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Optimization of Stocking Density of Mola (*Amblypharyngodon mola*) in Carp Polyculture under Low Cost Management for Rural Bangladesh

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Abstract: The optimization of stocking density of mola (*Amblypharyngodon mola*) in the polyculture with *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* and *Ctenopharyngodon idella* was investigated. Four treatments were tried with seven replicates each. Only carp fingerlings were stocked in the treatment 1 (control) and carps with mola were present in treatments 2, 3 and 4. Three stocking densities of brood mola i.e. 100, 150 and 200 fish were tested in treatments 2, 3 and 4, respectively with stocking density of carps fixed at 43 fingerlings per 40 m^2 pond. Most of the water quality parameters were not significant variations (P>0.05), however transparency and chlorophyll-a varied significantly among the treatments. Although water quality parameters showed some variations among treatments but they do not have any definite trend in respect of different stocking densities of mola. Although individual growth of rohu showed variations among treatments, the fish productions in all treatments were not significantly different (P>0.05). Comparatively higher yield was recorded in treatment-1 (without mola), however carp with lowest density of mola (100 mola per 40 m^2 pond area) was recommended for nutritional, socioeconomic and production point of view.

Key words: Optimization · Stocking Density · Mola · Carp Polyculture · Low Cost Management

INTRODUCTION

Aquaculture of Bangladesh is enriched with a significant number of indigenous and exotic carp fishes. Carps are basically the most important species to aquaculture in Bangladesh. In 2012-13, carp production was estimated as 35% of the total fish production in the country [1]. There are at least 13 endemic and 8 introduced species of carps, which are of interest to aquaculture in Bangladesh [2].

Polyculture of fish has been practised with the aim that different species stocked in the ponds occupy different niches with their complementary feeding habits, utilizing all the natural food available in the ponds and thus increasing the total fish production [3]. Stocking density of fish is one of the key factors, deciding management measures in scientific fish culture practices. It affects the amount of natural food available per fish and the level of supplementary feeding required [4-5] and hence the intensity of inter- and intra-specific food competitions in polyculture systems. In polyculture, both native and exotic species are stocked together. Many of these species have been found antagonistic and feeding competition to each other [6]. To overcome this situation, efforts have been made to develop a polyculture technique in rural Bangladesh with fast growing compatible species of carps and nutritionally rich mola [7-8]. It may exert synergistic effects in the polyculture and thus enhance fish production [9]. Mola is particularly important because of high content of vitamin-A than that of other edible fish species in Bangladesh [10-11]. A 100g mola contains approximately 1,960 µg vitamin-A, 1,071 mg

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calcium and 7 mg iron, whereas silver carp contains 17 µg vitamin-A, 268 mg calcium and rohu contains 27 µg vitamin- A and 317 mg calcium [12, 13].

Some research works have been conducted on the culture of Indian and Chinese carps with small indigenous fish species like mola, chela and punti in polyculture [7, 8, 14]. These initial findings inspired the polyculture of some small indigenous fish especially mola and punti with large carp. That will allow simultaneous production of small fish for peasant consumption and of large carp as cash crop. This needs further investigations to build up a sustainable technology. As part of a larger systematic attempt, this study has been set out to investigate the optimum stocking density of mola in carp polyculture technology under low cost management.

MATERIALS AND METHODS

Pond Selection and Preparation: The experiment was carried out for a period of 180 days in twenty-eight different sizes (400-1600 m^2) of rural farmers' ponds at Montola village, Mymensingh, Bangladesh. All ponds were rain fed, well exposed to sunlight and without an inlet or outlet. Before starting the experiment, all predatory fishes were removed from the ponds by repeated netting. Embankments were repaired and lime ($CaCO_3$) was applied at the rate of 250 kg ha^{-1}. After seven days of liming, the ponds were fertilized with cow manure at the rate of 1,000 kg ha^{-1} and urea and TSP each at the rate of 100 kg ha^{-1}.

Fish Stocking: Four treatments with seven replicates were tried and the ponds were selected by stratified random sampling according to the size. Fingerlings of fish of different species were collected from local supplier and stocked in the ponds. Rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*) and grass carp (*Ctenopharyngodon idella*) were at the number of 13, 13, 13 and 4, respectively per 40 m^2 pond area with an average 1.8 m depth of each treatment. Small indigenous fish, mola (brood fish) were stocked at the number of 100, 150 and 200 fish per 40 m^2 pond area in treatments 2, 3 and 4, respectively (Table 1). Before stocking, about 10% of fingerlings were measured for length and weight for each pond as sub-sample basis. Pond size and the number of each species stocked in different ponds are presented in Table 2.

Post Stocking Management: All ponds were subjected to the same regime of feed and fertilizer application. Fish were fed at a rate of 3% body weight per day for large carp with commonly available rice bran. The amount of daily feed supply was adjusted on the basis of sampled fish weights. After sampling, the sampled fishes were returned into the ponds. Ponds were fertilized with cow manure at the rate of 1,000 kg ha^{-1} at fortnightly intervals. Soft grasses and banana leaves for grass carp were supplied daily up to satiation. All feeds and fertilizer inputs were supplied from the farmers' households. In mola ponds, most of mola bred in the ponds quickly. After 3 months of stocking, mola was partially harvested at 7 days interval by lift net until the end of the trial. To overcome high population density, partial harvesting of mola (only used for family consumption) was encouraged from all mola ponds. The farmers' recorded the amount of harvested mola.

Analysis of Water Quality Parameters: Water quality parameters such as water temperature, transparency, pH, dissolved oxygen (DO), total alkalinity, nitrate-nitrogen, ammonia-nitrogen, phosphate-phosphorous and chlorophyll-a were determined monthly between 09.00 and 10.00 hrs on each sampling day. Monitoring of water temperature, transparency, pH and dissolved oxygen (DO) were done on the spot at the farmers' pond site. Total alkalinity, nitrate-nitrogen, ammonia-nitrogen, phosphate-phosphorous and chlorophyll-a were analysed at the Water Quality and Pond Dynamics Laboratory through collection of water samples from each pond. For nutrient analyses water samples were filtered previously. Water temperature was recorded with a Celsius thermometer and transparency was measured with a secchi disc of 20-cm diameter. Dissolved oxygen (DO) was measured directly with a digital DO meter (YSI Model-58) and a portable digital pH meter (Jenway pH meter, Model 3020) was used for measuring pH. Measurement of nitrate-nitrogen, ammonia-nitrogen and phosphate-phosphorous

Table 1: Fish species composition and stocking densities maintained per 40 m^2 pond area in different treatments

Fish species	Treatment-1	Treatment-2	Treatment-3	Treatment-4
Rohu (*L. rohita*)	13	13	13	13
Catla (*C. catla*)	13	13	13	13
Mrigal (*C. mrigala*)	13	13	13	13
G. carp (*C. idella*)	4	4	4	4
Mola (*A. mola*)	-	100	150	200

Table 2: Pond size and number of fish stocked in different ponds under four treatments

			Large carp (No.)				
Pond No	Treatment	Pond Area (m^2)	Rohu	Catla	Mrigal	G. carp	Small fish Mola (No.)
1	Treatment-1	323	105	105	105	32	0
2	(Control)	335	109	109	109	34	0
3		475	154	154	154	48	0
4		480	156	156	156	48	0
5		591	192	192	192	59	0
6		632	205	205	205	63	0
7		1838	597	597	597	184	0
8	Treatment-2	270	88	88	88	27	675
9		377	123	123	123	38	943
10		456	148	148	148	46	1140
11		378	123	123	123	38	945
12		489.6	159	159	159	49	1224
13		648	211	211	211	65	1620
14		367	119	119	119	37	918
15	Treatment-3	237	77	77	77	24	889
16		398	129	129	129	40	1491
17		330	109	109	109	33	1238
18		520	169	169	169	52	1951
19		943	306	306	306	94	3536
20		513	167	167	167	51	1924
21		440	143	143	143	44	1650
22	Treatment- 4	302	98	98	98	30	1511
23		354	115	115	115	35	1770
24		470	153	153	153	47	2350
25		498	162	162	162	50	2491
26		567	184	184	184	57	2835
27		754	245	245	245	75	3770
28		1040	338	338	338	104	5200

were carried out by a Hach kit (DR/2010, a direct reading spectrophotometer). Total alkalinity was determined by EDTA titrimetric method by using 0.02 N sulfuric acid and methyl orange as an indicator [15]. Chlorophyll-a was determined using a spectrophotometer (Milton Roy Spectronic, Model 1001) after acetone extraction [16].

Growth of Fish: Fish were sampled monthly with a cast net to estimate the growth in length (cm) and weight (g), and to check up the health condition of fish. About 15-20 fishes of each species were measured from each pond as sub-sample. These fishes were returned into the ponds after sampling.

The following parameters were measured to evaluate the growth of fishes:

Weight gain (cm) = Average final weight (g) – Average initial weight (g)

$$\text{Survival rate (\%)} = \frac{\text{No. of fish harvested}}{\text{Initial no. of fishes}} \text{ x } 100$$

Analysis of Specific Growth Rate (SGR): The growth performance of experimental fish in different treatments was measured by using following formula [17]:

Specific growth rate (SGR):

$$\text{SGR (\% bw/day)} = \frac{LogeW_2 - LogeW_1}{T_2 - T_1} x100$$

where, bw = Body weight W_1 = Initial live body weight (g) at time T_1 (day)
W_2 = Initial live body weight (g) at time T_2 (day)

Fish Harvesting: After 180 days of fish rearing all fishes were harvested from the experimental ponds. About 20% of fish of each species were measured from each pond to determine the final growth and all the fishes were weighed for the estimation of total production.

Statistical Analysis: The data was analyzed using the statistical package, Statgraphics, version 7 and SPSS, version 14. One way analysis of variance (ANOVA) was performed on all dependent variables to study if treatments had any significant effect. Duncan's New Multiple Range Test was applied to identify specific difference [18]. Standard error (± SE) of treatment means was calculated from the residual mean square in the analysis of variance.

RESULTS AND DISCUSSION

Water Quality Parameters: The water quality parameters are summarized in Table 3. Although water quality parameters showed some variations among treatments, they do not have any definite trend in respect of species combinations as well as presence or absence of mola. The results of water quality parameters in this study showed to be more or less similar with the findings of several previous works [7, 8, 19-23]. Moreover, all water quality parameters of the experimental ponds were found to be within the acceptable ranges for fish culture and there was no abrupt change in any parameter of the pond water during the tenure of experiment.

Growth and Yield of Fish: The details of fish growth and production of different fish species under the four treatments are shown in Table 4. Based on the number of the fish harvested at the end of the experiment, survival rates of various carp species ranged from 77.7 to 83.9%. Survival rates of rohu, catla, mrigal and grass carp was more or less similar in all treatments and there was no remarkable effect on survival rates in presence or absence of mola with different stocking densities in different treatments. The mean survival of all the species in different treatments were not singnificant (P>0.05). Kundu *et al.* [24] reported the survival of large carp species was at least 75% in Carp with Dhela polyculture. Laksmanan *et al*. [25] reported a survival rate of 80% with seven species composite culture of Indian and Chinese carps, while Kohinoor *et al*. [14] and Wahab *et al*. [21] reported the survival rates in polyculture were above 80% and 76-92%, respectively, in similar trials.

The specific growth rate (SGR) of grass carp was the highest (1.61-1.66) among all species (Table 4). Catla and mrigal showed similar specific growth rate (1.36-1.41) with non-singnificant difference (P>0.05) among the treatments. Rohu showed siginicantly higher SGR (1.49) in treatment 1 (control) than treatment 4 (1.29) but no significant difference (P<0.05) between treatments 2 and 3 with treatment 1. The SGR values of all fishes in this trial were lower than those reported by Kohinoor *et al*. [14] for Indian major carps in polyculture in a trial at the BAUs Field Laboratory, Mymensingh.

The mean weight of all the large carp species excluding rohu were not singnificantly different (P<0.05). Rohu was found to show distinct variation in weight gain, with a higher mean value of 233.3 g in treatment 1 followed by 184.6, 182.0 and 170.0 g in treatments 3, 2 and 4, respectively. Rohu showed siginicantly higher mean

Table 3: Average (±SE) water quality parameters of different treatments

Parameters	Treatment-1	Treatment-2	Treatment-3	Treatment-4	F - value
Temperature (°C)	27.37± 0.68[a]	26.99± 0.65[a]	27.48± 0.64[a]	27.72± 0.67[a]	0.214
	(17.70-32.50)	(17.00-32.20)	(17.80-32.60)	(17.30-33.50)	
Transparency (cm)	32.82± 1.45[a]	34.79± 1.71[a]	27.24± 1.31[b]	33.39± 1.48[a]	4.922
	(14.00-53.00)	918.00-79.00)	(15.00-53.00)	(18.00-61.00)	
Dissolved oxygen	4.02± 0.11[a]	4.25± 0.17[a]	4.49± 0.25[a]	4.26± 0.18[a]	1.064
(mgl^{-1})	(3.00-6.30)	(2.40-8.40)	(2.90-9.80)	(3.00-7.50)	
pH	(6.54-8.70)	(6.65-8.70)	(6.00-9.09)	6.30-8.80)	0.748
Total alkalinity	57.73± 4.03[a]	55.27± 4.32[a]	57.90± 4.67[a]	64.41± 5.09[a]	0.741
(mgl^{-1})	(20.0-140.0)	(14.0-167.0)	(20.0-162.0)	(18.0-167.0)	
NO_3-N (mgl^{-1})	0.13± 0.037[a]	0.13± 0.029[a]	0.15± 0.047[a]	0.14± 0.037[a]	0.105
	(0-1.30)	(0.01-1.06)	(0.01-1.85)	(0.01-1.20)	
NH_3-N (mgl^{-1})	0.37± 0.069[a]	0.37± 0.076[a]	0.41± 0.065[a]	0.36± 0.061[a]	0.095
	(0-2.43)	(0-2.61)	(0-1.84)	(0.01-2.29)	
PO_4-P (mgl^{-1})	0.46± 0.084[a]	0.32± 0.089[a]	0.35± 0.064[a]	0.35± 0.078[a]	0.639
	(0-2.40)	(0.01-3.82)	(0-1.84)	(0-2.49)	
Chlorophyll-a	130.6± 15.92[ab]	127.7± 12.85[ab]	160.9± 21.77[a]	96.24± 9.33[b]	2.855
(μgl^{-1})	(9.52-711.62)	(8.33-437.92)	(1.19-885.36)	(9.52-305.83)	

The range of observed values is given in parentheses. If main effects are significant, Letters followed by different superscripts indicate differences at 0.05 level of significance based on Duncan test

Table 4: Growth, survival, biomass production of fish under different treatments

Treatment	Fish Species	Mean wt. (g) of stocking ±SE	Mean wt. (g) of harvesting ±SE	Survival (%)	SGR (%)	Production (kg ha^{-1} 180 days^{-1}) Species wise ± SE	Total ± SE
Treatment-1	Rohu	15.7± 0.57	233.6±19.4^{a}	80.9	1.49^{a}	610.6± 46.7^{a}	
(control)	Catla	13.4± 0.43	174.9±12.7^{a}	80.9	1.41^{a}	458.3± 29.9^{a}	1953.9±88.1
	Mrigal	15.3± 0.36	196.1±15.5^{a}	82.4	1.41^{a}	523.7± 40.1^{a}	
	Grass carp	21.1± 0.34	433.0±55.3^{a}	82.9	1.65^{a}	361.1± 49.0^{a}	
Treatment-2	Rohu	15.3± 0.57	182.0±19.7^{ab}	81.9	1.36^{ab}	483.0± 50.8^{ab}	1882.7±121.2
	Catla	13.9± 0.40	169.0±11.9^{a}	80.1	1.38^{a}	438.6± 28.5^{a}	
	Mrigal	15.9± 0.51	206.9±21.3^{a}	80.0	1.41^{a}	535.4± 52.0^{a}	
	Grass carp	22.1± 0.26	441.1±53.8^{a}	80.9	1.64^{a}	356.1± 40.4^{a}	
	Mola	1.80± 0.10	0.89±0.051^{a}	NA	NA	69.4± 6.4^{a}	
Treatment-3	Rohu	15.9± 0.59	184.6±16.8^{ab}	82.1	1.35^{ab}	492.1± 42.8^{ab}	1864.7±113.0
	Catla	14.1± 0.51	165.3±12.2^{a}	81.4	1.36^{a}	437.3± 33.1^{a}	
	Mrigal	15.9± 0.74	200.4±9.3^{a}	82.0	1.41^{a}	533.6± 26.8^{a}	
	Grass carp	21.4± 0.57	435.0±46.8^{a}	77.7	1.66^{a}	340.3± 42.1^{a}	
	Mola	1.80± 0.16	0.80±0.076^{a}	NA	NA	61.3± 3.2^{a}	
Treatment-4	Rohu	16.3±0.61	170.0±14.5^{b}	83.9	1.29^{b}	464.9± 43.6^{b}	1803.3±124.9
	Catla	14.1± 0.40	167.7±10.0^{a}	81.4	1.37^{a}	443.9± 27.5^{a}	
	Mrigal	15.7± 0.87	191.9±12.0^{a}	82.0	1.39^{a}	510.1± 31.0^{a}	
	Grass carp	21.6± 0.48	406.0±54.7^{a}	79.6	1.61^{a}	326.0± 51.4^{a}	
	Mola	1.87± 0.11	0.87±0.029^{a}	NA	NA	58.7± 7.9^{a}	

Letters in the same column having the same superscript for particular species in different treatments are not significantly different (P>0.05). NA= Not applicable; SE= Standard error.

weight in treatment 1 (control) than treatment 4 but no significant difference between treatments 2 and 3 with treatment 1. It may be assumed that comparative lower weight gain of rohu was observed in treatment 4 due to presence of highest stocking density (200 mola per 40 m^2 pond area) of mola.

Production of rohu was the highest in treatment-1 (control) with an average production of 610.6 kg ha^{-1}, which was followed by treatment 3 (492.1 kg ha^{-1}), treatment 2 (483 kg ha^{-1}) and treatment 4 (464.9 kg ha^{-1}), respectively. Rohu showed significantly higher production in treatment 1 (control). This might be due to the fact that rohu competed for food and space with mola [26]. Miah and Dewan [27] reported that rohu is an omnivore with preference for debris and decaying vegetation. Comparatively lower growth of rohu occurred in highest densities of mola ponds (treatment 4) might be due to the fact that mola competed for food and space with rohu [14]. Within the mola ponds, rohu performed better in treatment 3, where mola was present at150 fish per 40 m^2 pond area.

The highest production of catla (458.3 kg ha^{-1}) was found in treatment-1, where there was no mola but lower production of catla occurred (treatments 2, 3 and 4) in mola ponds. Inclusion of mola reduced the growth of catla to some extent due to competition for food and space. Among different treatments, catla showed lower growth performance than other two carp's- rohu and mrigal. It may be due to unavailability of phytoplankton in all ponds because rural poor farmers did not supply inorganic fertilizer in their ponds regularly.

Bottom feeder mrigal had better production and more or less similar in all the treatments. The production values of mrigal were not significantly different (P>0.05) among treatments. There was no remarkable impact of mrigal in presence or absence of mola and their different stocking densities. The presence of grass carp are increased the production of mrigal. It may be due to normal feed of mrigal and was greatly supplementation the excreta of grass carp as semi-digestive micro-pelleted vegetation source of food.

The growth and production of grass carp were better in treatment 1 (361 kg ha^{-1}), where mola was absent. In mola ponds the productions of grass carp were 356, 340 and 326 kg ha^{-1} in treatments 2, 3 and 4, respectively. Gradually lower production of grass carp was found in mola ponds with connection of stocking densities of mola. Mola, may have some kind of stimulating effect on grass carp, however, exact mechanism is yet to be known.

In all the mola ponds under three treatments (2, 3 and 4), the number of mola was higher than the initial stocking number, as most of the mola bred in the captivity. Therefore the mean harvesting weight of mola decreased, and for that the specific growth rate was not applicable due to negative value.

Mola performed better in treatment-2, where all species of carps and stocking densities of mola 100 fish per 40 m^2 pond areas were present. In other treatments mola production was more or less similar. It was clear that mola production did not vary significantly with the stocking densities which was maintained 100, 150 and 200 mola fish per 40 m^2 pond in treatments 2, 3 and 4, respectively. In this experiment the lowest stocking density of mola (100 fish per 40 m^2 pond area) may be recommended in carp polyculture system to save the production cost.

During the study period of 180 days the overall highest production was obtained in treatment-1 (1,954 kg ha^{-1}), followed by treatments 2 (1,883 kg ha^{-1}), 3 (1,865 kg ha^{-1}) and 4 (1,803 kg ha^{-1}) which was higher than the observation of Kundu *et al.* [24]. In the present study, there was no significant difference ($P>0.05$) of total production among treatments with presence or absence of small fish mola with carps. From biomass production point of view, four species carp polyculture with rohu, catla, mrigal and grass carp (excluding mola) may be considered the best. However, from nutritional point of view carp polyculture with mola may be considered desirable.

CONCLUSION

There was no remarkable change of total production shown with the different stocking densities of mola in carp polyculture with rohu, catla, mrigal and grass carp. From this experiment it is clear that, with the introduction of mola in carp polyculture, the growth of rohu, catla, mrigal and grass carp was reduced to some extent. However, mola-carp polyculture is a suitable technology for rural poor can be benefited for family consumption through partial harvesting of mola and large carp as cash crop.

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