Journal of Fisheries Science
https://ojs.bilpublishing.com/index.php/jfs

ARTICLE

Culture Performance and Economic Return of Brown Shrimp (*Metapenaeus Monoceros*) at Different Stocking Densities Reared in Brackishwater Pond

Shawon Ahmed[1*] Md. Latiful Islam[1] Mizanur Rahman Washim[1] Nilufa Begum[2]

1.Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Khulna, 9280, Bangladesh
2.Bangladesh Fisheries Research Institute, Shrimp Research Station, Bagerhat, 9300, Bangladesh

ARTICLE INFO

Article history
Received: 15 May 2021
Accepted: 25 May 2021
Published Online: 30 May 2021

Keywords:
Benefit cost ratio
Brown shrimp
Growth
Production
Stocking

ABSTRACT

Shrimps are recognized as the white gold of Bangladesh because it is the second largest export earning product after garments sector. The brown shrimp (*M. monoceros*) have high growth rates together with that they tolerate wide ranges of salinity and environmental parameters which makes them highly attractive for culture purposes. The purposes of this research were to assess the cultural performance and economic profitability of brown shrimp (*Metapenaeus monoceros*) in brackish water ponds. This research lasted from February to June 2020 under three different stocking densities such as 35, 45 and 55 individuals/m2 in treatments T1, T2 and T3 at Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Khulna. After 90 days culture periods the total production was 1703.32±144.48, 2768.25±167.63 and 2535.03±253.52 kg/ha in T1, T2 and T3 respectively which was significantly higher ($p<0.05$) in T2 compared to T1 and T2. Benefit cost ratio (BCR) was 0.32, 0.87 and 0.52 in T1, T2 and T3 respectively and found significantly higher ($p<0.05$) in T2 than T1 and T3. Both cultural performance and economic analysis imply that brown shrimp (*M. monoceros*) with a stocking density of 450000 individuals/ha might be environment conciliatory and economically enduring in coastal areas of Bangladesh.

1. Introduction

Shrimp is contributing significantly to the national economy of Bangladesh through export earnings and creating employment opportunity. It is the second largest foreign exchange earning source in Bangladesh and 97% of the produced shrimp being exported [1]. In 2016-17, production of shrimp in Bangladesh was about 246188 tons through culture in about 275509 ha impoundments (locally called ghers) resulting production rate of 456 kg/ha [2]. Black tiger shrimp (*Penaeus monodon*, locally named as Bagda) is particularly stocked in these ghers. But this valuable shrimp industry faces massive production losses due to invasion of virus (WSSV) and AHPND (Acute Hepatopancreatic Necrosis Disease) [3]. Therefore, farmers have become highly farsighted about stocking of this shrimp species in their ghers and a large number of tiger shrimp farmers has already meant to shift their cultural pattern as well as searching for suitable species for stocking to their ghers. In this context, the brown shrimp, *Metapenaeus monoceros* (Fab.) (Locally called Harina)

**Corresponding Author:*
Shawon Ahmed,
Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Khulna, 9280, Bangladesh;
Email: shawon.ahmed.du@gmail.com
ORCID: https://orcid.org/0000-0003-3807-3486

can be a suitable candidate for culture in the brackishwater ghers. This shrimp offers a good potential for large scale commercial aquaculture primarily because of available natural seed and demand in the international market. The severity of disease incidence in this shrimp is not so alarming like that of *P. monodon*. Requirement of oxygen of this species is also very low and increases with the increase in salinity. In spite of having many advantages of production, the culture technology of the species has not yet developed in Bangladesh. *M. monoceros* grows up to 10.7 cm [4]. The food and feeding habits of *M. monoceros* in its juvenile phase was found to be a selective carnivore and a benthic feeder, active mainly during night [5]. Total consumption of oxygen in the penaeid prawn, *M. monoceros* was very low when exposed to 2 ppt salinity and very high in 25 ppt salinity [6]. They survived for a longer period when kept in higher salinities (12 ppt to 36 ppt) on acclimatization from lower to higher succeeding grades [7].

2. Materials and Methods

2.1 Study Location and Experimental Design

The research was performed in the pond complex of Bangladesh Fisheries Research Institute, Brackishwater Station (27.2046°N, 77.4977°E); Paikgacha under Khulna district, Bangladesh. The study was arranged in nine on-station earthen ponds of 0.1 ha each. The experiment was designed in three treatments with three different stocking densities (T1=35; T2=45 and T3=55 individuals/m^2 respectively) with three replications for each. However, a control experiment was also performed where the stocking density was maintained at the rate of 45 individuals/m^2, no water has been exchanged and no lime, fertilizer and feed were provided. The initial stocking size (length and weight) for the experiment was 1.5 cm and 0.05 g respectively.

2.2 Pond Management and Husbandry

Before stocking PL, the ponds were prepared according to the standard process described by [8]. An in-pond nursery was built in one corner of each pond made of a nylon net attached to a bamboo frame. After 4^{th} days of fertilization and sufficient plankton production, the required amount of shrimp PL was acclimated with pond water and stocked in April 2020. A commercial feed (Quality Shrimp Feed) was used to feed the shrimp at satiation. After the third week of nursery rearing, the juveniles were released into the entire pond by folding up the enclosure. At least 50 shrimps were sampled to check the feeding behavior and health condition of shrimp in fortnight intervals. After 90 days of culture, the shrimps were harvested by dewatering the ponds.

2.3 Hydrological Parameters

Physical and chemical parameters of water *viz*. dissolved oxygen, salinity, depth, alkalinity, temperature, P^H were analyzed in weekly basis according to the standard protocol (APHA 1992) [9]. DO was monitored by DO meter, model DO 175, Hach; salinity by an optical Refractometer (Atago, Japan); depth of water by a depth gauge; total alkalinity by titrimetric method in the morning and as mentioned in APHA (2005) just before sunrise; temperature was monitored by a mercury thermometer; transparency by a Secchi disk; and pH by a digital pH meter [10].

2.4 Observed Research Parameters

The observed parameters were the growth performance of the experimental shrimp and economic profitability parameters. The growth performance parameters include the survival rate (SR, %), specific growth rate (SGR, % bw/day), and feed conversion ratio (FCR) calculated according to the following equations:

$$\text{Survival rate, SR (\%)} = \frac{\text{Final population}}{\text{Initial population}} \times 100$$

$$\text{Specific growth rate, SGR}\left(\text{\% bw day}^{-1}\right) = \frac{\ln\left(\text{final weight}\right) - \ln\text{ (initial weight)}}{\text{days of culture}} \times 100$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Total weight of consumed feed}}{\text{Weight gain of shrimp}}$$

The economic profitability was estimated using the shrimp price in Paikgacha fish retail market, Khulna, Bangladesh in 2020. The economic profitability parameters were gross return, net profit and benefit cost ratio (BCR) calculated based on the following formulas:

$$\text{Total production cost} = \text{Total variable cost} + \text{Total fixed cost}$$

$$\text{Gross return} = \text{Total shrimp yield} \times \text{price of per kg of shrimp}$$

$$\text{Net profit} = \text{Gross return} - \text{total production cost}$$

$$\text{Benefit cost ration (BCR)} = \frac{\text{Net profit}}{\text{Total production cost}}$$

2.5 Proximate Analysis

For proximate composition, hot air oven method (dry-

DOI: https://doi.org/10.30564/jfsr.v3i1.3240

ing the sample at 105°C±2°C) was used to determine the moisture content until a constant weight was obtained (AOAC 1990) [11]. The crude lipid was estimated by extracting a weighed amount of sample with acetone in the Soxhlet extraction unit (model 1045) [12]. The crude protein content was analyzed by altering the nitrogen content acquired by the Kjeldahl method (Nx6.25) [13]. The ash content was determined after burning for 20 hours at 550°C [11]. Total carbohydrates were analyzed by subtracting the sum of the moisture, fat content, protein content and ash content from 100 [14]. The crude fibre content was determined according to the protocol mentioned by (Ayuba and Iorkohol 2010) [12]. Calcium was estimated through atomic absorption spectrophotometry and phosphorus was analyzed photometrically [15]. For the estimation of proximate composition three different samples were taken to determine each content.

2.6 Data Analysis

After 90 days of culture periods all the shrimp were harvested and the collected data were statistically analyzed with MS Excel and SPSS (Statistical Product and Service Solutions) version-20 to express the research findings in a meaningful way. One-way analysis of variance (ANOVA) and Duncan multiple range test was carried out to compare the treatments and significance level were assigned at 5% (P>0.05).

3. Results

3.1 Water Physico-chemical Characteristics

The changing pattern of physico-chemical parameters of water studied in this research viz. dissolved oxygen, salinity, depth, temperature, alkalinity and P^H recorded during the culture period in weekly basis were presented in Figure 1. The range and Mean±SD values of water quality parameters in three different treatments were presented in Table 1. Interestingly, all the hydrological parameters of the experimental ponds were within the favorable condition of Harina shrimp culture. The DO level of the experimental ponds varied between 5.13-10.97 mg/l (Figure 1A) with a mean±SD values of 8.11±1.10, 7.93±0.91 and 8.65±1.21 in T1, T2 and T3; respectively (Table 1).

Salinity is considered as one of the most fundamental factor for shrimp culture. The salinity level in different experimental ponds varied between (7-16) ppt (Figure 1B) with a mean±SD values of 11.04±2.27, 11.02±2.20 and 11.10±2.26 in T1, T2 and T3; respectively (Table 1). Salinity level was increased unwaveringly from April until reached its peak in June (16 ppt) and then it showed gradual decrement with least variation between the treatments. The depth level of the experimental ponds varied from (85-140) cm (Figure 1C) with a mean±SD values of 107.32±3.94, 98.00±4.33 and 132.71±4.36 in T1, T2 and T3; respectively (Table 1).

Temperature is also one of the critical physical modifiers that affects the growth, energy flow and biological effects in marine organisms. There was found least variation of temperature among the experimental ponds. The temperature of the experimental ponds varied between 30-35°C (Figure 1D) with a mean±SD values of 33.31±1.94, 32.92±1.66 and 32.97±1.66 in T1, T2 and T3; respectively (Table 1).

The recorded alkalinity of the study ponds were within 90-162 mg/l (Figure 1E) with a mean±SD values of 111.81±12.13, 111.78±12.28 and 114.64±16.98 in T1, T2 and T3; respectively (Table 1). The P^H range of the experimental ponds were within 7.63-8.80 (Figure 1F) with a mean±SD values of 8.43±0.2, 8.33±0.13 and 8.46±0.17a in T1, T2 and T3; respectively (Table 1).

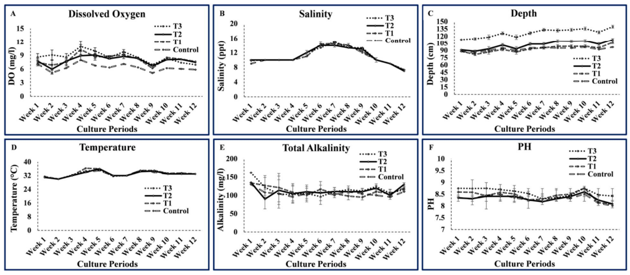

Figure 1. Water quality parameters of different treatments in weekly basis (A. Dissolved Oxygen; B. Salinity; C. Depth; D. Temperature; E. Total Alkalinity; F. PH)

3.2 Growth Performance of Brown Shrimp

The study was conducted in the pond complex (0.1 ha each) of the Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Khulna. The growth performance of Harina shrimp was monitored fortnightly (Figure 2). The average body weight was always higher in T2 in comparison with T1 and T3, respectively (Figure 2A). The average body weight of shrimp PL during stocking was same of 0.05g in all treatments and after 90 days of culture period brown shrimp attained an ABW of 9.15±0.6, 10.42±0.5 and 8.38±0.7 in T1, T2 and T3; respectively (Table 2). In three different stocking densities, ABW of brown shrimp in T2 was significantly higher (p<0.05) than the other two treatments (Table 2). Survival of brown shrimp in T2 was 59.04% which was found highest and significantly higher (p<0.05) than the other two treatments as the survival rate of brown shrimp were 53.19% and 55.00% in T1 and T3; respectively (Table 2).

DOI: https://doi.org/10.30564/jfsr.v3i1.3240

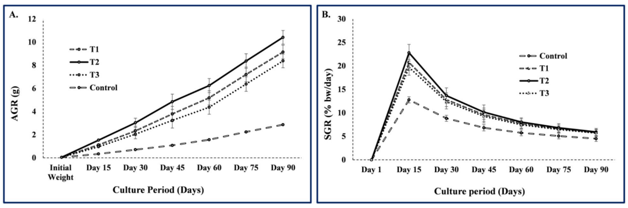

Figure 2. Growth performance of brown shrimp in different treatments during the complete experimental period (A) average body weight and (B) specific growth rate.

As shown in Figure 2B, SGR was highest of 19.70-22.81% in the 1st fortnight in the experimental ponds. The SGR declined with the progress of culture period and declined sharply to 7.45-8.04% up to 60 days of culture. After then, the SGR was almost straight for the rest of the culture period and finally declined to 5.69-5.93% in the last fortnight of culture. The SGR of brown shrimp after 90 days of culture period was 5.78±0.61, 5.93±0.56 and 5.69±0.71% in T1, T2 and T3; respectively. Total production was recorded as 1703.32±144.48, 2768.25±167.63 and 2535.03±253.52 kg/ha at T1, T2 and T3; respectively. The highest production obtained in T2 (45 individuals/m2) which was significantly higher ($p<0.05$) than T1 and T3; respectively. FCR value in T2 was 1.11 which was found lowest and significantly lower ($p<0.05$) than the other two treatments as the FCR of T1 and T3 were 1.51 and 1.41; respectively (Table 2).

3.3 Proximate Composition of the Commercial Diets

Moisture content ranged from 10 to 11%, crude protein ranged from 32 to 36%, fat content ranged from 7 to 8%, crude fibre ranged from 2.0 to 3.5%, ash ranged from 10 to 11%, calcium ranged from 3.0 to 3.2% and phosphorus ranged from 1.5 to 2.5% of the diets used in different stage of culture period (Table 3). However, crude protein content in pre-nursery diet (36±0.07%) was significantly ($P<0.05$) higher than that of nursery and growout diets. There was no significant ($P<0.05$) difference between the carbohydrate, ash and calcium content among three different diets respectively (Table 3). Besides, phosphorus content in each diet significantly ($P<0.05$) differs from each other.

Table 1. Water quality characteristics in different treatments during culture periods

Parameters	Treatment 1		Treatment 2		Treatment 3	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Dissolved Oxygen (mg/l)	6.17-10.29	8.11±1.10^{b}	5.13-9.08	7.93±0.91^{c}	6.95-10.97	8.65±1.21^{a}
Salinity (ppt)	7-16	11.04±2.27^{b}	7-16	11.02±2.20^{b}	7-15	11.10±2.26^{a}
Depth (cm)	85-107	98.00±4.33^{c}	88-113	107.32±3.94^{b}	113-140	132.71±4.36^{a}
Alkalinity (mg/l)	95-138	111.81±12.13^{b}	90-140	111.78±12.28^{c}	96-162	114.64±16.98^{a}
P^{H}	7.91-8.76	8.43±0.2^{b}	7.72-8.80	8.33±0.13^{c}	7.63-8.72	8.46±0.17^{a}
Temperature (℃)	30-35	33.31±1.94^{a}	30-35	32.92±1.66^{c}	30-35	32.97±1.66^{b}

*Different letter superscripts in the same column indicate significant difference ($p<0.05$).

Table 2. Growth and production of brown shrimp (*M. monoceros*) in different treatments

Treatments	Stocking Density (m^2)	Initial Length (cm)	Initial Weight (g)	Final Length (cm)	Final ABW (g)	Survival (%)	SGR (%)	Production (Kg/ha)	FCR
T1	35	1.5	0.05	12.17±0.7	9.15±0.6	53.19^{b}	10.55^{b}	1703.32±144.48^{c}	1.51^{b}
T2	45	1.5	0.05	15.63±1.9	10.42±0.5	59.04^{a}	11.24^{a}	2768.25±167.63^{a}	1.11^{a}
T3	55	1.5	0.05	11.34±2.6	8.38±0.7	55.00^{b}	10.16^{c}	2535.03±253.52^{b}	1.41^{b}

*Different letter superscripts in the same column indicate significant difference ($p<0.05$).

Table 3. Proximate composition of different feed used for the culture of brown shrimp

Parameters	Pre-nursery	Nursery	Growout
Moisture (%)	10±0.02^{b}	11±0.01^{a}	11±0.01^{a}
Protein (%)	36±0.07^{a}	32±0.05^{b}	32±0.08^{b}
Fat (%)	7±0.02^{b}	8±0.03^{a}	7±0.01^{b}
Carbohydrate (%)	22±0.03^{a}	22±0.02^{a}	22±0.03^{a}
Fibre (%)	2±0.01^{b}	3±0.02^{a}	3.5±0.02^{a}
Ash (%)	11±0.05^{a}	10±0.08^{a}	10±0.04^{a}
Calcium (%)	3.2±0.02^{a}	3±0.01^{a}	3±0.03^{a}
Phosphorus (%)	2.1±0.01^{b}	2.5±0.02^{a}	1.5±0.01^{c}

*Different letter superscripts in the same column indicate significant difference ($p<0.05$).

DOI: https://doi.org/10.30564/jfsr.v3i1.3240

3.4 Cost-Benefit Analysis

A benefit-cost ratio (BCR) is a ratio used in a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a project. The cost and economic benefit analysis of this research showed that the higher net profit was achieved in treatment T_2 (where stocking density was 450000 individuals/ha) than T_1 and T_3 (Table 4). Total cost (TC) is the total economic cost of production and is made up of variable cost, which varies according to the quantity of a good produced and includes inputs such as labour, land lease cost and raw materials, plus fixed cost. Total cost of production was recorded 514282 BDT/ha, 593388 BDT/ha and 667503 BDT/ha in T_1, T_2 and T_3 respectively (Table 4). However, highest return (1107300 BDT) and net

Table 4. Production performance and cost-benefit ratio of brown shrimp (*M. monoceros*) under three different stocking densities

Particulars	Quantity	Rate (BDT)	Treatments		
			T_1 (35ind./m^2)	T_2 (45ind./m^2)	T_3 (55ind./m^2)
Variable cost					
Pond preparation (man days)	130	350	45500	45500	45500
Eradication (kg bleaching)	55	40	2200	2200	2200
Labour charge for eradication	10	350	3500	3500	3500
Lime (kg)	400	25	10000	10000	10000
Dolomite (kg)	150	18	2700	2700	2700
Urea (kg)	50	16	800	800	800
Triple super phosphate (kg)	100	22	2200	2200	2200
Shrimp PL		0.3	105000	135000	165000
Shrimp feed (35% Protein)		75	87000	116200	124500
Shrimp feed (30% Protein)		70	98700	105000	133700
Molasses (kg)	150	35	5250	5250	5250
Salary of farm assistant (BDT)	3	10000	30000	30000	30000
Power cost (units)	250	7.5	1875	1875	1875
Land lease			50000	50000	50000
Harvest cost (BDT/kg)		5	8516	13841	12675
Fuel cost (kg)	50 L	65	3250	3250	3250
Total variable costs			456491	527316	593150
Fixed costs					
Interest		10%	46093	52718	59343
Depreciation			11698	13354	15010
Total fixed costs			57791	66072	74353
Production					
Total shrimp yield			1703.32	2768.25	2535.03
Price of shrimp			400	400	400
Economic analysis					
Total production costs			514282	593388	667503
Gross return			681328^c	1107300^a	1014012^b
Net profit			167046^c	513912^a	346509^b
Benefit/cost ratio			0.32^c	0.87^a	0.52^b

*Different letter superscripts in the same column indicate significant difference ($p<0.05$).

profit (513912 BDT) was obtained in T2 at SD 45 individuals/m^2 followed by T3 (1014012 BDT and 346509 BDT) at SD 45 individuals/m^2 and T1 (681328 BDT and 167046 BDT) at SD 35 individuals/m^2 and they were significantly ($P<0.05$) different from each other (Table 4). Cost-benefit ratio (BCR) was 0.32, 0.87 and 0.52 in T1, T2 and T3; respectively. BCR value of T2 was significantly higher ($p<0.5$) than T1 and T3 implies that net economic return is higher in treatment with 450000 individuals/ha stocking densities.

4. Discussion

Development of technique for the culture of brown shrimp (*M. monoceros*) in nine earthen brackishwater ponds under three different stocking density showed the feasibility of producing of shrimp product with good growth, survival, FCR and yield. Water quality parameters during the culture periods were within the acceptable range for growth and survival of normal shrimp production. Shofiquzzoha *et al.* (2001) reported that dissolved oxygen content of a shrimp farm should be greater than 4.0 mg/l [16]. Dissolved oxygen content during culture periods was well enough due to the use of paddle wheel aerator throughout the culture period (Figure 1A). The favorable salinity range for the growth of shrimp was 7 to 25 ppt [17]. This research was carried out before starting of rainy season and ends during the rainy season and there was much rain at the end time so it made salinity level below 10 ppt. Although the range of salinity varied between 7-16 ppt (Figure 1B) with an average value of 11 ppt (Table 1) during the culture period which is favorable for brown shrimp. Islam *et al.* (2004) reported that depth of a shrimp farm should be 80-120 cm [18]. The depth of the research ponds gradually increases with the arrival of rainy season. The depth become slightly higher (Figure 1C) than the range mentioned by (Islam *et al.* 2004) for a few days of culture period [18]. Although it was not hampered in the survival and growth of cultured shrimp. The optimum temperature for small shrimp is greater than 30℃ (less than 5 g) while for large shrimp the optimum temperature is about 27℃ [19]. The optimum temperature range of both shrimp and prawn found at 28-35℃ [20]. The optimum range of alkalinity for brown shrimp farming was 80-200 mg/l [21]. The optimum range of water P^H for shrimp culture is 7-9 [22]. Besides several authors have reported a wide variation in P^H 7.5-9.2 [23] and 7.68-8.35 [16] in shrimp farms and found favorable for shrimp culture. Water physico-chemical parameters such as temperature, alkalinity and P^H were in the suitable range for shrimp growth throughout the culture period (Table 1).

Growth pattern of brown shrimp, *M. monoceros* showed that average growth rate (AGR), specific growth rate (SGR), total production, survival rate (SR) and feed conversion ratio (FCR) were a worthy performance of shrimp growth in brackishwater ponds (Table 2, Figure A-B). Begum *et al.* (2020) reported that after 90 days of culture period of brown shrimp in brackishwater ponds the average body weight was 8.2±1.6, 7.3±2.4, and 5.1±2.8 g; mean FCR value was 1.2±0.15, 1.2±0.3 and 1.1±0.1; specific growth rate was 6.9±0.2, 6.8±0.4 and 6.5±0.1 with total production of 577.0±48.0, 608.0±62.0 and 764.0±72.0 kg/ha at 10, 20 and 30 individuals/m^2 stocking density respectively [8]. In this research the ABW, SGR, FCR and total mass weight was significantly higher (Table 2) than Begum *et al.* (2020) [8] due to high stocking density.

In the present study, the brown shrimp were fed with commercial feed (Quality) and proximate analysis revealed that maximum protein, ash and calcium percentage was recorded in pre-nursery feed, highest fat and phosphorus percentage recorded in nursery feed and maximum fibre content was found in growout feed (Table 3). Washim *et al.* (2016) reported that net benefit was 106484 BDT after 63 days of culture of black tiger shrimp where stocking density was 7 individuals/m^2 and BCR value was 1.41 [24]. Saha *et al.* (2016) also found net benefit BDT 79368 at 50000/ha density in 120 days culture period and BCR value was 1.29 [25]. The net benefit in this research found 167046, 513912, 346509 BDT and BCR value was recorded 0.32, 0.87 and 0.52 in T1, T2 and T3 respectively (Table 4) which implies treatment with 45 individuals/m^2 stocking density provides maximum return.

5. Conclusions

Highest body weight gain, survival, production, net economic return and BCR were achieved under the stocking densities of 45 individuals/m^2 indicated its superiority over other two stocking densities. From this research, it is concluded that culture of brown shrimp (*M. monoceros*) with 45 individuals/m^2 stocking density would be environment friendly and economically viable in brackishwater areas of Bangladesh. Validation through repetition of this density, enhancement of natural food production in culture ponds and use of low cost feeds needed to be tested to maximize the profit level before extension to farmer's field.

Acknowledgement

We are profoundly grateful to Bangladesh Fisheries

  DOI: https://doi.org/10.30564/jfsr.v3i1.3240

Research Institute (BFRI) for providing financial support to successfully complete the research work.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All the authors were an active part of the concept, design, analysis of data, drafting and revising the manuscript, while the SA and MLI performed the entire work together.

References

[1] Ahasan DA (2012) Bangladesh's Winning Maritime Boundary, Development, Conservation and Management of Fish Resources, National Fish Week 2012 Compendum (in Bengali), Narinda, Dhaka: Department of Fisheries, Ministry of Fisheries and Livestock, GoB., 23-25.

[2] DoF (2017) Yearbook of Fisheries Statistics of Bangladesh 2016~17. 34rd edition. Fisheries Resources Survey System, Department of Fisheries, Dhaka, Bangladesh. 129p.

[3] Shinn AP, Pratoomyot J, Griffiths D, Trong TQ, Vu NT, Jiravanichpaisal P, Briggs M (2018) Asian shrimp production and the economic costs of disease. Asian Fish. Sci. S, 31, 29-58. DOI: 10.33997/j.afs.2018.31.S1.003.

[4] Ahmed N (1967) Prawn and prawn fishery of East Pakistan. Govt. of East Pakistan, Dept. of Fisheries, Dhaka. 43p.

[5] Nandakumar G, Damodaran R (1998) Food and feeding habits of the speckled shrimp *Metapenaeus monoceros* (Fabricius). Journal of the Marine Biological Association of India, 40 (1 & 2). pp. 30-43.

[6] Janakiram B, Sekhar V, Reddy GR (1989) Oxygen consumption in the penaeid prawn, *Metapenaeus monoceros* under salinity stress. Indian J. Fish., 36(2):177-179.

[7] Sharif Y, Khan A, Huq QM (1991) Survival of juvenile *Metapenaeus monoceros* at different salinities at room temperature. Bangladesh J. Zool., 19(1): 13-20.

[8] Begum N, Rahman SL, Mahmud Y (2020) Culture potentials of brown shrimp, *Metapenaeus monoceros* (Fab.) under different stocking densities in south-western region of Bangladesh. Bangladesh Journal of Fisheries, 32(1), 39-44.

[9] APHA (American Public Health Association) (1992) Standard methods for the examination of water and waste water. 18th ed. American Public Health Association, Washington, D.C. 18: 132.

[10] APHA (American Public Health Association) (2005) Standard methods for the examination of water & waste water, American Public Health Association, Port city press, Baltimore, Maryland, USA.

[11] AOAC (1990) Official Methods of analysis of the association of the official analysis chemists. Association of official analytical chemists, 15th ed. AOAC International, Washington, DC, 1990.

[12] Ayuba VO, Iorkohol EK (2010) Proximate composition of some commercial fish feeds sold in Nigeria. 2010: 568-572.

[13] AOAC (1984) Official methods of analysis of the association of the official analysis chemists. Association of official analytical chemists, 14th ed. AOAC International, Washington, DC, 1984.

[14] Onyeike EN, Ayalogu EO, Ibegbulem CO (2000) Evaluation of the nutritional value of some crude oil polluted freshwater fishes. Global Journal of Pure and Applied Sciences, 6(2), 227-233.

[15] Fiske CH, Subbarow Y (1925) The colorimetric determination of phosphorus. Journal of Biological Chemistry 66: 375401.

[16] Shofiquzzoha AFM, Islam ML, Ahmed SU (2001) Optimization of stocking rates of shrimp (*Penaeus monodon*) with brackishwater finfish in a polyculture system. J. Bio. Sci., 1 (8): 694-697.

[17] Chiu YN (1988) Site selection for intensive prawn farms. In: Technical Consideration for the Management and Operation of Intensive Prawn Farms. Edited by Chiu YN, Santos LM, Juliano RO. Aquaculture Society, Iioilo city, the Philippines, PP. 25-28.

[18] Islam MS, Sarker MJ, Yamamoto T, Wahab MA, Tanaka M (2004) Water and sediment quality, partial mass budget and effluent N loading in coastal brackishwater shrimp farms in Bangladesh. Marine pollution bulletin, 48(5-6), 471-485. DOI: 10.1016/j.marpolbul.2003.08.025.

[19] Wyban J, Walsh WA, Godin DM (1995) Temperature effects on growth, feeding rate and feed conversion of the Pacific white shrimp. Aquaculture 138, 267-279. DOI: 10.1016/0044-8486(95)00032-1.

[20] Mazid MA (2009) Training manual on water quality management in shrimp farm Bangladesh quality support program fisheries. UNIDO, DHAKA, Bangladesh. 108.

[21] Debnath PP, Karim M, Kudrat-E-Kabir QAZM (2013) Comparative Study on Growth Performance of Bagda (*P. monodon*, Fabricius, 1798) in Traditional and Semi-intensive Culture Systems. Science and Technology 3(1): 1-16.

[22] Boyd CE, Fast AW (1992) Pond monitoring and

management. In: Marine Shrimp Culture: Principles and Practices, edited by A. W. Fast and L. J. Lester Elsevier, Amsterdam, PP. 497-508.

[23] Hoq ME (2002) Studies on mangrove fisheries resources of Sundarbans, its exploitation and utilization. Ph. D. Dissertation, Dept. of Fisheries Technology, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, 95-124 pp. In: Pro. Nat. Sem. Creeks, Estuaries and Mangroves Pollution and Conservation, 28-30 November, 2002, Thane, India. (Ed. Quadros, G.) pp. 116-119.

[24] Washim MR, Rahman SL, Nahar S (2016) Culture potential of SPF (specific pathogen-free) shrimp (*Penaeus monodon*) with special context of its growth and production performance in South west coastal region of Bangladesh. Int. J. Fish. Aquat. Stud., 4(6): 339-344.

[25] Saha SB, Nahar S, Ali A, Rahman SL (2016) Optimization of cropping pattern and stoking density for production of brackishwater shrimp, (*Penaeus monodon*). Bangladesh J. Zool., 44(1): 31-40.

  DOI: https://doi.org/10.30564/jfsr.v3i1.3240