding regime in an aquaculture situation, continual adjustment of the ration level is necessary to compensate the changing requirements (Sedgwick, 1979). An optimum ration size is very significant when considering the reduction in the cost of operation and better environmental hygiene.

It is a common practice to distribute the daily ration in different percentages when feed is offered three or more times during part of the day. Feeding strategies have also been found to influence water quality and shrimp health (Jory, 1995, Burford and Williams, 2001). In intensive farming operations, feeding frequency has an important role in improving overall yield and reducing the cost of production. Optimizing the feeding strategy is a prime consideration in intensive shrimp pond management and involves nutrition, processing and feed management. The present investigation was taken up to study the correlation if any between varying ration sizes and feeding frequency on growth in post larvae of the Indian white prawn *Penaeus indicus*.

The authors thank the Director, CMFRI for the facilities provided. The guidance and suggestions for improvement provided by Dr.N.Sridhar are gratefully acknowledged. The first author is grateful to the Indian Council of Agricultural Research, New Delhi, for the grant of Junior Research Fellowship. The help provided by Ms. Rosalie Shaffer of Panama City Laboratory, NOAA, USA in the form of numerous reprints, diskettes and constant encouragement is also gratefully acknowledged.

Material and methods

Experimental design and maintenance

Post larval *P. indicus* of a single brood stock, obtained from the Prawn Culture Laboratory, Narakkal, were transported in oxygenated water in polythene bags. The post larvae were held in 2.5 * 1.5 * 1 feet perspex tanks for a week for acclimatization to laboratory conditions before the start of the experiment. Larvae of similar size were selected, length measured, weighed individually and introduced in groups of 14 into 5-litre tubs provided with aeration and covered with nylon screen to prevent the escape of animals. The post larvae had an average initial length of 2.98 ± 0.21 cm and an average initial weight of 0.1313 ± 0.01 g. Two replicates were established for each treatment. Feeding was suspended and animals deprived of food for 48 hours before the start of the experiment. Feed was provided in pre weighed glass petri dishes and left over feed was collected after siphoning out faecal matter, transferred to an oven and dried at 80^{0}C for 24 hours and stored in a desiccator for further analysis.

Seawater of 30 ppt after filtering through No.30 bolting silk was used for the experiments. Twenty five percent of seawater from the experimental tubs was exchanged daily while complete replacement was done once every week. Physicochemical parameters temperature, *p*H, salinity, DO were monitored continuously. Every tenth day, length and weight of animals were measured. The experiment was conducted for a period of 30 days. At the end of the experimental duration, the length and weight of each post larvae were recorded. The feed used for the experiment was the starter grade of Higashi Feeds; a commercial shrimp feed of international repute. Analysis of the feed was carried out to determine the proximate composition.

Ration size and feeding frequency

Four different ration sizes (expressed as % body weight) chosen based on earlier published works. (New, 1989; Sick *et* *al.*, 1973) were 2 %, 12 %, 22 % and 32 %. Five feeding frequencies were selected to study the effect of different feeding frequencies on growth (Table 1). The feed was left in the tubs till the time of next feeding. One time night feeding at 20.00 hours as well as one time day feeding at 8 hours was carried out to know the variation in growth with respect to time. The timing was adjusted so as to provide uniform time interval between the different feeding frequencies. A control group was maintained which was fed fresh meat of white clam *Sunetta scripta ad libitum*.

Optimum ration size

Specific growth rate defined as

$$G = \frac{\log_e W_1 - \log_e W_0 \text{ * } 100 \text{ \% weight per day}}{t_1 - t_0}$$

(W_1 and W_0 are final and initial weight and t_1-t_0 is the experimental duration) was used as the expression of growth for investigating changes in the response of the post larvae to various ration sizes. G was plotted against ration level of each feeding frequency and by construction of a curve through the data; ration size was obtained geometrically (Sedgwick, 1979). The point at which the curve flattened gave the ration that stimulated maximum growth i.e. maximum ration. A tangent to the curve from the origin defined the optimum ration, which provided the greatest growth for the least intake. Extension of the curve to the abscissa gave the maintenance ration. Starved controls were maintained so that the lower regimes of the curves could be defined and maintenance rations estimated.

Analytical methods

Salinity of the seawater was estimated by Mohr- Knudsen method, dissolved oxygen by modified Winkler method as given in the Strickland and Parsons (1968) and *p*H by digital *p*H meter and temperature with the help of a thermometer.

The physical evaluation of the feed was recorded viz colour, shape, size and pellet diameter. Water stability of the feed was determined by the method described by Jayaram and Shetty (1981). Dry matter in feeds and experimental animals was determined by weighing before and after drying at 80 ^{0}C for 48 hours and cooling in vacuum desiccator. Protein was determined by Kjeldahl method, crude fat by Soxhlet extraction method (AOAC, 1990), chitin by Richards's method (1978), cal-

Table 1. *Feeding frequencies adopted for the trial*

Frequency	Feed timings
One time morning	0800 hrs
One time night 2000 hrs	
Two times	0800 hrs and 2000 hrs
Three times	0800 hrs, 1400 hrs and 2000 hrs
Four times	0800 hrs, 1200 hrs, 1600 hrs and 2000 hrs

cium by titration method (New, 1989). Sodium present in the feed was determined using fresh sample (New, 1989). Phosphorus present in the feed was analyzed by Molybdovanadate method (New, 1989) and determined from a standard curve.

Statistical analysis

Data obtained in the feeding experiments were subjected to analysis of variance (ANOVA) following the method of Snedecor and Cochran (1973). Differences across treatments in specific growth rate (SGR), protein efficiency ratio (PER), feed conversion ratio (FCR) and survival rate were determined by F test.

Results

Experimental conditions

The salinity of the water was maintained at 30 ± 1 ‰, dissolved oxygen at 4 ± 0.3 mlL^{-1}, *p*H at 8.02 ± 0.2 and temperature at 28.5 ± 5^{0}C.

Feed

The starter feed was of pale brown colour, with crumbles averaging in size of 1 mm with a diameter of 2 mm. The feed was quite stable in seawater with 90 - 92 % of dry matter remaining at the end of one hour, which decreased to 86 - 89 % after two hours. At the end of five hours, only a marginal additional loss ranging from 3 - 4 % was recorded. Percentage chemical composition of the feed showed it to be an ideal formulation with all the parameters meeting the nutritional requirements of post larvae. (Table 2).

Table 2. *Proximate composition of the experimental feed*

Parameters	%
Moisture	10.83
Dry matter (DM)	89.17
Crude Protein*	36.09
Ether extract *	8.00
Crude fibre *	2.34
Nitrogen free extract **	53.57
Organic matter ***	76.55
Ash	12.62
Acid insoluble ash	9.88
Energy value KJg^{-1}****	20.85
Chitin	1.58
Sodium	0.62
Calcium	2.95
Available P	0.71

* -calculated on DM %

** - NFE calculated by difference = 100 - (Moisture % +CP %+CF %+ EE %)

*** - OM = dry matter % - ash %

**** - Energy values calculated as protein 23.4 KJg^{-1}; fat 39.8 $KJg^{-1}$and carbohydrate 17.2 KJg^{-1}; fiber was assumed to have zero energetic value (Cho *et al.*, 1982)

Postlarvae

During the 30-day feeding experiments, the post larvae readily accepted the feeds and survival ranged from 57 - 100 %. Survival was found to be statistically significant (P < 0.05) with regard to change in ration size, though feeding frequency failed to elicit any significant difference (P > 0.05). Post larvae that were fed four times a day increased in weight more rapidly and utilized feed more efficiently than at other feeding frequencies. The growth response under four ration sizes is given in Table 3. The various treatments failed to reflect any significant difference (P > 0.05) in the performance in terms of FCR, PER, K_1 % and K_2 %, though significant difference was observed in terms of specific growth rate. ($P < 0.01$).

Length and weight

Results of final average increase in length and % increase in length are given in Table 3. In the groups maintained at one time morning and one time night feeding with 2 % ration size, there was a final weight gain by 175 % and 185 % respectively. In the other three groups, i.e., two, three and four times feeding, there was percentage increase in weight of 103, 2 and 6 respectively.

For post larvae fed 12 % ration size at the different frequencies, the percentage increase in length for all the five groups ranged from 13 % to 96 % at the end of 30 days feeding with no significant difference ($P > 0.05$). Percentage increase in weight however reflected 515 % and 477 % fold increase in the case of post larvae fed three and four times respectively.

For post larvae fed 22 % ration size, 81 % and 76 % increase in length was recorded for groups fed three and four times respectively, while there was not much difference in the other three groups. Here too, percentage increase in weight was comparatively very high (532 % and 435 %) for group fed three and four times respectively in comparison to the other three groups. There was a percentage increase in length of 84 % and 63 % in the

Table 3. *Growth performance of the* P.indicus *post larvae*

Ration size	Feeding frequency in length	% increase in weight	% increase (%)	Survival	SGR	FCR	PER	K_1%	K_2%
2 %	1 time (M)	40	175	61	0.2	1.7	1.6	58	64
	1 time (N)	49	185	93	0.2	1.3	2.1	75	104
	2 times	23	103	93	0.1	1.8	1.5	55	88
	3 times	6	2	98	0.03	8.2	0.3	12	40
	4 times	6	5.6	86	0.1	4.7	0.6	22	44
12 %	1 time (M)	13	61	89	0.5	1.4	1	71	84
	1 time (N)	29	113	79	0.7	6	0.5	17	18
	2 times	22	94	100	0.6	2	1.9	67	78
	3 times	97	477	100	0.8	1.8	1.7	55	95
	4 times	79	516	100	1.2	1.1	2.6	92	147
22 %	1 time (M)	9	532	89	0.6	2.3	1.2	47	49
	1 time (N)	25	90	86	1.2	1.7	1.6	58	76
	2 times	24	101	79	0.5	3.7	0.8	27	31
	3 times	81	532	71	2.1	1.1	2.5	91	126
	4 times	76	436	86	1.3	1.5	1.9	69	102
32 %	1 time (M)	84	532	75	0.6	3.9	0.7	26	29
	1 time (N)	19	85	71	1.1	2.1	1.3	48	56
	2 times	63	353	75	0.4	5.1	0.5	20	23
	3 times	30	104	57	1.4	2.3	1.2	43	54
	4 times	43	175	71	2.3	1.2	2.4	85	111

case of post larvae fed 32 % body weight per day once in the morning and two times respectively. Weight increased by 532 % in post larvae fed once in the morning.

Specific growth rate (SGR)

SGR is used in shrimp with the assumption that the population means have a soothing effect on the intermittent growth pattern caused by molting. SGR in post larvae fed 2 % ration was comparatively poor. At 12 % ration size, four times feeding resulted in a SGR of 1.2 followed by 0.5 at one time morning feeding. A SGR of 2 was obtained in post larvae fed 22 % ration size thrice a day followed by 1.3 in the case of animals fed four times. The best value observed for SGR (2.29) in the present study was in the case of group fed 32 % four times a day. Though the different feeding frequencies failed to reflect any significant variation ($P>0.05$) in the SGR of post larvae, ration size was found to have a significant influence on the SGR ($P<0.01$).

FCR and PER

For 2 % ration size, the best (lowest) FCR of 1.3 was obtained in the case of post larvae fed once in the morning. Best PER of 2.07 was obtained in group fed once in the night. In case of post larvae fed 12 % ration size, best FCR of 1.1 was obtained with a feeding frequency of four times; PER with the best value of 2.55 was also obtained in the same group.

Feeding post larvae a ration size of 22 % of body weight three times a day yielded the best FCR of 1.1 and PER 2.5. At 32 % ration size, best FCR of 1.2 and PER 2.4 were obtained in group fed four times daily. However, no statistical significance could be detected either between the ration sizes or the feeding frequencies with regard to both FCR and PER.

Gross Conversion Efficiency (K_1 %) and Net Conversion Efficiency (K_2 %)

The relative deployment of food may be expressed as the coefficient of gross efficiency K_1 and is closely related to FCR being essentially its inverse. The K_1 of different groups increased from 25 % to 92 % (four times feeding) with increase in ration size from 2 % to 12 %. At 22 % level, K_1 was 91 % for the three times feeding. Thereafter a decrease in ration size was observed in the K_1 value with increase in ration size to 32 % body weight. However, this increase in K_1 observed with change in ration size or feeding frequency was not significant statistically ($P > 0.05$).

Net efficiency (K_2) is the efficiency with which an animal utilizes for growth the part of its rations that exceed its maintenance ration. K_2 is always higher than K_1.Maximum values of 147 % was obtained with 12 % ration size for four times feeding. A slightly lower value of 126 % was obtained at 22 % ration size with three times feeding frequency.

Optimum ration size

Post larvae fed 12 % and 22 % rations four times daily increased in weight more rapidly and utilized their food more efficiently than at the other feeding frequencies. Survival was best (100%) for group fed 12 % ration size fed two, three and four times daily. The optimum ration was calculated at 12 % of the wet body weight per day. At higher rations, specific growth rate declined. Though starved controls were maintained, the lower regimes of the curves could not be defined and maintenance rations estimated accurately due to mortality and cannibalism. Rations below 8 % were termed maintenance rations, those above 24 % as maximum rations (Fig. 1).

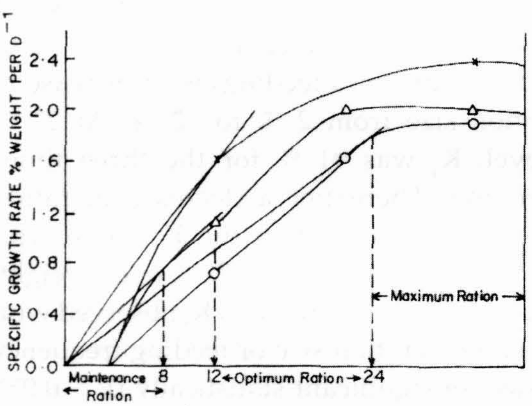

Fig. 1. *Rations, % wet body weight D^{-1}*

Discussion

The proximate composition analysis of the starter feed is very much in agreement with the composition of commercial feeds published (New, 1990) and the five brands of imported feeds analyzed by Sanhotra and Pereira (1996). Feed pellets that disintegrate faster in water facilitate only economic loss and pollution of water (Forster, 1972). The feed used for the experiment was found to be highly water stable as only 16 % loss was obtained in dry matter content after five hours of immersion in sea water. Sanhotra and Pereira (1996) observed a 14 - 18 % loss in the dry matter content of five commercial feeds analyzed by them.

Studies on the growth and yield of pink shrimp *Penaeus duorarum* showed that growth increased with increased feeding rate (Caillouet *et al.*, 1976). Manik *et al.*, (1980) while conducting experiments on postlarval *P.monodon*, found that when feed was given at 150 percent body weight per day, deterioration of the culture medium was within the tolerable range of the larvae. An inverse relationship between feeding rate and survival was found during the study on the effect of excess feed on post larvae of *P.monodon*. (Millamena, 1990). Forster (1972) reported having fed large (70 mg) post larvae of *P.monodon* with a compounded diet and obtained a good survival though slower growth as with fresh food. Khannapa (1977) fed much smaller *P.monodon* postlarva (5.5mg) with a compounded diet based on fish meal and rice bran and found that growth and FCR were best with 30 % protein in the diet. The results of the present study yielded overall good survival and FCR with the commercial feed at the four ration sizes in *P.indicus* postlarvae. Best results were obtained (FCR 1.09) with 12 % ration size fed four times per day.

Jones *et al*, (1979) stated mortality as a common problem in feeding processed diets to penaeid larval and post larval stages. However, in our study we did not encounter heavy mortality in any of the treatment groups maintained on the feed and survival was better compared to those fed clam meat. Overall results obtained indicate that the optimum feeding rate for post larvae is 12 %, which is comparable to the values reported by New (1990) and Paul Raj (1993). The SGR was also maximum at this ration. Caillouet *et al.* (1976) also reported an increase in average yield of pink shrimp *P.duorarum* with increase in feeding rate. Sreekumaran Nair *et al.* (1983) studied growth of *P.indicus* under different levels of feeding and reported growth in weight to be exponential under different levels of feeding, while growth in length was nearly linear. They reported a mild increase in these increments with time even in tanks fed twice or thrice a day. Hence they concluded that frequency of feeding rather than abundance of food, independent of its quality to play an important role in controlling the growth of penaeid prawns.

The cost of labor for feeding of shrimp ponds can be a significant component of the fixed costs (Lawrence and Lee, 1997). The feeding regime should be practical for commercial nurseries and can also serve as a standard against which the performance of a suitable, water stable feed can be measured. The results of the present study though difficult to compare with other works due to differences in stocking density, habitats, temperature and depth clearly show that ration over 12 % body weight is not required. Depending upon the availability of manpower, frequency of feeding could be increased. The overall target for any culture practice is maximum returns with minimum and best inputs. With the growing aspect of ecofriendly shrimp farming, there is need to regulate farming practices to the best returns to the environment also.

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