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Pond Culture of *Penaeus monodon* (Decapoda, Penaeidae) on The Red Sea Area of Sudan

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استزراع روبيانِ النمرِ العملاقِ (*Penaeus monodon*) على ساحل البحر الأحمر (السودان)

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Abstract

In this study the effect of two stocking densities (3 and 10 post larvae/m2) on the survival, growth performance, and apparent feed conversion ratio of the giant tiger shrimp, Penaeus monodon were evaluated over a period of six months in earthen ponds. The results of the study revealed that the survival rate of shrimps cultured under a low density of 3 *PL/m²* (60.0%) was higher than those grown under a high density of 10 *PL/m²* (50.5%). The weight gain of the shrimp was better under low density (49.82 g/shrimp) when compared to the group of shrimp grown under high density (35.2 *g/shrimp*). Apparently, the feed conversion ratios of the two groups grown under the low and high density were similar 3.1 and 3.2 respectively. In conclusion, a stocking density of less than 10 *PL/m²* is recommended for culturing P. monodon under the climatic conditions of the Sudanese Red Sea Coast.

Keywords: *Pond culture, Penaeus monodon, Red sea, Sudan, Shrimp.*

الملخص

في هذه الدراسةِ، تم تقييم تأثير كثافتي التخزين (3 و10 يرقة /م 2) على البقاءِ، النمو ونسبةِ تحويلِ الغذاءِ الظاهري لروبيانِ النمرِ العملاقِ (Penaeus monodon) على مدى ستّة أشهرٍ في أحواض ترابية. أوضحت نَتائِجَ الدراسةِ بأنّ نسبةِ بقاءِ الروبيانِ المستزرع تحت الكثافةِ المنخفضةِ (3/م 2) كَانتْ (60.6 %) أعلى مِنْ نسبةِ بقاءِ الروبيانِ المستزرع تحت الكثافةِ العاليةِ (10/م 2) والتي كانت (50.5 %). زيادة وزن الروبيانِ كَانتْ أفضلَ تحت الكثافةِ المنخفضةِ (49.82 جم/روبيان) عندما قورنت مع زيادة الوزن لتلك تحت الكثافة العالية (35.2 جم/روبيان). أما نسبة تحويل الغذاء الظاهري فوجدت للكثافة المنخفضة والعالية 3.1 و3.2 على التوالي. عليه خلصت الدراسة إلى أن الكثافة التخزينية اقل من (10 يرقة /م 2) يوصى بها لاستزراع روبيانِ النمرِ العملاقِ (Penaeus monodon) تحت الظروف المناخية لساحل البحر الأحمر السوداني.

الكلمات الدلالية: استزراع، النمرِ العملاقِ، البحر الأحمر، السودان، الروبيان.

1. Introduction

In recent years, appreciable developments have been made in aquaculture of shrimps all over the world. Total world shrimp production increased significantly during the last two decades. World shrimp aquaculture production has grown tremendously from a production of 200,000 tons in 1985 to approximately 2.7 million tons in 2005 (Megahed *et al*., 2013). Shrimps and prawns take the major share (39.03%) of the total world crustaceans production followed by freshwater crustaceans and crab/sea-spiders with a share of 25.38% and 13.80%, respectively. Recently, most of the shrimp aquaculture production comes from Asian countries. The lead countries with shrimp aquaculture production are China, Thailand and Vietnam. In 2005, 68 countries reported penaeid shrimp aquaculture production, 22 countries reported producing *Litopenaeus. vannamei*, while 23 countries were producing *Penaeus monodon* (FAO, 2007). *Penaeus monodon* is the species of choice due to its high growth rate, significant tolerance to environmental stress, ease in reproduction, and its unquestionable market demand (Shakir *et al*., 2014). Growth and production of shrimp species are dependant on the population density. It is a key factor for the farmers to determine the optimum stocking density of the animals being reared to maximize production and profitability (Shakir *et al*., 2014). Different ranges of salinity have been reported to support the survival and better growth of *P. monodon* (Muthu, 1980; Chen, 1984; Chanratchakool *et al*., 1994; Karthikeyan, 1994; Athithan *et al*., 2001; and Seneviratne *et al*., 2001). The black tiger shrimp, *P. monodon* is one of the largest penaeid shrimps in the world, reaching 270 *mm* in body length, and it is of considerable commercial importance in international markets (Motoh, 1985). *P. monodon* is indigenous to Sudanese waters (Reed, 1962; and El Hag, 1978).

The only trial of shrimp farming that took place in Sudan was initiated in 2002. The total area was 20 *ha* and it was located 40 *km* south of Port Sudan on the Red Sea coast. *P. monodon* was spawned in the hatchery using the technique of unilateral eyestalk ablation of females to achieve ovarian maturation and spawning. Formulated feed is imported from Saudi Arabia. Under the hyper-saline condition of the Red Sea coast (46 *ppt*), the grow-out period to marketable size (50 *g*) is about 6-7 months (personal contact). Among the countries of the Red Sea Coast, Saudi Arabia and Yemen have experienced some successful trials of commercial shrimp farming. In Saudi Arabia shrimp farming was initiated in 1988 by growing the Black tiger shrimp, *P. monodon*, *P. semisulcatus*, *P. japonicus* and *P. indicus* (Al-Thobaiti & James, 1996, 1998).

The purpose of this study was to evaluate the effect of two stocking densities (3 and 10 PL/m^2) on the survival, growth and feed conversion ratio of *P. monodon* grown under a semi-intensive commercial operation at the Sudanese Red Sea Coast.

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2. Materials and Methods

The study was carried out in in Baaboud Shrimp Farm located 40 *km* south of Port Sudan at the Red Sea coast of Sudan. The study was based on data collected from the farm during a– two grow-out seasons (two production cycles) of *P. monodon.* A 1-*ha* pond was selected and a detailed study was carried out with respect to the culture practices, water quality, feed utilization efficiency and shrimp production. Data was collected from this pond all through two successive production cycles extending each for 28 weeks, the pond was stoked with shrimp post larvae (PLs) produced in the farm hatchery.

The pond was first limed with calcium carbonate at arte of 1000 *kg/ha* and then filled with seawater. Both organic (chicken manure) and inorganic fertilizers (supperphosphate14) were used at a rate of 600–750 *kg/ha* and 30 *kg/ha*, respectively. Undesirable wild species, entering the pond with seawater supply, were eliminated by applying saponin at a rate of 90 *kg/ha*. The pond was initially stocked with *P.monodon* PLs at a rate of 30 individuals/m^2. In the second cycle the pond was stocked at a rate of 10 Pls of the same species/m^2. Two paddle wheel aerators (1 *HP*) were operated day and night to maintain dissolved oxygen levels above 4.0 *mg/l*.

Water quality parameters of pond water were continuously monitored. Dissolved oxygen and water temperature were recorded twice a day (08:00 *hr* and 16:00 *hr*); pH and turbidity were measured once a day at 16:00 *hr*, and salinity was recorded weekly. Regular sampling of shrimp stock in the pond was done weekly to monitor the growth and the stock size of the shrimp in the pond. The stock size was determined weekly using a cast net (CN) according to the following equation (ASEAN,1978);

$$X = [\text{Average number of shrimp caught by CN}] \times [\text{Pond size } m^2)]/[\text{Area of the CN } (m^2)] \quad \ldots\ldots\ldots.. \ (1)$$

Where X is the stock size in the pond (estimated population). The general performance the species during the grow-out periods was evaluated by determining the survival rate (%), daily weight gain and specific growth rate SGR (%/*day*) and were calculated as follows (ASEAN,1978):

$$\text{Survival (\%)} = 100\ [(\text{final no. fish} - \text{initial no. fish})/(\text{initial no. fish})] \quad \ldots\ldots\ldots.. \ (2)$$

$$\text{Daily weight gain } (g) = [\text{Av. final weight } (g)]-[\text{Av. initial weight } (g)]/[\text{Days of culture}] \quad \ldots\ldots\ldots.. \ (3)$$

$$\text{SGR } (\%/day) = [\text{Daily weight gain } (g)/\text{Av. final weight } (g)]\times[100] \quad \ldots\ldots\ldots.. \ (4)$$

Commercial pelleted feeds containing 45% protein (ARASCO, Saudi Arabia) were hand broadcasted. The feeds were given 4 times a day at 6 AM, 11 AM, 5 PM and 8 PM. The feeding rate was initially 10% of the body weight and then gradually reduced to reach 3% of the body weight by the harvesting time. Two trays measuring 50 *cm*×50 *cm* in each pond were used to determine the feeding rate. Size of the pellets was adjusted weekly accordingly to the size of the shrimp in the pond. For each production cycle the feed conversion ratio (FCR) was calculated as follows (ASEAN1978):

FCR = [Total feed weight given (*g*)]/[Shrimp weight gain (*kg*)] ……………….. (5)

When harvested, shrimp were initially netted using a gill net and then the remaining were harvested by completely draining the pond.

3. Results

The mean values of the different water quality parameters along with standard deviations are presented in Tables (1 and 2).

Table 1. Mean values with standard deviation of water quality parameters recorded during the 1st production cycle

Parameters	Mean±Sd.	Min.	Max.
Temperature, (^oC)	28.04±2.80	20.80	32.60
Dissolved Oxygen, (*mg/l*)	6.43 ± 0.821	4.20	9.20
Salinity, (*ppt*)	42.34±1.58	40.00	46.00
pH	8.16±0.5438	6.20	8.80
Turbidity, (*cm*)	51.48±5.47	40.00	70.00

Table 2. Mean values with standard deviation of water quality parameters recorded during the 2nd production cycle.

Parameters	Mean±Sd.	Min.	Max.
Temperature, (^oC)	28.25±1.42	22.00	31.00
Dissolved Oxygen, (*mg/l*)	5.23± 0.684	3.30	7.50
Salinity, (*ppt*)	41.86±1.49	40.00	45.00
pH	8.76±0.1460	8.40	9.20
Turbidity, (*cm*)	50.09±5.89	35.00	60.00

In the present study, the stocking density showed a clear impact on the survival rate, final body weight, specific growth rate, food consumption and FCR. Final survival rate and weight of shrimp in the first production cycle (low density) were comparatively higher than those in

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the second production cycle (high density Ponds). Shrimps cultured under high density ponds exhibited low survivability, combined with high feed conversion rates (FCR).

The culture *P. monodon* in the 1^{st} production cycle yielded 898 *kg/ha* attaining 60.0% survival rate presented in Table (3). The PLs, with a mean daily growth rate of 1.03 *g*, grew linearly from 0.27 *g* to average final weight to 50.0 *g* for the 183 *days'* period presented in Table (3).

The culture *P. monodon* in the 2^{nd} production cycle yielded 1799 *kg/ha* and attained 50.5% survival rate. The PLs, with a mean daily growth rate of 0.18 *g*, grew linearly from 0.4 *g* to average final weight 35.6 *g* for the 198 *days'* period presented in Table (3).

Table 3. Average Harvest Details of *P. monodon* Cultured during the 1^{st} and 2^{nd} production cycles

Parameter	First production cycle	Second production cycle
Stocking density. (PL/pond)	30,000	100,000
Stocking density, (PL/m^2)	3	10
Grow out period, (*day*)	182	198
Initial average body weight, (*g*)	0.18	0.4
Final average body weight, (*g*)	50	35.6
Weight gain, (*g*/shrimp)	49.82	35.2
Specific growth rate, (% /*day*)	1.03	1.02
Specific growth rate, (*g*/*day*)	0.27	0.18
Survival, (%)	60.0	50.5
Total No. harvested	15,000	50,500

Table 4. Total feed offered and the final biomass (*kg*) during the two production cycles

Gross yield/total feed	1^{st} cycle	2^{nd} cycle
Total feed offered (TFC), (*kg*)	2823	57000
Gross yield of whole shrimp, (*kg*)	898	1799

Table 5. Gross yield of whole shrimp (*kg*) , total feed offered (kg) and the feed conversion ratio (FCR) for each production cycle

Gross yield/total feed	1st cycle	2nd cycle
Cross yield of whole shrimp, (*kg*)	898	1799
Total feed offered, (*kg*)	2823	57000
Feed conversion ratio, (FCR)	3.1	3.2

4. Discussion

Among the physio-chemical parameters tested during the two production cycles, pH and DO appeared significantly differed among the two cycles as shown in Tables (1 & 2). The minimum dissolved oxygen concentrations in high stocking density pond were lower than the optimum level of 4 *ppm* for shrimp growth. Low dissolved oxygen concentrations in high stocking density pond might be due to huge biomass of shrimps. Low oxygen level is a common problem in pond with high stocking density that in turn increases disease susceptibility (Le Moullac et al.,1998).

The stocking density of shrimps is one of the vital zoo-technical factors that directly influence the survival, growth, behavior, health, feeding, yield and profit (Shakir et al., 2014). In the present study, the stocking density showed a clear impact on the survival rate, final body weight, specific growth rate, food consumption and FCR. Final survival rate and weight of shrimp in the 1st production cycle (low density) were comparatively higher than those in the 2nd production cycle (high density Ponds). Shrimps cultured under high density ponds exhibited low survivability, combined with high feed conversion rates (FCR). Shakir et al. (2010) stated that the stocking density of shrimps is one of the vital zoo-technical factors that directly influence the survival, growth, behavior, health, feeding, yield and profit. In this study, stocking density of 3 PL/m^2 resulted in lower yield. There was a significant increase in the mortality with increased stocking density. The average survival rate during the culture period was 50.5% in high density (10 PL/m^2) pond whereas 60.0% in low density pond (3 PL/m^2).

Several studies have evidenced that increased stocking density cause negative effect on survival and growth of shrimp (Penha-Lopes et al., 2006; and Schram et al., 2006). In the present study, a decreased survival of *P. monodon* with elevated stocking density was observed, which was similar to the results of Chakraborty *et al*. (1997) and Shakir et al. (2010) who reported that *P. monodon* stocked at 8 animals/m^2 were showed increased mortality, lower weight gains and higher food consumption. In many studies, the growth and

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production of cultured species were observed to be dependent on the population density (Backiel & LeCren, 1967).

In conclusion, results of the overall study envisages that growth, survival rate, SGR and FCR of shrimps reared in Sudan at low density pond were higher and therefore a stocking density of less than 10 PL/m^2 is recommend for culturing *P. monodon* under climatic conditions of the Sudanese Red Sea Coast.

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