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Introduction of Sahar (*Tor putit*ora) in Cage-Cum-Pond Integration System of Mixed-Sex Nile Tilapia (*Oreochromis niloticus*)

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Abstract
Introduction of sahar in cage-cum-pond integration system of mixed-sex Nile tilapia was evaluated using 15 outdoor cemented ponds of 24 m2 (4.9m × 4.9m) size with 1.25 m water depth placing a cage of 1.2m× 1m × 1m size holding 1 m3 water at the center of each pond at Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, for 158 days. The experiment was conducted in a completely randomized design (CRD) with five treatments replicated thrice. The treatments were: large sized Nile tilapia in cage and small sized Nile tilapia in pond (cage-cum-pond system) (T1); cage-cum-pond system with 2 sahar (T2), cage-cum-pond system with 4 sahar (T3), cage-cum-pond system with 8 sahar (T4) and cage-cum-pond system with 16 sahar (T5). Stocking density of caged and pond tilapia was 1 fish/m2 and 2 fish/m2, and size was 78-90 g and 15-16 g respectively. The feed, containing 20% crude protein, was supplied for caged tilapia at the rate of 2% body weight daily. Mean stocking size, harvest size, survival rate, daily weight gain and net fish yield of both caged and pond Nile tilapia were not significantly different among treatments ($p>0.05$). Mean harvest weight and daily weight gain of sahar in treatment 2 was significantly higher than other treatments ($p<0.05$). NFY of caged tilapia, pond tilapia and combined fish yield were not significantly different among treatments ($p>0.05$). Higher numbers of recruits were observed in control and lowest in the treatment 5 suggesting that higher number of sahar in this system effectively controls the tilapia recruits. This experiment showed that addition of sahar in the cage-cum-pond integration system of Nile tilapia effectively controls the number of tilapia recruits and increase NFY.

Key words: cage-cum-pond integration, Nile tilapia, Sahar

Introduction
Integrated cage-cum-pond culture system is a system where cage culture is integrated with semi-intensive pond culture with feeding artificial diets in cages and without feeding and fertilizing in open ponds to utilize natural foods from cage wastes. This integrated aquaculture system has been developed and practiced in catfish-tilapia (Lin and Diana, 1995) and tilapia-tilapia (Yi and Lin, 2000) cage-cum-pond integrated culture systems at Asian Institute of Technology (AIT), and in mixed-sex tilapia-tilapia (Shrestha, 2002), Sahar-carps (Shrestha *et al*. 2005), and catfish-carps (Shrestha *et al*. 2006) at Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal. Experiments conducted at IAAS showed that intensive culture of Nile tilapia in cage within pond with feeding can efficiently produce large fish (from 100-150 to 250-300 g), while smaller ones can be grown (from 20-40 to 125-150 g) in a semi-

intensive fashion in the open pond (Shrestha, 2002). Nile tilapia with 250 to 300 g size is considered as table size fish for market (Shrestha *et al*. 2000a, 2000b, 2000c).

This integrated system of mixed-sex Nile tilapia could be improved by introduction of sahar in open ponds as a predator for tilapia recruits control. Introduction of sahar in cage-cum-pond integration of mixed-sex Nile tilapia culture system not only control the over population of Nile tilapia, it also helps to conserves the declining sahar diversity in Nepal. Thus this study aims to improve the cage-cum-pond integrated system of mixed-sex Nile tilapia using sahar as predator to control recruits of tilapia and to enhance growth and production of mixed-sex Nile tilapia in cage and pond.

Materials and methods

This experiment was conducted in 15 outdoor cemented tanks of 24 m2 (4.9 m x 4.9.m) size with a cage of 1.2 m x 1 m x 1 m size (maintaining 1 m3 water volume) at the center of each tanks at the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal starting from 20 March to 25 August, 2005 for 158 days. The cemented ponds were completely drained out about 3 weeks before fish stocking and kept sun dried for one week and filled with tap water. The ponds were fertilized initially with Urea and DAP at the rate of 40 g and 85 g per pond, respectively. The cages having mesh size 7 mm were installed at the center of the pond. Each cage bottom was 15 cm above the pond bottom and holds 1 m3 water volume. Feeding trays were installed at the center of cage below the water level. The water depth of pond was maintained at 1.25 m during the experimental period by adding tap water to compensate the evaporation loss and water level of the cage was maintained at 1m. The experiment was laid in a completely randomized design (CRD) consisting five treatments with three replications each. The treatments were: large sized Nile tilapia in cage and small sized Nile tilapia in pond (cage-cum-pond system) (T1); cage-cum-pond system with 2 sahar (T2), cage-cum-pond system with 4 sahar (T3), cage-cum-pond system with 8 sahar (T4) and cage-cum-pond system with 16 sahar (T5). Fish were stocked in both cages and open ponds on March 20, 2005. 78-90 g of Nile tilapia at 1 fish/m2 were stocked in each cage. Similarly, 15-16 g size small Nile tilapia at 2 fish/m2 and 22-27 g size sahar at different densities i.e. 0, 2, 4, 8 and 16 as designed in treatments were stocked in open pond.

Caged tilapia were fed once daily with a locally made pellets containing 20% crude protein at the rate of 2% body weight per day while no feed or fertilizer was added into open ponds. Feed rations were adjusted fortnightly based on sampling weights and observed mortality of caged tilapia. Three batches of feed, with three replications of each batch, were analyzed for dry matter (DM) content, crude protein (CP) and ether extract (EE) following the method by AOAC (1980). Complete harvesting was done on 25th August 2005. During harvest the number of tilapia recruits were counted and separated into two groups based on size and their batch weight. Water temperature and dissolved oxygen was recorded weekly at two times i.e. morning at 6-7 am and afternoon at 3-4 pm at the depth of 15 cm and 120 cm using DO meter (YSI meter model 50B). The pH of column water sample was recorded weekly at two times i.e. morning at 6-7 am and afternoon at 3-4 pm using pH meter (ATC pocket meter).

Water transparency was measured weekly at 9-10 am using Secchi disk. Total alkalinity was analyzed weekly by taking composite water samples by column sampler at 6-7 am using titration method (APHA, 1985). Conductivity was measured at 6-7 am using SCT meter. Data were analyzed statistically using one-way ANOVA using SPSS (ver. 10) statistical software package. Differences were considered significant at the 95% confidence level ($p<0.05$). All means were given at ±1 standard error (S.E.).

Results and discussion

Fish growth, survival and production

Mean stocking size, harvest size, survival rate, daily weight gain and net fish yield of both caged and pond Nile tilapia were not significantly different among treatments ($p>0.05$; Table 1 and 2). However, mean survival rate of pond tilapia in control treatment was significantly higher than treatment 4 ($p<0.05$). One replication of treatment 5 was ignored for analysis due to mass mortality of sahar and Nile tilapia during 22nd week of the experimental period during the low dissolved oxygen. Mean harvest weight and daily weight gain of sahar in treatment 2 was significantly higher than other treatments ($p<0.05$), among which there were no significant differences ($p>0.05$; Table 3). Net fish yield (NFY) of sahar in treatment 5 was significantly higher than treatments 2 and 3 ($p<0.05$).

The daily weight gain of Nile tilapia in cage (1.1±0.1 g/f/d) was higher than the growth rate of caged tilapia (0.98 g/f/d) obtained by Shrestha (2000c). Treatment 2 produced better sized caged tilapia (267.7±21.9 g) which is comparable to 250-300 g table fish as reported by Shrestha (2002).

The mean growth rate of Nile tilapia in open pond recorded in the present study (0.2-0.4 g/f/d) was lower than 0.84 g/f/d, 0.68 g/f/d and 0.68 g/f/d as reported by Shrestha *et al.*, 2000a, 2000b and 2000c, respectively (Figure 1). The survival rate of pond tilapia in the present study (61-99%) was lower than those reported by Poudel (2003) and Acharya (2004) in sahar-tilapia polyculture.

The growth rate of sahar in the present study T_2 (1.0 g/f/d) was higher than those reported 0.32 g/f/d by Acharya (2004) which possibly due to warmer temperature in the present experiment. Initially, the growth rate of sahar was faster while around mid part of the experiment it gradually decreased and remained constant during the later part of the experiment. The mean survival rate of sahar in the present study (88-100%) was higher than the survival of sahar (33-42%) and (75-96%) obtained by Poudel (2003) and Acharya (2004), respectively.

Fish production

NFY of caged tilapia, pond tilapia and combined fish yield were not significantly different among treatments ($p>0.05$). However, NFY of sahar in open pond was significantly higher in treatment 5 then treatments 2 and 3 ($p<0.05$; Table 4).

The combined net fish yield (excluding tilapia recruits) in the present experiment ranged from 5.3 to 7.0 kg/pond. The extrapolated NFY in the treatment 5 was 2.9 mt/ha/158 days which was higher than that obtained (5.07 mt/ha/yr) by Pandit (2003) in polyculture of grass carp and Nile tilapia, similar to that obtained (5.8 mt/ha/yr) by Mandal (2001) in tilapia culture system, and lower than that obtained (14.5 mt/ha/yr) by Mishra (2002) in *Clarias*-tilapia polyculture at 1:1 ratio.

Table 1. Mean stocking and harvest size, daily weight gain, survival and net fish yield of Nile tilapia in cage (1m^3) during the 158-days culture period at 24 m^2 cemented tanks (Mean ± SE).

Parameter	**Treatment**				
	T1	**T2**	**T3**	**T4**	**T5**
Initial total wt. (kg)	1.9±0.03^a	2.2±0.12^a	1.9±0.1^a	2±0.1^a	1.9±0.1^a
Initial mean wt. (g)	77.8±1.4^a	90.3±5.0^a	79.2±4.2^a	84.7±2.8^a	80.6±3.5^a
Final total wt. (kg)	5.4±0.4^a	6.2±0.6^a	4.7±1.1^a	5.9±0.5^a	5.7±0.7^a
Final mean wt. (g)	232.8±5.7^a	267.7±21.9^a	228.9±16.3^a	247.2±19.4^a	237.5±19.2^a
Survival (%)	95.8±4.2^a	98.6±1.4^a	83.3±14.6^a	100±0.0^a	100±0.0^a
Daily wt. gain (g/f/d)	1.0±0.0^a	1.1±0.1^a	0.9±0.1^a	1.0±0.1^a	1.0±0.2^a
Net fish yield (kg/cage)	3.5±0.4^a	4.2±0.6^a	3.9±0.4^a	3.9±0.7^a	3.9±0.7^a

*Mean values with same superscript letters in the same row were not significantly different at p = 0.05

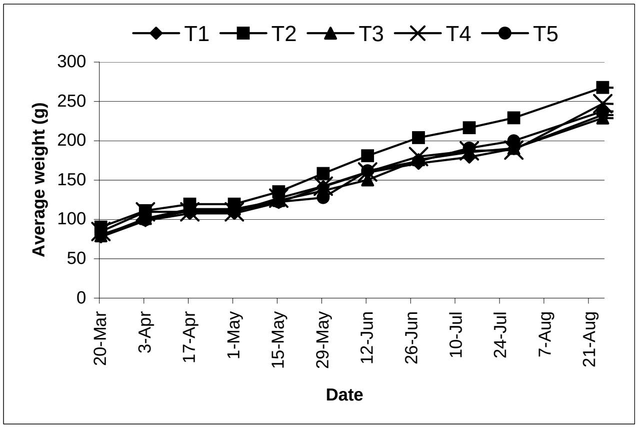

Figure 1. Fortnightly mean weight (g) of caged tilapia in different treatments during 158-day experimental period.

Table 2. Mean stocking and harvest size, daily weight gain, survival and net fish yield of Nile tilapia in open pond during the 158-days culture period at 24 m^2 cemented tanks (Mean ± SE).

Parameter	***Treatment***				
	T1	**T2**	**T3**	**T4**	**T5**
Initial total wt. (kg)	0.8±0.04^a	0.7±0.02^a	0.7±0.02^a	0.7±0.04^a	0.8±0.03^a
Initial mean wt. (g)	15.8±0.8^a	15.1±0.4^a	15.3±0.3^a	14.9±0.8^a	15.9±0.6^a
Final total wt. (kg)	2.5±0.7^a	3.0±0.4^a	3.2±0.4^a	2.1±0.9^a	3.1±0.9^a
Final mean wt. (g)	53.6±35.2^a	78.2±5.7^a	69.7±5.9^a	66.9±9.0^a	67.7±19.9^a
Survival (%)	98.6±0.7^a	79.2±5.2^{ab}	94.4±5.6^a	61.8±19.1^b	96.9±1.0^a
Daily wt. gain (g/f/d)	0.2±0.1^a	0.4±0.03^a	0.3±0.04^a	0.3±0.1^a	0.3±0.1^a
Net fish yield (kg/pond)	1.8±0.7^a	2.3±0.4^a	2.5±0.4^a	1.4±1.0^a	2.4±0.8^a

*Mean values with same superscript letters in the same row were not significantly different (p>0.05).

Table 3. Mean stocking and harvest size, daily weight gain, survival and net fish yield of sahar in open pond during the 158-days culture period at 24 m^2 cemented tanks (Mean ± SE).

Parameter	Treatment				
	T1	T2	T3	T4	T5
Initial total wt. (kg)	-	0.1±0.01^c	0.1±0.004^c	0.2±0.01^b	0.4±0.03^a
Initial mean wt. (g)	-	27.2±3.8^a	23.5±1.1^a	22.3±1.0^a	23.3±1.7^a
Final total wt. (kg)	-	0.4±0.1^c	0.5±0.0b^c	0.8±0.1^b	1.2±0.2^a
Final mean wt. (g)	-	182.0±26.3^a	122.9±2.1^b	108.1±13.2^b	83.3±16.7^b
Survival %	-	100±0.0^a	100±0.0^a	87.5±7.2^a	90.6±3.1^a
Daily wt. gain (g/f/d)	-	1.0±0.2^a	0.6±0.0^b	0.5±0.1^b	0.4±0.1^b
Net fish yield (kg/pond)	-	0.3±0.0^b	0.4±0.0^b	0.6±0.1^{ab}	0.8±0.2^a

*Mean values with different superscript letters in the same row were significantly different at p = 0.05.

Table 4. Individual and combined NFY of caged and pond tilapia, and sahar in different treatments during the 158-days culture period at 24 m^2 cemented tanks (Mean ± SE).

Parameter	Treatment				
	T1	T2	T3	T4	T5
Net Fish yield of Tilapia in cage (kg/cage)	3.5±0.4^a	4.2±0.6^a	2.8±1.1^a	3.9±0.4^a	3.9±0.7^a
Net Fish yield of Tilapia in pond (kg/pond)	1.8±0.7^a	2.3±0.4^a	2.5±0.4^a	1.4±1.0^a	2.4±0.8^a
Net Fish yield of sahar in pond (kg/pond)	-	0.3±0.0^b	0.4±0.0^b	0.6±0.1^{ab}	0.8±0.2^a
Total Yield (kg/pond)	5.3±0.9^a	6.8±0.8^a	5.6±0.8^a	5.9±1.4^a	7.0±1.8^a

*Mean values with same superscript letters in the same row were not significantly different at p = 0.05.

Table 5. Mean number, size and yield of Nile tilapia recruits in different treatments during the 158-days culture period at 24 m^2 cemented tanks (Mean ± SE).

Parameter	Treatment				
	T1	T2	T3	T4	T5
Mean number/tank	602.7±176.4^a	173.3±9.7^b	107.3±36.2^b	42.3±18.5^b	6.0±6.0^b
Mean weight (g/fish)	3.9±0.8^c	26.5±3.3^b	21.3±4.2^b	44.8±2.6^a	10.0±10.0^c
Mean total weight (kg/tank)	2.3±0.7^{ab}	4.6±0.7^a	2.6±1.1^{ab}	1.8±0.8^b	0.1±0.1^b

*Mean values with different superscript letters in the same row were significant ($p<0.05$) in all treatments.

Table 6. Apparent food conversion ratio of caged tilapia, combined caged and pond tilapia, and combined caged and pond tilapia with sahar in different treatments during the 158-days culture period at 24 m^2 cemented tanks (Mean ± SE).

Para meter	Treatment				
	T1	T2	T3	T4	T5
FCR for caged tilapia	3.0±0.3^a	3.0±0.3^a	5.8±3.1^a	2.9±0.1^a	2.8±0.2^a
FCR for caged + pond tilapia	2.1±0.3^a	1.9±0.1^a	1.8±0.1^a	2.3±0.4^a	1.8±0.2^a
FCR for caged + pond tilapia + sahar	2.1±0.3^a	1.8±0.1^a	1.7±0.1^a	2.0±0.3^a	1.6±0.2^a
FCR for total fish	1.4±0.1^{ab}	1.1±0.1^b	1.2±0.1^{ab}	1.5±0.1^a	1.5±0.2^a

*Mean values with same superscript letters in the same row were not significantly different at p = 0.05

Table 7. Weekly mean and range of water quality parameters in different treatments during the 158-days culture period at 24 m^2 cemented tanks.

Parameters	**Treatments**				
	T1	**T2**	**T3**	**T4**	**T5**
Dissolved oxygen (mg/L) at 10 cm depth during 6-7am					
Mean	7.0±0.5	7.5±0.6	7.1±0.5	7.7±0.6	7.1±0.5
Range	2.7-11.7	3.3-11.6	3.1-10.6	2.6-12.3	2.8-11.4
Dissolved oxygen (mg/L) at 120 cm depth during 6-7am					
Mean	6.8±0.6	7.0±0.7	6.5±0.6	7.1±0.7	6.5±0.6
Range	2.5-11.7	3.3-11.3	2.9-10.5	2.6-11.7	2.6-11.4
Dissolved oxygen (mg/L) at 10 cm depth during 2-3pm					
Mean	8.8±0.4	9.6±0.6	9.3±0.6	10.4±0.7	8.4±0.5
Range	6.4-13.0	3.8-21.0	6.2-16.5	6.3-17.6	4.9-13.3
Dissolved oxygen (mg/L) at 120 cm depth during 2-3pm					
Mean	8.1±0.5	8.4±0.6	7.8±0.6	8.8±0.7	7.5±0.6
Range	3.6-12.9	3.6-13.4	4.1-14.0	5.2-17.6	2.9-12.1
Temperature (^{0}C) at 10 cm depth during 6-7am					
Mean	29±0.4	29±0.4	29±0.3	29±0.4	29±0.4
Range	24-33	24-32	24-33	24-33	24-33
Temperature (^{0}C) at 120 cm depth during 6-7am					
Mean	29±0.4	29±0.3	29±0.3	29±0.4	29±0.3
Range	24-33	24-32	24-33	24-33	24-33
Temperature (^{0}C) at 10 cm depth during 2-3pm					
Mean	31±0.4	31±0.5	31±0.5	31±1	31±0.5
Range	27-37	27-37	27-37	27-37	27-37
Temperature (^{0}C) at 120 cm depth during 2-3pm					
Mean	30±0.4	30±0.4	30±0.4	30±0.5	30±0.4
Range	25-34	25-34	26-34	25-34	25-34
pH at 10 cm depth during 6-7am					
Mean	9.1	9.0	8.9	9.1	9.1
Range	8.3-10.3	7.9-10.7	8.0-10.4	8.2-11.0	8.8-10.2
pH at 10 cm depth during 2-3pm					
Mean	9.5	9.5	9.4	9.5	9.4
Range	8.6-10.8	8.6-11.2	8.5-10.7	8.8-11.3	8.7-10.4
Transparency (cm) during 8-9 am					
Mean	76±3	58±3	57±4	53±5	67±5
Range	50-107	38-92	32-102	28-88	33-115
Total alkalinity (mg/L $CaCO_3$) during 9-10 am					
Mean	96.0±5.3	95.7±5	97.9±4.3	92.8±6.2	95±4.7
Range	58.1-165.3	47.0-153.7	58.8-178.9	54.3-161.6	62.3-137.6
Conductivity (µmhos/cm) at 6-7 am					
Mean	150±11	158±43	157±13	161±16	145±11
Range	103-225	112-245	107-235	103-287	103-230

Tilapia recruits

Mean number and total yield of tilapia recruits in different treatments during culture period are presented in Table 5. Tilapia recruits were observed from the 12th week after stocking. Higher numbers of recruits were observed in control than other treatments ($p<0.05$). The number of recruits decreased linearly with increasing stocking density of sahar (Figure 2). Mean weights of recruits were significantly highest in treatment 4 (44.8±2.6) and lowest in control treatment (3.9±0.8).

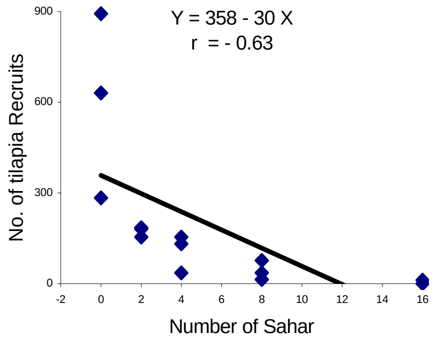

Figure 2. Relationship between stocking density of sahar and number of tilapia recruits.

Table 5 showed that mean number and yield of tilapia recruits were highest in the control treatment and lowest in the treatment 5 suggesting that higher number of sahar in this system effectively controls the tilapia recruits.

Apparent food conversion ratio (AFCR)

AFCR of caged tilapia, combined caged and pond tilapia, and combined caged and pond tilapia with sahar was not significantly different among treatments ($p>0.05$; Table 6). However, higher AFCR of caged tilapia was observed in treatment 3 than other treatments ($p<0.05$). AFCR of total including tilapia recruits was significantly higher in treatment 4 (1.5±0.1) and treatment 5 (1.5±0.2) than in treatment 2 (1.1±0.1).

Table 6 showed that FCR of caged tilapia ranged from 2.8 - 5.8, which decreased to 1.8 - 2.1 when pond tilapia was included. The higher FCR of caged tilapia was probably due to high mortality of caged tilapia, loss of feed, and loss of energy in breeding and parental care.

Water quality

All of the water quality parameters measured during the experimental period were not significantly different among treatments ($p>0.05$; Table 7) and found within the desirable range for fish production (Boyd, 1990). However, dissolved oxygen concentration was very low (0.4 mg/L) in one replication of treatment 5 during 22nd week of the experimental at morning, which is coincided with the mass mortality of fishes. Water temperature was fluctuated without any particular trend during the experimental period. Lower water temperature was recorded in the morning (24-33 ^{o}C) and higher in afternoon (26-38 ^{o}C) during experimental period; possibly due to diurnal fluctuation.

This experiment showed that 78-90 g Nile tilapia grew to 229-268 g in cage and 15-16 g Nile tilapia grew to 54-78 f size in open pond in 158 days, resulting an extrapolated NFY of 5.8 mt/ha/yr. This experiment also showed that the number of recruits decreased linearly with increasing stocking density of sahar. Treatment 5 effectively controlled the tilapia recruits and increased the NFY. Thus from this experiment it can be concluded that addition of sahar in the cage-cum-pond integration system of Nile tilapia effectively controls the number of tilapia recruits and increase NFY.

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