Our Nature (2008)6:38-46

Growth Performance of Silver Barb (*Puntius gonionotus*) in Mono and Polyculture Systems

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Received: 26.03.2008, Accepted: 04.09.2008

Abstract

An experiment was conducted for 190 days from September 15, 2005 to March 25, 2006 in 12 outdoor concrete tanks of 24 m^2 (4.9 m × 4.9 m) size and 1.25 m in water depth, at the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal to evaluate the growth performance and profitability of silver barb in mono and polyculture systems. The experiment was laid out in a completely randomized design (CRD) with four treatments having three replications each. There was one mono and three polyculture systems of silver barb with different fish species as treatments: (1) Silver barb at 1.5 fish/m^2 (control); (2) Silver barb at 1.5 fish/m^2 plus common carp at 0.2 fish/m^2; (3) Silver barb at 1.5 fish/m^2 plus male Nile tilapia at 0.3 fish/m^2; and (4) Silver barb at 1.5 fish/m^2 plus carps at 0.5 fish/m^2 (silver carp 40%, bighead carp 20%, and common carp 40%). Silver barb were fed with 23% CP feed @ 4% body weight daily.

At harvest, the mean weight, daily weight gain, gross fish yield (GFY) and net fish yield (NFY) of silver barb in monoculture treatment were significantly greater than in polyculture with common carp ($p < 0.05$), whereas there were no differences with polyculture with Nile tilapia ($p > 0.05$). However, survival of silver barb was not significantly different among treatments ($p > 0.05$). The combined GFY in polyculture with Nile tilapia treatment was significantly greater than in polyculture with common carp and in polyculture with other carps ($p < 0.05$). The NFY was highest in polyculture with Nile tilapia (4.4 ton/ha/yr), intermediate in polyculture with other carps (3.5 ton/ha/yr) and lowest in polyculture with common carp (2.9 ton/ha/yr) and monoculture (2.5 ton/ha/yr). Water quality parameters were not much difference in different treatments; however, water temperature was a crucial as it was less than 20 ^{o}C for about 3 months (mid November to mid February). All the treatments produced positive net returns; however, the net returns were higher in polyculture with Nile tilapia than in other treatments. This study demonstrated that silver barb polyculture with male Nile tilapia is far better than other combinations.

Keywords: Silver barb, Monoculture, Polyculture

Introduction

Silver barb (*Puntius gonionotus*) is an important tropical fish species on account of its fast growth rate, palatability, easy and year-round reproduction, and adaptability to a wide range of culture conditions (Hussain *et al*., 1989). It has been one of the most popularly cultured freshwater fish species in many parts of the world, especially in Southeast Asia (Alim *et al*., 1998; Sarker *et al*., 2002). It was introduced in Nepal in 1991 and kept at various Government farms for its evaluation (Shrestha, 2001). However, it remained within Government fence and was not made available to farmers. The production potentiality of silver barb for culture in seasonal ponds, ditches and canals has already been proven and created a significant profitability in many countries of Southeast Asia (Sarker *et al*., 2002). However, no research work on this species for its potential in different culture combinations has been conducted in Nepal. Silver barb mono and polyculture with different fish species fed on different natural resources may play an important role to efficiently utilize the production potential of the ponds. Considering the above fact this study was undertaken to observe the production potential and determine the feasibility of culturing silver barb in monoculture and polyculture with different fish species in the sub-tropical climate of Nepal. The objective of this study is to evaluate the growth performance of silver barb under mono and polyculture systems with male Nile tilapia and carps, to assess the yield in different species combination and to assess the profitability in mono and polyculture.

Materials and methods

This experiment was conducted in twelve 24-m^2 (4.9 m × 4.9 m) size and 1.25 m water depth concrete tanks for 190 days starting from September 15, 2005 to March 25, 2006 at the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal. The experiment was conducted in a completely randomized design (CRD) with four treatments having three replications each. There was one mono and three polyculture systems of silver barb with different fish species as treatments. The treatment structure was designed as: silver barb (*Puntius gonionotus*) at 1.5 fish/m^2 (treatment 1, control); Silver barb at 1.5 fish/m^2 plus common carp (*Cyprinus carpio*) at 0.2 fish/m^2 (treatment 2), silver barb at 1.5 fish/m^2 plus hand-sexed male Nile tilapia (*Oreochromis niloticus,* chitralada strain) at 0.3 fish/m^2 (treatment 3), and silver barb at 1.5 fish/m^2 plus carps at 0.5 fish/m^2 (silver carp, *Hypophthalmichthys molitrix* 40%, bighead carp, *Aristichthys nobilis* 20%, common carp 40%) (treatment 4).The water depth was maintained 1.25 m in each tank by weekly topping with tap water. Two groups of silver barb fingerlings, large 36.8 to 38.1 gm size and small 7.0 to 8.8 gm size at ratio of 2:1, and fingerlings of hand-sexed male Nile tilapia, common carp, silver carp and bighead carp of average weight of 45.8 gm, 25.1 to 27.5 gm, 54.2 gm, and 101.8 gm respectively were stocked in their respective ponds. Feed was calculated only to silver barb and fed once daily with locally available home-made sinking pellet feed (23% CP). Feeding was calculated to 4% of body weight at the beginning and the rate was decreased during the colder months when the fish refused to feed. The quantity of feed was adjusted biweekly based on fish growth measurements of silver barb.

In situ water temperature, dissolved oxygen, transparency and pH were recorded weekly at 6-7 am using alcohol thermometer, dissolved oxygen meter (YSI meter model 50B), Secchi disk and ATC pocket pH meter, respectively. Similarly, fortnightly total alkalinity, total ammonium nitrogen, and soluble reactive phosphorus (SRP) were recorded by taking composite water samples at 6-7 am (APHA, 1985). The growth of fish were measured biweekly by sampling 20% fish of each species. Complete harvesting was done on March 25, 2006. At harvest all the ponds were dried and fish were harvested for taking total count and weight for each species. Net fish yield (NFY) was calculated as ton/ha/crop and growth rate was calculated as g/fish/d. The experimental period of 190 days was considered as one crop. A partial budget analysis was conducted based on farm-gate prices for harvested fish and market prices for all costs in Nepal (Shang, 1990). Data were analyzed statistically by analysis of variance (ANOVA) using SPSS (version 11.0) statistical software package (SPSS Inc., Chicago). All means were given with ±1 standard error (S.E.).

Results and discussion

Fish growth and production

Mean stock weight, stock number, harvest number and survival of both large and small silver barb were not significantly different among treatments ($p > 0.05$; Table 1). At harvest, the mean weight of large silver barb in monoculture (133.7 gm) was significantly greater than in polyculture with common carp (96.9 gm) ($p < 0.05$), whereas there were no significant differences with tilapia polyculture (125.0 gm) and polyculture with other carps (101.3 gm) ($p > 0.05$). The mean harvest weight of small silver barb in monoculture (81.9 gm) was significantly greater than polyculture with common carp (54.0 gm) ($p < 0.05$), whereas there were no significant difference with tilapia polyculture (82.5 gm) and polyculture with other carps (59.3 gm) ($p > 0.05$; Table 1).

Daily weight gain of large silver barb in monoculture (0.5 gm/f/d) was significantly greater than polyculture with common carp (0.3 gm/f/d) and polyculture with other carps (0.3 gm/f/d) ($p < 0.05$). Similarly, daily weight gain of small silver barb in monoculture (0.4 gm/f/d) was significantly greater than polyculture with common carp (0.2 gm/f/d) ($p < 0.05$) The daily weight gains of both large and small silver barb in the present experiment showed treatment-dependent growth that ranged from 0.3 to 0.5 gm/f/d and 0.2 to 0.4 gm/f/d for large and small silver barb, respectively, which are lower than those reported by Sarker *et al*. (2002) in silver barb monoculture (0.7 gm/f/d) and silver barb-common carp (1:1) polyculture (0.8 gm/f/d). The main reason of lower daily weight gains in the present experiment might be due to the lower water temperature for most of the experimental periods compared to the experiment conducted by Sarker *et al*. (2002).

Results showed that the growth of both large and small silver barb was faster during the early days of experiment, almost no growth during mid-November to mid February, and again the growth was faster during the later days of the experiment in all the treatments (Figure 1 and 2). This growth trend is directly related to the water temperature in the present study (Figure 3). The growth was faster when the water temperature was higher because the silver barb is truly tropical species.

Mean stock weight, stock number, mean harvest weight, harvest number, daily weight gain and survival rate of common carp in silver barb-common carp polyculture treatment and polyculture with 4 carps treatment were not significantly different ($p > 0.05$) (Table 2). Survival of Nile tilapia, silver carp and bighead carp was 100% in their respective treatments (Table 3).

Combined GFY in polyculture with tilapia and polyculture with other carps (2.6 ton/ha/190 days) were significantly greater than in monoculture and polyculture with common carp ($p < 0.05$; Table 4), whereas there was no significant difference between monoculture and polyculture with common carp, and polyculture with tilapia and polyculture with other carps ($p > 0.05$; Table 4). Similarly, the combined NFY was highest in polyculture with tilapia,

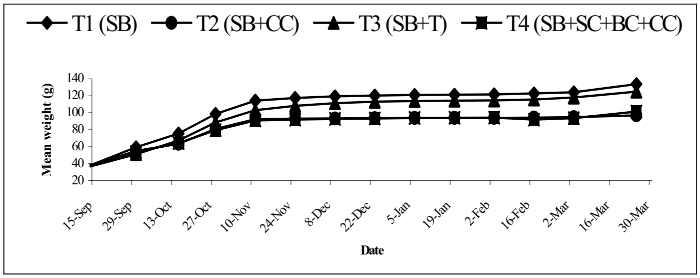

Figure 1. Growth trend of large silver barb in different treatments during the experimental period of 190 days. SB=Silver barb, CC=Common carp, T=Tilapia, SC=Silver carp, BC=Bighead carp.

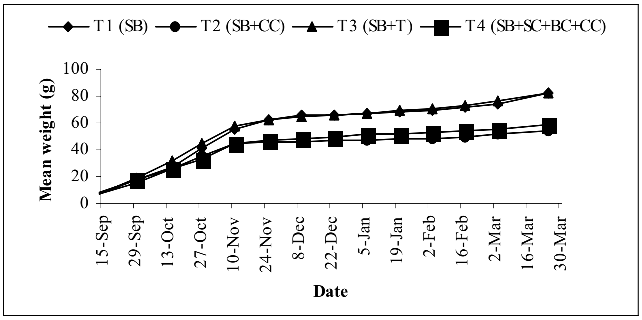

Figure 2. Growth trend of small silver barb in different treatments during the experimental period of 190 days. SB=Silver barb, CC=Common carp, T=Tilapia, SC=Silver carp, BC=Bighead carp.

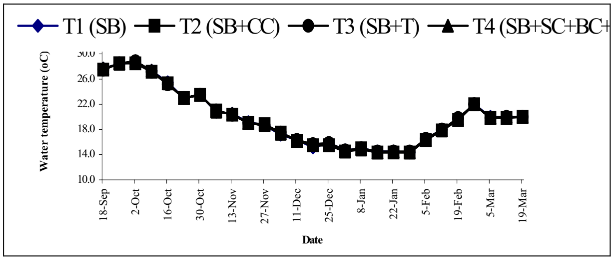

Figure 3. Weekly mean water temperature (°C) during the experimental period of 190 days. SB=Silver barb, CC=Common carp, T=Tilapia, SC=Silver carp, BC=Bighead carp.

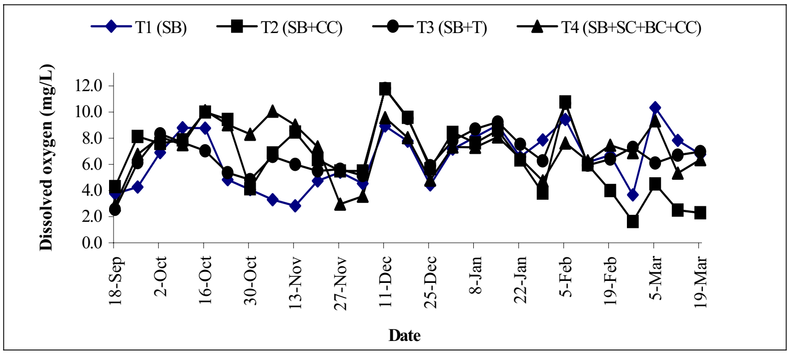

Figure 4. Weekly mean dissolved oxygen (mg/l) during the experimental period of 190 days. SB=Silver barb, CC=Common carp, T=Tilapia, SC=Silver carp, BC=Bighead carp.

Table 1. Mean stock and harvest weight, number, daily growth rate, and survival of large and small silver barb in different treatments (Mean ± SE) at 24 m^2 cemented tanks for 190 days.

Parameters	Treatments			
	T_1 (Monoculture)	T_2	T_3	T_4
		Polyculture with		
		Common carp	Nile tilapia	Silver+Bighead +Common
Large Silver barb				
Mean stock weight (g)	38.1±1.8 ^{a}	37.8±0.7 ^{a}	36.8±0.3 ^{a}	38.1±2.2 ^{a}
Stock number	24.0±0.0 ^{a}	24.0±0.0 ^{a}	24.0±0.0 ^{a}	24.0±0.0 ^{a}
Mean harvest weight (g)	133.7±8.2 ^{a}	96.9±9.3 ^{b}	125.0±12.8^{ab}	101.3±10.4^{ab}
Harvest number	24.0±0.0 ^{a}	23.3±0.3 ^{a}	23.7±0.3 ^{a}	23.7±0.3 ^{a}
Daily weight gain (g/f/d)	0.5±0.0 ^{a}	0.3±0.0 ^{b}	0.5±0.1 ^{ab}	0.3±0.0 ^{b}
Survival (%)	100±0.0 ^{a}	97.2±1.4 ^{a}	98.6±1.4 ^{a}	98.6±1.4 ^{a}
Small Silver barb				
Mean stock weight (g)	7.0±0.9 ^{a}	7.5±0.8 ^{a}	7.6±0.3 ^{a}	8.8±1.0 ^{a}
Stock number	12±0.0 ^{a}	12±0.0 ^{a}	12±0.0 ^{a}	12±0.0 ^{a}
Mean harvest weight (g)	81.9±2.6 ^{a}	54.0±5.1 ^{b}	82.5±9.6 ^{a}	59.3±9.9 ^{ab}
Harvest number	11.3±0.3 ^{a}	11.7±0.3 ^{a}	11.7±0.3 ^{a}	11.0±0.6 ^{a}
Daily weight gain (g/f/d)	0.4±0.0 ^{a}	0.2±0.0 ^{b}	0.4±0.1 ^{a}	0.3±0.1 ^{ab}
Survival (%)	94.4±2.8 ^{a}	97.2±2.8 ^{a}	97.2±2.8 ^{a}	91.7±4.8 ^{a}

Mean values with same superscript are not significantly different at $p = 0.05$.

Table 2. Mean stock and harvest weight, number, daily growth rate, and survival of common carp in different treatments (Mean ± SE) at 24 m^2 cemented tanks for 190 days.

Parameters	Treatments			
	T_1 (Monoculture)	T_2	T_3	T_4
		Polyculture with		
		Common carp	Nile tilapia	Silver+Bighead +Common
Mean stock weight (g)	-	25.1±0.6 [a]	-	27.5±1.9 [a]
Stock number	-	5.0±0.0 [a]	-	5.0±0.0 [a]
Mean harvest weight (g)	-	396.1±33.6[a]	-	305.1±32.8 [a]
Harvest number	-	4.7±0.3 [a]	-	5.0±0.0 [a]
Daily weight gain (g/f/d)	-	2.0±0.2 [a]	-	1.5±0.2 [a]
Survival (%)	-	93.3±6.7 [a]	-	100.0±0.0 [a]

Mean values with same superscript are not significantly different at p = 0.05 by paired t-test.

Table 3. Mean stock and harvest weight, number, daily growth rate, and survival of Nile tilapia, silver carp and bighead carp in their respective treatments (Mean±SE) at 24 m^2 cemented tanks for 190 days.

Parameters	**Nile tilapia** (T_3)	**Silver carp** (T_4)	**Bighead carp** (T_4)
Mean stock weight (g)	45.8±1.8	54.2±3.9	101.8±3.0
Stock number	8.0±0.0	5.0±0.0	3.0±0.0
Mean harvest weight (g)	370.4±28.4	162.4±11.9	251.2±26.6
Harvest number	8.0±0.0	5.0±0.0	3.0±0.0
Daily weight gain (g/f/d)	1.7±0.1	0.6±0.0	0.8±0.1
Survival (%)	100.0±0.0	100.0±0.0	100.0±0.0

Table 4. Extrapolated GFY, NFY and mean FCR of all fish species in different treatments (Mean ± SE) for 190 days culture cycle.

Parameters	Treatments			
	T_1 (Monoculture)	T_2	T_3	T_4
		Polyculture with		
		Common carp	Nile tilapia	Silver+Bighead +Common
GFY (t/ha/crop)				
Large silver barb	1.3±0.1 [a]	0.9±0.1 [b]	1.2±0.1 [ab]	1.0±0.1 [ab]
Small silver barb	0.4±0.0 [ac]	0.3±0.0 [b]	0.4±0.0 [a]	0.3±0.0 [bc]
Common carp		0.8±0.0 [a]		0.6±0.1 [a]
Nile tilapia			1.2±0.1	
Silver carp				0.3±0.0
Bighead carp				0.3±0.0
Combined	1.7±0.1 [b]	2.0±0.1 [b]	2.9±0.1 [a]	2.6±0.2 [a]
NFY (t/ha/crop)				
Large silver barb	1.0±0.1 [a]	0.6±0.1 [b]	0.9±0.1 [ab]	0.6±0.1 [b]
Small silver barb	0.3±0.0 [a]	0.2±0.0 [b]	0.4±0.0 [a]	0.2±0.0 [b]
Common carp		0.7±0.0 [a]		0.6±0.1 [a]
Nile tilapia			1.1±0.1	
Silver carp				0.2±0.0
Bighead carp				0.2±0.0
Combined NFY (t/ha/crop)	1.3±0.1 [b]	1.5±0.1 [bc]	2.3±0.1 [a]	1.8±0.2 [c]
AFCR	2.8±0.2 [a]	2.6±0.2 [ab]	1.9±0.1 [c]	2.1±0.2 [bc]

Mean values with same superscript are not significantly different at p = 0.05.

Table 5. Mean and range of water quality parameters at different sampling dates throughout the experimental period of 190 days.

Parameters	Treatments			
	T_1 (Monoculture)	T_2	T_3	T_4
		Polyculture with		
		Common carp	Nile tilapia	Silver+Bighead +Common
Temperature (^oC)	19.9±0.0 ^{a} (14.7-28.7)	19.8±0.0 ^{a} (14.5-28.5)	19.9±0.0 ^{a} (14.7-28.8)	19.8±0.1 ^{a} (14.5-28.8)
Dissolved oxygen (mg/L)	6.4±0.2 ^{a} (2.8-10.3)	6.6±0.4 ^{a} (1.6-11.8)	6.9±0.4 ^{a} (2.6-11.8)	7.1±0.8 ^{a} (2.9-10.1)
Secchi disk transparency (cm)	78.0±2.5 ^{a} (46.7-108.0)	51.0±6.2 ^{b} (30.0-96.7)	68.6±12.4 ^{ab} (49.7-103.3)	56.3±8.1 ^{ab} (32.3-98.3)
pH	8.9 (8.1-9.9)	9.2 (8.5-10.4)	9.1 (8.4-10.1)	9.1 (8.3-10.3)
Total alkalinity (mg/L $CaCO_3$)	122.0±5.6 ^{a} (84.9-142.8)	98.8±2.6 ^{b} (66.3-120.2)	112.1±2.7 ^{ab} (72.8-137.5)	104.3±5.4 ^{b} (70.6-124.1)
Soluble reactive phosphorus (mg/L)	0.26±0.00 ^{a} (0.03-0.57)	0.12±0.05 ^{b} (0.01-0.32)	0.19±0.06 ^{ab} (0.03-0.47)	0.20±0.03 ^{ab} (0.01-0.49)
Total ammonium nitrogen (mg/L)	0.53±0.07 ^{a} (0.04-1.10)	0.32±0.04 ^{b} (0.07-0.67)	0.30±0.01 ^{b} (0.04-0.58)	0.32±0.04 ^{b} (0.07-0.70)

Mean values with same superscript are not significantly different at p = 0.05. Data in parenthesis are range value.

intermediate in polyculture with other carps, and lowest in monoculture polyculture with other carps and polyculture with common carp ($p < 0.05$). The net fish yield of silver barb in monoculture (1.3 ton/ha/190 days) and combined net fish yield in polyculture with common carp (1.5 ton/ha/190 days) and polyculture with other carps (1.8 ton/ha/190 days) were lower than those reported by Hussain *et al*. (1989) and Sarker *et al*. (2002) which was attributed to the low water temperature in the present experiment. Hussain *et al*. (1989) registered a net production of 2.0 ton/ha/5 months of silver barb feeding on rice bran with a stocking density of 16000/ha. Similarly, Sarker *et al.* (2002) reported net fish yield of 1.6 ton/ha/5 months and 2.0 ton/ha/5 months in silver barb monoculture and polyculture with common carp (1:1), respectively in the yard ditches of Bangladesh where fish were fed with rice bran and stocking density was 1.5 fish/m^2 in both systems.

The overall increase of fish production in silver barb-Nile tilapia polyculture system in this experiment might have been due to the synergistic interaction from fecal input of silver barb and utilization of natural foods of the pond by Nile tilapia. The excreta had enriched the pond fertility that helped to increase the growth and production of Nile tilapia. Shahabuddin *et al*. (1994) found positive effect of silver barb on the growth of common carp. This also shows the Nile tilapia male growth advantage over female as reported by Hepher and Pruginin (1982) and Mires (1995).

AFCR in polyculture with tilapia (1.9) was significantly lower than in monoculture (2.8) and polyculture with common carp (2.6) ($p < 0.05$) but there were no significant differences between monoculture and polyculture with common carp, and polyculture with tilapia and polyculture with other carps (2.1) ($p > 0.05$). Food conversion ratio of fishes in the present experiment showed the treatment dependent value that ranged from 1.9 to 2.8. The better food conversion ratio was observed in the silver barb-Nile tilapia polyculture system.

Water quality

Most of the water quality parameters at each sampling dates were found within a suitable range for fish production (Boyd, 1982) and seemed to be less affected by different culture systems (Table 5). This might indicate that the addition of carps and Nile tilapia into the silver barb ponds did not affect the water quality. However, water temperature was a crucial factor to affect the culture system in a consistent manner during most part of the experimental period as it was less than 20^{o}C for about 3 months (mid November to mid February; Figure 3). Results showed that there were no significant differences in temperature and dissolved oxygen concentration among the treatments ($p > 0.05$). Secchi disk transparency and soluble reactive phosphorous in the monoculture was significantly higher than in polyculture with common carp ($p < 0.05$), while there were no significant differences among other treatments ($p > 0.05$). Total alkalinity in monoculture was significantly higher than in polyculture with common carp and polyculture with other carps ($p < 0.05$). The pH was relatively higher during the early days of the experiment and then decreased and fluctuated throughout the entire culture period. Total ammonium nitrogen in the monoculture was significantly higher than in other treatments ($p < 0.05$), among which there were no significant differences ($p > 0.05$). This was probably due to the low consumption of total ammonium nitrogen by planktons. Soluble reactive phosphorous in the monoculture ponds were higher (0.26 mg/l) than other treatments probably due to the low concentration of planktons.

Economics

The income in the experiment was estimated by simple analysis. Fixed costs were not included in the analysis as the analysis was intended to only compare relative difference in efficiency between the treatments, and we assumed those to be similar for all the treatments. The cost estimation was based on local market prices of fingerlings, feed, and fish and lime materials. Results showed that all the treatments produced positive gross margin, however the gross margin was higher in the silver barb-Nile tilapia treatment (395,100 NRs/ha/yr) than in monoculture and other polyculture treatments. Similarly, the gross margins were intermediate in polyculture with carps (313,600 NRs/ha/yr) and lowest in the monoculture (201,600 NRs/ha/yr) and polyculture with common carp (241,100 NRs/ha/yr).

Acknowledgements

This experiment was the thesis work of Mr. Shiva Narayan Chaudhary for the partial fulfillment of the M.Sc. Aquaculture course of the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal. The authors are grateful to the Crop Diversification Project (CDP) for providing research fund and Department of Aquaculture, IAAS, Rampur for providing research facilities and staffs' support.

References

Alim, M.A., M.M.H. Chowdhury and S.M.N. Nabi 1998. Polyculture of fish (*Labeo rohita, Hypophthalmichthys molitrix* and *Puntius gonionotus*) with prawn (*Macrobrachium rosenbergii*) in gher farming systems. Paper presented in 3rd ANR Aquaculture and Fisheries Workshop, 4-5 October, Dhaka, Bangladesh, arranged by CARE Bangladesh.

APHA 1985. *Standard Methods for the Examination of Water and Wastewater*, 16th edition. American Public Health Association American Water Works Association 1015, Fifteenth Street NW, Washington DC. 1268p.

Boyd, C.E. 1982. *Water Quality Management for Pond Fish Culture*. Elsevier Science Publishers, Amsterdam, Netherlands. 318p.

Hepher, B. and Y. Pruginin 1982. Tilapia culture in Ponds under Controlled Condition. In *Detritus and Microbial Ecology in Aquaculture* (Eds. D.J.V. Moriarty and R.S.V. Pullin), ICLARM, Manila, Philippines. pp. 185-203.

Hussain, M.G., M. Akteruzzaman, A.H.M. Kohinoor and K.A. Shah 1989. Semi intensive culture of silver barb. *J. Fish* *12*: **32-38.**

Sarker, P.K., B.B.P. Chowdhury, M.S.A. Khan, H.K. Pal and S. Mondal 2002. A Study on Silver barb (*Puntius gonionotus*) Monoculture Vs. Mixed Culture with Carp (*Cyprinus carpio*) in the Yard Ditches of Bangladesh. Online *Journal of Biological Sciences* ***2*(*4*)**: 230-231.

Shahabuddin, M., M.S. Miah and M.S. Alam 1994. Study on Production Optimization through Polyculture of Indigenous and Exotic Carps. *Bangladesh J. Train. Dev*. *7*: 67-72.

Shang, Y.C. 1990. *Aquaculture Economic Analysis*: *An Introduction*. World Aquaculture Society, Baton Rouge, Louisiana, 211p.

Shrestha, B.C. 2001. Aquaculture Production and Aquatic Resources in Nepal. Paper presented in the National Strategy on Aquatic Animal Health Management held in 12-14 December 2001 at Balaju, Katmandu.