EFFECT OF INITIAL BODY WEIGHT AND STOCKING DENSITY ON GROWTH PERFORMANCE OF FRESH-WATER PRAWN (*M. rosenbergii*) POST-LARVAE AND JUVENILES

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SUMMARY

Freshwater prawn-postlarvae, M. rosenbergii averaging 0.04 ± 0.001g in weight [Experiment 1] were reared for 90day at four stocking densities (200, 400, 800 and 1200 prawn /m^2) using 12 circular fiberglass tanks (0.36 m^2 and 0.6 m water depth). Prawns were fed a manufactured diet containing 35% crude protein. Different growth measurements of prawn were recorded at 15 days intervals. The results showed that growth performance was significantly (P≤ 0.05) decreased with increasing the stocking density. Survival rate was inversely related to stocking densities, since there were significant differences among the four densities. The food conversion ratio "FCR" increased with increasing stocking density, the differences were significant among the four densities.

In the second experiment freshwater prawn-juveniles, M. rosenbergii averaging 0.30 ± 0.02g in weight were cultured for 90 days, with different stocking densities (50, 100, 150 and 200 prawn /m^2) using the same method as in first experiment. The results showed that growth performance was significantly (P≤ 0.05) decreased with increasing the stocking density. Survival rate was inversely related to stocking density, since there were significant differences among the four densities, while the difference between stocking density of 50 and 100 prawn /m^2-was not significant. The food conversion ratio "FCR" increased with increasing the stocking densities, since the fourth density (200 prawn /m^2) was significantly higher than that achieved in the first one (50 prawn /m^2). Increasing stocking density resulted in increasing carcass protein and ash content, while carcass fat and dry matter content decreased but differences were not significant.

Therefore, it could be concluded that monoculture of freshwater prawn juveniles (average weight 0.3g & stocking density 50 prawn/m^2) and postlarvae (average weight 0.04g & stocking density 200 prawn/m^2) were more suitable to carry out for optimum growth performance and survival rate.

Keywords: Freshwater prawn (M. rosenbergii), Post-larvae-juveniles, stocking density, growth performance

INTRODUCTION

Production of the freshwater prawn (*Macrobrachium rosenbergii*) has increased substantially in recent years. These increases are partially based on several positive production attributes which include resistance to the diseases which have severally impacted penaeid production (Wang *et al.*, 1998), the potential of producing large average sizes (New, 2000 a&b), and the recognition that prawn culture may be more environmentally sustainable than intensive penaeid shrimp production (Tidwell and D'Abramo, 2000). Culture systems of freshwater prawn, however, began to be developed only after the life cycle of *Macrobrachiun rosenbergii* was closed in a Malaysian laboratory (Ling, 1977). This stimulated widespread interest in the culture of this species and other palaemonidss. Thus, freshwater prawn farming continued to expand elsewhere. At the present time, the annual world production of *M. rosenbergii* reached 27000 metric tones, the majority of which are from South-east Asian countries (Tidwell *et al.,* 2004). It is desirable to determine an optimum stocking rate which allows high growth rates of all individuals stocked together with high survival. The usual densities tested in grow-out ponds range from 1 to 20 prawns stocked /m^2 (Ra'anan, 1982). In Egypt, the culture of freshwater prawns (*M. rosenbergii*) has great economic interest for the following reasons: wide brackish surfaces are available, the climatic situation is very favorable and the market prices are high. The climate permits outdoor cultivation of freshwater prawns only during the warmer nine months of the year (El-Gayar *et al.*, 1994). The aims of this study were to investigate the effect of different sizes and stocking densities on rearing of freshwater prawn (*M. rosenbergii*) post-larvae and juveniles in tanks.

MATERIALS AND METHODS

This study was carried out at Fish Research Center (F.R.C.), Suez Canal University, Ismailia, Egypt, in order to determine the effect of sizes and stocking densities of freshwater prawn (*M.rosenbergii*) on growth performance, survival rate, and carcass composition of prawn.

Experimental prawn:

Freshwater prawn *(Macrobrachium rosenbergii)* post-larvae and juveniles used in this study were obtained from the Maryut Fish Farming Company, Alexandria in aerated tanks. Freshwater prawn were graded, homogeneous sizes were selected and kept in circular tank for each. They were fed for fifteen days on the same diet which used in this study, to adapt them for the experimental conditions. Unhealthy prawns were removed from the tanks and replaced with others healthy.

Experimental tanks:

Twenty four fiberglass circular tanks (0.36m^2 each, mean depth 0.6m) were used for rearing the freshwater prawn in both experiments. Water in tanks was obtained from a well and aerated by a constant supply of air blower. PVC pipes have been used in tanks to provide shelters for prawns and reduce aggressive interaction (Lee and Wickins, 1992). Faeces were siphoned together with 20% of the water volume from each tank and replaced with fresh water daily, before morning feeding.

Experimental design:

Experiment 1:

This experiment was devoted to study the effect of stocking densities on growth performance, and survival rate of prawn-postlarvae. Twelve circular tanks were used and stocked with prawn-postlarvae averaging 0.04±0.001g in weight (Willis and Berrigan, 1979). Prawns were stocked in tanks at four different stocking densities i.e. 200, 400, 800, 1200 per square mater (Chen, 1990). Each stocking density had three replicates.

Experiment 2:

Prawn juveniles were stocked in the twelve circular tanks at four different stocking densities i.e. 50, 100, 150, 200 prawns/m^2 with three replicates for each density. At the stocking time, average weight of prawn juveniles were 0.3±0.02g in weight (Tidwell *et al.*, 2005). The experimental period lasted 90 days.

During rearing period in both experiments, the physical-chemical analysis of water (temperature, pH, dissolved oxygen, total hardness, salinity), growth performance and survival rate of prawns were determined every 15 days intervals.

Experimental diet:

The diet used in feeding the experimental prawn was obtained from Sinai Shrimps 21 Company, Port Said its compassion was according to (NRC, 1983). The diet was grounded to very small size of less than 15mm mesh and stored in a refrigerator (4^oC) during the experimental duration to avoid the nutrients deterioration. The ingredients composition and proximate analysis of this diet are provided in Table (1).

Table 1. Ingredients composition and proximate analysis of the diet fed to prawns in this study

Ingredients	**%**
Fish meal	15.0
Soybean meal	36.0
Crab meal	10.0
Corn gluten meal	20.0
Wheat bran	12.0
Fish oil	2.0
Pellet binder *	2.0
Vitamin mix **	0.5
Trace mineral mix ***	0.5
Dicalcium phosphate	1.25
Choline chloride	0.05
Ascorbic acid	0.70
- Chemical composition of the diet (% as fed):	%
Moisture	12.9
Ash	10.8
Crude protein	35.0
Crude fat	05.0
Crude fiber	03.0
Nitrogen-free extract	33.3

* Pellet binder was hemicellulose.
** Vitamin mix contains: thiamin,1.01%; riboflavin, 1.32%; pyridoxine, 0.9%; nicotinic acid, 8.82%; folic acid, 0.22%; vitamin B12, 0.001%; pantothenic acid, 3.53%; menadion, 0.2%; ascorbic acid, 33.07%; vitamin A, 4,409,200(IU)/kg; vitamin D3 ,2,204,600(IU)/kg; vitamin E, 66,138(IU)/kg; ethoxyquin, 0.66%.
*** Trace mineral mix contains: Mn, 10.0%; Zn, 10.8%; Fe, 7.0%; Cu, 0.7%; I, 0.24%; Co, 0.10%; Ca (carrier).

Feeding regime:

The daily feeding rate for the first week was 20 % of the total stocking biomass and thereafter was adjusted at the beginning of each of the next two weeks. Every two weeks thereafter, tank samples provided information for the adjustment of feeding quantity based on actual prawn biomass in each tank. The freshwater prawns were fed the experimental diet twice a day at 9.00 am and 5.00 p.m. A feeding rate assigned to a particular range of wet weights (Table 2) according to D' Abramo *et al.*, (1989). The experimental diet was offered by hand spreading.

Table 2. Weight dependent feeding rates used to determine biweekly feeding schedules for grow out tanks

Weight (g)	Daily fed as percentage of body weight
0-1	20
1-2	15
2-5	12
5-10	9
10-15	8
15-20	7
20-25	6
25-30	5
30 ~	3

Physical and chemical analysis of water:

Water temperature was measured using oxygen- temperature meter (YSI model L57). Water temperature of the experimental tankes was monitored daily throughout the experimental period (Marques *et al.*, 2000) and the average was taken per 15 days. Water pH was measured using pH meter (model 56, NR 87 BB 203). The pH values of each tank was monitored daily in the late afternoon (D'Abramo *et al.*, 1989). The average pH values of water was recorded every 15 days intervals throughout the experimental period. The dissolved oxygen in the water was measured by using oxygen- temperature meter (YSI model L 57). Concentration of dissolved oxygen (mg/L) of each tank was measured daily during the early morning and the average dissolved oxygen of water was recorded every 15 days intervals during the experimental period (D'Abramo *et al.*, 1989). Salinity of water was determined using a refractometer, ATAGO. Total hardness of water throughout the experimental period was estimated using the method described by Brown *et al.* (1991).

Parameters tested:

Whole prawn carcass was analyzed for protein, fat, ash and moisture contents by standard AOAC (1990) methods. The following parameters were used to evaluate prawn growth performance in both experiments:

Mean Prawn Weight= the average weight of prawn at t days

Weight Gain (WG) = $W_1 - W_0$

Average Daily Weight Gain (ADG) = $(W_1 - W_0) / t$

Percentage Weight Gain (%) = $(W_1 - W_0) X100 / W_0$

Specific Growth Rate (% day) SGR = $(\text{Ln } W_1 - \text{Ln } W_0) X 100 / t$

Food Conversion Ratio (FCR) = feed fed / $(W_1 - W_0)$ (De- Silva and Anderson, 1995) .

Survival rate (%) = $N_i X 100 / N_0$ (Harrell *et al.*, 1990) .

Where:

W_1 = Final wet weight (g)

W_0 = Initial wet weight (g)

t = Time interval in days
N_i = Number of prawn at the end
N_0 = Number of prawn initial stocked

Statistical analysis:

The data obtained in this study were analyzed by one-way ANOVA procedure of Statistical Analysis System (SAS, 1988). Means were compared by Duncan's new multiple range test (Zar, 1996).

RESULTS AND DISCUSSION

Environmental conditions:

The recorded values in Table (3) showed suitable environmental conditions for rearing of freshwater prawn *(M. rosenbergii)* during the experimental period. The water temperature ranged from 26.5°C to 27.6°C. These values were within the acceptable range of temperature recorded for *M. rosenbergii* (New and Singholka, 1985). These results are in agreement with those obtained by Sadek and Moreau (1996). They noticed that optimal water temperatures for optimum growth and survival of *M. rosenbergii* are 26-31°C. Also, Marques *et al.* (2000) found that, the optimal temperature for *M. rosenbergii* is 23.5 to 27°C. Changes in pH values of water during the experimental period were illustrated in Table (3). It is clear that the minimum pH value was 7.5 and the maximum pH was 8.2. This range was in the optimum range of pH recorded for *Macrobrachium rosenbergii* (Sadek and El-Gayar, 1993). Similar results were obtained by Mei Chen and Chu-Chen (2003). They indicated that, optimal pH values for optimum growth and survival rate of *M. rosenbergii* are 7.4-8.2. Also, Tidwell *et al.* (2004) noted that, pH values for *M. rosenbergii* varied from 8.0 to 9.6 (mean of 8.9 ± 0.3). Throughout the experimental period, the dissolved oxygen was measured and Table (3) illustrate the changes in the mean values of dissolved oxygen concentrations. It is clear from the data that the minimum and maximum value of the dissolved oxygen were 5.8 and 6.5mg /L., respectively. This range was suitable for *M. rosenbergii* feeding and growth as reported by Tidwell *et al.* (2004).

As shown in Table (3) the minimum and maximum value of the salinity, during the rearing period, were 0.12 and 0.23‰, respectively. It is clear from the data that the salinity was suitable for the growth of *M. rosenbergii.* Sadek and Moreau (1996) found optimal growth and survival rate for *M. rosenbergii* in either freshwater or water of low salinity (2‰). On the other hand, Sadek and El-Gayar (1993) reported that, optimal salinities for growth and survival to metamorphosis for *M. rosenbergii* have been generally reported as 7.2 - 15‰. From the data recorded, it can be seen that the lowest value of total hardness was (65.3mg /L.), while the highest value was, 74.2mg /L. The water having this hardness is suitable for *M. rosenbergii*. Similar results were obtained by New and Singholka (1985). They indicated that, optimum water hardness levels for optimal growth and survival for *M. rosenbergii* appear to lie between 65 and 200mg/L. Also, Brown *et al.* (1991) found that, at hardness levels between 30 and 75mg /L $CaCO_3$, survival was good, ranging from 67 to 100% (mean 92.5%).

Table 3. Mean values of physical and chemical characteristics of water during the whole experimental period (90 day) for both experiments

Period of rearing (day)	Water temperature (°C)	pH	Dissolved oxygen (mg /L)	Salinity (ppt)	Total hardness (mg /L)
15	26.5	7.5	6.5	0.12	65.5
30	26.7	7.8	6.3	0.12	65.3
45	27.5	8.1	5.9	0.22	74.0
60	27.6	8.2	5.8	0.23	74.2
75	27.3	8.0	6.0	0.22	73.5
90	26.8	7.9	6.2	0.13	68.1

Experiment 1:

Mean individual weights:

Table (4) illustrates the mean individual weight of *M. rosenbergii*-postlarvae in tanks for 90 days at different stocking densities (i.e. 200, 400, 800 and 1200 prawn /m^2). It can be noticed from the data that mean initial weight of post-larvae at stocking was 0.04 ± 0.001g for all densities. At the end of the experimental period, the final average body weights (FBW) of *M. rosenbergii*-postlarvae were 1.302, 1.220, 0.634 and 0.438g for densities 200, 400, 800 and 1200 prawn /m^2, respectively. It can be concluded that the maximum and the minimum sizes of *M. rosenbergii*-postlarvae were attained at lower and higher stocking rates, respectively (being 1.302 and o.438g). The statistical analysis of mean results indicated that the mean individual weight of *M. rosenbergii*-postlarvae was not significantly (P> 0.05) different between the stocking densities of 200 and 400 prawn /m^2, but the differences between densities of 200, 400, 800 and 1200 prawn /m^2 were significant (P< 0.05). Such results coincide with those of Marques *et al.* (2000). They reported that prawn weight decreased when density increased.

Table 4. Effect of different stocking densities in the first experiment on mean individual weight (g) of *Macrobrachium rosenbergii*, post-larvae (Mean ± SE)

Period(day)	Stocking rate (Prawn / m^2)			
	200	400	800	1200
At-stocking	0.04±0.001	0.04±0.001	0.04±0.001	0.04±0.001
15	0.079±0.006^a	0.078±0.001^a	0.071±0.002^a	0.066±0.006^a
30	0.152±0.001^a	0.148±0.006^a	0.119±0.001^b	0.105±0.002^b
45	0.284±0.006^a	0.274±0.001^a	0.190±0.001^b	0.161±0.002^b
60	0.497±0.001^a	0.479±0.006^a	0.293±0.006^b	0.235±0.006^b
75	0.829±0.006^a	0.786±0.001^a	0.437±0.002^b	0.329±0.002^c
90	1.302±0.002^a	1.220±0.002^a	0.634±0.002^b	0.438±0.006^c

Means with different superscripts within the same row are significantly different (P< 0.05).

Mean weight gain:

Table (5) illustrates the mean weight gain at 15 days intervals for all treatments. This table indicated that weight gain at the end of the experimental period was 0.473, 0.434, 0.197 and 0.109g/prawn for the stocking densities 200, 400, 800 and 1200 prawn /m^2, respectively. It can be seen that the average weight gain per prawn in the experimental groups was decreased with increasing stocking densities. Similar results were obtained by Marques *et al.* (2000). Generally, significant (P≤ 0.05) differences were found among the stocking rates. But the difference was not significant between stocking rates 200 and 400 prawn /m^2.

Table 5. Effect of different stocking densities in the first experiment on mean weight gain (g /prawn) of *Macrobrachium rosenbergii* , post-larvae (Mean ± SE)

Period(day)	Stocking rate (Prawn / m^2)			
	200	400	800	1200
15	0.039±0.002^a	0.038±0.001^a	0.031±0.006^b	0.026±0.001^c
30	0.073±0.001^a	0.070±0.001^a	0.048±0.001^b	0.039±0.002^c
45	0.132±0.006^a	0.126±0.002^a	0.071±0.002^b	0.056±0.006^c
60	0.213±0.001^a	0.205±0.002^a	0.103±0.006^b	0.074±0.002^c
75	0.332±0.002^a	0.307±0.001^a	0.144±0.001^b	0.094±0.001^c
90	0.473±0.001^a	0.434±0.001^a	0.197±0.001^b	0.109±0.002^c

Means with different superscripts within the same row are significantly different (P< 0.05).

The average daily weight gain (ADG):

Table (6) illustrated the changes in the average daily weight gain of prawn reared in tanks under different stocking densities (i.e. 200, 400, 800 and 1200 prawn /m^2). It can be seen from the table that the average daily weight gains at the end of the experimental period were 0.032, 0.029, 0.013 and 0.007g /prawn for stocking densities 200, 400, 800 and 1200 prawn /m^2, respectively. The gain per prawn per day decreased as the stocking density increased. Since the maximum average gain per prawn per day was attained at the stocking density of 200 prawn /m^2. It decreased by increasing the stocking density from 200 to 1200 prawn /m^2. Similar results were obtained by Sadek and Moreou (1996). The statistical analysis showed that there were significant differences among the average daily weight gains of the prawn at the different stocking densities. But the differences were not significant among stocking density 200, 400 and 800 prawn /m^2 on one side and between 800 and 1200 prawn /m^2 on the other side.

Table 6. Effect of different stocking densities in the first experiment on average daily weight gain (ADG) (g/prawn) of *Macrobrachium rosenbergii*, post-larvae (Mean ± SE)

Period(day)	Stocking rate (Prawn / m^2)			
	200	400	800	1200
15	0.0026±0.001^a	0.0025±0.001^a	0.0020±0.006^a	0.0017±0.006^a
30	0.0048±0.006^a	0.0045±0.006^a	0.0032±0.001^a	0.0026±0.001^a
45	0.0090±0.001^a	0.0080±0.002^{ab}	0.0050±0.001^{ab}	0.0040±0.006^b
60	0.014±0.002^a	0.013±0.001^a	0.007±0.001^b	0.005±0.001^b
75	0.022±0.006^a	0.020±0.002^a	0.010±0.001^a	0.006±0.002^a
90	0.032±0.002^a	0.029±0.006^a	0.013±0.001^b	0.007±0.006^c

Means with different superscripts within the same row are significantly different (P< 0.05).

Relative growth rate (RGR) :

Table (7) shows RGR of *M. rosenbergii*-post larvae for all treatments. The results indicated that the RGR of prawn for different stocking densities was initially high and then gradually declined. These results are in agreement with the finding of Al-Farsi (1997), who found that RGR of *Penaeus japonicus* was decreased gradually with time. From data obtained, it could be noticed thate the RGR of *M. rosenbergii*-post larvae varied by varying the stocking density, since the RGR decreased as the stocking density increased (from 200 prawn /m^2 to 400, 800 and 1200 prawn /m^2). It can be seen that the RGR at the end of the experimental period were 57.1, 55.2, 45.1 and 33.1% for stocking densities 200, 400, 800 and 1200 prawn /m^2, respectively. The mean data, showed that there were significant differences between the RGR of the prawn at the different stocking densities. But the difference between stocking density 200 and 400 prawn /m^2 was non significant. This is in full agreement with that found by Marques *et al.* (2000).

Table 7. Effect of different stocking densities in the first experiment on mean relative growth rate (% growth) of *Macrobrachium rosenbergii* , post-larvae (Mean ± SE)

Period (day)	Stocking rate (Prawn / m^2)			
	200	400	800	1200
15	97.5±0.12[a]	95.0±0.17[b]	77.5±0.06[c]	65.0±0.17[d]
30	92.0±0.17[a]	89.7±0.12[b]	67.6±0.12[c]	59.1±0.17[d]
45	86.8±0.06[a]	85.1±0.06[b]	59.7±0.12[c]	53.3±0.17[d]
60	75.0±0.12[a]	74.8±0.17[a]	54.2±0.17[b]	45.9±0.17[c]
75	66.8±0.06[a]	64.1±0.17[a]	49.1±0.12[b]	40.0±0.12[c]
90	57.1±0.12[a]	55.2±0.06[a]	45.1±0.06[b]	33.1±0.06[c]

Means with different superscripts within the same row are significantly different ($P<0.05$).

Specific growth rate (SGR):

The calculation of this parameter (SGR) is useful for comparing growth of prawn of different sizes (Jauncey and Ross, 1982). Changes in SGR value of *M. rosenbergii*-post larvae reared in tanks at different stocking densities were illustrated in Table (8). That SGR of prawn at the end of the experimental period were 3.01, 2.93, 2.48 and 1.91 % day for stocking densities 200, 400, 800 and 1200 prawn /m^2, respectively. The tendency in the SGR of prawn observed in the experimental groups, all over the rearing periods, was coincided with the same trend which was observed in the RGR which previously discussed. Since, the SGR values of prawn were initially high and then gradually declined throughout the experimental period. The statistical analysis demonstrated significant specific growth rate differences between densities, while the difference between stocking density 200 and 400 prawn /m^2 was non significant. This is in agreement with the finding of Niu *et al.* (2003).

A number of possible causes of the reduction of growth in prawn with increasing density have been suggested. These factors may operate singly or simultaneously: Firstly: increasing the density usually exacerbates problems with water quality (Wyban *et al.*, 1988). Secondly: increasing density increases the susceptibility of prawn to disease (Doubrovsky *et al.*, 1988), since, the prawn grows through a series of moltings and during and immediately after molting the prawn is extremely susceptible to physical injury. Thirdly: competition for food may affect the growth at higher densities, as Segal and Roe (1975) who reported deprivation of food to smaller prawn by larger ones when cultured in groups, even if food was given in excess. In addition, in ponds, increasing the density raises pressure on natural food resources (Hopkins *et al.*, 1988) and, as food conversion efficiency is often reduced (Sandifer *et al.*, 1987), the total food costs rise (New, 1987).

Table 8. Effect of different stocking densities in the first experiment on mean specific growth rate (SGR, % /day) of *Macrobrachium rosenbergii*, post-larvae (Mean ± SE)

Period (day)	Stocking rate (Prawn / m^2)			
	200	400	800	1200
15	4.54±0.012[a]	4.54±0.013[a]	3.83±0.017[b]	3.34±0.014[c]
30	4.36±0.005[a]	4.27±0.012[a]	3.44±0.015[b]	3.09±0.017[c]
45	4.16±0.013[a]	4.11±0.017[a]	3.12±0.005[b]	2.85±0.006[c]
60	3.73±0.017[a]	3.72±0.006[a]	2.88±0.013[b]	2.52±0.012[c]
75	3.41±0.004[a]	3.30±0.012[a]	2.67±0.012[b]	2.24±0.013[c]
90	3.01±0.006[a]	2.93±0.005[a]	2.48±0.006[b]	1.91±0.017[c]

Means with different superscripts within the same row are significantly different ($P< 0.05$).

Survival rate (%):

Table (9) represents the changes of the survival rate of *M. rosenbergii* reared in tanks under different stocking densities. It can be seen that final figures of survival rates at the end of the experimental period showed a great differences among all densities, since it ranged between 48.4±0.17 and 81.0 ± 0.12% for all densities. The survival rate of prawn was decreased as the stocking densities increased. Similar results were obtained by Tidwell *et al.* (2004). They showed that the highest rate of survival was recorded at the lowest density. However, in this study, the highest rate of survival was recorded at the lowest density of 200 prawn/m^2 and the lowest at 1200 prawn /m^2. The statistical analysis showed that, there were significant differences in the survival rate among densities (200, 400, 800 and 1200 prawn /m^2). The fourth density (1200 prawn/m^2) characterized by high number of mortalities (low survival % of prawn was about 48.4%). This poor survival % could be attributed to poor conditions of the prawn, especially high stocking density. Increased prevalence of disease has been associated with increased stocking density (Doubrovsky *et al.* 1988), since the prawn grows through a series of molting during or/and after molting, the shrimp is extremely susceptible to physical injury. On the other hand, Segal and Roe (1975) reported that the competition for food on higher densities leads to deprivation of food to smaller prawn by larger ones even if it was given in excess.

Table 9. Effect of different stocking densities in the first experiment on the survival rate (%) of *Macrobrachium rosenbergii*, post-larvae (Mean ± SE)

Period (day)	Stocking rate (Prawn / m^2)			
	200	400	800	1200
15	93.1±0.15[a]	88.2±0.12[b]	77.4±0.12[c]	63.7±0.06[d]
30	90.2±0.04[a]	82.6±0.17[b]	72.3±0.06[c]	59.5±0.13[d]
45	87.5±0.17[a]	79.2±0.05[b]	69.4±0.17[c]	57.6±0.12[d]
60	86.1±0.12[a]	77.8±0.14[b]	67.4±0.05[c]	54.2±0.06[d]
75	84.7±0.06[a]	76.4±0.12[b]	65.3±0.12[c]	52.8±0.12[d]
90	81.0±0.12[a]	72.9±0.06[b]	61.5±0.17[c]	48.4±0.17[d]

Means with different superscripts within the same row are significantly different ($P< 0.05$).

This study demonstrated that *M. rosenbergii*-post-larvae is capable of good growth with high survival when stocked at 200 prawn /m^2 (Table 9). Marques *et al.* (2000) found that, differences in survival among densities (100, 200, 300, 400, 600 and 800 prawn /m^2) were not significant. Differences in prawn growth were significantly higher at 100 and 200 PLs /m^2 densities than the highest one (800PLs

/m^2). They concluded that total biomass was increased significantly higher at densities of 400, 600 and 800 PLs /m^2, when compared to lower ones (100 and 200 PLs /m^2). On the other hand, Wyban *et al.* (1988) found that increased stocking densities up to 100 *P. vannamei* / m^2 did not appear to affect shrimp growth or survival in experimental ponds in South Carolina. They concluded that shrimp production is doubled by increasing stocking density from 45 /m^2 to 100 /m^2.

Feed conversion ratio (FCR):

Table (10) shows feed conversion ratio (FCR) of *M. rosenbergii*-postlarvae reared in tanks under different stocking densities. The food conversion ratios of prawn at the end of the experimental period were 2.85, 2.97, 3.58 and 4.24 for densities 200, 400, 800 and 1200 prawn /m^2, respectively. The mean food conversion ratio of the prawn increased as densities increased, since the FCR achieved in the fourth density was significantly higher than achieved in the first one (being 4.24 and 2.85, respectively). These results are in agreement with those obtained by El-Sherif (2001). He found that mean feed conversion ratio increased as density increased. Also, Siddiqui and Al-Hinty (1993) found that mean feed conversion ratio (with increasing densities of 2, 4, 8 and 16 prawn /m^2) were 2.7, 2.9, 4.0 and 4.4, respectively. While, Willis and Berrigan (1979) reported food conversion ratios of 1.03, 1.31 and 1.45: 1 for densities 5, 10 and 20 /m^2, respectively. It may be assumed that these different values given by different authors are due to the quality of feed used and to other environmental factors.

Table 10. Effect of different stocking densities in the first experiment on the mean feed conversion ratio of *M. rosenbergii*, post-larvae (Mean ± SE)

Period (day)	Stocking rate (Prawn / m^2)			
	200	400	800	1200
15	2.28±o.046 ^{d}	2.34±0.023 ^{c}	3.19±0.052 ^{b}	3.55±0.028^a
30	2.30±0.006 ^{d}	2.38±0.o46 ^{c}	3.26±0.035 ^{b}	3.82±0.012 ^{a}
45	2.26±0.034 ^{d}	2.33±0.017 ^{c}	3.17±0.040 ^{b}	3.53±0.017 ^{a}
60	2.29±0.052 ^{d}	2.37±0.040 ^{c}	3.25±0.029 ^{b}	3.81±0.005 ^{a}
75	2.36±0.035 ^{d}	2.45±0.028 ^{c}	3.34±0.023 ^{b}	4.10±0.011 ^{a}
90	2.85±0.029 ^{d}	2.97±0.012 ^{c}	3.58±0.046 ^{b}	4.24±0.023 ^{a}

Means with different superscripts within the same row are significantly different (P< 0.05).

Experiment 2:

Mean individual weights:

It was observed from Table (11) that the initial average weight of juvenile at the beginning of the experiment was 0.30 ± 0.02g for all densities. The finial average body weights at the end of the experimental period showed great differences between different stocking densities, since it was decreased at high stocking density. The stocking density 50 prawn /m^2 showed the highest body weight (3.47g /juvenile) followed by the stocking of 100 prawn /m^2 (3.23g /juvenile), then stocking density of 150 prawn / m^2 (2.64g /juvenile), finaly stocking density of 200 prawn /m^2 (1.48g /juvenile). From these results, it could be noticed that the average individual weight of prawn observed in the experimental groups was found to be inversely related to stocking density. This is in agreement with the findings of Tidwell *et al.* (2004). They reported that lower stocking density gave relatively the highest growth. On the other hand, Wyban *et al.* (1987) found that individual body weights for marine shrimp

Penaeus vannamei were 18.1, 17.1, 12.4 and 8.7g for stocking densities 5, 10, 15 and 20 shrimp /m^2, respectively. The statistical analysis indicated that the differences among the mean weight of the prawn obtained from the stocking density of 50, 100, 150 and 200 prawn /m^2 were significant (P ≤ 0.05). But the difference was not significant between stocking rates of 50 and 100 prawn /m^2.

Table 11. Effect of different stocking densities in the second experiment on mean individual weight (g) of *M. rosenbergii*, juvenile (Mean ± SE)

Period (day)	**Stocking rate (Prawn / m^2)**			
	50	**100**	**150**	**200**
At-stocking	0.30±0.02	0.30±0.02	0.30±0.02	0.30±0.02
15	0.56±0.012 ^{a}	0.55±0.017 ^{a}	0.50±0.014 ^{b}	0.42±0.013 ^{c}
30	0.97±0.011 ^{a}	0.92±0.012 ^{a}	0.79±0.023^b	0.57±0.025 ^{c}
45	1.52±0.023 ^{a}	1.42±0.021 ^{a}	1.17±0.017^b	0.74±0.012 ^{c}
60	2.10±0.013 ^{a}	1.96±0.170 ^{b}	1.61±0.022 ^{c}	0.96±0.017 ^{d}
75	2.78±0.025 ^{a}	2.59±0.020 ^{a}	2.12±0.011 ^{b}	1.21±0.006^c
90	3.47±0.014^a	3.23±0.012 ^{a}	2.64±0.018 ^{b}	1.48±0.023 ^{c}

Means with different superscripts within the same row are significantly different (P<0.05).

Mean weight gain:

Table (12) illustrates the mean weight gain at 15 days intervals for all the stocking densities. The average weight gains were 0.69, 0.64, 0.52 and 0.27 g/prawn at the end of the experimental period for the stocking densities 50, 100, 150 and 200 prawn /m^2, respectively. The data also indicated that the mean weight gain sharply decreased with increasing stocking densities. Such results have been confirmed by El-Sherif (2001). The statistical analysis indicated that there were significant (P ≤ 0.05) differences among the stocking densities, but not between 50 and 100 prawn/m^2.

Table 12. Effect of different stocking densities in the second experiment on mean weight gain (g /individual prawn /15 days) of *M. rosenbergii,* juvenile (Mean±SE)

Period(day)	Stocking rate (Prawn / m^2)			
	50	100	150	200
15	0.26±0.012 ^{a}	0.25±0.011 ^{a}	0.18±0.006 ^{b}	0.12±0.014 ^{c}
30	0.41±0.017 ^{a}	0.37±0.022 ^{a}	0.29±0.015 ^{b}	0.15±0.006 ^{c}
45	0.55±0.023 ^{a}	0.50±0.005 ^{a}	0.38±0.020 ^{b}	0.18±0.017 ^{c}
60	0.58±0.012 ^{a}	0.54±0.014^a	0.44±0.011^b	0.22±0.015^c
75	0.68±0.015 ^{a}	0.63±0.021 ^{a}	0.51±0.005 ^{b}	0.25±0.052 ^{c}
90	0.69±0.011^a	0.64±0.013 ^{a}	0.52±0.023 ^{b}	0.27±0.015 ^{c}

Means with different superscripts within the same row are significantly different (P<0.05).

Average daily weight gain:

Table (13) represents the changes of the average daily weight gain of M. *rosenbergii*-juveniles reared at different stocking densities. It can be seen from that the averages of weight gains /prawn /day were 0.017, 0.016, 0.012 and 0.008g for stocking densities 50, 100, 150 and 200 prawn /m^2, respectively during the first period (15 days). At the end of the experimental period, the data indicated that, the average daily weight gain of prawn reached its maximum of 0.046, 0.043, 0.035 and 0.018g, respectively. It can be seen that there were differences in the average daily weight gain of prawn at different stocking densities. The gain per prawn per day decreased as the stocking density increased. Similar results were obtained by Zaki and Abdel-Halim (1997). The statistical analysis showed that there were significant differences among the average daily weight gain of the prawn at different stocking density. But the difference was not significant between stocking density of 50 and 100 prawn /m^2.

Table 13. Effect of different stocking densities in the second experiment on the average daily weight gain (g /day) of *M. rosenbergii*, juvenile (Mean ± SE)

Period (day)	Stocking rate (Prawn / m^2)			
	50	100	150	200
15	0.017±0.001 ^{a}	0.016±0.003 ^{a}	0.012±0.006 ^{b}	0.008±0.005 ^{c}
30	0.027±0.005 ^{a}	0.024±0.001 ^{a}	0.019±0.003 ^{b}	0.010±0.002 ^{c}
45	0.036±0.002 ^{a}	0.033±0.013 ^{a}	0.025±0.012 ^{b}	0.012±0.013 ^{c}
60	0.039±0.011 ^{a}	0.036±0.005 ^{a}	0.029±0.011 ^{b}	0.015±0.006 ^{c}
75	0.045±0.013 ^{a}	0.042±0.012 ^{a}	0.034±0.002 ^{b}	0.017±0.013 ^{c}
90	0.046±0.006^a	0.043±0.011^a	0.035±0.004^b	0.018±0.012^c

Means with different superscripts within the same row are significantly different ($P< 0.05$).

Relative growth rate (RGR):

Results concerning the RGR are illustrated in Table (14). It can be seen that the percentages in weight gain of prawn or the stocking densities 50, 100, 150 and 200 prawn /m^2 were 86.66, 83.33, 60.00 and 40.00%, respectively during the first rearing period. Thereafter, the weight gain percentage of prawn being gradually decreased by time. Similar results were obtained by Al-Farsi (1997) who indicated that the RGR of shrimp (*P. japonicus*-juvenile) was initially high and then gradually declined. From data obtained, it could be noticed that the RGR of *M. rosenbergii*-juvenile varied by varying the stocking density, since the RGR decreases as the stocking density increased (50, 100, 150 and 200 prawn /m^2). It can be seen from the table that the RGR at the end of the experimental period was decreased (24.82, 24.71, 24.25 and 22.31%) by increasing stocking densities from 50, 100, 150 to 200 prawn /m^2, respectively. The statistical analysis showed that the differences among the stocking densities were significant. But the difference between stocking density 50 and 100 prawn / m^2 was not significant. This is in full agreement with that found by Tidwell *et al.* (2003).

Table 14. Effect of different stocking densities in the second experiment on mean relative growth rate (% growth) of *M. rosenbergii*, juvenile (Mean ± SE)

Period (day)	**Stocking rate (Prawn / m^2)**			
	50	**100**	**150**	**200**
15	86.66± 0.12^a	83.33±0.17^b	60.00±0.01^c	40.00±0.03^d
30	73.21±0.14 ^{a}	67.27±0.05 ^{b}	58.00±0.17 ^{c}	37.50±0.12 ^{d}
45	56.70±0.05 ^{a}	54.35±0.13 ^{a}	48.10±0.14 ^{b}	31.57±0.17 ^{c}
60	38.16±0.17 ^{a}	38.03±0.11 ^{a}	37.61±0.15 ^{b}	29.72±0.05 ^{c}
75	32.38±0.17 ^{a}	32.14±0.02 ^{a}	31.67±0.06 ^{b}	26.04±0.01 ^{c}
90	24.82±0.11 ^{a}	24.71±0.06 ^{a}	24.25±0.04 ^{b}	22.31±0.02 ^{c}

Means with different superscripts within the same row are significantly different ($P< 0.05$).

Specific growth rate "SGR" :

Table (15) illustrates the changes in the SGR of M. *rosenbergii*- juveniles under different treatments. The tendency in the SGR of prawn observed in the experimental groups, all over the periods of rearing, was coincided with the same trend which was observed in the RGR which previously discussed. Since, the SGR values of prawn in all treatments were initially high and then gradually declined throughout the experimental period of 90 days. In the same time, the SGR of prawn varied by varying the treatments. The results show that the SGR of prawn at the end of the experimental period were decreased (1.48, 1.47, 1.46 and 1.34%/ day) for stocking densities 50, 100, 150 and 200 prawn /m^2, respectively. The statistical analysis showed that the differences among the stocking densities on the specific growth rates of prawn were significant (P<0.05). But the differences between stocking densities 50 and 100 prawn /m^2 were not significant. Similar results was obtained by Tidwell *et al.* (2004).

Table 15. Effect of different stocking densities in the second experiment on mean specific growth rate (%/day) of *M. rosenbergii*, juvenile (Mean ± SE)

Period (day)	Stocking rate (Prawn / m^2)			
	50	100	150	200
15	4.16±0.011^a	4.04±0.006^b	3.13±0.004^c	2.24±0.025^d
30	3.66±0.017^a	3.43±0.013^b	3.05±0.021^c	2.04±0.017^d
45	3.12±0.005^a	2.89±0.018^b	2.62±0.035^c	1.74±0.012^d
60	2.15±0.012^a	2.14±0.015^a	2.12±0.018^a	1.73±0.018^b
75	1.87±0.017^a	1.85±0.020^a	1.83±0.012^a	1.54±0.005^b
90	1.48±0.005^a	1.47±0.011^a	1.46±0.017^a	1.34±0.013^b

Means with different superscripts within the same row are significantly different (P< 0.05)

Survival rate (%) :

Table (16) shows the survival rate of *M. rosenbergii*-juveniles reared in tanks under different stocking densities. The survival rates of prawn during the experimental period were high at all densities. This is mainly due to: Firstly: the acclimation of the prawn prior to the start of stocking in tanks. Secondly: this experiment started with *M. rosenbergii*-juveniles of an initial average weight 0.3g, such size shows high tolerance to the unfavorable conditions (Zaki and Abdel-Halim, 1997). Thirdly: the ecological conditions throughout the experimental period were suitable for prawn rearing, especially the average water temperatures (which ranged between 27.6 and 26.5^{o}C), since Marques *et al.*, 2000 noted that optimal water temperatures for optimum growth and survival of *M. rosenbergii* are 26-31^{o}C. The results showed that the survival % of prawn were decreased (72.2, 69.4, 62.9 and 51.4%) for stocking densities 50, 100, 150 and 200 prawn /m^2, respectively at the end of the experimental period. These results indicated that the survival % decreased with increasing of the stocking density. This is in full agreement with the results reported before by Tidwell *et al.* (2003 & 2004). On the other hand, Gopal Rao *et al.* (1986) found that the survival rates of *M. malcolmsonii* in ponds ranged from 44.2 to 57.2% for the 390 days grow out period. Low survival was due to algal blooms of *Spirogyra sp.* and *Euglena sp.*, which led to depletion of dissolved oxygen and consequent by ecological imbalance. Wyban *et al.* (1987) showed that the survival rate of shrimp (*Penaeus vannamei*) averaged 70.8 ± 6.3% and there were no significant differences among densities (5, 10, 15 and 20 shrimp/m^2). The statistical analysis showed that significant differences in survival % were observed among the densities, while the difference between stocking density 50 and 100 prawn/m^2 was non significant.

Table 16. Effect of different stocking densities on survival rate (%) of *M. rosenbergii*, juvenile (Mean ± SE)

Period (day)	Stocking rate (Prawn / m²)			
	50	100	150	200
15	89.0±0.115[a]	86.1±0.112[a]	79.6±0.123[b]	66.6±0.152[c]
30	83.3±0.120[a]	80.6±0.170[a]	74.1±0.057[b]	61.1±0.116[c]
45	82.0±0.057[a]	78.2±0.120[a]	72.2±0.174[b]	59.7±0.231[c]
60	81.2±0.110[a]	77.7±0.231[a]	70.4±0.115[b]	56.9±0.211[c]
75	77.7±0.173[a]	75.0±0.017[a]	66.6±0.180[b]	54.2±0.059[c]
90	72.2±0.116[a]	69.4±0.123[a]	62.9±0.113[b]	51.4±0.173[c]

Means with different superscripts within the same row are significantly different ($P<0.05$).

Feed conversion ratio (FCR):

Data concerning the feed conversion ratio of *M. rosenbergii*-juveniles reared in tanks under different stocking densities were illustrated in Table (17). Feed conversion was increased (3.19, 3.32, 4.63 and 5.80) for stocking densities 50, 100, 150 and 200 prawn /m^2, respectively (i.e. feed conversion ratio of prawn increased as densities increased). Such results coincide with those of Tidwell *et al.* (2004).

Table 17. Effect of different stocking densities in the second experiment on mean feed conversion ratio of *M. rosenbergii*, juvenile (Mean ± SE)

Period (day)	Stocking rate (Prawn / m²)			
	50	100	150	200
15	2.37±0.040[c]	2.43±0.017[c]	3.49±0.051[b]	4.02±0.011[a]
30	2.39±0.337[c]	2.46±0.035[c]	3.53±0.017[b]	4.12±0.012[a]
45	2.35±0.028[c]	2.42±0.011[c]	3.47±0.040[b]	3.94±0.023[a]
60	3.38±0.046[c]	2.45±0.029[c]	3.51±0.005[b]	4.16±0.035[a]
75	2.46±0.034[c]	2.51±0.006[c]	3.56±0.028[b]	4.35±0.023[a]
90	3.19±0.052[d]	3.32±0.012[c]	4.63±0.017[b]	5.80±9.006[a]

Means with different superscripts within the same row are significantly different ($P< 0.05$).

Chemical composition of prawn tissue:

Table (18) showed that protein content and ash content increased with increasing stocking densities, while fat content decreased as the stocking densities increased. However, the differences were not significant in crude protein, ether extract and ash among carcasses of all stocking density groups. These results are in agreement with those obtained by Zaki and Abdel-Halim (1997), who found that the dry matter content of prawn bodies was 25.18–26.47%, the crude protein was 53.83–57.54%, ether extract was 5.41–5.81% and ash content was 18.69–20.56% for the juvenile *M. rosenbergii* (on dry matter basis). Also, El-Sherif (2001) revealed that dry matter contents had ranged between 23.81 and 24.33% and differences due to stocking density (25 and 50L/L) were insignificant for the juvenile *M. rosenbergii.* On the other hand, Alava and Pascual (1987) and Sarac *et al.* (1994) found that the crude protein content of dry prawn bodies was 61.8–75.8% for the juvenile *Penaeus monodon* and 62.1 – 67.8% for the juvenile *Metapenaeus monoceros*, respectively. The differences in body composition could be attributed to several factors such as variations in species, age, molting cycle and available nutrients in diets.

Table 18. Chemical composition (on dry matter basis%) of whole body of *M. rosenbergii*-juvenile in the second experiment reared at different densities for 90 days

Stocking rate (Prawn/m^2)	DM	CP	EE	Ash	Rest
50	26.2±0.1[a]	55.3±0.01[a]	5.6 ± 0.0[a]	20.5±0.01[a]	18.6±0.2[a]
100	25.9±0.0[a]	55.6±0.2[a]	5.3 ± 0.1[a]	20.9± 0.05[a]	18.2±0.0[a]
150	25.5±0.01[ab]	55.9±0.04[a]	5.2 ± 0.4[a]	21.3 ± 0.1[a]	17.6±0.2[b]
200	25.2±0.02[b]	56.2±0.5[a]	4.8 ± 0.01[a]	21.5 ± 0.0[a]	17.5±0.1[b]

Means with different superscripts within the same column are significantly different at ($P \leq 0.05$).
DM= Dry Matter (%), CP= Crude Protein (%), EE= Ether Extract (%).

CONCLUSION

It could be concluded from the previous results that stoking density of fresh water brawn *(M.rosenbergii)* juveniles (average weight 0.3g) were more suitable for monoculture than postlarvae (average weight 0.04). Increasing stoking density of either postlarvae or juveniles resulted lower growth performance, survival rate and feed utilization.

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تأثير كثافة التخزين والوزن المبدئى على أداء النمو للطور اليافع وطور ما بعد اليرقة لجمبرى المياه العذبة

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استهدفت هذه الدراسة تربية طور ما بعد اليرقة لجمبرى المياه العذبة (تجربة ١) بمتوسط وزن (٠.٠٠٤ ± ٠.٠٠١جم) وذلك فى أربع كثافات تخزينية (٢٠٠– ٤٠٠– ٨٠٠– ١٢٠٠جمبرى/م٢– فى ثلاث مكررات لكل كثافة) باستخدام ١٢ حوض دائرى فيبرجلاس (٠.٣٦م٢– وعمق ٠.٦م). إستمرت التجربة لمدة ٩٠ يوماً مع التغذية على عليقة متوازنة ومصنعة تحتوى على ٣٥٪ بروتين. تم عمل التحاليل الفيزوكيمائية لمياه الأحواض مع تغيير ٢٠٪ منها يومياً– كما تم تقدير قياسات أداء النمو المختلفة كل أسبوعين خلال فترة التجربة.

وقد أوضحت نتائج التجربة الأولى أن معدل النمو انخفض معنوياً ($P\leq0.05$) بزيادة الكثافة التخزينية للجمبرى– كما أن معدل البقاء أظهر علاقة عكسية مع الكثافات التخزينية المختلفة حيث كانت الفروق بمعنوية عالية. وقد زاد معامل تحويل الغذاء (FCR) بزيادة كثافة التخزين وكانت الفروق معنوية بين الكثافات الأربع.

كما تم رعاية الطور اليافع لجمبرى المياه العذبة (تجربة ٢) بمتوسط وزن (٠.٣ ± ٠.٠٠٢جم) لمدة ٩٠ يوماً بكثافات تخزينية مختلفة (٥٠– ١٠٠– ١٥٠– ٢٠٠ جمبرى/ م٢– فى ثلاث مكررات لكل كثافة) مع استخدام نفس مواصفات تجربة (١) وكانت النتائج كما يلى:

(١) انخفاض معدل النمو معنوياً ($P\leq0.05$) بزيادة الكثافة التخزينية للجمبرى.

(٢) معدل البقاء للجمبرى كان على علاقة عكسية مع الكثافات التخزينية المستخدمة.

(٣) زيادة معامل تحويل الغذاء (FCR) بزيادة كثافة التخزين.

(٤) بزيادة الكثافة التخزينية زاد كل من المحتوى البروتينى ورماد الجسم بينما قل كل من الدهن والمادة الجافة لجسم الجمبرى– وكانت الفروق غير معنوية فى كل الأحوال.

وعلى ذلك يمكن التوصية بتطبيق الإستزراع المنفرد لكل من الطور اليافع لجمبرى المياه العذبة (بمتوسط وزن ٠.٣ جم& كثافة تخزينية ٥٠ جمبرى /م٢) وطور ما بعد اليرقة (بمتوسط وزن ٠.٠٠٤ جم & كثافة تخزينية ٢٠٠ جمبرى /م٢) للحصول على أعلى معدلات للنمو والبقاء.