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Effects of different feeding levels and frequencies on growth performance, feed utilization, survival and body composition of the freshwater prawn, *Macrobrachium rosenbergii* (De Man, 1879).

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ABSTRACT

A 12-week randomized factorial design 3 x 4 x 2 (three feeding levels, four feeding frequencies, and two replicates) rearing trial was conducted in glass aquariums with an average initial weight of 0.014 ± 0.01 g/ pL_{25} and an average initial length of 1.10 ± 0.12 cm/ of freshwater prawn, *Macrobrachium rosenbergii*. The study was conducted to examine the effects of three feeding levels and four feeding frequencies on growth performances, survival rate % feed utilization and body composition. Three feeding levels of 3, 5 and 10% of daily recorded body weight and four feeding frequencies were performed; once/day at 9.00 h, twice/day at 9.00 and 20.00h, thrice/day at 9.00, 15.00 and 21.00h, and four times/day at 9.00, 13.00, 17.00 and 21.00h. The results revealed that, mean final weight (g/animal), mean final length (cm/animal), gain in weight (g/animal), gain in length %, SGR and survival rate % were significantly (P£ 0.01) increased with increasing feeding level and exhibited the highest values at the 5% feeding level. While, feed conversion ratio, feed efficiency ratio, protein efficiency ratio and feed intake (g/animal) were significantly (P £ 0.01) the best at the 3% feeding level. Feeding frequency affected the growth performance values significantly which increased with increasing feeding frequencies and had the best values at the feeding frequency of 3 times daily. Interaction between feeding levels and feeding frequencies in all parameters was studied. Results concluded that feeding levels of 5% body weight daily at feeding frequencies of 3 times daily for freshwater prawn, *Macrobrachium rosenbergii*, juveniles exhibited the highest growth performance, survival rate % and the best feed utilization parameters. In this context, it seems to be the most desirable feeding level and frequency under these experimental conditions.

INTRODUCTION

The giant, freshwater prawn, *Macrobrachium rosenbergii* offers high farming potential with its qualities such as fast growth rate, good survival and high tolerance to a wide range of degrees of temperature and salinity, absence of major disease problems compatibility with non-predacious species of fish **(Paul & Rahman, 2016).**

M. rosenbergii has been introduced into Egypt in he late eighties by the Ministry of Agriculture, and culture trials of this species have been fairly successful at Maryut Fish

Farming Company, near Alexandria (**Sadek & El-Gayar, 1993)**. However, the determination of its optimal feeding schedule is needed to sustain an efficient production. Studies on feeding frequency and its effects on shrimp growth are conflicting. **Sedgwick (1979), Robertson *et al*. (1993)** and **Tacon *et al.* (2002)** recorded positive effect on shrimp growth with the increase of feed frequency. On the other hand, **Velasco *et al.* (1999), Smith *et al. (*2002)** and **Carvalho and Nuens (2006)** found no direct relation between those two factors. **Pontes *et al.* (2008)** recorded that, in shrimp farming feed is commonly offered two or three times per day. Ration is determined by feed tables, which mainly consider stocked shrimp biomass. Moreover, juvenile shrimp, *Litopenaeus vannamei,* (Boone) fed three and four times had similar weight gains and were greater than those fed seven times. One of the approaches for optimizing feed use in shrimp ponds involves determining the circadian rhythm of the animal's digestive enzyme activity. Feed is then offered at times that are more favorable to its consumption and metabolic use **(Molina *et al.*, 2000; Gamboa *et al.*, 2003)**. **Akyiama and Polanco (1997)** recommended four feeding per day, with each farmer adjusting ration according to pellet water stability. In shrimp grow-out, it has always been thought that a higher number of daily rations led to a faster shrimp growth, a better feed conversion efficiency and an improved water quality **(Sedgwick, 1979; Robertson *et al.*, 1993; Jaime *et al.*, 1996)**. Feeding frequency and feed amount per feeding is an integral part of a feed management. It is generally believed that distributing a daily ration in multiple feedings improves shrimp growth and reduces water quality deterioration. Thus, multiple feeding per day are recommended and often done by shrimp growers. Additionally, 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 **(Jory, 1995**). It is noteworthy that, determination of the optimum feeding levels and feeding frequency for reared prawn would help to maximize feed conversion efficiency and minimize feed wastes **(Sampath, 1984**) The amount of feed given per day is a function of the estimated prawn biomass in the pond. Based on experience of farmers in South Carolina, daily feed levels are ranging from 10 to 15% of the estimated biomass. Studies conducted on feeding levels and frequencies on freshwater prawn, *M. rosenbergii* are limited, thus the objective of this study was to determine the effect of different feeding levels and feeding frequencies on growth performance and survival of this species which help in its feeding management.

MATERIALS AND METHODS

Study site

The experimental studies were carried out at Invertebrate laboratory at the Barrage Fish Farm (El-Qanater El-Khayria) belonging to the National Institute of Oceanography and Fisheries. The study lasted for 12 weeks from the 1st of April 2016 to the 23rd of June of the same year.

Test organism

The freshwater prawn, *M. rosenbergii* (Pl25) were purchased from Maryot Fish Farm (Alexandria, Egypt), with mean length of 1.1±0.001 cm and mean weight of 0.01±0.001g. The differences in initial weight and length were insignificant indicating the complete randomization of individuals in experimental groups at the start. The prawns were acclimated for a week before starting the experiment.

Feeds and experimental design

The formulation of the diet used is presented in Table (1); the diet contained approximately 34.67% crude protein, 3.87%, crude lipid 4.02 % crude fiber, 6.29% ash and 393.728 gross energy.

Table 1: Ingredients and proximate analysis of the diet fed to freshwater prawn, *Macrobrachium rosenbergii* reared at different feeding levels and frequencies (all values on dry matter basis %)

Ingredients	**%**
Fish meal (61% CP)	15.0
Yellow corn (8.8 CP)	10.0
Wheat bran (14% CP)	22.0
Soybean (44%CP)	50.0
Cottonseed Oil	1
Vitamins and minerals [1]	2
Proximate analysis [2]	88.66
Dry matter	34.67
Crude Protein	3.87
Crude lipid	4.02
Crude Fiber	6.29
Ash	39.71
N.F.E[3]	393.728
Gross Energy(K Cal/ 100 G diet)	

[1]Premix supplied the following vitamins and minerals(mg or IU)/ kg of diet, vit. A, 8000 I.U.; vit. D3, 4000 I.U.; vit. E 50 I.U.; vit. K3, 19 I.U.; vit. B2, 25 mg; vit. B3, 69 mg; vit. B6, 20 mg; Nicotinic acid, 125 mg; Thiamin, 10 mg; Folic acid, 7 mg; Biotin, 7 mg; Pantothenate, 15 mg; vit. B12, 75 mg; Choline, 900 mg; vit. C, 500 mg; Manganese, 350 mg; Zinc, 325 mg; Iron, 30 mg; Iodine, 0.4 mg; Cobalt 2 mg; Copper, 7 mg; Selenium, 0.7 mg and 0.7 mg B.H.T. according to **Xie, *et al.*, (1997).**

[2]Values represent the mean of three sample replicates.

[3]Nitrogen free extract (NFE) = {100 - (moisture + crude protein + crude fat + ash + crude fiber)}

[4]Gross energy was calculated using the gross energy values for the macronutrients (5.6 kcal/g protein, 9.5kcal/g fat and 4.1 kcal/g carbohydrate) according to **Sanz, *et al.*,** (1994).

Three feeding levels×4 feeding frequency factorial design was formed with two replications. The feeding levels 3, 5 and 10% of body weight were used for each feeding frequency. Feed was accurately weighed using an electronic balance (Model JK-200) and offered as follows:

*****Once/day at 9.00 h.

*Twice/day at 9.00 and 20.00h.

*****Thrice/day at 9.00, 15.00 and 21.00h.

*****Four times/day at 9.00, 13.00, 17.00 and 21.00h.

Daily ration was manually divided into similar amounts for each feeding frequency. Prawn were hand-fed 6 days per week for 12 weeks.

Growth performance

% gain in length=(final length –initial length/ initial length)x100

% gain in weight=(final weight –initial weight/ initial weight)x100

Specific growth rate (SGR) = ln w2-ln w1 x100/ T **(Brown, 1957)**

Where ln is the natural logarithm,W1 is the initial fish weight (g),W2 is the final fish weight(g) and T is the experimental period in days.

Feed conversion ratio(FCR) = Feed intake (g)/ Weight gain (g**) (Castell & Tiews, 1980)**

Feed efficiency = Weight gain(g)/ Amount of feed consumed **(Ballestrazzi *et al*., 1994)**

Protein efficiency = Weight gain(g)/ Protein intake (g) **(Halver & Hardy, 2002)**

Feed intake (G/Fish) is the amount of feed given or supplied during the experimental period for each fish per gram.

Experimental aquaria and water quality

Twenty four glass aquaria, each of 60×50×40 cm, were filled with dechlorinated tap water. Each aquarium was continuously aerated by means of an electric compressor. Small plastic cylinders and some stones were put at the bottom of each aquarium as a shelter for prawn. Twenty individuals were placed in each aquarium in duplicate. About 50% of water was replaced every day, and the uneaten food was siphoned daily.

For prawns measurements, ten individuals were measured and weighed before starting the experiment, and growth parameters and survival were recorded at 15 day intervals till the completion of the experiment. For weight estimation, individual prawn was removed from its aquarium, placed on absorbent tissue paper to remove most external water, then weighed to the nearest 0.01 gm by using a chyo-balance(Model MR-220).Total length was measured from the tip of rostrum to the tip of telson by holding prawn against a graduated ruler, and prawns were then returned quickly to their aquaria.

As long as temperatureis concerned; dissolved oxygen and pH were monitored thrice weekly using a graduated mercury thermometer, digital oxygen meter (Model HANNA HI8043) and digital pH meter (Model ML 1010). The water quality parameters were relatively constant throughout the study. Water temperature varied from 24 to 29.2C^{o} with a mean of 27C^{o}±1.98, dissolved oxygen ranged from 5.3 to 6.7 mgL^{-1} with a mean of 6.4±0.529 mgL^{-1} . The range of pH was 7.3- 9.0 with a mean of 8±0.577. No specific stress was observed during the rearing period. The variations in water quality parameters monitored in this study were within the acceptable range for rearing *M. rosenbergii* larvae **(Armstrong *et al.* 1976; Daniels *et al.* 1992; Roustaian *et al*., 1999).**

Proximate composition

Chemical analysis of carcass were performed using the methods of **AOAC (1995)**. Moisture was determined by oven drying at 100C^{o} for 18 h, crude protein was determined by Kjeltec method(Total N×6.25), crude lipid was done using the ether

extraction method using a 1043 Soxtec System HT(Hoganas, Sweden), and ash was identified after combustion at 600C°.

Statistical analysis

Data were analyzed by two-way analysis of variance using the SAS General Linear Models procedure (Statistical Analysis Systems 1993). Significance between feeding levels, between feeding frequencies, and their interaction were determined using Duncan's multiple range test **(Duncan, 1955)**. Treatments effects were considered significant at $P \leq 0.05$.

RESULTS

1. Growth performance:

Effects of feeding levels (FL) % and feeding frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile mean initial weight (g), mean final weight (g), mean initial length (cm), and mean final length (cm) after 12 weeks of rearing in the present study are presented in Table (2).

Table 2: Effects of feeding levels and frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile, initial body weight (g), final body weight (g), initial body length (cm) and final body length (cm) after 12 weeks of rearing. Values are means ± SD.

Classification	Average body weight (g)		Average body length (cm)	
	Initial	Final	Initial	Final
Feeding level (FL)	**N.S.**	******	**N.S.**	******
3 %	0.014 ± 0.01	0.787 ± 0.37 c	1.10 ± 0.12	4.68 ± 0.64 [c]
5%	0.014 ± 0.01	1.542 ± 0.86 [a]	1.10 ± 0.12	5.56± 1.04 [a]
10%	0.014 ± 0.01	1.273 ± 0.54 [b]	1.10 ± 0.12	5.18± 0.72[b]
Feeding Frequency (FF)	N.S.	**	N.S.	**
1	0.014 ± 0.01	0. 499 ± 0.12[d]	1.10 ± 0.12	4.03 ±0.29 [d]
2	0.014 ± 0.01	0. 947 ± 0.39 [c]	1.10 ± 0.12	4.93± 0.45 [c]
3	0.014 ± 0.01	1. 817 ± 0.65 [a]	1.10 ± 0.12	5.89 ± 0.68[a]
4	0.014 ± 0.01	1.540 ± 0.54 [b]	1.10 ± 0.12	5.70 ± 0.56[b]
FL x FF	N.S	**	N.S.	**
R^2	0.00	0.75	0.00	0.84

1. Significant level: N.S. = P > 0.05, ** = P ≤ 0.01.
2. Significance tested with Duncan's multiple range test. Means that have the same letters within each classification column are not significantly different from each other.
3. FL = Feeding levels (3, 5 & 10% of body weight daily); FF = Feeding frequency (1, 2, 3 & 4 times daily).

It is evident from Table (2) that, there was no significant differences in the initial weight or length of prawn at the beginning of the experiment. While, at the end of the trial average final weight and length were affected significantly ($P \leq 0.01$) by feeding level % and feeding frequencies. The highest average final weight and length of prawn

were recorded with the feeding level of 5% body weight daily at three times feeding frequency; whereas, the lowest were recorded in the feeding level of 3% body weight daily at the feeding frequency of one time daily. There was a significant ($P \leq 0.01$) interaction between feeding levels and feeding frequencies. A positive correlation was detected between feeding levels, feeding frequencies and final average weight and length of the prawn. When the feeding level or frequencies increased, the final average body weight and length of prawn increased.

Effects of feeding levels (FL) % and feeding frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile average gain in weight (g), average gain in weight (%), average gain in length (cm) and average gain in length (%) after 12 weeks of rearing are presented in Table (3).

Table 3: Effects of feeding levels and frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile, gain in weight (g), gain in weight (%), gain in length (cm/animal), gain in length (%) after 12 weeks of rearing. Values are means ± SE.

Classification	Average gain in weight (g/animal) (%)		Average gain length (cm/animal) (%)	
	Initial	Final	Initial	Final
Feeding level (FL)	**	**	**	**
3%	0.774 ± 0.38 [c]	5528.6 ± 1808.2[c]	3.58 ± 0.65[b]	329.9 ±75.6 [b]
5%	1.533± 0.86 [a]	10950.0±5906.0 [a]	4.46± 1.04 [a]	411.0 ± 109.4[a]
10%	1.259 ± 0.54 [b]	8992.9 ±3878.2[b]	4.35± 0.99	400.5 ± 101.5[a]
Feeding Frequency (FF)	**	**	**	**
1	0.485 ± 0.12 [d]	3464.3 ± 937.4[d]	2.93 ± 0.30 [d]	270.8 ± 47.3 [c]
2	0.933 ± 0.40 [c]	6664.3 ± 2191.2 [c]	3.83 ± 0.46 [c]	353.3 ± 65.5[b]
3	1.808 ± 0.65 [a]	12914.3± 5298.0 [a]	4.79 ± 0.67 [b]	441.0 ± 80.2 [a]
4	1.529 ± 0.55 [b]	10921.4 ± 3589.7[b]	4.96 ± 0.72 [a]	456.6 ± 84.6[a]
FL x FF	**	**	**	**
R^2	0.75	0.54	0.84	0.65

1. Significant level: N.S. = P > 0.05, ** = P ≤ 0.01.
2. Significance tested with Duncan's multiple range test. Means that have the same letters within each classification column are not significantly different from each other.
3. FL = Feeding levels (3, 5 & 10% of body weight daily); FF = Feeding frequency (1, 2, 3 & 4 times daily).

It is evident from Table (3) that, the average gain in weight (g), average gain in weight (%), average gain in length (cm) and average gain in length (%) were affected significantly ($P \leq 0.01$) by feeding levels and feeding frequencies. Furthermore, the highest average gain in weight (g), average gain in length (cm), average gain in weight % and average gain in length % were recorded with the feeding level of 5% body weight daily at feeding frequency of three times daily. On the other hand, the lowest values of the aforementioned variables were recorded in the feeding level of 3% body weight daily at the feeding frequency of one time daily. In result, the prawn fed on the feeding level of

5% body weight daily grew faster and had 109.5 folds more than the groups of prawn fed with 3% body weight daily recording a growth value of 55.3 folds. It was noticed that, groups of prawn fed three times daily grew faster and had 129.1 folds compared to groups of prawn fed one time daily which recorded the lowest growth of 34.6 folds. There was a significant ($P \leq 0.01$) interaction between feeding levels and feeding frequencies. Positive correlationS were identified between feeding levels, frequencies and average gain in weight (g), average gain in length (cm), average gain in weight % and average gain in length %. Markedly, when the feeding levels or frequencies were increased, an increase of the average gain in weight (g), the average gain in length (cm), the average gain in weight % and the average gain in length % of prawn was observed as well.

Effects of feeding levels (FL) % and feeding frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile condition factor (K), survival rate % and specific growth rate (%/day) after 12 weeks of rearing are presented in Table (4).

Table 4: Effects of feeding levels and frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile, condition factor (K) survival rate (%) and specific growth rate (% /day) after 12weeks of rearing. Values are means ± SE.

Classification	**Condition factor (K)**	**Survival rate (%)**	SGR **(%/day)**
Feeding levels (FL)	**	**	**
3%	0.71 ± 0.12 [c]	65.0 ± 6.6 [a]	4.73 ± 0.70 [b]
5%	0.80 ± 0.10 [b]	67.2 ± 7.2 [a]	5.45 ± 0.87 [a]
10%	0.86 ± 0.13 [a]	62.1 ± 4.8 [b]	5.31 ± 0.72 [a]
Feeding Frequency (FF)	**	**	**
1	0.75 ± 0.09 [c]	57.2 ± 1.6 [c]	4.29 ± 0.49 [d]
2	0.75 ± 0.18 [c]	67.2 ± 2.1 [a]	4.98 ± 0.67 [c]
3	0.86 ± 0.08 [b]	70.0 ± 8.5 [a]	5.79 ± 0.61 [a]
4	0.80 ± 0.13 [a]	64.5 ± 2.1 [b]	5.59 ± 0.59 [b]
FL x FF	**	**	**
R^2	0.31	0.76	0.64

1. Significant level: N.S. = P > 0.05, ** = P ≤ 0.01.
2. Significance tested with Duncan's multiple range test. Means that have the same letters within each classification column are not significantly different from each other.
3. FL= Feeding levels (3, 5 & 10% of body weight daily); FF= Feeding frequency (1, 2, 3 & 4 times daily).

It is evident from Table (4) that, the condition factor (K), survival rate % and specific growth rate (%/day) were affected significantly ($P \leq 0.01$) by feeding levels % and feeding frequencies. The highest survival rate % and specific growth rate (% /day) were recorded with the groups of prawn fed the feeding level of 5 % body weight daily at feeding frequency of three times daily, and the lowest rates were recorded in the groups

of prawn fed on the feeding levels of 3% body weight daily at feeding frequency of one time daily. The groups of prawn fed the feeding levels of 10% body weight daily had significantly the highest condition factor (K) (0.86). While, the lowest rate (0.71) was recorded with groups of prawn fed the feeding levels of 3 % body weight daily. Moreover, groups of prawn fed three times daily feeding frequency had the highest values of condition factor (K), survival rate % and specific growth rate (%/day); whereas, the lowest were recorded with groups of prawn fed one time feeding frequencies daily. There was a significant ($P \leq 0.01$) interaction between feeding levels and feeding frequencies in terms of condition factor (K), survival rate % and specific growth rate (%/day). Additionally, positive correlations were determined between feeding levels, frequencies and condition factor (K), survival rate % and specific growth rate (%/day). Hence, it was remarked that, when an increase was noted in the feeding levels or/and frequencies, the condition factor (K), survival rate % and specific growth rate (%/day) also showed an increase.

1.1.Feed utilization:

Effects of feeding levels (FL) % and feeding frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and feed intake (g/animal) after 12 weeks of rearing are presented in Table (5).

As shown in Table (5), the results of feed conversion ratio, feed efficiency ratio, protein efficiency ratio and total feed intake were significantly ($P \leq 0.01$) affected by feeding levels and feeding frequencies. The best results of FCR, FER and PER were obtained at the lowest feeding levels of 3% of the body weight daily with 3 times daily feeding frequencies. The lowest feed intake (g/animal) was obtained at the lowest feeding levels of 3% body weight daily at one time feeding frequency. The highest feed intake was achieved at the feeding level of 10% body weight daily at 3 times daily feeding frequency. There was a significant interaction between feeding levels and feeding frequencies in terms of all feed utilization parameters. In addition, a positive correlation was determined between feeding levels, frequencies and all the feed utilization parameters. When an increase was detected in the feeding frequencies and feeding levels all the feed utilization parameters were increased.

Table 5: The effect of feeding levels and frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile, feed conversion ratio (FCR), feed intake (FI, g/juvenile), feed efficiency ratio (FER) and protein efficiency ratio (PER) after 12 weeks of rearing. Values are means ± SD.

Classification	PER	FCR	FI	FER
		(g/ juvenile)		
Feeding level (FL)	**	**	**	**
3 %	0.70 ± 0.18 [a]	0.488 ± 0.16 c	1.53 ± 0.41 [a]	4.42 ± 1.16 [a]
5 %	1.04 ± 0.31 [b]	1.419 ± 0.64 [b]	1.04 ± 0.30 [b]	3.01 ± 0.85 [b]
10%	2.13 ± 0.65 [c]	2.407 ± 0.68 [a]	0.51 ± 0.15 [c]	1.48 ± 0.44 [c]
Feeding frequency (FF)	**	**	**	**
1	1.58 ± 0.88 [c]	0.780 ± 0.47 [d]	0.84 ± 0.43 [c]	2.42 ± 1.24 [c]
2	1.36 ± 0.78 [b]	1.334 ± 0.95 [c]	0. 96 ± 0.46 [b]	2.79 ± 1.32 [b]
3	1.12 ± 0.64 [a]	1.985 ± 1.03 [a]	1.18 ± 0.60 [a]	3.39 ± 1.72 [a]
4	1.09 ± 0.54 [a]	1.655 ± 0.85 [b]	1.13 ± 0.50 [a]	3.27 ± 1.43 [a]
FL x FF	**	**		**
R^2	0.75	0.89	0 .73	0.73

1. Significant level: N.S. = P > 0.05, ** = P ≤ 0.01.
2. Significance tested with Duncan's multiple range test. Means that have the same letters within each classification column are not significantly different from each other.
3. FL= Feeding levels (3, 5 & 10 % of body weight daily); FF= Feeding frequency (1, 2, 3 & 4 times daily).

1.1.1.Body composition*:*

Effects of feeding levels (FL) % and feeding frequencies on freshwater prawn, *Macrobrachium rosenbergii* juvenile whole body proximate composition (%) of moisture, crude protein, crude fat and crude ash after 12 weeks of rearing are presented in Table (6).

Results revealed that, moisture content was not significantly ($P > 0.05$) influenced by either feeding levels or feeding frequencies. Protein content of prawn was significantly ($P \leq 0.01$) influenced by feeding levels, though not by feeding frequencies. On the other hand, crude fat contents of prawn were significantly $(P \leq 0.01)$ influenced by feeding levels and frequencies. Moreover, ash contents were not influenced by feeding levels but was significantly $(P \leq 0.01)$ influenced by feeding frequencies. There was a significant interaction between feeding levels and feeding frequencies in terms of all whole body composition contents. A positive correlation was detected between feeding levels, frequencies and all whole body composition contents.

Thus, it can be concluded that, feeding levels of 5% body weight daily at feeding frequencies of 3 times daily for freshwater prawn, *Macrobrachium rosenbergii*, juveniles exhibited the highest growth performance, survival rate % and the best feed utilization parameters. It can be assumed to be the most desirable feeding levels and frequencies under those experimental conditions.

Table 6 : The effect of feeding levels and frequencies on whole body composition (% dry basis) of freshwater prawn, *Macrobrachium rosenbergii,* juvenile after 12 weeks of rearing. Values are means ± SD.

Classification	Moisture	Crude protein	Crude fat	Crude ash
Feeding level (FL)	**N.S.**	*	*	N.S.
3%	3.29 ± 5.2[b]	60.35 ± 1.2 [b]	7.10 ± 0.87 [ab]	5.95 ± 0.68
5 %	75.18 ± 6.0[a]	61.70 ± 1.7 [a]	6.63 ± 0.98 [b]	5.75 ± 0.62
10 %	76.53 ± 5.0 [a]	60.23 ± 1.6 [b]	7.58 ± 0.96 [a]	5.57 ± 0.45
Feeding frequency (FF)	**N.S.**	**N.S.**	**	**
1	74.37 ± 6.4	60.48 ± 1.38	7.49 ± 0.61 [a]	5.31 ± 0.45 [b]
2	74.28 ± 5.2	61.47 ± 1.29	6.26 ± 0.67 [b]	6.00 ± 0.64 [a]
3	75.69 ± 3.9	61.06 ± 2.25	7.00 ± 1.29 [ab]	5.93± 0.67 [a]
4	75.66 ± 6.6	60.04 ± 1.30	7.68 ± 0.69 [a]	5.78± 0.39 [ab]
FL x FF	**	**	**	**
R^2	0.08	0.29	0.47	0.28

1. Significant level: N.S. = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01.
2. Significance tested with Duncan's multiple range test. Means that have the same letters within each classification column are not significantly different from each other.
3. FL= Feeding levels (3, 5 & 10 % of body weight daily); FF= Feeding frequency (1, 2, 3 & 4 times daily).

DISCUSSION

Feeding frequency and feeding levels had a significant effect on growth performance and food consumption of *Macro brachium rosenbergii* juveniles. Both consumption and growth rates appeared to increase with the number of meals per day up to three meals, also results of the present study revealed that growth and survival of *M. rosenbergii* were significantly increased with increasing feeding frequency and exhibited the highest values at the 5% feeding level. These findings agree with those of **Sedgwick (1979)**, **Robertson *et al* (1993)** and **Tacon *et al*. (2002**) who reported a positive effect on shrimp growth when feeding frequencies were increased to four times a day compared to the once- daily feeding in the study of *Penaeus merguiensis.* Result of the present study coincides with the finding of **Akyiama and Polanco (1997)** who recommended four feeding frequencies per day for shrimp . Generally, studies on feeding frequency and its effect on shrimp growth are conflicting.

Taechanuruk and Stickney(1982) indicated that feeding frequency had a significant effect on the food consumption of adult *M. rosenbergii*, while feeding twice daily induced the highest consumption compared with feeding once or three times, this may be due to molting frequency and percentage moult that are greatly modified by the feeding level. Additionally, the intermoult period decreased as the feeding level increased **(Katre & Reddy 1976)**. On the other hand, **Tavabe *et al.* (2012)** stated that 2 times feeding frequencies/day is the best for *M. rosenbergii* and has a strong effect on larval stage index, survival rate and time to reach post larvae. In addition, the present result is in agreement with that obtained by **Dwyer *et al.* (2002)** on Yellowtail flouder fish who stated that fish fed a higher feeding frequencies gained more weight and added more length than fish fed the lower feeding frequencies. A similar trend was observed with small *P. merguiensis* fed four times daily and grew faster and had better feed conversion than those fed only once daily **(Chiang & Liao 1985; Chen *et al*, 1989)**. The current result agrees with that obtained by **Pontes *et al*. (2015)** who found that offering feed only once per day is not recommended compared to offering it two, three and four times per day for *Fenneropenaeus. paulensis* grown in pen enclosures, because although the results for survival were similar and the food conversion was higher, the consumption of feed was higher and the biomass increase and individual weight gain were smaller. The water quality remained within the appropriate standards for culture and was similar for all the treatments.

In contrast to the present result with respect to the once per day frequency, **Miau and Tu (1993),** testing frequencies of one to four feedings daily, found no difference in the growth of juveniles of *Fenneropenaeus penicillatus*. Although conversion efficiency has been estimated for different species such as *Litopenaeus stylirostris* **(Baillet *et al.*, 1997)**, *L. vannamei* **(Velasco *et al.*, 1999)**, *Fenneropenaeus chinensis* **(Zhang *et al.*, 2008),** *P. monodon* **(Ye *et al.*, 2009).** On the other hand, **Mensi and Heinen (1988)** found that feeding once per day produced the best growth and highest survival and yield of juveniles *M. rosenbergii*.

For intensively cultured *P. vannamei*, it is suspected that feeding more than once daily is preferable **(Chamberlain, 1988; Wyban & Sweeney, 1989)**, although previous studies have not specifically addressed daily feeding frequency. Results of the present experiment clearly indicated that growth increases with feeding frequency up to 3 times/day and growth decreases at frequency of 4 times/day, this result is in agreement with that of **Wang *et al*. (1998)**, who reported that both consumption and growth rates appeared to increase with the number of meals per day up to three meals, and further increases in feeding frequency did not result in greater growth of the hybrid sunfish. Additionally, **Pontes *et al.* (2008)** stated that juveniles shrimp *Litopenaeus vannamei* feeding 3 times/day resulted in greater ingestion and higher growth rates as compared to frequencies of four and seven times/day. Corroborating those results, **Josekutty and Jose (1996)** observed that juveniles *P. monodon* had similar weight gain when fed three or

four times/day, with values higher than those fed once and twice. In this respect **Goda *et al* (2010)** reported that feeding frequency 4 times per day was recommended for *M. rosenbergii* . However, **Velasco *et al.* (1999)** did not observe any difference in the growth or survival of *L. vannamei* fed 3, 5, 8, 11or 15 times over a 20 days period. While, **Smith *et al.* (2002)** studied the effect of four feeding frequencies (3, 4, 5 and 6 times/day) on the growth and survival of the shrimp *P. monodon* fed with a commercial pellet feed. The previous researchers concluded that feeding frequency had no effect on growth rate, feed conversion ratio, shrimp survival or water quality parameters, suggesting that there is no benefit from feeding *P. monodon* more frequently than three times/day when using a feed that is nutritionally adequate and has high water stability. Surprisingly, **Heine and Mensi (1991)** demonstrated that *M. rosenbergii* fed once daily was superior to feeding more often, because feeding more often should reduce losses of nutrients due to leaching. Thus, feeding once a day allowed more time for microbial colonization of feed than feeding two or three times a day. Microbial colonization, which is believed to be important for detrital feeders such as shrimp and prawns **(Caillouet *et al*.1973; Newell & Fell 1975)** may increase the nutritional suitability of the food particles. However, **Caillouet *et al*. (1973)** found that, feeding penaeid shrimp (*P. duorarum*) once or three times per night in out door tanks did not affect survival, growth or yield.

Marques (1997) working with juveniles of *Furfantepenaeus paulensis* in flooting cages reported no differences on shrimp growth when feeding frequency was increased from 2 to 4 times/day. Conversely, **Robertson *et al.* (1993)** found a positive influence feeding frequency on shrimp growth when working with *L. vannamei* stocked at 40 shrimp /m^2 in 1 m^2 open-bottom enclosures. The previous authors concluded that shrimp fed 4 times/day attained faster growth than when fed once and twice / day. Similar results were reported by **Jaime *et al*. (1996)** when working with *L. schmitti* at 4 shrimp/m2 in 500m2 ponds. The adjustment in feed meals may lead to a reduction in feed wastes and improvement in FCR, and this adjustment in feed rations are based on the amount of feed remains collected from the previous day **(Smith *et al*., 2002; Carvalho & Nunes, 2006).**
Whole body composition in the present study indicated that moisture was not significant affected by feeding levels or frequency, a result that matches with a study performed by **Lee *et al.* (2000)** on juveniles flounder, *Paralichthys olivaceus* .

On the other hand, **Koshio *et al*.(1992)** reported that feeding frequency did not affect the content of protein, lipid or lipid class and fatty acids of prawn whole body of *M. rosenbergii*. Furthermore, **Webster *et al*. (1992)** suggested that there was no significant differences in percentage moisture, protein and lipid in fillet of channel catfish fed either once or twice daily.
The present study proved that growth performance, highest SGR, best FCR and good survival of *M. rosenbergii* post larvae can be achieved by feeding 3 times daily with 5% feeding level which improved and enhanced growth performance.

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