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Research Article**PERFORMANCE OF PANGAS (*Pangasianodon hypophthalmus*) UNDER DIFFERENT DENSITIES IN CAGES SUSPENDED IN EARTHEN POND****S. N. Mehta¹, S. K. Wagle², M. K. Shrestha¹, and N. P. Pandit¹**¹Agriculture and Forestry University, Rampur, Chitwan, Nepal²Fisheries Research Division, Nepal Agriculture Research Council, Godawari, Nepal**ABSTRACT**

Pangas (*Pangasianodon hypophthalmus*) is a highly productive freshwater fish species. An experiment was done at the Regional Agriculture Research Station, Tarahara, Nepal to assess production and economics of pangas at different stocking densities. The experiment was conducted in 12 nylon net cages (1 cm mesh size and 25 m³), fixed in a 7000 m² earthen pond for 90 days. The experiment was set up using a completely randomized design (CRD) with 4 treatments, each replicated thrice. The treatments were: 80000 fish/ha (T₁), 100000 fish/ha (T₂), 120000 fish/ha and 140000 fish/ha (T₄). Pangas yearlings of average weight 81.2±0.7 g were stocked in each cage. Fish were fed with 30% CP pellet feed twice daily @ 3% of body weight. At harvest, the average weight of fish in T₁, T₂, T₃ and T₄ were 547.2, 552.8, 531.0 and 537.5 g, respectively, with an average growth rate of 5.2, 5.2, 5.0 and 5.1 g/fish/day, respectively. There were no significant differences in average harvest weight and growth rate of fish among treatments. The survival rate of pangas was significantly lowest in T₄ (85.5%), intermediate in T₃ (91.3%) and highest in T₁ (96.8%) and T₂ (95.6%) (p<0.05). The extrapolated gross yield of pangas in T₁, T₂, T₃ and T₄ were 42.4, 52.9, 58.2 and 64.4 t/ha/cycle, respectively. The extrapolated gross yield was significantly higher in T₃ and T₄ than T₁ (p<0.05). The gross margin was highest in T₃ (NRs. 10511.4/cage), intermediate in T₂ (NRs. 8184.1/cage) and lowest in T₄ (NRs. 5798.9/cage). Growth of this fish was higher at lower stocking densities, but highest production was obtained at highest stocking density. Based on the results of this study we can conclude that stocking density of pangas at 120000 fish/ha (T₃) is more profitable.

Key words: Survival, gross yield, net yield, food conversion ratio, gross margin**INTRODUCTION**

Pangas catfish (*Pangasianodon hypophthalmus*), belonging to the family Pangasiidae under the order Siluriformes, is a newly introduced exotic fish species in Nepal. This fish is commonly known as “pangas” or “baikhi” in Nepal. The origin of pangas catfish was from the Mekong River of Vietnam to Chao Phraya River of Thailand and distributed to other countries such as Malaysia, Indonesia and China (FAO, 2016). Commercial culture and production of pangas has recently been expanded dramatically in some Asian countries especially in China, Thailand, Vietnam and Bangladesh. This fish is sold to more than 130 countries globally, mainly in the form of white fillets. Pangas is now considered as the third most important freshwater fish group within the aquaculture sector (FAO, 2016). This species gained popularity because of its omnivorous feeding habit, fast growth rate, high stocking capacity, easy culture system, high disease resistance, good market demand and tolerance to a wide range of environmental change (Sarkar et al., 2007; Ali et al., 2005; Rohul Amin et al., 2005). Another important fact is that this fish can easily be acclimatized to the artificial feed, as it is an omnivorous fish, in controlled conditions. Pangas can be cultured in high stocking density as this fish has a higher number of erythrocytes than any other fish, plus an additional respiratory organ, and can breathe through bubbles and skin which help it tolerate an environment short of dissolved oxygen (Shrestha et al., 2015).

There is a huge demand for pangas in Nepalese markets due to lower market price and presence of fewer spines inside body. Moreover, the vast majority of people consume this fish due to its delicacy and taste with high fat content. It indicates that this fish can make a significant contribution in increasing fish production, poverty alleviation and livelihoods support in Nepal. Pangas are generally cultured completely on supplemental feed in intensive aquaculture system. In monoculture, due to the use of large quantity of supplemental feed, pond water receives high quantity of inorganic nutrients from the microbial decomposition of unused fish feed and metabolic wastes. These nutrients favor excessive production of phytoplankton in pond water that can support additional number of planktivorous fishes without further feed or management cost (Sayeed et al., 2008). Thus, polyculture of pangas with planktivorous fishes might have advantageous to improve water quality and fish production.

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In Nepal, few farmers of Terai region has introduced pangas from India by their own efforts and doing successful cultivation since few years. However, seed and culture technologies are the major constraints to expand this business as the breeding and culture technology of this species has not well developed in Nepal. Artificial propagation of pangas has been recently started in some Government farms of Nepal with partial success. Identification of breeding season and the role of temperature and precipitation to stimulate spawning have been studied in the Regional Agriculture Research Station, Tarahara (NARC). There is need of more researches on development of culture package in Nepal.

Stocking density is a key factor affecting growth, production and survival of fish besides food supply and its quality, genetics and environmental conditions. In many cultured species, growth is inversely related to stocking density and this can be attributed to social interactions (Huang and Chiu, 1997; Irwin et al., 1999). Rearing fish at inappropriate stocking densities may impair growth and reduce immune competence due to factors such as social interactions and deterioration of water quality, which can affect both feed intake and conversion efficiency of the fish. To obtain maximum economic return it would be necessary to stock the ponds at optimum stocking densities for desired growth and survival of fish. However, there is no any reports available on the effects of stocking density on the growth and production of pangas in cages fitted in pond. Therefore, the objective of this study was to assess growth, production and economics of pangas kept at different stocking densities.

MATERIALS AND METHODS

This experiment was conducted in 12 nylon net cages suspended in an earthen pond at the Regional Agriculture Research Station, Tarahara, Sunsari, Nepal for 90 days during 5 May to 7 August 2017. The size of cage used in the present experiment was 5.0 m x 5.0 m x 1.25 m and the mesh size was 1.0 cm. Total area of the pond was 7000 m². The cages were installed in pond with bamboo poles, about 4 m away from the pond dike. In each cage, a feeding tray made by bamboo (*Nanglo* in Nepali; 25 cm diameter) was hung from the four upper corners of the cage with the help of nylon rope.

The experiment was set up in a Completely Randomized Design (CRD) with 4 treatments and 3 replications of each treatment. The treatments were four different stocking densities of pangas: (1) 80000 fish/ha (T₁), (2) 100000 fish/ha (T₂), (3) 120000 fish/ha (T₃) and (4) 140000 fish/ha (T₄). Pangas yearlings of average weight 81.2 g (weight range 79.5 to 83.7 g) were stocked. These fish were produced in previous years by breeding pangas at the Regional Agriculture Research Station, Tarahara.

Fish were fed twice daily (8:00 to 9:00 a.m. and 3:00 to 4:00 p.m) with commercial sinking pellet feed at the rate of 3.0% (dry weight basis) of the body weight of fish. Feed requirement was adjusted fortnightly by measuring the growth of fish. In situ weekly measurement of water temperature, dissolved oxygen (DO), and pH was conducted using DO meter and pH meter at a depth of 20 cm from surface at 6.00-7.00 am (Boyd and Tucker, 1992). Final harvesting of fish was done on 7 August 2017. All fish in each cages were weighed in batch.

The fish production and related parameters were analyzed following formulae:

$$\text{Net fish yield (t ha}^{-1} \text{ yr}^{-1}) = \text{Harvest weight (kg)} - \text{Stocked weight (kg)}.$$

$$\text{Food conversion ratio (FCR)} = \frac{\text{Quantity of feed supplied (kg)}}{\text{Net fish yield (kg)}}$$

$$\text{Survival rate (\%)} = \frac{\text{Total number of fish harvested}}{\text{Total number of fish stocked}} \times 100$$

Simple economic analysis was done to determine the economic returns from each treatment (Shang, 1990). The economic analysis was mainly based on farm gate price for the harvested fish and current local market prices for all other inputs in Nepal. A farm gate price of pangas was 250 NRs kg⁻¹. Prices for pangas fingerlings were 20 NRs piece⁻¹. Prices for lime, DAP, urea and feed was 20, 55, 30 and 60 NRs kg⁻¹ respectively. The calculation for cost of working capital was based on an annual interest rate of 10%.

$$\text{Gross margin (NRs)} = \text{Gross revenue (NRs)} - \text{Total Variable costs (NRs)}$$

Statistical analysis of data was performed by using one-way analysis of variance (ANOVA) using SPSS (version 21.0) statistical software package (SPSS Inc., Chicago). Arcsine transformations were

performed on percent data. Differences were considered significant at the 95% confidence level ($P < 0.05$). All means were given with \pm standard error (S.E.).

RESULTS

Fish growth, survival and production

The average stock weight of pangas in T_1 , T_2 , T_3 and T_4 were 80.1, 81.2, 82.7 and 81.8 g, respectively (Table 1). There were no significant difference in average stock weight among treatments ($P > 0.05$). At harvest, the total weight of pangas in T_1 , T_2 , T_3 and T_4 were 106.1, 132.2, 145.6 and 160.9 kg/cage, respectively. The total harvest weight was significantly higher in T_3 and T_4 than T_1 ($p < 0.05$). The average harvest weight of pangas in T_1 , T_2 , T_3 and T_4 were 547.2, 552.8, 531.0 and 537.5 g, respectively without any significant difference among treatments ($P > 0.05$; Table 1).

The daily weight gain of pangas in T_1 , T_2 , T_3 and T_4 were 5.2, 5.2, 5.0 and 5.1 g/fish/day, respectively. There were no significant difference in daily weight gain among treatments ($P > 0.05$). The survival rate of fish in T_1 , T_2 , T_3 and T_4 were 96.8, 95.6, 91.3 and 85.5 g/fish/day, respectively. The survival rate was significantly lowest in T_4 , intermediate in T_3 and highest in T_1 and T_2 ($p < 0.05$; Table 1). Fortnightly growth trend of pangas in each treatment during the experimental period is shown in Figure 1. In all treatments, pangas grew steadily during the entire culture period.

Table 1. Growth performance and survival of pangas in different treatments. Data based on 25 m³ water volume. Mean values with same superscript in the same row are not significantly different ($p > 0.05$)

Parameters	Treatments			
	T_1 (80000 fish/ha)	T_2 (100000 fish/ha)	T_3 (120000 fish/ha)	T_4 (140000 fish/ha)
Stocking				
Total count	200 \pm 0.0	250 \pm 0	300 \pm 0	350 \pm 0
Total weight (kg)	16.0 \pm 0.1	20.3 \pm 0.2	24.5 \pm 0.3	28.6 \pm 0.3
Average weight (g)	80.1 \pm 0.2 ^a	81.2 \pm 0.8 ^a	82.7 \pm 0.3 ^a	81.8 \pm 1.0 ^a
Harvesting				
Total count	193.7 \pm 1.8 ^a	239.0 \pm 2.6 ^b	274.0 \pm 3.6 ^c	299.3 \pm 2.4 ^d
Total weight (kg)	106.1 \pm 9.2 ^a	132.2 \pm 5.4 ^{ab}	145.6 \pm 5.8 ^b	160.9 \pm 12.7 ^b
Average weight (g)	547.2 \pm 42.6 ^a	552.8 \pm 18.4 ^a	531.0 \pm 14.3 ^a	537.5 \pm 41.3 ^a
DWG (g/fish/day)	5.2 \pm 0.5 ^a	5.2 \pm 0.2 ^a	5.0 \pm 0.2 ^a	5.1 \pm 0.5 ^a
Survival (%)	96.8 \pm 0.9 ^c	95.6 \pm 1.1 ^c	91.3 \pm 1.2 ^b	85.5 \pm 0.7 ^a

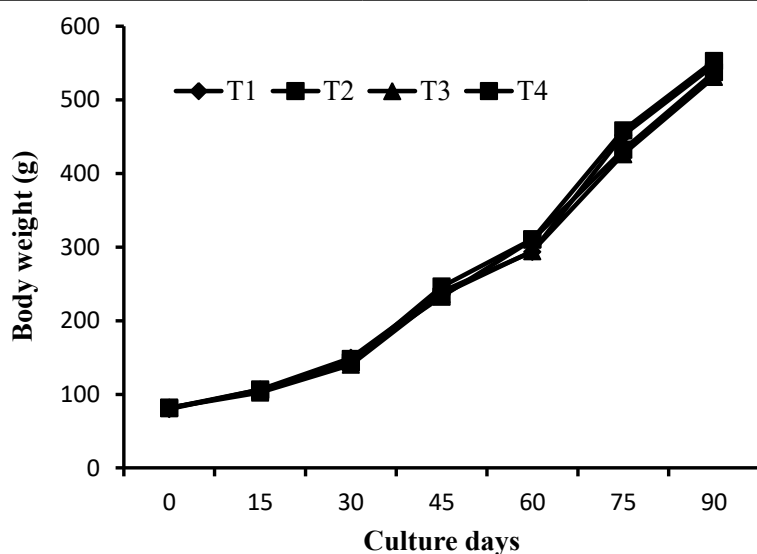


Figure 1. Fortnightly growth trend of pangas in each treatment during the experimental period

The extrapolated gross and net yield of pangas in different treatments are presented in Table 2. The extrapolated gross yield of pangas in T₁, T₂, T₃ and T₄ were 42.4, 52.9, 58.2 and 64.4 ton/ha/cycle, respectively. Similarly, the extrapolated net yield of pangas in T₁, T₂, T₃ and T₄ were 36.0, 44.8, 48.4 and 52.9 ton/ha/cycle, respectively. The extrapolated gross yield was significantly higher in T₃ and T₄ than T₁ (p<0.05). Similarly, the extrapolated net yield was significantly higher in T₄ than T₁ (p<0.05). The food conversion ratio (FCR) of pangas in T₁, T₂, T₃ and T₄ were 1.8, 1.8, 1.7 and 2.1, respectively (Table 2).

Table 2. Gross and net yield of pangas in different treatments. Data based on 25 m³ water volume. Mean values with same superscript in the same row are not significantly different (p>0.05)

Parameters	Treatments			
	T ₁ (80000 fish/ha)	T ₂ (100000 fish/ha)	T ₃ (120000 fish/ha)	T ₄ (140000 fish/ha)
Gross yield (kg/25 m ² /cycle)	106.1±9.2 ^a	132.2±5.4 ^{ab}	145.6±5.8 ^b	160.9±12.7 ^b
Extrapolated gross yield (t/ha/cycle)	42.4±3.7 ^a	52.9±2.1 ^{ab}	58.2±2.3 ^b	64.4±5.1 ^b
Extrapolated net yield (t/ha/cycle)	36.0±3.7 ^a	44.8±2.1 ^{ab}	48.4±2.3 ^{ab}	52.9±5.0 ^b
FCR	1.8±0.1 ^{ab}	1.8±0.1 ^{ab}	1.7±0.0 ^a	2.1±0.1 ^b

Water quality

Weekly mean and range of water quality parameters of the experimental pond during the experimental period are shown in Table 3 and Figures 2-4. Most of the water quality parameters showed cyclic variation, but were within the recommended range for the growth performance of pangas. The mean morning temperature, afternoon temperature, dissolved oxygen and pH were 27.67 °C, 31.17 °C, 2.50 mg/L and 8.67, respectively (Table 3).

Table 3. Mean and ranges of water quality parameters of the experimental pond

Parameters	Mean and Range
Temperature (7.00 am)	27.7 (21.0 -31.0)
Temperature (3.00 pm)	31.2 (24.0 -36.0)
Dissolved oxygen (mg/L)	2.5 (1.1-4.5)
pH	8.7 (8.4-9.3)

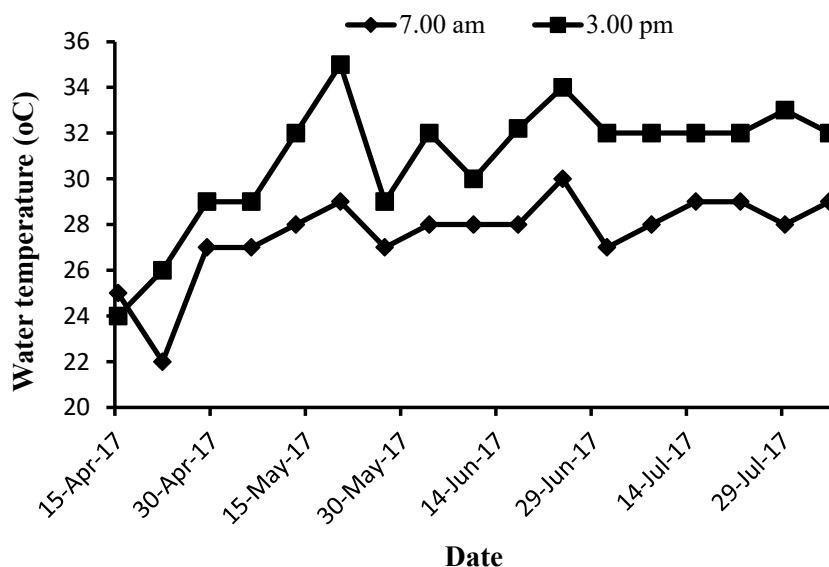


Figure 2. Weekly mean temperature (°C) of pond water at 7.00 am and 3.00 pm during the experimental period

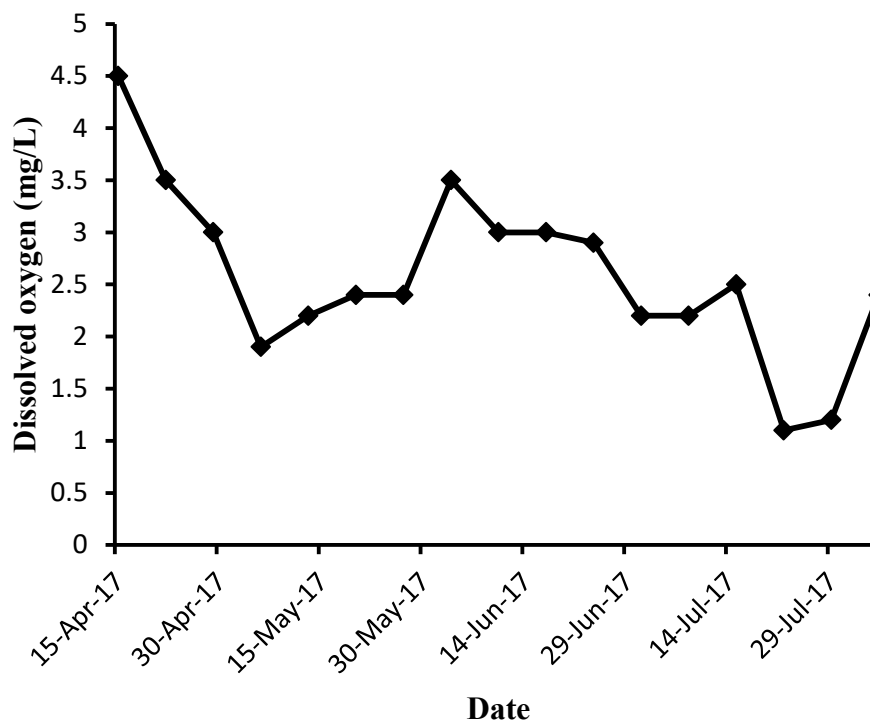


Figure 3. Weekly mean dissolved oxygen (mg/L) of pond water at 6.00–8.00 am during the experimental period

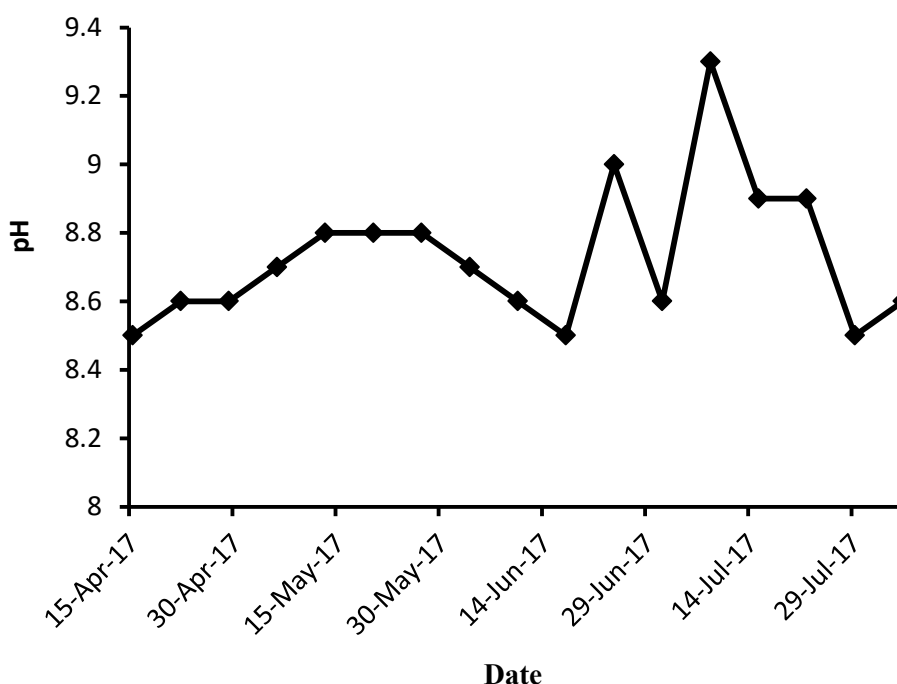


Figure 4. Weekly mean pH of pond water at 6.00–8.00 am during the experimental period

Economic analysis

The variable costs, return, gross margin and B/C ratio of pangas production in the present experiment are presented in Table 4. The total variable costs in T_1 , T_2 , T_3 and T_4 were NRs. 19897, 24857, 25890 and 34431 per 25 m² cage, respectively. The total return in T_1 , T_2 , T_3 and T_4 were NRs. 26529, 33041, 36401 and 40230 per cage, respectively. The comparative economic analysis showed that all the treatments produced positive gross margin. The gross margin was highest in T_3 (NRs. 10511/cage), intermediate in T_2 (NRs. 8184/cage) and lowest in T_4 (NRs. 5799/cage) and T_1 (NRs. 6632/cage). The B/C ratio in T_1 , T_2 , T_3 and T_4 were 0.33, 0.33, 0.41 and 0.16, respectively. The B/C ratio was significantly highest in T_3 and lowest

in T_4 ($p < 0.05$). The cost per kilogram fish production in T_1 , T_2 , T_3 and T_4 were NRs. 189, 188, 178 and 215, respectively.

Table 4. Comparative economic analysis in Nepalese currency (NRs) for each treatment. Data based on 25 m³ water volume per 3 months basis. Mean values with same superscript in the same row are not significantly different ($p > 0.05$)

Parameters	Treatments			
	T_1 (80000 fish/ha)	T_2 (100000 fish/ha)	T_3 (120000 fish/ha)	T_4 (140000 fish/ha)
Variable costs				
Seed	5000±0	6250±0	7500±0	8750±0
Feed	13038±588	16297±917	15986±395	22501±1455
Lime	30±0	30±0	30±0	30±0
Fertilizer	20±0	20±0	20±0	20±0
Interest (10%)	1808±59	2259±92	2353±39	3130±145
Total variable costs (A)	19897±647	24857±1009	25890±434	34431±1600
Return				
Fish sale (B)	26529±2309	33041±1342	36401±1445	40230±3163
Gross margin (B-A)	6632±2007 ^a	8184±1074 ^a	10511±1059 ^a	5799±1579 ^a
B/C ratio	0.33±0.1 ^b	0.33±0.1 ^b	0.41±0.0 ^c	0.16±0.0 ^a
Cost per kg fish production	189±13	188±7	178±5	215±8

DISCUSSION

The effect of stocking density on growth, production and economics of pangas in earthen pond net-cage culture system was assessed. The present study demonstrated that the growth rate of pangas varied in different stocking densities, with larger harvest size and higher growth rate in low density treatments. The average harvest size and daily growth rate of pangas in the present experiment were 547.2, 552.8, 531.0 and 537.5 g, and 5.2, 5.2, 5.0 and 5.1 g/fish/day, respectively in the stocking density of 80000 (T_1), 100000 (T_2), 120000 (T_3) and 140000 (T_4) fish/ha. These results match with the findings of Malik et al. (2014) who also achieved best growth of pangas at lower stocking densities. It is well-known fact that growth rate of fish progressively increases as the stocking density decreases and vice-versa. This is because a relatively less number of fish of similar size in a cage could get more space, food, less competition and dissolved oxygen etc. reported by various authors in different fish species (Narejo et al., 2010; Irwin et al., 1999; Narejo et al., 2005; Hannibal et al., 2011). The growth rate of pangas in the present experiment was higher than those reported by Shrestha et al. (2015). The better growth rate of pangas in the present experiment might be attributed to the larger stocking size and optimum water temperature, which increased the feed intake and metabolic rate of the fish. The survival of pangas in the present experiment was 96.8, 95.6, 91.3 and 85.5 per cent in the stocking density of 80000 (T_1), 100000 (T_2), 120000 (T_3) and 140000 (T_4) fish/ha, respectively. The survival was found to be negatively influenced by stocking densities. It might be due to the high competition and space among the fishes. Lower density gave larger size and higher survival rate in *Heteropneustes fossilis* (Narejo et al., 2005; Narejo et al., 2010).

The extrapolated gross and net productivity of pangas in the present experiment were 42.4, 52.9, 58.2 and 64.4, and 36.0, 44.8, 48.4 and 52.9 ton/ha/cycle, respectively in the stocking density of 80000 (T_1), 100000 (T_2), 120000 (T_3) and 140000 (T_4) fish/ha. The extrapolated gross yield was significantly higher in T_3 and T_4 than T_1 ($p < 0.05$). This result was similar with the findings of Malik et al. (2014). According to Shang and Tisdell (1997), farm productivity usually increases with culture intensity, but it eventually declines after a certain level of intensity due to deteriorated water quality, diseases, and thus, resulting in reduced growth and high mortality. The apparent food conversion (AFCR) of pangas in the present experiment was 1.8, 1.8, 1.7 and 2.1 in the stocking density of 80000 (T_1), 100000 (T_2), 120000 (T_3) and 140000 (T_4) fish/ha, respectively. The AFCR was found to be negatively influenced by stocking densities. It might be due to the slow growth

rate, high competition and space among the fishes. The FCRs in the present experiment was slightly higher compared to most experiments of commercial pangas culture. Ahmed et al. (2010) reported that FCR was lower in the intensive farming system (1.60), compared with semi-intensive (1.69) and extensive (1.71) farming. Similarly, Phuong et al. (2007) reported that manufactured pelleted feeds had a lower FCR for pangas catfish farming in Vietnam due to the high nutritional value, compared with farm-made feeds. The FCR using pelleted feeds for pangas catfish farming in the Mekong Delta ranged from 1.5 to 1.7 (Hung et al., 2007).

The water quality parameters of experimental pond were recorded throughout the study period and were within the acceptable ranges for pangas culture as reported by Boyed (1990) and Ayson (2008). Better growth rate of pangas in the present experiment might be attributed to the optimum water temperature (21-36 °C) during culture period, which increased the feed intake and metabolic rate of the fish. The food conversion ratio was also better. Probable explanation of improved feed efficiency of fish maintained at higher temperature might be the increased feed intake of the fish with increase in water temperature, which resulted in better growth of the fish, leading to better feed conversion ratio. Another probable explanation may be the less energy required for the process of thermoregulation to the fish kept at this temperature. Goolish and Adelman (1984) observed that an increase in temperature resulted in better utilization of feed in fish than those kept under lower temperature (20.9-24.3 °C). The dissolved oxygen concentration (1.1-4.5 mg/L) was at satisfactory level for pangas culture. *Pangasius spp.* is an air-breathing fish thus it can tolerate low oxygen. However, the optimum level of dissolved oxygen for better growth and production is 5 to 6 mg/L. The lowest level it can tolerate is 0.1 mg/L (Ayson, 2008).

Income in the present experiment was estimated by simple budget analysis. Fixed costs such as ponds, hapas etc. were not included in the analysis as it was intended to only compare relative differences in efficiency between the treatments and fixed costs were assumed to be similar for all the treatments. All cost estimation was based on local market prices of fingerlings, fertilizers and feed. Results showed that all the treatments produced positive gross margins ranging from 2319600 to 4204400 NRs./ha. The gross margin was highest in T₃ (NRs. 4204400/ha), intermediate in T₂ (NRs. 3273600/ha) and lowest in T₄ (NRs. 2319600/ha) and T₁ (NRs. 2652800/ha). Pangas production is fully dependent on quality feed and other factors, including farm size, stocking rate, fertilization and management skill, and the importance of feed increases with the intensification of culture systems. Feed cost generally constitute the highest single operational cost, accounting for 76%, 69% and 59% of total costs in extensive, semi-intensive and intensive farming, respectively (Ali et al., 2018). It is therefore essential that the feed should achieve maximum efficiency in terms of pangas production (Ahmed et al., 2010).

CONCLUSION

Findings of this study demonstrated that pangas has high production potential than carp polyculture. It showed that growth and production of pangas in earthen pond net-cage culture system is significantly different at various stocking densities. Growth of this fish was higher at lower stocking densities, but highest production was obtained at highest stocking density. Based on the results of the study we can conclude that stocking density of pangas at 120000 fish/ha (T₃) is more profitable.

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REFERENCES

- Ahmed, N., Alam, M.F. & Hasan, M.R. (2010). The economics of sutchi catfish (*Pangasianodon hypophthalmus*) aquaculture under three different farming systems in rural Bangladesh. *Aquaculture Research* 41, 1668-1682.
- Ali, H., Rahman, M.M., Jahan, K.M., & Dhar, G.C. (2018). Production economics of striped catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878) farming under polyculture system in Bangladesh. *Aquaculture* 491, 381-390.
- Ali, M.Z., Haque, M.K.I., Parveen, R., Hussain, M.G. & Mazid, M.A. (2005). Growth and reduction of cost of production of *Pangasius hypophthalmus* (Sauvage, 1878) with alternate feeding schedules. *Indian*

- Journal of Fishery* 52(4), 397-404.
- Ayson, J.P. (2008). Culture of *Pangasius spp.* Bureau of Fisheries and Aquatic Resources, Republic of the Philippines Department of Agriculture: 6p
- Boyd, C.E. (1990). Water Quality in Ponds for Aquaculture. USA: Alabama Agricultural Experiment Station, Auburn University. 482 p.
- Boyd, C.E. & Tucker, C.S. (1992). Water Quality and Pond Soil Analysis for Aquaculture. USA: Alabama Agricultural Experiment Station, Auburn University. 183 p.
- FAO. (2016). The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome. 200 p.
- Goolish, E.M. & Adelman, I.R. (1984). Effects of ration size and temperature on the growth of juvenile common carp (*Cyprinus carpio* L.). *Aquaculture* 36, 27-35.
- Hannibal M.C, Amparo L.F. & Aurelio A.C. (2011). Effect of stocking density on growth performance, survival and production of silver pompano, *Trachinotus blochii* in Marine Floating Cages. *Asian Fisheries Science* 24, 321-330.
- Huang, W.B. & Chiu, T.S. (1997). Effects of stocking density on survival, growth size variation, and production of Tilapia fry. *Aquaculture Resources* 28,165-173.
- Hung L.T., Truc L.T.T. & Huy H.P.V. (2007). Case study on the use of farm-made feeds and commercially formulated pellets for pangasiid catfish culture in the Mekong Delta, Vietnam. In: Study and Analysis of Feeds and Fertilizers for Sustainable Aquaculture Development, FAO Fisheries Technical Paper 497 (ed. by M.R. Hasan, T. Hecht, S.S. De Silva & A.G.J. Tacon), pp. 363-377. Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.
- Irwin S., Halloran J.O. & Fitzgerald, R.D. (1999). Stocking density, growth and growth variation in juvenile turbot, *Scophthalmus maximus* (Rafinesque). *Aquaculture* 178, 77-88.
- Malik, A., Kalhor, H., Shah, S.A. & Kalhor, I.B. (2014). The Effect of different stocking densities on growth, production and survival rate of pangas (*Pangasius hypophthalmus*) fish in cemented tanks at Fish Hatchery Chilya Thatta, Sindh-Pakistan. *International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS)* 1(10), 129-136.
- Narejo, N.T, Dayo, A. Dars, B.A, Mahesar, H., Laghari, M.Y. & Lashari, P.K. (2010). Effect of stocking density on growth and survival rate of *Labeo rohita* (hamilton) fed with formulated feed. *Sindh University Reserch Journal (Science Series)* 42(1), 35-38.
- Narejo, N.T., Salam, M.A. Sabur, M.A. & Rahmatullah, S.M. (2005). Effect of stocking density on growth and survival of indigenous catfish, *Heteropneustes fossilis* (Bloch) reared in cemented cisterns fed on formulated feed. *Pakistan Journal of Zoology* 37(1), 49-52.
- Phuong N.T., Sinh L.X., Thinh N.Q., Chau H.H., Anh C.T. & Hau N.M. (2007). Economics of aquaculture feeding practices: Vietnam. In: Economics of Aquaculture Feeding Practices in Selected Asian Countries, FAO Fisheries Technical Paper 505 (ed. by M.R. Hasan), pp. 183-205. Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.
- Rohul Amin, A.K.M., Bapary, M.A.J., Islam, M.S., Shahjahan, M. & Hossain M. A. R. (2005). The impacts of compensatory growth on food intake, growth rate and efficiency on Feed utilization in Thai pangas (*Pangasianodon hypophthalmus*). *Pakistan journal of Biological Science* 8(5), 766 -770.
- Sarkar, M.R.U., Khan, S. & Haque, M.M. (2007). Production and economic return in pangasiid catfish (*Pangasius hypophthalmus*) monoculture and polyculture with silver carp (*Hypophthalmichthys molitrix*) in farmer's ponds. *Bangladesh Journal Fishery Research* 9(2), 111-120.
- Sayeed, M.A.B., Hossain, G.S., Mistry, S.K. & Huq, K.A. (2008). Growth performance of Thai pangus (*Pangasius hypophthalmus*) in polyculture system using different supplementary feeds. *Journal of Zoology Rajshahi University* 27, 59-62.
- Shang Y.C. & Tisdell C.A. (1997). Economic decision making in sustainable aquaculture development. In: Sustainable Aquaculture (ed. by J.E. Bardach), pp.127-148. John Wiley and Sons, New York, NY.
- Shang, Y.C. (1990). Aquaculture Economic Analysis: An Introduction. World Aquaculture Society, Baton Rouge, Louisiana, 211 pp.
- Shrestha, M.K., Pandit, N.P., Bista, J.D. & Dahal, S.P. (2015). Polyculture of mixed-sex Nile tilapia (*Oreochromis niloticus*) with pangas catfish (*Pangasius hypophthalmus*). *Nepalese Journal of Aquaculture and Fisheries* 2, 86-93.