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Stocking density effects on growth indices, survival and production of stinging catfish shing (*Heteropneustes fossilis*) in secondary nursing

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Abstract
To optimize the stoking density of stinging catfish shing (*Heteropneustes fossilis*) in secondary nursing, the experiment was conducted in six earthen ponds of 5.0 decimal each for a period of 8 weeks from 01 July 2017 to 25 August 2017. Three stocking densities maintained with 250000, 312500 and 375000 fingerling ha^{-1} designated as treatment T1, T2, and T3 each having two replications. All the fishes were fed MEGA pre starter fish feed (36% protein) for the first 4 weeks and starter feeds (32% protein) for rest of 4 weeks. Feeds were applied twice daily at the rate of 10% for the first two weeks and were decreased by 2% every two weeks thereafter. The water quality parameters were appropriate level for fish culture. The growth performances and survival of *H. fossilis* fingerlings were significantly ($p < 0.05$) higher in T1 than those obtained from T2 and T3, respectively. The lowest feed conversion ratio (FCR) was in T1 then followed by T2 and in T3. The gross and net production were significantly ($P < 0.05$) higher in T2 than those in T1 and T3. However, the highest net benefit was in T2 where the stocking density was 312500 fingerlings ha^{-1}. Therefore 312500 fingerling ha^{-1} (T2) is the most appropriate stocking density for secondary nursing of *H. fossilis* for better creation and additionally higher net advantages.

Keywords: *H. fossilis*, stocking density, growth, survival, production

1. Introduction

The stinging catfish was first formally described in 1974 as *Silurus fossilis*. The genus *Heteropneustes* was established in 1976. *Heteropneustes* is derived from the Greek “heteros” meaning “other”; Greek “pneo” meaning “to breath” (atmospheric air) and “fossilis” means “ancient”. *H. fossilis* is native to Bangladesh, Pakistan, India (including the Andaman Islands), Nepal, Sri Lanka, Barma, Thailand and Lous [1]. It is mainly found in pond, ditches, swamps and marshes, but sometimes found in muddy rivers also. It can tolerate slightly brackish water. It is omnivorous. This species breeds in confined waters during the monsoon months, but can breed in ponds, derelict ponds, and ditches when sufficient rain water accumulates. It is always marketed in live condition. It contains high amount of iron (226 mg 100 g^{-1}) and fairly high content of calcium compared to many other freshwater fishes [2]. Due to medicinal value, *H. fossilis* has high economic importance and great demand [3]. The people who are unable to utilize animal fats, *H. fossilis* is very suitable for them as it is a one kind of lean fish [4].

Previously this fish was available in natural fresh water bodies of Bangladesh. But in recent years, the fish has become gradually been endangered as the natural habitats and breeding grounds of this fish has been severely degraded due to over exploitation, ecological changes, reduction of water bodies, application of pesticides in rice cultivation, release of chemical effluents from industrial plants and hydrological changes due to construction of flood control infrastructure [5,6].

The seed production of *H. fossilis* through induced breeding and culture technology have been developed [7] but fry and fingerlings rearing has not yet been well developed due to its scarcity and lack of appropriate rearing technology. On the other hand, suitable size of fingerlings is very important to conserve and improve fish culture. Therefore, the present work has been undertaken to develop a suitable and economically viable technology for production of *H. fossilis in secondary nursing.*

2. Materials and Methods

2.1 Study area and experimental design

The experiment was conducted from 01 July 2017 to 25 August 2017 (8 weeks) in six earthen ponds of farmer, situated near to Bangladesh Agricultural University Campus, Mymensingh. On the basis of stocking density, the ponds were divided into three treatments such as T1, T2 and T3.

2.2 Pond preparation, fingerling stocking and feeding

All the experimental ponds were rectangular in shape with inlet and outlet. Before stocking the fish, the ponds were dried and lime was applied at the rate of 250 kg ha^{-1}. Five days after liming, the ponds were filled with ground water by pumping. After that, the ponds were manured with cowdung at the rate of 2.5 tones $ha^{-}1$. Seven days after manuring, dipterex was applied at the rate of 1 ppm on the surface of the water to kill aquatic insects. After 7 days of applying dipterex, the ponds were stocked with 250000, 312500 and 375000 fingerlings ha^{-1}. During the stocking the average weights of fingerlings were 3.94±0.09, 3.93±0.09 and 3.99±0.07 g in T1, T2 and T3, respectively. Fishes were fed with commercially available Mega fish feed twice daily once early in the morning and next in the evening (6:00 am BDT and 7:00 pm BDT). The Mega pre-starter fish feed (containing 36% protein) was applied for the first 4 weeks and starter feeds (32% protein) applied for the rest of 4 weeks. One day after stocking the fish, feeds were applied at the rate of 10% for the first two weeks and it was readjusted by sampling which was 8% for second two weeks, 6% for third two weeks and 4% for rest of two weeks. For proper feeding, the feed was broadcasted homogenously in each time.

2.3 Water quality parameters and plankton abundance

Water quality parameters such as water temperature, pH, DO (Dissolved oxygen) and transparency were recorded weekly for 8 weeks between 09:00 am and 10:00 am. Temperature was measured by Celsius thermometer; dissolved oxygen recorded by Hanna DO meter (Model-HI 9146, Romania), pH recorded by Milwaukee pH meter (Model-P^H55/P^H56, USA), and transparency recorded by secchidisc with measuring tape. Plankton abundance in the experimental ponds was also estimated weekly. Ten liters of water, collected from different locations and depths of each pond were filtered through fine-meshed plankton net (25 µm) to obtain a 50 ml sample. The samples were preserved immediately with 5% buffered formalin in plastic bottles. Plankton density was estimated by using a sub-sampling technique. A Sedgwick-Rafter (S-R) cell was used under a calibrated compound microscope for plankton counting. Plankton cells in 10 randomly chosen squares were counted for quantitative estimation using the formula proposed by Rahman [8].

2.4 Evaluation of growth performances

To observe the growth performance, survival and also readjust the feeding rate of *H. fossilis* weekly sampling was carried out with a seine net in the morning (from 8:00 am to 9:00 am). The weight of fish samples was taken by using portable balance (Model HI 400EX). After sampling, fishes were released into the respective ponds immediately. The following formulae have been used to determine the SGR, survivals, FCR and production of *H. fossilis.*

$$\text{SGR (\% per day)} = \frac{\text{ln final weight} - \text{ln initial weight}}{\text{Number of experimental days}} \times 100$$ [9]

$$\text{Survival (\%)} = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$$

$$\text{Food conversion ratio (FCR)} = \frac{\text{Feed fed (dry matter)}}{\text{Live weight gain}}$$ [10]

Production= No. of fish harvested × Average final weight of fish

2.5 Statistical analysis

One way analysis of variance (ANOVA) was used to look the growth rates, survival and production. All data were analyzed using the SPSS. The Duncan's test was used to determine differences among treatment means. Differences were considered statistically significant at $P < 0.05$.

3. Results and Discussion

Water quality parameters and plankton abundance

The comparison of mean values of water quality parameters among three treatments were recorded during the experimental period is presented in Table.1. Water temperature of the ponds water under different treatments was recorded weekly. The water temperature was more or less similar in different ponds. The mean values of water temperature were 29.88 ± 1.02, 30.00 ± 1.22 and 30.53 ± 1.26 ^{0}C in T1, T2 and T3 respectively (Table 1). There was no significant difference ($p > 0.05$) among the treatments when ANOVA was performed (Table 1). Dewan [11] recorded temperature range of 19.0-35.0^{0}C from a pond situated at Mymensingh where as Wahab [12] recorded from 28.50^{0}C to 31.30^{0}C in their experimental ponds. Dissolved oxygen is one of the most important factors which were recorded during the experimental period. The values of dissolved oxygen ranged from 4.8 to 5.8, 3.8 to 5.2 and 3.6 to 4.8 mg l^{-1} where as the mean values were 5.21 ± 0.32, 4.50 ± 0.44 and 4.14±0.43 mg l^{-1} in treatments 1, 2 and 3 respectively (Table 1). The mean values of dissolved oxygen were significantly different ($p < 0.05$) among the treatments. Similar results were also reported by Paul [13], Uddin [14] and Monirozzaman and Mohllah [15] in various fish culture ponds. The mean values on dissolved oxygen were acceptable range for fish culture. The mean values of pH were satisfactory level for fish culture. The values of pH ranged from 5.9 to 8.1, 6.4 – 8.4 and 6.3 to 8.6 and mean values were 7.00 ± 0.76, 7.36 ± 0.69 and 7.68 ± 0.67 in T1, T2 and T3 respectively (Table 1). The mean pH value in T3 is significantly different ($p < 0.05$) from T1 but not T2. The findings of the present study also agree well with those observed by Hossain [16] and Kohinoor [17, 18]. Transparency recorded in this experiment was 23.69 ± 2.60, 29.19 ± 2.99 and 34.69 ± 5.62 cm in T1, T2 and T3, respectively. The mean transparency level was significantly ($p < 0.05$) higher in T3 and consistently lower in T1, which might be due to the reduction of the plankton population by higher density of fish [19, 20]. Microscopic organisms and suspended organic matter also affected the transparency of pond water [21]. The transparency of productive water bodies should be 40 cm or less according to Rahman [8]. The mean values of total alkalinity were 115.69 ± 6.19, 107.69 ± 5.22 and 101.81 ± 6.43 in T1, T2 and T3, respectively. The mean values of total alkalinity were significantly different ($p < 0.05$) among the treatments. Similar results were also found in the studies of Monir and Rahman [22]. The mean values of ammonia-nitrogen (NH_4-N) were 0.08 ± 0.02, 0.10 ± 0.02 and 0.11 ± 0.02 in T1, T2 and T3, respectively. The value of T1 is significantly lower ($p < 0.05$) than other treatments. However, the present level of ammoni-nitrogen content in the experimental ponds is not lethal to the fishes [17, 18].

Table 1: Mean values (± SD) and ranges of water quality parameters and plankton abundance of weekly samples over the 8-week experiment

Parameters	T1	T2	T3
Water temperature (°C)	29.88±1.02^a (28.00-32.00)	30.00±1.22^a (28.0-32.00)	30.53±1.26^a (28.0-32.50)
Dissolved oxygen (mg^{-}l)	5.21±0.32^a (4.8-5.8)	4.50±0.44^b (3.8-5.2)	4.14±0.43^c (3.6-4.8)
pH	7.00±0.76^b (5.9-8.1)	7.36±0.69^{ab} (6.4-8.4)	7.68±0.67^a (6.3-8.6)
Transparency (cm)	23.69±2.60^c (18.0-27.0)	29.19±2.99^b (24.0-34.0)	34.69±5.62^a (27.0-43.0)
Total alkalinity (mgl^{-l})	115.69±6.19^a (108.0-127.0)	107.69±5.22^b (101.0-119.0)	101.81±6.43^c (92.0-111.0)
Total ammonia-nitrogen (mgl^{-l})	0.08±0.02^c (0.05-0.12)	0.10±0.02^b (0.07-0.12)	0.11±0.02^a (0.09-0.14)
Phytoplankton (cellsl^{-1})	12350±2430^a (7985-15895)	10430±2172^b (6548-13457)	8295±1995^c (4985-11549)
Zooplankton (cellsl^{-1})	6726±1457^a (4231-9472)	5379±1110^b (4005-7231)	4484±959^c (2983-6321)

Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

During the experimental period, the total phytoplankton and zooplankton have been estimated from the experimental ponds and given in Table 1. The total phytoplankton ranged from 4985 to 15895 cellsl^{-1} and the mean abundance were 12350 ± 2430 (T1), 10430 ± 2172 (T2) and 8295 ± 1995 cellsl^{-1} (T3), respectively. The total zooplankton ranged from 2983 to 9472 cellsl^{-1} whereas the mean abundance were 6726 ± 1457, 5379 ± 1110 and 4484 ± 959 cellsl^{-1} in T1, T2 and T3, respectively. Significantly higher ($p < 0.05$) plankton abundance was recorded in T1 might be due to the lower density of fish than those in T2 and T3. It seems likely that in the ponds where stocking density was high, consumption of plankton by the fishes was also high. However, the plankton population of the present study showed to be more or less similar with the findings of Rahman [23] and Monir and Rahman [22].

Growth performance and yield

The mean initial weight, final weight, specific growth rate (SGR% per day), survival rate and food conversion ratio (FCR) were recorded during the study period and given in Table2.

Table 2: Growth performances, survival and feed utilization of Shing (*H. fossilis*) fingerlings after 8 weeks of rearing; mean ± SE with range in parentheses

Treatments	Initial weight (g)	Final weight (g)	SGR (% day^{-1})	Survival rate (%)	FCR
T1	3.93±0.09^a (3.90-3.96)	17.08±0.69^a (17.53-17.89)	1.17±0.02^a (1.5-1.18)	85.75 ± 0.72^a (85.03-86.47)	1.99 ± 0.01^a (1.98-1.99)
T2	3.94±0.09^a (3.84-4.04)	16.84±0.65^a (16.63-17.05)	1.13±0.03^a (1.10-1.16)	83.64±0.68^b (82.96.-84.32)	2.04±0.01^a (2.03-2.04)
T3	3.99±0.07^a (3.97-4.01)	14.01±0.75^b (13.80-14.01)	0.98± 0.02^b (0.96-0.99)	65.12±1.41^c (63.71-66.52)	2.80±0.12^b (2.68-2.91)

Figures in the same column having the same superscript are not significantly different ($p > 0.05$)

The growth in weight of *H. fossilis* under different stocking densities at weekly intervals is shown in Fig 1. The increase in weight was always higher in T1 than T2 and T3. The mean final weight attained under T1, T2 and T3 were 17.08 ± 0.69, 16.84 ± 0.65 and 14.01 ± 0.75 g, respectively.

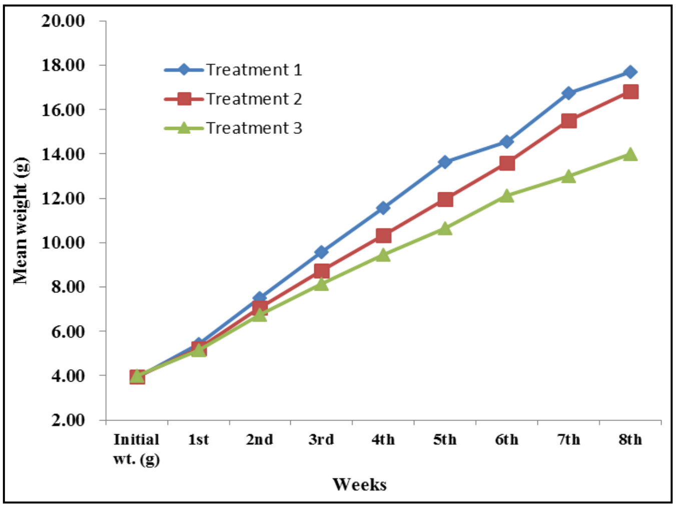

Fig 1: Mean weight of Shing (*H. fossilis*) at different stocking densities over the rearing period of 8 weeks

The highest mean final weight was also obtained in T1 (17.08±0.69 g) and lowest in T3 (14.01 ± 0.75 g). The mean weight in T3 was significantly lower ($p > 0.05$) than T1 and T2. The Specific growth rate (SGR % per day) were significantly lower ($p < 0.05$) in T3 (0.98± 0.02) than those obtained in T1 (1.17 ± 0.02) and T2 (1.13 ± 0.03). The mean weight and specific growth rate (SGR % per day) were lowest in T3 than T1 and T2 due to higher stocking density in T3 (375000 fingerlings ha^{-1}) compared to those of T1 (250000 fingerlings ha^{-1}) and T2 (312000 fingerlings ha^{-1}). But there were no significant difference showed ($p > 0.05$) between T1 and T2 in case of mean weight and SGR when ANOVA was performed. The results also indicated that higher growth rate was always observed at lower stocking densities in the experiment. More or less similar types of growth were observed by Kohinoor [6], who recorded the growth 49.50 to 69.42 g from six months cultured of *H. fossilis*. The low growth rate of *H. fossilis* appeared to be related with higher densities. The present results coincide with the findings of Narejo [24] who achieved best growth at lower stocking densities in shing farming. The highest survival rate was also observed in T1 (85.75 ± 0.72%), where the stocking density was 250000 fingerlings ha^{-}1 and the lowest was in T3 (65.12 ± 1.41%) where the stocking density was 375000 fingerlings ha^{-1}. The survival rate was significantly differences ($p > 0.05$) among the treatments. In the present study highest survival rate was found where the stocking density was lowest. More or less similar results were found Khan [5] and Kohinoor [6] whose recorded survival rates of *H. fossilis* 76.13 to 98.81 and 71 to 81.7, respectively. The lowest stocking densities provide more space, food and less competition, which were reported by various authors like Ahmed [25], Hasan [26] and Haque [27].

The Food Conversion Ratio (FCR) was found significantly lower ($P < 0.05$) in T1 (1.99 ± 0.01) than T2 (2.04 ± 0.01) and T3 (2.80 ± 0.12) due to lower stocking density T1 (250000 fingerlings ha^{-1}) than T2 (312000 fingerlings ha^{-1}) and T3 (375000 fingerlings ha^{-1}). But there was no significant variation ($p > 0.05$) was found between T1 and T2. Reddy and Katro [28] and Das and Ray [29] observed increasing trends of FCR values with increasing ration size in the growth trials of air breathing catfish (*Heteropneustes fossilis*) and Indian major carp (*Labeo rohita*),respectively. However, the lower FCR value in the present study indicates better food utilization efficiency, despite the values increased with increasing stocking densities.

The mean initial stocking weight as well as gross and net production of *H. fossilis* at the end of the experiment has been presented in Table 3. The net production of *H. fossilis* is shown graphically in Fig 2. From the Table 2, it is found that the initial weights at stocking and total production (kg ha^{-1}) at harvesting under different stocking densities were significantly different ($p < 0.05$).

Table 3: The gross and net productions of Shing (*H. fossilis*) fingerlings after 8 weeks of rearing; mean ± SE with range in parentheses

Treatments	Initial stocking wt. (kg ha^{-1})	Total production (kg $pond^{-1}$)	Production (kg ha^{-1})	
			Gross	Net
T1	982.50±7.50^{c} (975.00-990.00)	75.93±0.14^{b} (75.79-76.06)	3796.26±6.71^{b} (3789.55-3802.97)	2813.76±14.21^{b} (2799.55-2827.97)
T2	1231.25±31.25^{b} (1200.00-1265.50)	85.40±0.82^{a} (84.58-86.23)	4270.26±41.08^{a} (4229.18-4311.33)	3039.01±9.83^{a} (3029.18-3048.83)
T3	1396.50±7.00^{a} (1389.50-1403.50)	68.93±0.98^{c} (67.95-69.90)	3446.07±48.73^{c} (3397.34-3494.79)	2049.57±41.73^{c} (2007.84-2091.29)

Figures in the same column having the different superscript are significantly different ($p < 0.05$)

The mean gross and net production after 8 weeks of rearing period were 3796.26±6.71 and 2813.76 ± 14.21, 4270.26 ± 41.08 and 3039.01 ± 9.83 and 3446.07 ± 48.73 and 2049.57 ± 41.73 kg ha^{-1} at the stocking densities of T1 (250000), T2 (312500) and T3 (375000) fingerlings ha^{-1}, respectively. The growth and survival decreased with increased stocking density, but the total production did not maintain the same trends. The highest production was obtained in ponds stocked at 312500 fingerlings ha^{-1} which significantly ($p < 0.05$) from the production obtained from T1 and T3. The lowest production was found in ponds stocked with 375000 fingerlings ha^{-1} (Table 3). Water quality parameters were favorable ranges during the experimental period. However, Khan [5] observed the effect of different stocking densities on production of catfish (*H. fossilis*) in earthen ponds and got the production 2080 to 3364 kg ha^{-1}. Kohinoor [6] obtained production 7549 to 8786 kg ha^{-1} in six month culture from *H. fossilis* at different stocking densities. This production has differed from the present findings due to different culture period and stocking densities. However, Monir and Rahman [22] obtained gross production of 3170 kg ha^{-1} to 7525.86 3170 kg ha^{-1} in 8 weeks rearing from *H. fossilis* at different stocking densities. These results are more or similar with the above findings. In the present study, the growth and survival were inversely related to the stocking densities of fingerling. But in case of total production, the stocking density of 312500 fingerlings ha^{-1} showed better results than the stocking densities of 250000 and 375000 ha^{-1}.

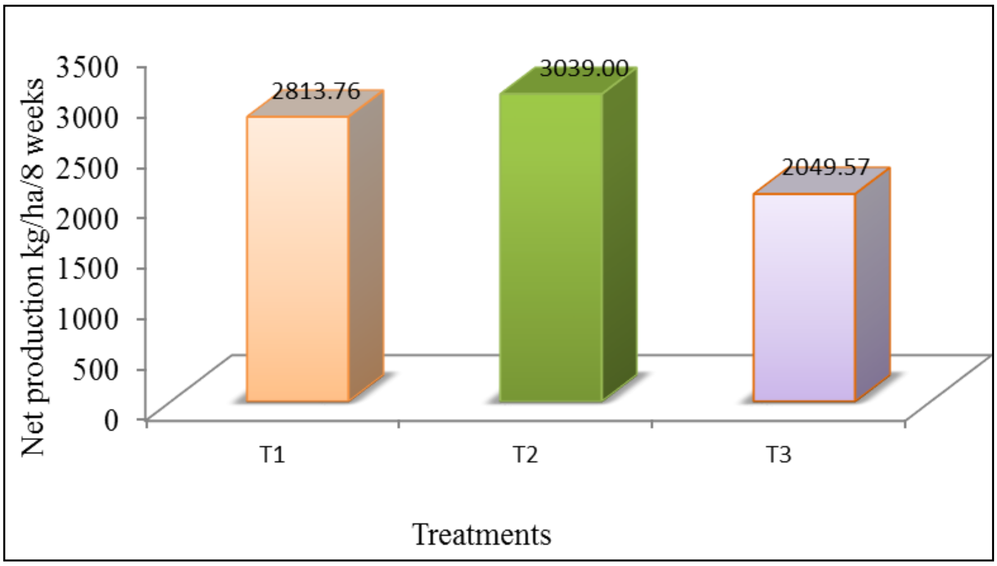

Fig 3: Showing the net production of (kg/ha/8weeks) of *H. fossilis*

3.4 Cost-benefit analysis

The present experiment over 8 weeks rearing of *H. fossilis*, the total cost of production (BDT ha^{-1}) was lower in $_1$ (6, 71,100) than those in T2 (7, 73,200) and T3 (8, 27,389) (Table 3). The net benefits were calculated in secondary nursing as BDT 5, 43,703; 5, 93,283 and 1, 37,511 ha^{-1} for T1, T2 and T3, respectively. However, the highest net benefits were obtained of BDT 5, 93,283 from T2 where the stocking density was 312500 fingerlings ha^{-1} (Table 4). Rahman [30] have got the net benefits of BDT 69,277.32 ha^{-1} of Reba Carp (*Cirrhinus ariza*) nursing over a period of 8 weeks by applying formulated feed. Rahman and Monir [20] analyzed the cost and benefits of Thai koi (*Anabas testudineus*) for 7 weeks of nursing and obtained the net benefit of BDT 2, 40, 757 to 5, 71, 112 per hectare. Monir and Rahman [22] also analyzed the cost and benefits of Shing (*H. fossilis*) and have got the net benefits of BDT 4, 00, 8, 00 to 11, 29, 133 ha^{-1} for a period of 8 weeks nursing. In this experiment, the net benefits were differed from the above findings due to different culture period and species. However, it could be concluded that 312500 fingerlings ha^{-1} is the most appropriate stocking density for secondary nursing of *H. fossilis* for better production and higher net benefits.

Table 4: Costs and benefits from the nursing of Shing (*H. fossilis*) fingerlings production in 1-ha earthen ponds for a rearing period of 8 weeks

Items	Description	Treatments		
A. Cost		**T1 (BDT)**	**T2 (BDT)**	**T3 (BDT)**
Pond lease	For 4 months (BDT 75,000.00/ha/yr)	25, 000	25, 000	25, 000
Lime	250 kg @ BDT 25.00/kg	6,250	6,250	6,250
Cow dung	2500 kg @ BDT 7.00/kg	17,500	17,500	17,500
Dipterex	8 kg @ BDT 1,100.00/kg	8,800	8,800	8,800
Fingerling	BDT 0.70/Piece	1,75,000	2,18,750	2,26,500
Feed	Starter-1 @ BDT 50.00/kg	3,76,750	4,35,100	4,81,539
Labour	2 labour for 3 months @ BDT 260/Day	46,800	46,800	46,800
Miscellaneous	(Oxy-flow, carrying cost etc.)	15,000	15,000	15,000
Total costs		6,71,100	7,73,200	8,27,389
B. Gross benefit				
Selling price of fish**	BDT 320.00/kg (T1 & T2) and BDT 280.00/kg (T3)	12,14,803	13,66,483	9,64,900
Net benefits (B-A)		5,43,703	5,93,283	1,37,511

* 1 US $ = BDT 82.00

4. Conclusion

The growth and survivals of Shing (*H. fossilis*) were inversely related to the stocking density of fingerlings in this experiment for secondary nursing but it isn't same patterns for getting total production and net benefits. Overall consideration, 312500 fingerlings ha^{-1} showed the highest performance than those obtained at highest and lowest stocking rates. So, it could be suggested that the stocking density of 312500 fingerlings ha^{-1} advisable for secondary nursing of Shing (*H. fossilis*) at farmers level for better economic efficiency.

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