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TANK SIZE AND AQUACULTURE MANAGEMENT INFLUENCE ON THE PRODUCTION OF GOLD FISH, *CARASSIUS AURATUS* (L.), UNDER TROPICAL CONDITIONS

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Abstract

Growth performance of gold fish Carassius auratus (L.) produced in tanks of different size and treated under different management regimes were compared. Tanks of two different size and make were used (concrete; capacity: 2000 l and earthen; capacity: 59650 l) for four management regimes: (1) live zooplankton fed to fish larvae in concrete (CLF) and earthen tanks (ELF); (2) application of poultry manure in concrete (CPM) and earthen tanks (EPM); (3) application of cow manure in concrete (CCD) and earthen tanks (ECD); and (4) a control treatment for concrete (CC) and earthen tanks (EC). Fish larvae (0.10 ± 0.007 g) were cultured for 11 weeks. Weight gain of gold fish was highest in the ELF treatment. There was a significant difference in the survival of gold fish among the treatments, ranging from 64.83% in CC to 93.40% in ELF. Significantly higher values of pH and dissolved oxygen were obtained in the live food and control treatments (for both concrete and earthen tanks), compared to the manured treatments. The concentration of total alkalinity, BOD, $PO_4 - P$, $NO_3 - N$ and specific conductivity were significantly higher in EPM and ECD, compared to other treatments. The results indicate that introduction of live zooplankton into culture units resulted in higher growth of fish larvae. Better growth of cultured fish were obtained in larger earthen tanks compared to smaller concrete tanks through maintenance of superior water quality and greater abundance of plankton.

Key words: gold fish, management, tank size, water quality, plankton, fish production

INTRODUCTION

The international trade in ornamental fish provides employment opportunities for thousands of rural people in developing countries [5]. Every year, there are new advancements in breeding, transport and aquarium technology. In India, ornamental fish producers culture fish both in concrete and earthen tank units, as and when available, without giving proper importance to the culture requirements of the target species [11,18]. Generally, ornamental fish units in India are subjected to a wide range of management practices, from application of organic manure [14,17] to supplementary feeding [15,32] and supply of plankton [12,13,16,20,21] from exogenous sources.

There is a paucity of documentation on how experimental units themselves may affect production [6]. The limited literature available is difficult to be compared and interpreted because the experiments are done with different designs, fish, seasons, protocols etc [6]. Since any management applied would have a different effect on the interactions of water quality, phytoplankton and zooplankton, with respect to earthen and concrete tanks, it could lead to differences in survival and growth of fish produced in both systems [18]. In the present study, we examined the effect of differential aquaculture management on water quality, plankton abundance, growth and survival of gold fish *Carassius auratus* (L.) produced in earthen and concrete tanks.

MATERIAL AND METHOD

Twelve concrete (2.13 x 0.91 x 1.22 m; capacity: 2000 l each) and twelve earthen

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tanks (9.14 x 6.10 x 1.07 m; capacity: 59650 l each) in the Rainbow Ornamental Fish Farm of Jalpaiguri district, India were employed for the experiments. Gold fish larvae (0.10 ± 0.007 g) from the same parental stock were acclimatized for a week prior to placing them in the tanks on 3 August 2009. The fish were harvested on 19 October 2009. A layer of 10 cm of soil was placed at the bottom of each concrete tank which was then filled with 2000 l of groundwater 10 days prior to fish stocking. The outlets to the concrete tanks were constructed in such a manner that water in excess of 2000 l would automatically flow out. A plankton net bordered each outlet to prevent any plankton loss with the outflowing water. Extra groundwater was added to each earthen tank to maintain the water level as and when required.

Fish larvae were stocked in the culture tanks, and were reared for 11 weeks according to one of the four management regimes for each of the tank types:

(i) Introduction of exogenous plankton into the concrete (CLF) and earthen tanks (ELF). Live plankton was cultured in a series of plankton culture ponds where poultry manure was applied as fertilizer every 10 days at 0.26 kg/ m^3 (dry weight), as standardized in an earlier experiment [17]. For feeding the larvae, about 30 l and 1000 l of water, respectively, was transferred to each concrete and earthen tank; (ii) Direct application of poultry manure in the concrete (CPM) and earthen tanks (EPM) at a dose as mentioned above; (iii) Direct application of cow manure in the concrete (CCD) and earthen tanks (ECD) at the similar dose, as mentioned above; (iv) A control treatment for the concrete (CC) and earthen tanks (EC), where a pellet diet (Tokyu Corp., Japan), containing 32% crude protein was applied as food.

Each treatment had three replicates. The stocking density in all the tanks was 0.3 fish/ l, as optimized in an earlier experiment [15]. From the concrete tanks, 5% water was replaced with ground water every day in place of aeration [14]. There was no water exchange for the earthen tanks. The entire experimental unit was covered by a single layer of bird netting. Constant water levels were maintained in the culture tanks by supplying ground water periodically to compensate for loss due to evaporation. Approximately 30 l and 1000 l of excess water was discharged from the CLF and ELF tanks, respectively, every day during the introduction of live plankton. The manures were collected from local dairy and poultry farms, and allowed to decompose for 10 days prior to application.

Water samples were collected weekly at 9 A.M. and routine water quality parameters (pH, alkalinity, dissolved oxygen, BOD) and the concentrations of nutrients (NO_3 – N, NO_2 – N, NH_4 – N and PO_4 – P) were estimated according to methods as described in standard literature [2]. Samples of plankton were collected with plankton net made of standard bolting silk cloth (No. 21 with 77 mesh/ cm^2) two times in a week. Collected plankton samples were concentrated to 20 ml and preserved in 4% formalin. Enumerations of 1 ml of concentrated plankton were performed under a stereoscopic microscope using Sedgwick Rafter Counting Cell. The plankton were identified with the aid of literature [3,28].

The weights of the fish were recorded at the beginning and during harvest. During the process, all the fish stocked in the tanks were weighed individually to the nearest 0.001 g. The number and percent of deformed individuals were also calculated during harvest. However, for the four treatments maintained in the earthen tanks, individual data could not be recorded from each of the 17895 fish stocked in every one tank. In its place, 1000 fish were randomly selected so as to represent each unit, and data relating to weight gain and fish deformities were collected from these fishes.

Dead fish were removed daily, they were not replaced during the course of study, and differences between the number of fish stocked and the number of fish at harvest were used to calculate percent mortality in each treatment. Final survival and deformities percentage were normalized using angular transformation [25] before being subjected to further statistical analysis. The data on body weight, SGR, survival rate and fish deformities were compared using one-way analysis of variance (ANOVA) and Tukey's Honestly Significant Difference Test [36].

RESULTS AND DISCUSSIONS

The results of various water quality parameters are presented in Table 1. Compared to the manured treatments, the live-food and control treatments (for both concrete and earthen tanks) recorded significantly higher ($P < 0.05$) values of pH and dissolved oxygen (DO) (Table 1). The concentration of total alkalinity, BOD, $PO_4 - P$, $NO_3 - N$ and specific conductivity were higher ($P < 0.05$) in EPM and ECD, compared to other treatments. However, $NO_2 - N$ and $NH_4 - N$ were significantly higher ($P < 0.05$) in the manured treatments maintained in concrete tanks (CPM and CCD), than other treatments (Table 1). Overall, the live-food treatments (CLF and ELF) yielded the lowest values ($P < 0.05$) of BOD and nitrogenous compounds throughout the study period (Table 1).

Examination of plankton concentration showed considerable differences in diversity and abundance between different treatments. On an average, plankton concentration (no./ l) was highest in EPM, followed in decreasing order by ELF, ECD, CLF, CPM, CCD, EC and CC treatments ($P < 0.05$). Under any culture system, zooplankton abundance (no./ l) was significantly greater in the live-food treatments, than in the poultry manured treatments (Figure 1). Cladocerans, which formed a substantial proportion of the total plankton composition in the live food and manured units, were either absent or present in very low numbers in the control units (CC and EC, respectively). Copepoda was the dominant group in all treatments (Figure 1), except the live-food treatments (CLF and ELF), where cladocerans were more abundant. The phytoplankton concentration was significantly higher ($P < 0.05$) in the manured treatments than the live-food treatments (Figure 1).

The maximum concentration of zooplankton in the live-food units (Figure 1) could be an outcome of improved water quality, expressed in terms of lower values of BOD and $NH_4 - N$, and higher values of DO, which is conducive to fast reproduction of some of the major zooplankton [10,18], and also due to the regular supply of live plankton. Manured earthen tanks offered better environment for plankton reproduction in terms of lower $NH_4 - N$ and $NO_2 - N$ levels, compared to manured concrete tanks in the present experiment. Growth, reproduction and survival of zooplankton species are influenced by environmental factors; the most important of which are quality and availability of food, temperature and water quality of the culture medium [7,27,30,33,35].

At harvest, maximum weight gain of gold fish (Table 2) was achieved in the ELF treatment, followed in decreasing order by CLF, EPM, ECD, CPM, CCD, EC and CC treatments ($P < 0.05$). There was a significant difference ($P < 0.05$) in survival of gold fish among the treatments, ranging from 64.83% in CC to 93.40% in ELF (Table 2). The percentage of deformed gold fish was significantly higher ($P < 0.05$) in CC and EC, compared to other treatments (Table 2).

The present experiment reflects that supply of live plankton is potentially capable of supporting nearly 34% (earthen tanks) to 65% (concrete tanks) higher weight gain than that obtained in the poultry manured treatments. The cow dung treated units appeared to be even less productive and is in agreement with earlier observations [17,18]. Cyprinid larvae are known to prefer natural food items such as free living protozoa and rotifers, and larger planktonic organisms like cladocerans and copepods at fry and fingerling stage [22]. Studies on feeding behaviour and food selection of gold fish indicated a strong preference for cladocerans and negative selection of copepods and phytoplankton [13,19]. A similar manuring dose (0.26 kg/ m^3) was applied to the concrete and earthen tanks. It appears that the assimilatory capacity of earthen tanks was higher than that of concrete tanks. In earthen tank culture, a natural bio filter is offered by the ecosystem that breaks down harmful nitrogenous wastes [23]. It seems that the layer of soil that was placed in the bottom of the concrete tanks failed to replicate an authentic pond environment [18].

Table 1 Summary of major water quality parameters analyzed for the eight treatments at weekly intervals during the 11 - week growth period. Means with different letter as superscript are significantly different (P < 0.05)

Parameters	Treatments							
	CLF	CPM	CCD	CC	ELF	EPM	ECD	EC
pH	7.08±0.11[a]	6.11±0.10[cd]	5.62±0.09[de]	6.79 ± 0.15[a]	6.40±0.12[abc]	5.61±0.13[de]	5.18±0.18[e]	6.18±0.12[bcd]
Dissolved oxygen (mg / l)	7.44±0.10[a]	5.15±0.25[e]	5.80±0.26[cde]	6.76±0.15[ab]	6.40±0.25[abc]	5.11±0.15[e]	5.48±0.26[de]	6.19±0.19[bcd]
BOD (mg / l)	1.28±0.04[d]	2.35±0.15[b]	1.95±0.16[bc]	1.57±0.09[cd]	2.09±0.12[b]	3.90±0.21[a]	3.35±0.18[a]	2.34±0.12[b]
Total alkalinity (mg / l)	34.14±2.31[c]	66.24±3.96[b]	60.47±3.45[b]	40.12±2.25[c]	37.19±1.65[c]	80.18±5.17[a]	71.36±3.60[ab]	40.55±2.22[c]
PO_4 – P (mg / l)	0.132±0.019[e]	0.446±0.041[bc]	0.365±0.035[cd]	0.132±0.018[e]	0.175±0.008[e]	0.710±0.036[a]	0.578±0.040[ab]	0.195±0.025[de]
NH_4 – N (mg / l)	0.158±0.019[de]	0.675±0.044[a]	0.502±0.025[b]	0.383±0.027[bc]	0.090±0.009[e]	0.275±0.009[cd]	0.214±0.030[de]	0.240±0.025[cd]
NO_2 – N (mg / l)	0.016±0.002[c]	0.039±0.036[a]	0.032±0.025[ab]	0.014±0.004[c]	0.006±0.001[c]	0.023±0.003[bc]	0.020±0.002[bc]	0.008±0.001[c]
NO_3 – N (mg / l)	0.075±0.008[d]	0.238±0.015[b]	0.173±0.010[bc]	0.087±0.009[cd]	0.155±0.009[bcd]	0.400±0.028[a]	0.365±0.018[a]	0.160±0.010[bcd]
Specific conductivity (mmhos / cm)	0.25±0.006[d]	0.46±0.018[c]	0.43±0.021[c]	0.24±0.004[d]	0.41±0.018[c]	0.73±0.037[a]	0.50±0.042[b]	0.39±0.022[c]

Table 2 Growth performance, survival and deformities estimated in gold fish after rearing in earthen and concrete tanks under different management regimes for 11 weeks

Treatments								
	CLF	ELF	CPM	EPM	CCD	ECD	CC	EC
Harvest weight (g ± SE)	4.77±0.09[b]	5.79±0.18[a]	2.89±0.06[e]	4.36±0.05[c]	2.70±0.03[e]	3.90±0.09[d]	1.78±0.05[g]	2.18±0.14[f]
Weight gain (g ± SE)	4.67±0.09[b]	5.69±0.18[a]	2.79±0.06[e]	4.26±0.05[c]	2.60±0.03[f]	3.80±0.09[d]	1.68±0.05[h]	2.08±0.04[g]
SGR (% / day ± SE)	5.01±0.09[b]	5.27±0.18[a]	4.36±0.06[d]	4.90±0.05[bc]	4.27±0.03[d]	4.75±0.09[c]	3.74±0.05[f]	4.00±0.04[e]
Survival (%)	90.10[b]	93.40[a]	80.50[d]	84.21[c]	76.18[e]	80.11[d]	64.83[f]	77.12[e]
Deformed individuals (%)	4.46[e]	2.20[f]	7.41[d]	4.12[e]	8.16[c]	4.35[e]	18.12[a]	10.51[b]

Data in the same rows with different superscripts are significantly different (P < 0.05).

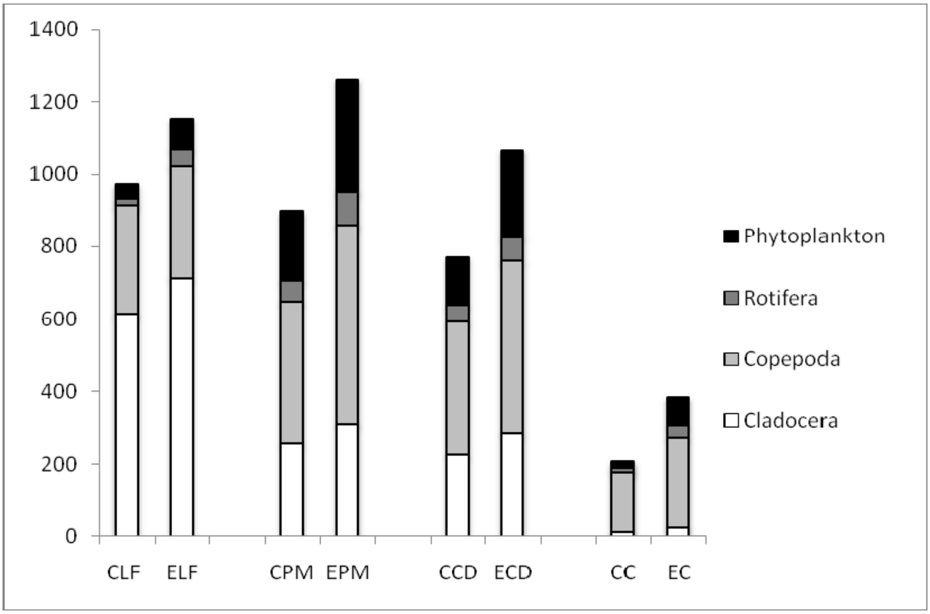

Fig. 1 Plankton abundance (no./l) in the eight treatments

The gap between the increasing sizes of industrial tanks or cages, and research units may affect the relevance of the scientific data, as this gap is believed to influence fish performance and is a matter of growing concern for aquaculture researchers [6]. Since literature on comparisons of different experimental units are rare, a possible solution to increase the industrial relevance of the data, and to minimize the effects of the scale gaps, has been to simulate fish performance from data obtained in smaller tank sizes through modeling [1,6,8]. In the present experiment, under any management regime, higher weight gain and survival rate of gold fish were observed in the earthen tanks compared to concrete tanks. The limited literature available with other fish species shows similar results. Significantly lower growth rates of channel catfish, *Ictalurus punctatus* were obtained in concrete pools compared to earthen ponds [31]. The younger fry of walleye, *Stizostedion vitreum,* are usually cultured in ponds as the growth rate is better compared to tanks [34]. Commercial production of yellow perch (*Perca flavescens*) fingerlings is carried out in ponds and concrete tank culture is not widely practiced [24]. In case of koi carp (*Cyprinus carpio*), earthen tanks appeared to be better alternative to concrete tanks for any particular management regime [18]. In contrast, better growth of tilapia (*Oreochromis niloticus*) and cachama (*Colossoma macropomu*) was reported in indoor tanks (under intensive aquaculture) compared to outdoor ponds in a 3-month experiment conducted at An Giang University, Vietnam [29]. Unfortunately, the authors did not discuss the causes of their findings thoroughly. Perhaps the results were influenced by the high protein supplementary feed and other modern management employed in the intensive culture units.

Significantly higher percentage of deformed gold fish in the control treatments could be attributed to the commercial diet applied in these units. Similar results were obtained with crucian carp, *Carassius carassius* when fed with commercial diets [26]. Nutritional deficiencies in koi carp have also been observed in control units where a pelleted feed was applied [18].

CONCLUSIONS

The results indicate that introduction of live zooplankton into culture units resulted in higher growth of fish larvae. Better growth of cultured fish were obtained in larger earthen tanks compared to smaller concrete tanks through maintenance of superior water quality and greater abundance of plankton.

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