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Production performance of different indigenous and exotic carps at different densities in pond polyculture system

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Abstract: Production performance of Indian and Chinese carps in pond polyculture system was conducted in 16 farmer's ponds in two *upazillas* (Adomdighi and Dupchacia) under Bogra district. Two combinations viz., A and B (combination A, 6 species and combination B, 7 species) consisted of four treatments .In combination A silver carp, catla, rohu, mrigal, common carp and grass carp were used and in combination B above those with silver barb were used. The treatment differed from each other in respect of stocking density which was 30, 35, 40 and 45 per decimal in treatment I, II, III and IV, respectively. Duplicate treatments (I, II, III and IV) were used for each combinations of A and B with two replications for each. The growth rate of silver carp was higher than all other species except grass carp. The survival rate and contribution to the total production of silver carp was also highest. The exotic species showed the highest growth rate than the indigenous carps in all the treatments. There was no significant difference among the survival in different fishes in different treatments although there was an increase in mortality with the increase in density. Among the treatments of combination A, the highest production of fish (gross 6689, 47 kg/ha and net 6741.60 kg/ha) was recorded in treatment III and the lowest production (gross 5399.42 kg/ha and net 5199.05 kg/ha) was recorded in treatment I. In combination B of different treatments the highest production (gross 6123.77 kg/ha and net 5716.20 kg/ha) was recorded in treatment III and lowest production (gross 5228.01 kg/ha and net 5036.93 kg/ha) was recorded in treatment I. Significantly higher ($P<0.05$ production of fish was achieved in combination A than the combination B. Significant differences were ascertained among treatment's production, highest production was achieved in treatment III (6989 kg/ha/ 305 days i.e. 8364 kg/ha/yr). There was significant differences between the production of treatment I and III, and IV, II and III, and also between III and IV but no significant difference was found between treatment I and II and between II and IV. The results indicated that the production increased that the production increased with the increase of stocking density 9980 up to fingerlings/ha i.e. 40/decimal and decreased with the further increase in density. Thus the combination of 3 indigenous carps and 3 exotic carps at the stocking density of 40/decimal is suggested to use in family pond aquaculture in Bangladesh.
Key word: Indigenous carps, Exotic carps, Stocking density, combination, Production

Introduction

Bangladesh has 13 lakh ponds comprising of 1.47 lakh hectares. Only 51.7% of which are being cultured, 30.6% culturable, the rest17.7% are still in derelict condition (DOF, 1999).Therefore, on the one hand it is required to bring the culturable and derelict pond under culture programme. On the other hand fish culture techniques should be improved to increase fish production. Polyculture is the system in which fast growing compatible species of different feeding habits are stocked in different proportions in the same pond (Jhingran, 1975) has been practicing from the very beginning of the fish culture in China and in Indian sub-continent. The basic principles of the polyculture, i.e. culture of species of different feeding habits in the same pond is the best utilization of natural foods of different strata and zones without any harm to each other. It is a fact that, polyculture may produce an expected result if the fish with different feeding habits are stocked in proper ratios and combinations (Halver, 1984). This principle based on the assumption that fish growth is an expression of their reaction to, among other things, the sources of natural food in the environment (Shephered and Bromage, 1992). Synergism and antagonism between ecologically different species depends on stocking densities of each species on food availability. With increasing stocking density beyond the optimal level, competition for food and space would be started. As a result, fish could not use natural food efficiently and production slows down. Thus, the various relationships between different fish groups must be understood in order to maintain appropriate stocking densities for each species (Heper and Pruginin, 1981). Selection of fish species plays an important role for any culture practices. Stocking density of different fish species in a polyculture system also plays a vital role on overall production of fish. Higher density of a species may affect the growth of another species. Similarly lower density of a species may reduce the overall production. Therefore, the better utilization of different strata and zones of a pond three or more species with proper ratio must be stocked. Ahmed (1992) gave the primary importance in species selection for polyculture to Indian major carps; rohu, catla, mrigal and calbaus. In recent years, some exotic fish species draw an attention to farmers for their better growth performance. Fisheries scientists introduced several exotic carps in order to obtain more production at minimum cost with the shortest possible period. They are now being cultured in combination with the local carps. Among those, silver carp, grass carp, common carp; silver barb are the most popular species. Interaction among fish species may hinder or stimulate growth even in a balance polyculture system (Milstein, 1990). These interactions affect either on food resources or on the environment. We will have to utilize the opportunity of this special quality of exotic species for increasing national fish production through polyculture.

Government of Bangladesh also interested to increase fish production with the culture of both exotic and indigenous fish in pond polyculture system and our farmers are attracted to culture exotic fishes in combination with our native carps. In fact, exotic species have a vital role to boost up the fish production of Bangladesh. But there is no standard stocking density model for higher production of fish. In the view of above facts the experiment entitled on "polyculture of different indigenous and exotic fish species at different densities" was undertaken to evaluate the effects of species composition on fish growth and to assess the effects of stocking density and species combinations on fish production in pond culture.

Materials and Methods

The present study was conducted in farmers' ponds under semi-intensive rearing system during the period of 16 July 2006 to 20 May 2007. Sixteen perennial flood free rain fed ponds were selected for the study in two Thanas (Adomdighi and Dupchacia) under Bogra district. Ponds size was varied from 0.117 hectare to 0.623 hectare having an average depth range from 1.54 to 2.14 m. Four (Two, 6 species + Two, 7 species) replicate ponds were maintained under each of the four different stocking densities culture model or treatments. Ponds were numbered randomly from 1 to 16. Ponds having odd number were stocked with 6 species of which 3 indigenous (Catla, Rohu, Mrigal) and 3 exotic carps (Silver carp, Grass carp, Common carp) and even number were stocked with the above 6 species and an additional species silver barb. All the ponds were properly prepared before stocking with fingerlings. The ponds were receiving sufficient sunlight. All kinds of aquatic vegetation were removed. The predatory and undesirable fishes were eradicated by netting repeatedly and cleaned by poisoning with rotenone at the rate of 5 mg/L. Liming was done immediately at the rate of 250 kg/ha. All the ponds were fertilized with cow dung at the rate of 2964 kg/ha after 3 days of liming. Urea and T.S.P were applied to all ponds at the rate of 22.23 kg/ha and 14.82 kg/ha, respectively after 5 days of using cow dung. Fingerlings were stocked after 7 days of fertilizer application when light plankton bloom was appeared. Over wintering healthy fingerlings were collected from a local fish vendor. The sizes of the fingerlings were 9-13 cm in length. The ponds were stocked from 16 to 19 July'2008 in the every morning. However, 16 ponds were divided into two combinations. In combination A, 8 ponds were stocked with 6 species of which 3 indigenous and 3 exotic species and stocking density was maintained 7410, 8645, 9880 and 11115/ha in duplicate. In combination B, the remaining 8 ponds, were stocked with those 6 species and an additional species silver barb and the total stocking density was maintained by the same way in duplicate as combination A. Organic fertilizer cow dung was applied when needed at the rate of 1235 kg/ha. Inorganic fertilizer urea and T.S.P. were also applied at the rate of 22.23 kg/ha and 14.82 kg/ha, respectively. For the proper growth of fishes supplementary feed consisting of rice bran (75%) and mustard oilcake (25%) was given to fish at the rate of 2% of the body weight everyday in the morning between 9.00 to 11.00 a.m. Individual weights of minimum 10% of initially stocked fishes of each species in numbers were recorded monthly to estimate the total fish biomass for adjusting the feeding rate as well as to know the growth and health status. For grass carp and silver barb green grasses, soft banana leaves, duckweeds were provided to the fishes. At the end of the experiment all the fishes were harvested by netting repeatedly with a seine net and draining out water from each pond and subsequently counted species wise. Afterward the final weight of each species was measured. The survival rate of each fish species for the treatments of both combinations was estimated by deducting the number of each fish species from the initial stocking number, the gross production of fish in each treatment was calculated by multiplying the average final weight and the survival of each fish species combinations, and the net production was also estimated by multiplying the average net weight gained and the survival of each fish species combinations during the study period. The obtained mean values of growth, survival and yield were compared by using analysis of Variance (ANOVA). Duncan's Multiple Range Test (DMRT) was employed to differentiate the mean fish production in different treatments at 5% level of significance.

Results

Survival rate

At the end of the experiment the survival rate of fishes of each species for each treatment was estimated separately and the values are presented in Table 1and 2. Survival rates of all the species lies in between 87 to 97% in combination A and in between 83 to 97% in combination B. There were no significant differences between the survival rate of silver carp in different treatments, which ranged between 93.35 to 96.92% in combination A and 93.62 to 96.76% in combination B. In combination A, the range of survival rate of catla, rohu, mrigal, common carp and grass carp in different treatments were 85.81-90.06%, 88.64-93.11%, 84.93-91.36%, 82.69-89.48% and 92.66-95.29%, respectively. Silver carp showed the highest survival rate in treatment I and lowest in treatment IV. Catla and mrigal showed highest survival rate in treatment III, whereas, rohu and grass carp in treatment I.

In combination B the survival rate of silver barb, catla, rohu, mrigal, common carp, grass carp and silver barb in different treatments were found 93.62%, 86.49-90.19%, 83.42-89.17%, 88.31-92.85%, 86.22-88.80%, 92.29-94.58% and 85.07-92.95%, respectively. The highest survival rate of silver carp, rohu, common carp and silver barb in treatment I, whereas, the survival rate of catla, mrigal and grass carp were highest in treatment II. In both combinations of four treatments the average highest survival rate was found in treatment I and lowest in treatment IV. In the present study mean survival rates of various fishes were recorded 92.38%, 91.28%, 91.33% and 88.01% in treatments I, II, III and IV , respectively in combination A and survival rates of different fish were recorded 91.71%, 91.21%, 90.58% and 88.14% in treatments I, II, III and IV in combination B. Survival rate did not vary significantly between two combinations. In the present study the highest survival rate was observed in treatment I of combination A where the stocking density was7410 fish/ha and species combination was 6. No significant differences were found between others treatments except treatment IV where the density was 11115 fish/ha in combination A. In combination B the highest survival rate was observed in treatment I where the stocking density was low and the trend of survival rate was the same as in combination A.

Table 1. Showing the survival rate (%), gross and net production (kg/ha) and percent contribution to the yield in the different treatments in combination A

Treat-ments	Species	Weight (g)			Survival rate (%)	Production (kg)						Percent contribution to the yield (kg)
						Species - wise		Total		Treatment wise/ha.		
		Initial	Final	Weight gain		Gross	Net	Gross	Net	Gross	Net	
I	Silver carp	27.65	921.17	893.52	96.92	1302.9	1256.3	3520.42	3389.78	5399.42	5199.05	37.01
	Catla	26.25	542.37	516.12	89.76	236.56	223.48					6.72
	Rohu	26.23	617.84	591.61	93.11	557.44	533.04					15.83
	Mrigal	25.98	552.98	527.00	91.23	483.04	462.18					13.72
	Common carp	23.53	731.66	708.13	87.96	310.57	300.25					8.82
	Grass carp	33.25	1366.3	1333.1	95.26	629.82	614.54					17.89
II	Silver carp	25.14	883.96	858.82	96.47	723.69	700.80	2102.52	2016.67	6111.98	5862.41	34.42
	Catla	24.60	570.61	546.01	88.58	174.79	163.80					8.83
	Rohu	25.20	597.35	572.15	92.11	2279.9	268.91					13.32
	Mrigal	25.90	541.26	515.36	86.53	326.16	304.58					15.51
	Common carp	24.25	705.41	681.16	89.48	160.34	155.30					7.63
	Grass carp	34.20	1352.8	3118.6	94.51	437.55	423.28					20.81
III	Silver carp	27.30	909.50	882.20	95.14	1443.7	1419.5	4361.43	4206.76	6989.47	6741.60	33.10
	Catla	27.00	563.76	536.76	90.06	395.48	374.12					9.07
	Rohu	27.30	600.56	573.26	90.18	663.62	634.03					15.22
	Mrigal	26.65	578.43	551.78	91.36	745.96	700.76					17.10
	Common carp	25.70	762.52	736.77	88.59	315.91	303.55					7.24
	Grass carp	34.80	1375.4	1340.6	93.86	796.81	774.84					18.27
IV	Silver carp	26.45	759.29	732.84	93.35	850.41	813.45	2544.09	2431.66	6344.36	6063.99	33.43
	Catla	25.12	415.97	390.85	85.81	213.55	199.33					8.39
	Rohu	26.73	520.27	493.54	88.64	367.53	347.95					14.45
	Mrigal	25.78	464.60	438.82	84.93	387.40	369.05					15.23
	Common carp	22.40	656.08	633.68	82.69	271.33	259.81					10.67
	Grass carp	32.15	1236.7	1204.5	92.66	453.87	442.07					17.84

Fish production

Among the four treatments of combination A, both gross (6989.47 kg/ha) and net (6741.60 kg/ha) production were highest in treatment III, where species composition were silver carp, catla, rohu, mrigal, common carp and grass carp, and the lowest (gross 5399.42 kg/ha and net 5199.05 kg/ha) of the same were recorded in treatment I. The gross and net production recorded in treatment II were 6111.98 kg/ha and 5862.41 kg/ha, whereas, the gross and net production were 6344.36 kg/ha and 6063.99 kg/ha in treatment IV. In combination B, where seven species (above six species and an additional species, silver barb) were stocked, the highest gross and net production were 6123.77 kg/ha and 5716.20 kg/ha in treatment III. In this combination, the gross and net productions were 5228.01 kg/ha and 5036.93 kg/ha; 5486.50 kg/ha and 5309.29 kg/ha in treatments I, II, III and IV, respectively. In the present study silver carp was the most dominating species contributing to the bulk of the total production. Species-wise contributions of the total production are presented in Table 1 and 2. In combination A, silver carp contributed 37.01% in treatment I, 34.42% in treatment II, 33.10% in treatment III and 33.43% in treatment IV. Grass carp and mrigal occupied the second and third position, respectively in term of their contribution to the total fish production in different treatments. Contribution of grass carp were 17.89%, 20.81%, 18.27% and 17.84 %in treatments I, II, and III and IV, respectively.

Mrigal contributed to 13.72% in treatment I, 15.51% in treatment II, 17.10% in treatment III and 15.23% in treatment IV. Catla made a contribution of 6.72%, 8.83%, 9.07% and 8.39% in treatments I, II, III and IV. Rohu was found to be contributed 15.83% in treatment I, 13.32% in treatment II, 15.22% in treatment III and 14.45% in treatment IV. In combination B, the contribution of silver carp was highest in all the treatments. Grass carp and mrigal occupied the second and third position of the total contribution. The contribution of silver carp was 38.30%, 38.01% and 36.98% in treatment I, II, III and IV, respectively, whereas, grass carp contributes 18.01%, 16.77%, 15.17.17% and 14.49% ; mrigal 15.49%, 15.51%, 15.72% and 17.78%; rohu 12.22%, 11.65%, 12.02% and

12.33% catla 6.54%, 8.35%, 7.37% and 6.36%, respectively. Silver barb contributed minimum in production in all the treatments of combination B. Statistically analysis showed that total production was significantly higher in combination A than B (Table 3).

Table 2. Showing the survival rate (%), gross and net production (kg/ha) and percent contribution to the yield in the different treatments in combination B

Treat-ments	Species	Weight (g)			Survival rate (%)	Production (kg)						Percent contribution to the yield (kg)
		Initial	Final	Weight gain		Species - wise		Total		Treatment wise/ha.		
						Gross	Net	Gross	Net	Gross	Net	
	Silver carp	28.00	927.45	899.45	96.76	1459.5	1411.24					38.30
	Catla	27.10	521.21	494.11	87.92	249.43	234.21					6.54
	Rohu	28.00	590.19	562.19	89.17	464.79	448.63					12.22
I	Mrigal	26.43	588.18	561.75	91.77	590.15	566.24	3811.22	3671.92	5228.01	5036.93	15.49
	Common carp	24.00	761.64	737.64	88.75	245.03	235.31					6.43
	Grass carp	35.00	1327.7	1292.2	95.28	686.53	666.75					18.01
	Silver barb	17.40	347.34	329.94	92.29	114.78	109.54					3.01
	Silver carp	27.70	882.95	855.25	94.51	1026.6	990.38					38.01
	Catla	26.55	508.35	481.80	90.19	225.50	212.96					8.35
	Rohu	27.40	491.72	464.32	86.84	314.60	295.31					11.65
II	Mrigal	27.01	524.20	497.19	92.85	418.82	394.77	2700.70	2587.29	5467.00	5237.43	15.51
	Common carp	23.05	710.04	686.99	88.75	153.74	149.08					5.69
	Grass carp	33.70	1307.4	1273.7	94.58	452.88	440.68					16.77
	Silver barb	16.05	329.65	313.59	90.76	108.56	104.11					4.02
	Silver carp	26.65	832.49	805.84	94.38	2223.8	1987.20					37.87
	Catla	26.56	512.23	485.67	88.32	432.71	407.96					7.37
	Rohu	26.95	491.28	464.33	86.66	706.12	668.17					12.02
III	Mrigal	25.60	542.59	516.99	91.76	922.95	901.11	5872.70	5481.84	6123.77	5716.20	15.72
	Common carp	24.65	704.92	680.27	88.80	300.60	287.75					5.12
	Grass carp	30.80	1310.8	1280.0	92.37	891.17	855.05					15.17
	Silver barb	18.28	363.22	344.94	91.74	395.38	374.60					6.73
	Silver carp	25.35	741.71	716.36	93.62	1078.5	1038.01					36.98
	Catla	25.65	410.52	384.87	86.49	185.52	172.42					6.36
	Rohu	25.75	416.41	390.66	83.42	359.49	335.97					12.33
IV	Mrigal	25.95	447.39	421.44	88.31	518.51	480.02	2916.16	2771.45	5586.51	5309.29	17.78
	Common carp	24.38	710.04	685.66	86.22	157.19	152.22					5.39
	Grass carp	31.85	1158.2	1126.3	93.84	422.69	408.86					14.49
	Silver barb	16.30	295.86	279.56	85.07	194.28	183.95					6.66

Table 3. ANOVA table for gross production (kg/ha) of fishes in different treatments

Source of variation (S.V.)	Sum of squares	Degree of freedom	Mean squares (M.S.)	F- ratio	Significance level
Combination	1430069.2	1	1430069.2	28.931	0.0002
Densities	3115214.2	3	1038738.1	21.014	0.001
Residual	543738.3	11	49430.8	-	-
Total	5090021.7	15	-	-	-

Discussion

In the present study mean survival rates of various fishes were recorded 92.38%, 91.28%, 91.33% and 88.01% in treatments I, II, III and IV , respectively in combination A and survival rates of different fish were recorded 91.71%, 91.21%, 90.58% and 88.14% in treatments I, II, III and IV in combination B. Survival rate did not vary significantly between two combinations.

Lakshmanan *et al*. (1971) observed survival rate of 80% with seven species composite culture of Indian and Chinese carps in which ponds were fertilized with both organic and inorganic fertilizer. In another study, Wahab *et al*. (1995) found that the survival rate of all fish including silver barb was higher than 80% in polyculture of indigenous major carps. In the treatments the survival rate of all species was high enough for aquaculture. The fact indicated that the higher stocking density causes the higher mortality of the fish, which was expected.

The variations of production of fishes were found in different treatments of combination A and B. In combination A treatment III showed highest production followed by treatment IV, II and I. Whereas, in combination B, treatment III also showed highest production followed by treatment IV, II and I. The highest production recorded in treatment III of both combinations might be attributed to better stocking density in this treatment than the rest of the treatments. An average 6520.73 kg/ha305 days (Table 4) was recorded from treatment III. silver carp, grass carp and rohu which contributed the bulk of the production; say in treatment III of combination A they contributed 37.01%, 17.89% and 15.83% to the total yield.

Though fish production was maximum in treatment III of combination A but catla and common carp could not make a significant contribution (6.72% and 8.82%) to the total yield. The exotic carps such as silver carp, grass carp and common carp played a very significant and dominant role in total fish production in the present polyculture experiment. In combination A the highest yield of 6989.47 kg/ha/305 days was recorded in treatment III and in combination B, highest yield of 6123.77 kg/ha/305 days was recorded in treatment III and in B, highest yield of 6123.77 kg/ha/305 days. A comparison between two combinations, average gross production with 6 species combination was resulted better than the 7 species combination. Lakshmanan *et al.* (1971) obtained good result in polyculture with Chinese and Indian major carps by stocking in varying proportions in different densities. The fish production recorded by them varied from 2230 – 4209 kg/ha/yr. Good results were also obtained by Singh *et al.* (1972) from polyculture experiment using silver carp, grass carp, common carp together with Indian major carps and the yield recorded by them was kg/ha/yr. Mathew *et al*. (1988) obtained the production of 10183 kg/ha/yr when stocking density is 8000 nos./ha in six carp fish species polyculture system. Gupta *et al*. (1990) also reported good results from the polyculture of Indian carps with exotic species and the yield recorded by them were 7000-9000 kg/ha/yr, 7445 kg/ha/yr, 4917 kg/ha/yr, respectively. Hossain *et al*. (1997) obtained the average production of carps 2133 kg/ha in 105 days in mixed culture system using supplementary feed (rice bran and mustard oilcake 1:1). However Mazid and Hussain (1999) reported that present average yield (nationwide) of carp polyculture is nearly 1800-2000 kg/ha and by using BFRI's mature carp polyculture technology this production rate could be increased four to five fold. *i.e.* with this technology production rate to range of 7000 to 10000 kg/ha is possible. The result of the present study demonstrated that stocking density of 9980 fish/ha. i.e.40 fish/decimal in treatment III of combination A is best suited for carp polyculture. An addition of silver barb in polyculture has decreased the growth of Indian major carps while significantly increased that of common carp which indicate a direct competition between indigenous carps and silver barb under the present polyculture combination. Therefore, for carp polyculture silver barb is not an encouraging species. It might be encouraging when additional food like duckweeds can be supplied. Mazid and Hussain (1999) forecasted a possible production of 7000-10000 kg/ha/yr in place of the present status 1800-2000 kg/ha/yr. Following the combination suggested by BFRI, the fish production was achieved up to 6989 kg/ha/305 days which is equivalent to 8364 kg/ha/yr in the present study considering the same rate of fish growth, although the time not consider in this experiment was from 20th May to 15th July which is considered good season to be grown. Therefore, actual production might be greater than the calculated one. At last it can be said that the combination of 3 indigenous carps (rohu, catla and mrigal) and 3 exotic carps (silver carp, common carp and grass carp) at the stocking density of 40/decimal can be employed in the family pond aquaculture in Bangladesh with small cost of production. The effects of stocking density and species combination on fish growth and production were observed in the present study, Fish stocked at different densities gave different rate of growth and production in the experimental ponds, Statistical analysis indicate that production varied significantly among the treatments. Treatment III (i.e. density 40 fish/decimal or 9980 fish/ha) was found to provide best result in terms of production, which is followed by treatment IV, treatment II and treatment I respectively. On the other hand combination A (i.e. species combination 6) gave significantly better result than the combination B.

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