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EFFECT OF STOCKING DENSITY ON SURVIVAL, GROWTH PERFORMANCE, FEED UTILIZATION AND PRODUCTION OF MARINE SHRIMP *PENAEUS SEMISULCATUS* IN EARTHEN PONDS

ZAKI, M. A.[1*], A. A. NOUR[2], M. M. ABDEL-RAHIM[3] AND T. M. SROUR[4]

[1]Animal and Fish Production Dept., Faculty of Agricu., Alex. Univ., Alex., Egypt..
[2]Animal production Dept., Faculty of Agric.,(Damanhour) Alex., Univ., Egypt.
[3]Marine Hatchery, General Authority for Fish Resources Development Km21, Alex., Egypt.
[4]Animal and Fish Production Dept., Faculty of Agric., (Saba-Basha), Alex. Univ., Alex., Egypt

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ABSTRACT

Marine shrimp *Penaeus semisulcatus* juveniles with an average weight of 2.4 gm were stocked at 3, 6, 9, 12, and 15 pcs/m^2 in ten outdoor earthen ponds (each 4000 m^2 area and 80 cm depth). Juveniles were fed for 16 weeks on two experimental diets containing 52 and 42 % dietary protein for the first 8 weeks and the next 8 weeks, respectively.

Growth performance of the experimental shrimp was improved by decreasing stocking density.

The average final weights were 18.53, 16.97, 15.98, 15.35, and 15.04 gm for shrimp stocked at 3, 6, 9, 12, and 15 pcs/ m^2, respectively. The significant difference ($P \leq 0.05$) of gain, average daily gain (ADG) and specific growth rate (SGR %) were observed for shrimp stocked at 3 pcs/m^2 grew significantly ($P \leq 0.05$). However, no significant differences were showed among growth of shrimp stocked at 9, 12, and 15 pcs/m^2 respectively. Feed conversion ratio (FCR) was increased significantly ($P \leq 0.05$) by increasing the stocking density. Values of protein efficiency ratio (PER), protein productive value (PPV %) and energy utilization ($P \leq 0.05$) decreased significantly by increasing the stocking density of marine shrimp. Production of cultured shrimp increased significantly ($P \leq 0.05$) (497.8, 865.2, 1178.4, 1435.9, and 1638.0 kg/ ha) with an increase in stocking density 3, 6, 9, 12, and 15 pcs/m^2, respectively. Finally it could be concluded that growth performance of marine shrimp *Penaeus semisulcatus* decreased with increasing stoking density otherwise, the production increased.

INTRODUCTION

Increasing stocking density of fish and shrimp in ponds usually increases the deterioration of pond sediment (Blackburn *et al*., 1988; Garnier and Barillier, 1991 and Ray and Chien, 1992), increases the susceptibility of prawns to disease (Hanson and Goodwin, 1977; Baticados *et al*., 1986 and Doubrovsky *et al*., 1988), decreases growth of shrimp (Sandifier *et al*., 1987; Ray and Chien, 1992; Daniels *et al*., 1995 and Palomino *et al.*, 2002), increases pressure on natural food resources (Hopkins *et al*. and 1988; Allan and Maguire, 1992a), reduces food conversion efficiency (Sandifier *et al*., 1987 and Martin *et al*., 1998), and rises the total food costs (New, 1987).

Optimum returns and profits for using the highest stocking density are relative survival and growth rates (Hanson and Goodwin, 1977), yield, farm size, and market price (Hardman *et al*., 1991). Unfortunately, there are no articles discussing the grow-out of *P. semisulcatus*, and the available research discussed only brood-stock management,

* Corresponding author

larval rearing (Jackson *et al.*, 1992 and Kumlu *et al.*, 2000), and nursing (Issar *et al.*, 1987 and Seidman and Issar, 1988). The present work aimed to investigate the suitable stocking rate of *P.semisulcatus* regarding growth parameters, survival, production and chemical composition of shrimp (*Penaeus semisulcatus*).

MATERIALS AND METHODS

Experimental Facilities:

This experiment was conducted in 10 earthen ponds (each of 4000m^2 water area) in Shrimp and Fish International Company (SAFI Co.), Sharm El Sheikh, South Sinai, Egypt, for 16 weeks. Each pond was supported with two inlet water pipes (4 inches) and one discharge pipe (8 inches). Every pond was supported with two paddle wheels. The fresh marine water with salinity of 40 ppt was obtained from the Red Sea using 50 horsepower water pumps**.**

Pond Preparation and Shrimp Stocking:

Ponds were prepared for stocking juvenile shrimp with organic fertilizers (shrimp meal and soybean meal) at 50 kg/fed. to improve the natural productivity. Initial chemical fertilizers were added after 2 – 3 days including 25 kg urea/fed., 0.8 L phosphoric acid/fed. and 14 kg/fed sodium silicate (100 % conc.). Shrimp with an average weight of 2.4 gm / animal were stocked in 10 grow-out earthen ponds at five stocking densities (3, 6, 9, 12, and 15 pcs/m^2). Shrimp were obtained from the hatchery of the same farm (SAFI Co.). Shrimp were stocked in hapa nets 4 x 4m for 12 hrs. to estimate the mortality rate and re-estimate the actual densities.

Experimental Management:

Shrimp were fed on the home-made feeds produced in the farm using wet extruder. Two diets were used in the present experiment, the first diet containing 52% protein and offered to shrimp during the first 8 weeks after stocking. The second diet containing 42% protein as an original diet and offered to shrimp during the last 8 weeks of the experiment. Feed ingredients and chemical composition of the two tested diets are shown in Table 1.The *ad libitum* feeding method was applied by using feeding nets. Half of the daily feeds were offered in the feeding trays and the rest were distributed on 50% of the pond area by hand. The feeding frequency was 3, 4 and 3 meals per day during weeks 1-4, 5-12 and 13-16, respectively (the same for all stocking densities).

Daily water exchanges rates were 5, 10, 12.5, and 12.5% during weeks 1-4, 5-8, 9-12 and 13-16, respectively. Water exchange rate adjustment was obtained by decreasing water level to the accurate height and then re-compensating the water volume except during the molting period. Operational water column in all ponds was 120 cm. At least 60% of the daily water exchange occurred at night. The location of paddle-wheels was changed every month to reduce the un-aerobic area after checking the bottom quality by diving. Paddle-wheels were operated 8, 10, 12, and 14 hrs per day during weeks 1-4,5-8,9-12 and 13-16, respectively.

Table (1): Feed ingredients and chemical composition of the experimental diets used for feeding marine shrimp (*Penaeus semisulcatus*) under five stocking densities.

Item	Diets No.	
	1	2
Ingredient (%):		
Wheat flour	20	22.0
Soy bean meal	5	5
Yeast	1.2	1.2
Fish meal (Herring 72%)	51.2	40
Shrimp meal	16	25.2
Dun fat[1]	2.5	2.5
Cod liver oil	0.5	0.5
Gelatin as a binder	1.5	1.5
Soya lecithin	1	1
Biogen[2]	0.3	0.3
Amino- vita sol[3]	0.3	0.3
Potassium phosphate	0.5	0.5
Chemical composition (%), on dry matter basis:		
Dry matter	90.50	92.60
Crude protein	51.95	42.87
Ether extract	9.10	9.12
Crude fiber	0.53	0.38
Ash	6.53	6.92
Nitrogen free extract	31.89	40.71
Gross energy (kcal/100g) [4]	509.97	495.20
P/E Ratio (mg protein/Kcal)	101.87	86.57

[1]Dunafat is marine powdered lipid.
[2] Biogen used composed of allicin 0.247 micromillgram, high- unit hydrolytic enzyme 3690 units/gm, Bacillus subtilis Nato 6 x10^7 cells 1 gm, and Ginseng extract.
[3] Amino- vitasol is a product composed of amino acids, vitamins and minerals.
[4]Gross energy, calculated on the basis of 5.64, 4.11 and 9.44 Kcal GE/g protein, NFE and lipid, respectively (NRC, 1993).

Shrimp were harvested at night by catching nets, (8 m width and 2 m height). Shrimp were starved for 24 hrs. at least before harvesting. The harvested shrimp was subjected directly to chilled water containing sodium meta-bisulphate to kill shrimp during 30 seconds only as a result of decreasing water content of oxygen until 0.2-0.0 ppm.

Zoo- technical methods:

Bi-weekly samples of the grown shrimp (60 pcs at least) were caught from each pond to estimate the periodical growth performance and the total biomass. At the end of the experiment, large sample of shrimp around 500 pcs was taken to estimate the actual final weight of shrimp. The total biomass of shrimp was calculated and the final survival rates were estimated.

The other parameters such as, average daily gain, specific growth rates, final biomass of shrimp (gm/m^2), production and feed conversion ratio (FCR) were calculated. Another parameter used to judge the quality of produced shrimp was length-weight relationship or condition factor. A sample of 100 pcs shrimp from each hapa (50 males and

50 females) was used to measure the weight and length of the produced shrimp. The length-weight relationship was drawn depending on the best equation shown by the SPSS program. Also, the minimum, maximum, and average values for condition factor for males and females were calculated.

Samples from shrimp at the end of the experiment and stocked fry each were used to perform chemical analysis. Chemical analysis of feeds and shrimp was conducted according to AOAC (1990) methods.

Water quality parameters were measured for all ponds. Dissolved oxygen and water temperature were measured daily using oxygen meter YSI 57. pH values were measured daily at 4 pm using pinpoint PH meter. Un-ionized ammonia was measured daily at 11:00 am using HACH DR 890 (colorimeter).

Statistical Analysis:

The results of final weight, weight gain, ADG, SGR, survival, production, FCR, protein gain, protein productive value, protein efficiency rate, fat gain, energy gain, and energy utilization were subjected to one-way analyses of variance using the software package (SPSS 10). The significant differences among treatments (3, 6, 9, 12, and 15 pcs of shrimp/m^2) were performed using the LSD test at a level of $P \leq 0.05$ significance according to Steel and Torrie (1980). The statistical software program (SPSS 10) was used to define the best equation to express the length-weight relationship.

RESULTS AND DISCUSSION

Water Quality Parameters:

Mean values of water temperature, dissolved oxygen, pH, and un-ionized ammonia are presented in Table 2. Mean value of water temperature was 24.6 ^oC at 6 Pm and 23.51^o C at 6 am with no significant differences among stocking densities ($P \geq 0.05$). These values of water temperature were less than the recommended value (30 ^oC) for rearing larvae of *P. semisulcatus* (Jackson *et al*., 1992; Rothlisberg, 1998 and Kumlu *et al*., 2000). O' Brien (1994) found that *P. esculentus* grew faster at 30 ^oC compared with 24 ^oC. Wu and Dong (2002) found that the intermolt period was significantly prolonged at two lower temperatures (18 and 22 ^oC), than at two higher temperatures (26 and 30^oC).

Mean values of dissolved oxygen (DO_2) were 7.79 ppm at 6 pm and 6.01 ppm at 6 am with significant ($P \leq 0.05$) differences among stocking densities in the morning and afternoon, respectively. The recorded values of DO_2 were within the good range for all the aquatic organisms (Vernberg, 1983 and Rosas *et al*., 1997).

Low dissolved oxygen values may occur in ponds stocked with high densities (Allan and Maguire, 1992a). Oxygen concentration below 2 ppm reduced significantly ($P \leq 0.05$) growth and survival of Penaeid for small sizes (0.2-0.5 gm) (Sediman and Lawrence, 1985). Decreasing dissolved oxygen than 4.5 ppm, might decrease the metabolic potential (lower growth and /or lower activity level), and lower the ability to respond to the pathogenic organisms (Le Blanc and Overstreet, 1991).

Values of pH in the present study were within the preferable range with no significant differences among densities. Ray and Chien (1992) found that pH had negative correlation with stocking density and time. Alexander (1977) mentioned that under an aerobic condition, the intermediate products from carbohydrate catabolism were organic acids such as formic, acetic, propionic, and butyric acids.Mean values of un-ionized ammonia are presented in Table 2, with significant ($P \leq 0.05$) differences between 3 and 6 pcs/m^2 on one side and 9, 12, and 15 pcs/m^2 on the other side. However, the recorded values of ammonia were less than the lethal limit (LC_{50}) for *P. semisulcatus* that was 0.22 ppm (Wickins, 1976). Increasing stocking density increased significantly the concentration of ammonia (Allan and Maguir, 1992b; Johnston *et al*., 2000 and Palomino *et al*., 2002).

Table (2): Water temperature, dissolved oxygen, pH and un-ionized ammonia for earthen grow-out ponds stocked with marine shrimp (*Penaeus semisulcatus*) at different stocking densities.

Time of measuring	Stocking density (pcs/m²)					Average [1]
	3	6	9	12	15	
	Water temperatures (°C)					
6 pm	24.45 [a] ± 1.22	24.48 [a] ± 1.20	24.63 [a] ± 1.19	24.68 [a] ±1.17	24.76 [a] ± 1.18	24.60 [a] ± 0.50
6 am	23.23 [a] ± 1.23	23.31 [a] ± 1.22	23.51 [a] ± 1.22	23.65 [a] ± 1.19	23.84 [a] ±1.20	23.51 [b] ± 0.52
Mean	23.84 [a] ±1.18	23.40 [a] ± 1.07	24.07 [a] ± 1.12	24.17 [a] ±1.12	24.30 [a] ± 1.16	24.06± 0.61
	Dissolved oxygen (ppm)					
6 pm	7.98 [a] ± 0.28	7.89 [ab] ± 0.25	7.80 [b] ± 0.27	7.67 [b] ± 0.30	7.61 [b] ± 0.31	7.79 [a] ± 0.12
6 am	6.46 [a] ± 0.16	6.24 [ab] ± 0.18	5.95 [b] ± 0.20	5 .78 [b] ± 0.21[b]	5.64 [b] ± 0.24	6.01 [b] ± 0.09
Mean	7.22 [a] ± 0.20	7.07 [a] ± 0.27	6.88 [ab] ± 0.23	6.73 [b] ± 0.26	6.63 [b] ± 0.28	6.90±0.15
	PH					
6 pm	8.61 [a] ± 0.03	8.57 [a] ± 0.03	8.55 [a] ± 0.03	8.52 [a] ± 0.03	8.50 [a] ± 0.03	8.55 [a] ± 0.01
6 am	8.44 [a] ± 0.03	8.43 [a] ± 0.03	8.39 [a] ± 0.02	8.37 [a] ± 0.02	8.36 [a] ± 0.02	8.40 [b] ± 0.01
Mean	8.53 [a] ± 0.03	8.51 [a] ± 0.02	8.47 [a] ± 0.02	8.45 [a] ± 0.02	8.43 [a] ± 0.02	8.48± 0.01
	Un- ionized ammonia (NH_3) ppm [2]					
6 am	0.016 [b] ± 0.005	0.023 [b] ± 0.003 [b]	0.037 [a] ± 0.008	0.041 [a] ± 0.009	0.053 [a] ± 0.008	0.034 ± 0.005

Means (± S.E) in the same row with different superscripts are significantly different ($p \leq 0.05$).
[1] Means (± SE) in this column having the same superscript are not significantly different ($p \geq 0.05$).
Values represent means of 20 readings (2 readings x 5 weeks x 2 replicates)
[2] Values represent means of 10 readings (1 reading x 5 weeks x 2 replicates)

Growth Performance:

The bi-weekly growth parameters of marine shrimp (*Penaeus Semisulcatus*) under five stocking densities are given in (Table 3 and Fig.1) for gain , average daily gain ADG (mg/pce/day), and specific growth rate (SGR %), respectively. The data noticed that growth performance was improved by decreasing the density of shrimp. That is a logical result (Allan and Maguire, 1992b; Ray and Chien, 1992 and Palomino *et al.*, 2002). Lee and Shleser (1984) reported that live weight and growth curves were strongly affected by stocking density for. Lanari *et al.*, (1989) revealed that both low stocking density and water exchange rate delayed the inflection point of the curves, indicating a higher food availability and better water quality, the data in the present study showed the same trend.

The results of the effect of stocking density of marine shrimp on the final weight, ADG, and SGR at five stocking densities are presented in Table 3 and Fig.1. The average final body weights of shrimp were 18.53, 16.97, 15.98, 15.35, and 15.04 gm/pce at density of 3, 6, 9, 12, and 15 pcs/ m^2, respectively. Significant ($P \leq 0.05$) differences were detected among the tested densities. The average daily gains (ADG) of shrimp were 141.5, 127.8, 119.1, 113.6, and 110.9 (mg/ pce/ day) at 3.6.9.12.and 15 pcs/ m^2, respectively with significant differences ($P \leq 0.05$) among densities. Values of SGR % were 1.8, 1.72, 1.67, 1.63, and 1.61 (% / day) at 3, 6, 9, 12, and 15 pcs/m^2, respectively with significant differences among densities ($P \leq 0.05$).

Analyses of variance of growth parameters (gain, ADG, and SGR) showed that the growth rate at density of 3 pcs of shrimp/m^2 was significantly higher ($P \leq 0.05$) than the rest densities. While, no significant differences were detected among the densities of 9, 12, and15 pcs/m^2 ($P \geq 0.05$).

Growth of penaeid shrimps declined and yield increased as density increased (Apud *et al.*, 1981; Maguire and Leedow, 1983; Sandifer *et al.*, 1987 and Wyban *et al.*, 1987). Reduced growth of shrimp at higher densities attributes mainly to reducing grazing activity in ponds (Hanson and Goodwin, 1977; Maguire and Leedow, 1983 and Allan and Maguire, 1992b).

The optimum stocking density will depend upon the area of the pond, the required harvesting size of shrimp, and the number of crops per year where the farmer intends to grow with the best economic returns (Kungvankij and Chua, 1986 and Treadwell *et al.*, 1991). The normal stocking density used in different culture systems differs according to cultured shrimp species (Kungvankij and Chua, 1986) and culture conditions (water exchange, feed quality, number of paddle-wheels used….etc.).

Table (3): Effect of different stocking densities (3, 6, 9, 12, and 15 pcs/m2) on growth performance of marine shrimp (*Penaeus semisulcatus*) reared in earthen grow- out ponds.

Item	**Stocking density of shrimp (Pcs/m^2)**					
	3	**6**	**9**	**12**	**15**	**Average**
Initial weight (gm/pce)	2.40	2.40	2.40	2.40	2.40	2.40
Final weight (gm/pce)	18.53 ^{a}	16.97	15.98 ^{c}	15.35 ^{d}	15.04 ^{d}	16.37
Gain (gm/pce)	16.13 ^{a}	14.57 ^{b}	13.58 ^{bc}	12.95 ^{c}	12.64 ^{c}	13.97
ADG (mg/pce/day) [1]	141.5 ^{a}	127.8 ^{b}	119.1 ^{bc}	113.6 ^{c}	110.9 ^{c}	122.55
SGR (% /day) [2]	1.80 ^{a}	1.72 ^{b}	1.67 ^{bc}	1.63 ^{c}	1.61 ^{c}	1.68

Means in the same row with different superscripts are significantly different ($p \leq 0.05$).
[1] ADG = average daily gain: (Final wt. – Initial wt.) / period (days).
[2] SGR = specific growth rate: 100 (Ln Final wt. - Ln Initial wt.) / Period (days).

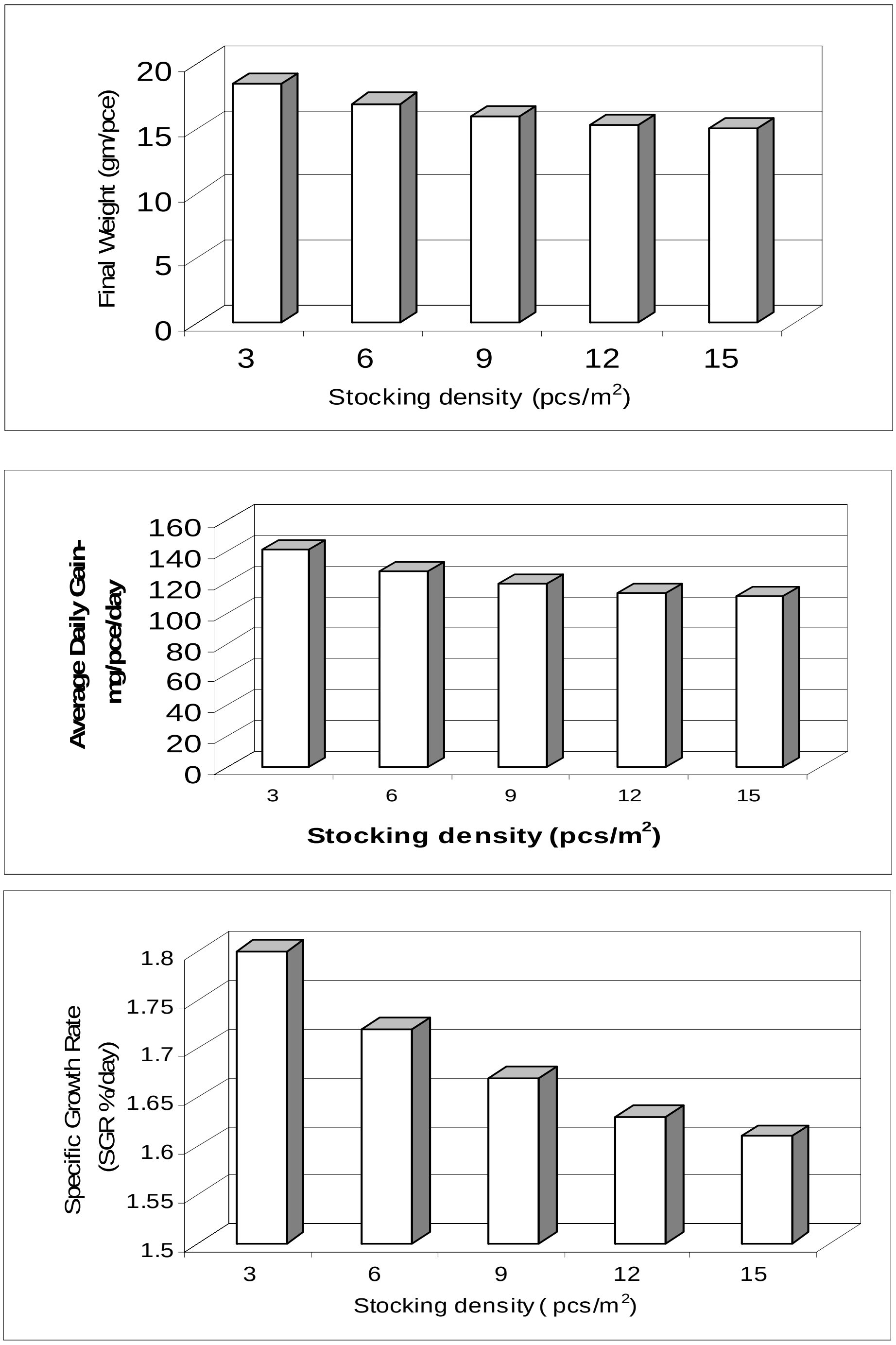

Fig. 1. Effect of different stocking densities (3, 6, 9, 12, and 15 pcs/m2) on growth Performance of marine shrimp (*Penaeus semisulcatus*) reared in earthen grow-out ponds.

Feed Conversion Ratio:

Data in Table 4. and figure 2 showed the results of effect of stocking density on the feed conversion ratio (FCR) of marine shrimp. The values of feed conversion ratios were 2.05, 2.20, 2.38, and 2.62, and 2.77, at 3, 6, 9, 12, and 15 pcs of shrimp /m^2 respectively. Values of FCR increased significantly ($P \leq 0.05$) with increased shrimp density. Increasing stocking density reduced feed conversion efficiency (Sandifer *et al.*, 1987). The results of the present experiment agreed with the literatures under the same conditions (Apud *et al.*, 1983; Clifford, 1992 and Allan and Maguire, 1992b). Feed conversion value of 3-5 for fish, mussel, and other unprocessed feeds and 1.5-2.5 for artificial diets (by dry weight) is acceptable (Apud *et al*., 1983).

Protein and energy utilization

The effect of different stocking densities (3, 6, 9, 12, and 15 pcs/$m^{2)}$ on protein and energy utilization by the experimental marine shrimp is shown in Table 4. Mean values of protein efficiency ratio (PER) were 0.80, 0.74, 0.68, 0.64, and 0.62 for the tested densities, respectively. The results of protein productive value (PPV %) were 14.32, 12.82, 11.29, 9.83, and 9.15% for the previous densities, respectively. Values of. Analyses of variance of PER, PPV%, and showed significant differences ($P \leq 0.05$) among stocking densities. The differences between the density of 12, and 15 pcs/m^2, and also between 6, and 9 pcs/m^2 were insignificant ($P \geq 0.05$). Energy utilization values (EU %) were 12.27, 11.00, 9.89, 8.89, and 8.48 % at 3, 6, 9, 12 and 5 pcs/m^2, respectively. Results of the analysis of variance of energy utilization showed significant differences ($P \leq 0.05$) among shrimp densities. The results of the present study were within the acceptable ranges given by Sudaryono *et al*., (1999) and Davis and Arnold, (2000).

Survival Rate:

Survival rates of the growing marine shrimp *P. semisulatus* used in present experiment were 89.6, 85.1. 82.0, 78.0, and 72.7% at 3, 6, 9, 12, and 15pcs /m2, respectively (Table 4 and figure 2). Values of survival rates decreased significantly ($P \leq 0.05$) with increasing shrimp density. However, the differences between the density of 12 and 15 pcs/, and so among 6, 9, and 12 pcs/ m^2 were not significant ($P \geq 0.05$).

These values of survival rates are economically, technically good, acceptable and agree with what found by Nunes and Parsons (1998) for semi-intensive culture (14.3 pcs/m^2) system with 69 - 71.9 % survival rate. Apud *et al*. (1981) found that increasing density of *P. monodon* from 2.5 to 20 prawn/m2 resulted in slight but significant ($p \leq 0.05$) reductions in survival. On contrary, Allan and Maguire (1992b) found that increasing stocking density of *P. monodon* from 5 to 40 pcs/m^2 had no effect on survival. The same trend was obtained by Wyban *et al.* (1987) using shrimp densities from 5 to 20 pcs/m^2 of *P. vannamei*, and Sandifer *et al.* (1987) using densities from 10 to 40 pcs/m^2 of *P. monodon*.

Yield production:

Data on the total yield production/ha of cultured shrimp in the present experiment are shown in Table 4. and figure 2.The results showed that cultured shrimp biomass increased as shrimp density increased. Total production yield (kg/ha) of cultured shrimp was 497.8, 865.2, 1178.4, 1435.9, and 1638.0 kg/ ha at 3, 6, 9, 12, and 15 pcs/m^2 stocking density, respectively. Average production of cultural shrimp was significantly ($P \leq 0.05$) different among densities. Unfortunately, there is no much available data concerning the production of cultured green tiger shrimp *P. Semisulcatus*, except that mentioned by Yap and Landoy (1993).

Yap and Landoy (1993) mentioned that semi-intensive culture system of *P. semisulcatus* in earthen ponds using imported shrimp pellets supplemented with trash fish is capable of producing 1200 kg/ha with average weight of 15 gm within a 4- month rearing period using pure seawater with initial salinity of 40 to 42 ppt even with inadequate water exchange due to lack of proper pumps. Allan and Maguire (1992b) found that shrimp biomass increased linearly as stocking density increased. Kungvankij (1985) obtained 725, 761 and 855 kg/ha/crop when stocked juvenile shrimp (*P. monodon*) at 4, 8, and 12 pcs/m^2, respectively with no significant differences among densities and high significant differences among the net profit in favor of the density of 4/m^2.

Condition Factors:

The effect of different stocking density of marine shrimp on the condition factor of males and females are given in Table 5. Females have higher values of condition factors than males (0.7994 vs. 0.7638). Also, increasing stocking density decreased the average value for males and females. This reflects better feed utilization and /or less competition for feeds and more suitable environment. The results of the present experiment agree with the findings of Primavera *et al*. (1998).

From the above-mentioned results, it could be concluded that decreasing stocking density resulted in better growth, survival and quality of marine shrimp *Penaeus semisulcatus*. Meanwhile, with increasing the stocking density the production of shrimp increased but in a low final weight and survival compared to low stocking density.

Table (4): Effect of different stocking densities (3, 6, 9, 12, and 15 pcs/m2) on feed conversion ratio, protein efficiency ratio, protein productive value (%), energy utilization , survival rate (%) and yield production (kg/ha) of marine shrimp (*Penaeus semisulcatus*) reared in earthen grow-out ponds.

Item	Stocking density of shrimp (Pcs/m^2)					
	3	6	9	12	15	Average
Feed conversion ratio (FCR)[1]	2.05[a]	2.20[b]	2.38[c]	2.62[d]	2.77[e]	2.40 ± 0.04
Protein efficiency ratio (PER)[2]	0.80[a]	0.74[b]	0.68[c]	0.64[cd]	0.62[d]	0.69 ± 0.02
Protein productive value (PPV) [3]	14.32[a]	12.82[b]	11.29[c]	09.83[d]	09.15[d]	11.48 ± 0.49
Energy utilization (EU %) [4]	12.27[a]	11.00[b]	09.89[bc]	08.89[c]	08.48[c]	10.10 ± 0.35
Survival rate (%) [5]	89.06[a]	85.10[ab]	82.00[ab]	78.00[bc]	72.70[c]	81.48 ± 2.12
Yield production (kg/ha)	497.80[e]	865.20[d]	1178.40[c]	1435.90[b]	1638.0[a]	1123.10 ±7.51

[1]FCR=Feed intake (gm)/Gain weight(gm)

[2]PER = Protein efficiency ratio: wet weight gain (gm)/protein intake (gm)

[3]PPV(%) =$(P-P_0)100/P_i$ where P is protein content in shrimp carcass at the end of the experiment, P_0 is the protein content in shrimp carcass at start of experiment and P_i is the protein intake.

[4]EU (%) = $(E-E_0)100/E_i$ where E is the energy in shrimp carcass at the end of the experiment , $E_0$is the energy in shrimp carcass at the start of the experiment and E_i is the energy intake .

[5] Survival rate (%) = 100 × (no. of shrimp at the end / no. of shrimp at the start)

Table (5): Effect of different stocking densities (3, 6, 9, 12, and 15 pcs/m2) on condition factors (K) for males and females of marine shrimp (*Penaeus semisulcatus*) reared in earthen ponds at five stocking densities.

Stocking density (pcs/m^2)	Condition factor (K)*						Average
	Males			Females			
	Minimum	Maximum	Average	Minimum	Maximum	Average	
3	0.74	0.79	0.767	0.79	0.88	0.824 0.796	0.796
6	0.71	0.80	0.766	0.76	0.85	0.811	0.789
9	0.72	0.82	0.765	0.75	0.85	0.796	0.781
12	0.71	0.85	0.764	0.74	0.83	0.784	0.774
15	0.71	0.85	0.757	0.73	0.86	0.782	0.770
Average	0.718	0.822	0.7638	0.754	0.854	0.7994	0.782

* Condition factor = (Weight (gm) /$length^3$(mg)).

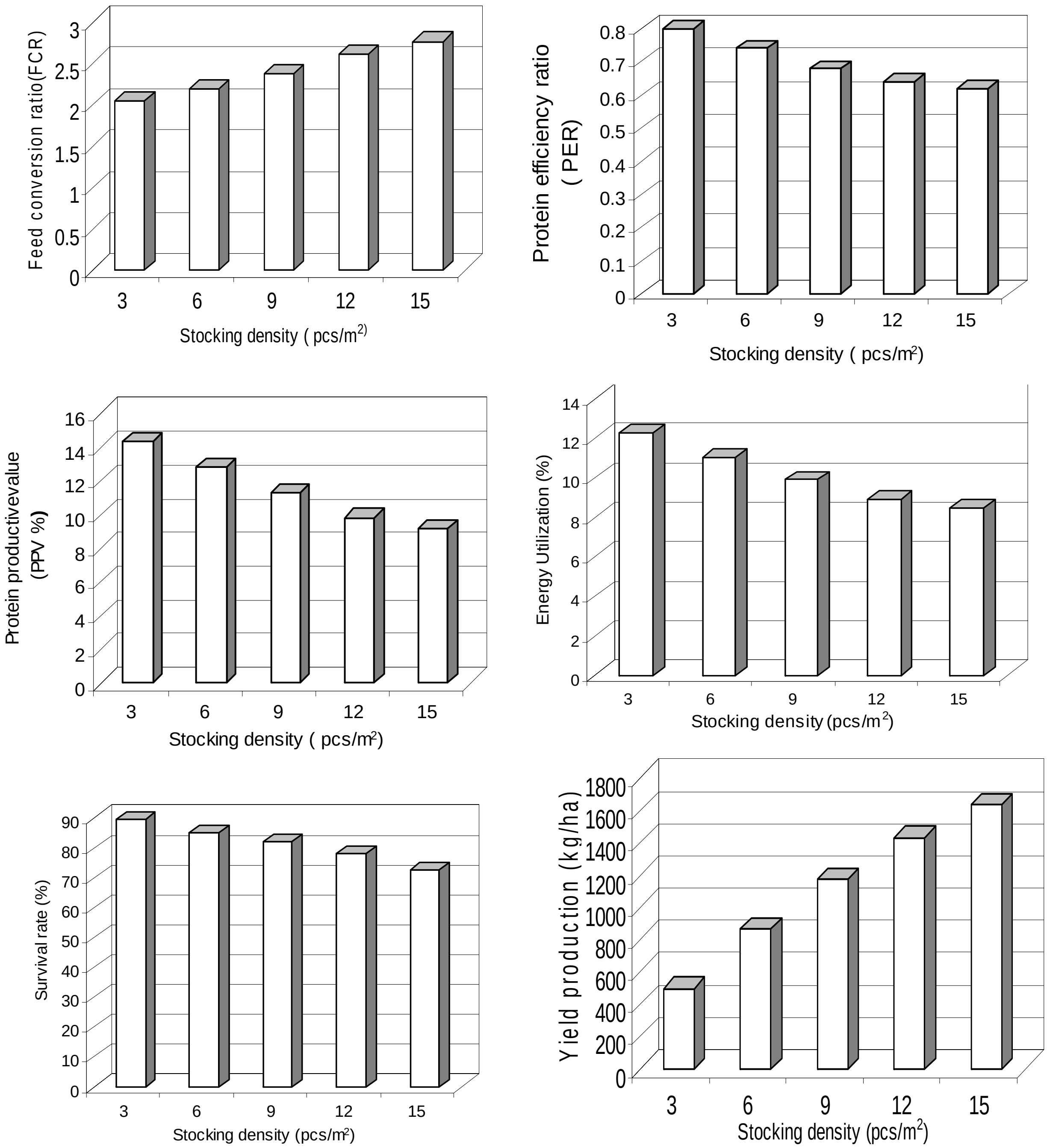

Fig. (2): Effect of different stocking densities (3, 6, 9, 12, and 15 pcs/m2) on feed conversion ratio, protein efficiency ratio, protein productive value (%), energy utilization, survival rate (%) and yield production (kg/ha) of marine shrimp (*Penaeus semisulcatus*) reared in earthen grow-out ponds.

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