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Evaluation of growth and water quality in pangasiid catfish (*Pangasius hypophthalmus*) monoculture and polyculture with silver carp (*Hypophthalmichthys molitrix*)

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Abstract

An experiment was carried out to evaluate the fish growth and water quality in pangasiid catfish (*Pangasius hypophthalmus* Sauvage) monoculture and polyculture with silver carp (*Hypophthalmichthys molitrix* Valenciennes) in nine (0.05 acre each) earthen ponds under three treatments each with three replications for a period of 98 days. In treatment 1 (T_1) 12000 pangasiid catfish per acre (2.47 acre = 1 ha), in treatment 2 (T_2) 6000 pangasiid catfish plus 6000 silver carp per acre and in treatment 3 (T_3) 8000 pangasiid catfish plus 4000 silver carp per acre were stocked. A commercial pelleted feed containing 28% crude protein and 6% lipid was fed to the pangasiid catfish at the rate of 8%, 6% and 4% of the body weight per day during the first month, second month and rest of the culture period, respectively. The growth of fishes was found significantly ($p<0.05$) different among the treatments. Highest growth of pangasiid catfish was found in T_2 and lowest in T_1, and in case of silver carp the growth was highest in T_3. Among the studied water quality parameters dissolved oxygen, nitrate-nitrogen, phosphate-phosphorus and phytoplankton cell density differed significantly ($p<0.05$). The dissolved oxygen was highest in T_2 and lowest in T_1. The nitrate-nitrogen, phosphate-phosphorus and phytoplankton cell density were highest in T_1 and lowest in T_2. The results suggest that polyculture of pangasiid catfish and silver carp at the ratio of 1:1 with a total density of 12000 fishes per acre is suitable for good fish growth and better water quality maintenance.

Keywords: Pangasiid catfish, Silver carp, Polyculture, Growth, Water quality

Introduction

The introduction of fast growing exotic fish species in aquaculture system has long been considered as a means of increasing production. Accordingly, the government of Bangladesh has imported several fish species from various countries in different years. Among the exotic species, pangasiid catfish *Pangasius hypophthalmus* Sauvage is extensively cultured.

In Bangladesh intensive monoculture of pangasiid catfish is mostly being practiced. In this culture system farmers stock the fish at high densities and offer large quantity of feed for getting higher profit within short time, which resulted in excessive accumulation of metabolic- and feed-wastes in the pond bottom. The decomposition of these metabolic- and feed-wastes makes the pond water nutrient rich that favour the excessive growth of phytoplankton. Since, in intensive culture system pangasiid catfish do not eat phytoplankton; they remain unutilized and subsequently deteriorate the water quality through algal die-off and create many unexpected problems, such as declined dissolved oxygen, reduced fish growth and off-flavour in fish flesh. Lovell and Sackey (1973) reported that some blue-green algae are responsible for off-flavour in fish because these algae synthesize chemical compounds such as geosmin and 2-methylisoborneol which are excreted into the water and absorbed by fish, giving them an off-flavour. Off-flavour lowers the consumer demand and market price of pangasiid catfish. As a result, pangasiid catfish farming is becoming less profitable and losing its importance in the culture sector. In this situation, if algal bloom of pangasiid catfish ponds can be managed and utilized in a positive way converting algae into fish-flesh then farmers might be benefited sustaining the pangasiid catfish farming practice.

Planktivorous silver carp *Hypophthalmichthys molitrix* Valenciennes has been reported to be stocked in aquaculture ponds to manage phytoplankton bloom in different countries (Dunseth, 1977; Pierce, 1983; Drenner *et al.*, 1987). Similarly in our country silver carp could be stocked in pangasiid catfish ponds for proper utilization of phytoplankton and maintenance of water quality. Silver carp will graze upon phytoplankton that will help to keep aquatic environment suitable for better growth of pangasiid catfish. The present study was undertaken to evaluate the fish growth and water quality in pangasiid catfish monoculture and polyculture with silver carp.

Materials and Methods

The experiment was carried out for a period of 98 days during May to August 2002 in nine (0.05 acre each) earthen ponds at on-campus research pond facilities of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The ponds were treated with lime (CaO) at the rate of 100 kg/acre ten days prior to release of fish fingerlings. The experimental fishes (pangasiid catfish: 21.19 - 22.33g; silver carp: 5.60 - 6.07g size) were bought from a local vendor and acclimatized in a pond close to the experimental ponds before start of the experiment.

In the experiment three treatments each with three replicates were evaluated following randomized complete block design (RCBD). In treatment 1 (T_1) 12000 pangasiid catfish per acre; in treatment 2 (T_2) 6000 pangasiid catfish plus 6000 silver carp per acre and in treatment 3 (T_3) 8000 pangasiid catfish plus 4000 silver carp per acre were stocked. A commercial pelleted feed (Quality Fish Feed Ltd., Bangladesh) containing 28% crude protein and 6% lipid was fed to pangasiid catfish at the rate of 8 %, 6 % and 4% of the body weight of the fishes per day during the first month, second month and rest of the culture period, respectively. The daily feed ration was divided into two halves, one half was fed in the morning (0900 to 0930 h) and the other half in the evening (1700 to 1730 h). The amount of feed for the first two weeks was based on the average weight of the fish at day zero and then adjusted biweekly based on mean weight of sampled fishes. Fish growth was evaluated using specific growth rate (SGR), daily weight gain (DWG) and percent weight gain indices. Some water quality parameters viz., surface temperature, water depth, transparency, dissolved oxygen, pH, nitrate-nitrogen (NO_3-N), phosphate-phosphorus (PO_4-P) and chlorophyll-*a* were routinely measured in the culture ponds between 9.00 - 10.00 h on each sampling day. Temperature, water depth, transparency, dissolved oxygen and pH was measured weekly using a Celsius thermometer, a graduated pole, a Secchi-disk, a portable waterproof dissolved oxygen meter (HI 9142, Hanna Instruments, Portugal) and a portable pH meter (HI 8424, Hanna Instruments, Portugal) respectively. Nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) were measured biweekly using an Odyssey DR/2500 spectrophotometer

(HACH, USA) following the procedure described in the manual. Chlorophyll-*a* and plankton composition were measured biweekly. Chlorophyll-*a* was determined by a direct reading spectrophotometer (Milton Roy Spectronic 1001 Plus, USA) after acetone extraction (Greenberg *et al.*, 1992). For identification and quantification of plankton, samples were collected by passing a known volume of pond water through 15-μm mesh sized plankton net and the concentrated samples were preserved in 5% buffered formalin. Quantitative analysis of plankton was done using a Sedgwick-Rafter counting cell (S-R cell, Graticules Ltd.). The plankton on 20 randomly selected fields of the Sedgwick-Rafter counting chamber was counted under a compound microscope. Plankton number (cells/l) was calculated according to Beveridge (1985). Taxonomic identification of plankton up to genus level was done in the laboratory using the keys described in Prescott (1962), Pontin (1978) and Bellinger (1992).
ANOVA of the fish growth and water quality data was done at $p<0.05$. When a significant difference ($p<0.05$) between treatment means was detected, a LSD test was used to compare the means (Gomez and Gomez, 1984).

Results and Discussion

Growth and survival of fishes

Growth and survival of pangasiid catfish and silver carp were calculated and compared among the treatments. The mean final weight, daily weight gain (DWG), specific growth rate (SGR), percent weight gain and survival of pangasiid catfish and silver carp in different treatments are summarized in Table 1. The mean final weight, daily weight gain, specific growth rate and percent weight gain of pangasiid catfish was significantly ($p<0.05$) higher in polyculture ponds in comparison to monoculture ponds. The highest mean final weight, daily weight gain, specific growth rate and percent weight gain of pangasiid catfish were found in polyculture ponds where pangasiid catfish and silver carp were stocked at the ratio of 1:1. The highest mean final weight, daily weight gain, specific growth rate and per cent weight gain of silver carp were found in polyculture of pangasiid catfish and silver carp stocked at the ratio of 2:1. Survival rate of both species remained high in all treatments ranging from 87 - 93% for pangasiid catfish and 90 - 92% for silver carp with no significant difference ($p>0.05$) among the treatments.

Water quality parameters

The mean (± SE) values and ranges of water quality parameters in different treatment ponds are summarized in Table 2. Surface water temperature in all treatment ponds was more or less same and ranged from 28.2 to 31.7 °C. The depth of water column and pH of water ranged from 98.66 to 133.81 cm and 6.24 to 9.57, respectively, and there was no significant ($p>0.05$) difference of these parameters among the treatments. The dissolved oxygen varied significantly ($p<0.05$) among the treatments during the experimental period. The dissolved oxygen was lowest in pangasiid catfish monoculture ponds and highest in pangasiid catfish and silver carp polyculture ponds at the ratio of 1:1. The dissolved oxygen was found to decrease in all treatments with the progress of the culture period (Fig. 1). The total alkalinity differed significantly ($p<0.05$) among the treatments. The concentrations of nitrate-nitrogen and phosphate-phosphorus varied significantly ($p<0.05$) among the treatments. With the progress of the culture period the nitrate-nitrogen and phosphate-phosphorus contents of water in the ponds were found to increase in all treatments, but the rate of increase was higher in pangasiid catfish monoculture ponds (Fig. 1).

Table 1. Growth performance (mean ± SE; n = 3) and survival (mean ± SD; n = 3) of pangasiid catfish and silver carp in ponds of different treatments during the study period of 98 days from May to August 2002

Growth indices	Species	Treatment 1	Treatment 2	Treatment 3
Initial weight (g)	Pangasiid catfish	21.25 ± 0.79	21.19 ± 0.16	22.33 ± 1.01
	Silver carp	-	5.69 ± 0.29	6.07 ± 0.10
Final weight (g)	Pangasiid catfish	446.07 ± 2.67^{b}	600.63 ± 1.57^{a}	472.03 ± 1.95^{b}
	Silver carp	-	113.50 ± 1.51	125.75 ± 1.65
DWG (g/day)	Pangasiid catfish	4.33 ± 0.03^{b}	5.91 ± 0.01^{a}	4.59 ± 0.03^{b}
	Silver carp	-	1.10 ± 0.02	1.22 ± 0.02
SGR, % (g/day)	Pangasiid catfish	3.11 ± 0.04^{b}	3.41 ± 0.01^{a}	2.12 ± 0.05^{b}
	Silver carp	-	3.07 ± 0.07	3.09 ± 0.03
Weight gain (%)	Pangasiid catfish	2004.24 ± 27.91^{b}	2734.72 ± 9.67^{a}	2023.06 ± 36.76^{b}
	Silver carp	-	1938.86 ±130.01	1972.22 ± 55.52
Survival (%)	Pangasiid catfish	92.00 ± 0.58	95.00 ± 0.58	94.00 ± 0.58
	Silver carp	-	90.00 ± 0.03	91.00 ± 0.03

Values in the same row with the same superscript are not significantly different (p>0.05)

Table 2. Water quality parameters (mean ± SE; n = 3) in ponds of different treatments. Each mean value is the mean of three replication ponds collected on fourteen sampling dates

Water quality parameters	Treatment 1	Treatment 2	Treatment 3
Temperature (°C)	30.03 ± 0.01	30.06 ± 0.02	30.04 ± 0.02
Transparency (cm)	24.76 ± 3.31^{b}	34.30 ± 3.77^{c}	28.07 ± 2.41^{ab}
Water depth (cm)	112.88 ± 2.49	117.66 ± 3.23	117.20 ± 2.05
pH	7.59 ± 0.05	7.12 ± 0.04	7.31 ± 0.06
DO (mg/l)	3.84 ± 0.09^{b}	4.95 ± 0.12^{a}	4.19 ± 0.12^{b}
Total alkalinity (mg/l)	114.30 ± 0.87	103.70 ±1.22	105.71±1.11
NO_3-N (mg/l)	1.90 ± 0.15^{a}	1.10 ± 0.06^{c}	1.64 ± 0.10^{b}
PO_4-P (mg/l)	1.50 ± 0.09^{a}	1.02 ± 0.13^{b}	1.40 ± 0.05^{a}
Chlorophyll-*a* (μg/l)	257.71 ± 38.50^{a}	167.62 ± 18.15^{b}	240.74 ± 30.73^{a}

*Figures in the same row having the same superscript are not significantly different (p>0.05)

The growth of phytoplankton increased along with the increase of nitrate-nitrogen and phosphate-phosphorus (Fig. 1). Higher growth of phytoplankton was observed in pangasiid catfish monoculture ponds where nitrate-nitrogen and phosphate-phosphorus concentration was higher, followed by the ponds of pangasiid catfish – silver carp polyculture at the ratio of 1:1 and pangasiid catfish – silver carp polyculture at the ratio of 2:1. Highest chlorophyll-*a* content and lowest Secchi transparency was found in pangasiid catfish monoculture ponds.

The sampled phytoplankton population comprised of four major groups: Cyanophyceae (11 genera), Chlorophyceae (15 genera), Bacillariophyceae (8 genera) and Euglenophyceae (3 genera). The mean values of plankton with their different groups are shown in Table 3.

Cyanophyceae was the most abundant group of phytoplankton with the mean density of 79.27 ± 13.01 x 10^3 cells/l (60.63% of total phytoplankton) in pangasiid catfish monoculture followed by pangasiid catfish – silver carp polyculture at the ratio of 2:1 (44.79% of total phytoplankton) and pangasiid catfish – silver carp polyculture at the ratio of 1:1 (34.73% of total phytoplankton), respectively. The highest mean density of Chlorophyceae was 45.34 ± 2.76 x 10^3 cells/l (37.35% of total phytoplankton) in pangasiid catfish – silver carp polyculture at the ratio of 2:1 but in case of per cent composition it was highest in pangasiid catfish – silver carp polyculture at the ratio of 1:1 (34.96 ± 4.20 x 10^3 cells/l; 41.86% of total phytoplankton). Only a few bacillariophytes and euglenophytes were observed.

Table 3. Phytoplankton population (mean ± S.E; x10^3cells/l; n = 3) in ponds of different treatments. Each mean value is the mean of three replication ponds collected on fourteen sampling dates

Phytoplankton group	Treatment 1	Treatment 2	Treatment 3
Bacillariophyceae	12.60 ± 0.60	15.14 ± 1.12	16.44 ± 0.62
Chlorophyceae	32.31 ± 3.49	34.96 ± 4.20	45.34 ± 2.76
Cyanophyceae	79.27^a ± 13.01	29.01^b ± 4.26	54.37^a ± 1.94
Euglenophyceae	6.57 ± 0.97	4.43 ± 0.98	5.25 ± 0.25
Total phytoplankton	130.75^a ± 15.21	83.66^b ± 7.57	121.44^a ± 13.92

* Figures in the same row having the same superscript are not significantly different (p>0.05).

The results of the present study clearly demonstrated that pangasiid catfish – silver carp polyculture resulted in higher pangasiid catfish growth and better water quality compared with pangasiid catfish monoculture. Similar to this, earlier studies on polyculture of channel catfish, *Ictalurus punctatus* with planktivorous fishes resulted in higher growth of channel catfish (Pretto, 1976; Dunseth and Smitherman, 1977). The higher growth of pangasiid catfish in the present study was possibly due to better water quality prevailed in those polyculture treatments. In polyculture treatments, feed requirement was less due to smaller number of pangasiid catfish as they were replaced (50% in T_2 and 33% in T_3) by silver carp which could have resulted in lower nutrients loading in water through decomposition of leftover feed and metabolic wastes. Reduced loading of nutrients could have helped in maintaining better water quality by retarding the growth of phytoplankton to form blooms. Moreover, silver carp improved the water quality conditions by grazing down the phytoplankton. Kajak *et al.* (1975) found decreased quantity of phytoplankton especially blue-green algae in the presence of silver carp. Dunseth and Smitherman (1977) found fewer algae in catfish ponds stocked with silver carp and tilapia compared to control ponds with catfish alone. Smith (1985, 1988) and Radke and Kahl (2002) reported that silver carps are effective in reducing large-sized phytoplankton biomass in aquaculture ponds. The growth of pangasiid catfish was highest in pangasiid catfish – silver carp polyculture at the ratio of 1:1 due to its own lowest stocking density as well as better water quality in terms of dissolved oxygen and phytoplankton. The growth of silver carp was found to decline with the increase of its own stocking density in pangasiid catfish – silver carp polyculture. This result agreed with Allen (1974), Refstie and Kittelsen (1976), Refstie (1977) and Vijayan and Leatherland (1988) who found decline in individual growth rate of fishes with increasing levels of stocking density. Allen (1974) found declined growth of channel catfish at densities more than 540 fish/m^3.

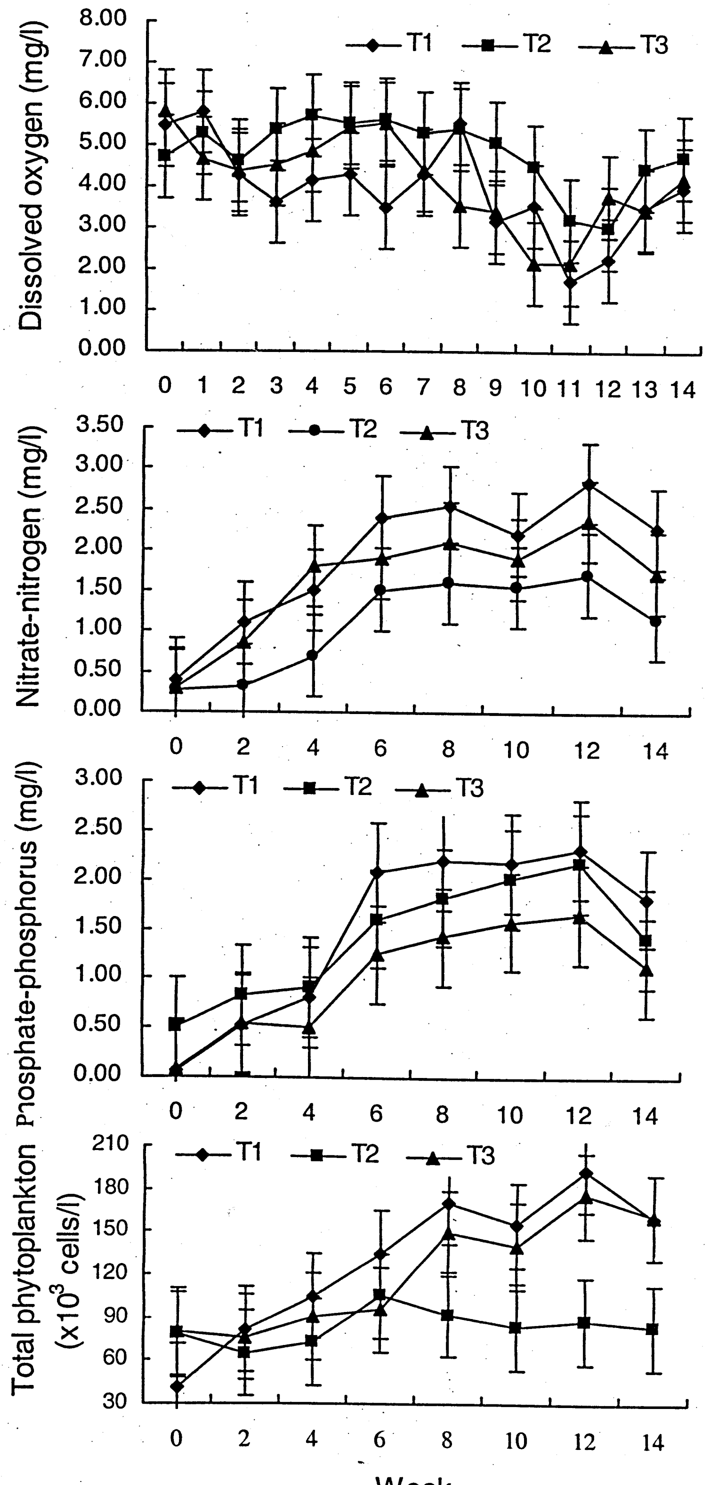

Fig. 1. Changes of dissolved oxygen, nitrate-nitrogen, phosphate-phosphorus and total phytoplankton in different treatments during the study period

In the present study, some water quality parameters differed significantly during the grow-out period with the exception of temperature and water depth. Average temperature and water depth in all treatments were almost similar and within suitable range for aquaculture production. Dissolved oxygen, nitrate-nitrogen, phosphate-phosphorus, chlorophyll-*a* and phytoplankton abundance were significantly ($p<0.05$) different among the treatments. The dissolved oxygen was lowest in pangasiid catfish monoculture ponds. This was possibly due to higher BOD and COD because fish and algal biomass as well as unused feed and metabolic wastes were high in those ponds. In general the dissolved oxygen was found to decline gradually in all treatments with the progress of the culture period. This might be due to higher consumption of dissolved oxygen in respiration of increasing fish biomass in the later end of the study. The concentrations of nitrate-nitrogen and phosphate-phosphorus were found to increase in all treatment ponds with the progress of the culture period and the rate of increase was highest in pangasiid catfish monoculture. The increase in concentrations of these nutrients was probably due to the gradual deposition and subsequent decomposition of unused portion of feed and fish excrements. Cole and Boyd (1986) found increased average nitrite-nitrogen with the increased feeding rate in aquaculture ponds. Boyd (1982) reported that uneaten food supplied more nutrients to algae in channel catfish ponds, because catfish assimilate up to 40% of the nitrogen and 65% of the phosphorus that they consume.

The phytoplankton abundance was found significantly different ($p<0.05$) among the treatments, the highest in pangasiid catfish monoculture ponds and the lowest in pangasiid catfish - silver carp polyculture at the ratio of 1:1. The daily feed loading was higher in pangasiid catfish monoculture ponds than in pangasiid catfish - silver carp polyculture due to higher number of pangasiid catfish in the former. Due to this reason metabolic wastes along with feed wastes were higher in pangasiid catfish monoculture, which could have supplied more nutrients (NO_3-N and PO_4-P) to algae that might have favoured higher algal growth. Boyd (1973, 1985) reported that pond, which receives applications of fish feed, have abundant phytoplankton growth because roughly 75 percent of the nutrients in feed eventually reach the water in excretory products.

The findings of the present study suggest that polyculture of pangasiid catfish and silver carp at the ratio of 1:1 with a total density of 12000 fishes per acre is suitable for good fish growth and better water quality maintenance. However, the situation may vary with the local environmental conditions. Further study with other planktivorous carps at different stocking ratios and densities in different environmental situations is suggested to get comprehensive results.

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References

Allen, K.O. 1974. Effects of stocking density and water exchange rate on growth and survival of channel catfish *Ictalurus punctatus* in circular tanks. *Aquaculture*, 4: 29-39.

Bellinger, E.G., 1992. *A Key to Common Algae: Freshwater, Estuarine and some Coastal Species*. 4th ed. The Institution of Water and Environmental Management, London, 138 pp.

Beveridge, M.C.M. 1985. Methods of biological analysis. *In* H.P. Stirling, ed. *Chemical and Biological Methods of Water Analysis for Aquaculturists*, p.106-114. Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA, Scotland.

Boyd, C.E. 1973. The chemical oxygen demand of waters and biological materials from ponds. *Trans. Am. Fish. Soc.*, 102: 606-611.

Boyd, C.E. 1982. *Water quality management for pond fish culture*. Elsevier, New York, 318 pp.

Boyd, C.E. 1985. Chemical budgets for channel catfish ponds. *Trans. Am. Fish. Soc.*, 114: 291-298.

Cole, B.A. and Boyd, C.E. 1986. Feeding rates, water quality and channel catfish production in ponds. *Prog. Fish-Cult.*, 48: 25-29.

Drenner, R.W., Hambright, K.D., Vinyard, G.L., Gophen, M. and Pollingher, U. 1987. Experimental study of size-selective phytoplankton grazing by a filter-feeding cichlid and the cichlid's effects on plankton community structure. *Limnol. Oceanogr.*, 32: 1138-1144.

Dunseth, D.R. 1977. Polyculture of channel catfish, *Ictalurus punctatus,* silver carp, *Hypophthalmichthys molitrix*, and three all-male tilapias, *Sarotherodon* sp. Ph.D. Dissertation, Auburn University, Auburn, Alabama. 62 pp.

Dunseth, D. and Smitherman, R.O. 1977. Pond culture of catfish, tilapia and silver carp. Auburn Univ. Agr. Sta., Alabama. *Highlights Agril. Res.*, 24 (3): 4.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research.* 2nd ed. John Wiley & Sons, New York, 680 pp.

Greenberg, A.E., Clesceri, L.S. and Eaton, A.D. (eds.). 1992. *Standard methods for the examination of water and wastewater.* American Public Health Association, American Water Works Association and Water Pollution Control Federation. 18th ed. Washington D.C, USA. 1268 pp.

Kajak, Z., Rybak, J.I., Spodniewska, I. and Godlewska-Lipowa, W.A. 1975. Influence of the planktivorous fish *Hypophthalmichthys molitrix* (Val.) on the plankton and benthos of the eutrophic lake. *Pol. Arch. Hydrobiol*, 22: 301-310.

Lovell, R.T. and Sackey, L.A. 1973. Absorption by channel catfish of earthy-musty flavour compounds synthesized by cultures of blue-green algae. *Trans. Am. Fish. Soc.,* 102: 774-777.

Pierce, B.A. 1983. Biotic effects of grazing by tilapia (*Oreochromis aurea*) on phytoplankton populations in solar silos. *J. Freshwat. Ecol.*, 2: 293-304.

Pontin, R.M. 1978. *A Key to British Freshwater Planktonic Rotifera.* Freshwater Biological Association Scientific Publication No. 38, Titus Wilson & Son Ltd., Kendal, England, 178 pp.

Prescott, H.G. 1962. *Algae of the Western Great Lakes Area*. Wm. C. Brown Co. Inc. Dubuque. Iowa, 977 pp.

Pretto, R. 1976. Polyculture systems with channel catfish as the principal species. Ph.D. Dissertation, Auburn University, Alabama, 190 pp.

Radke, R.J. and Kahl, U. 2002. Effects of a filter-feeding fish [silver carp, *Hypophthalmichthys molitrix* (Val.)] on phyto- and zooplankton in a mesotrophic reservoir: results from an enclosure experiment. *Freshwat. Biol.*, 47: 2337-2344.

Refstie, T. 1977. Effect of density on growth and survival of rainbow trout. *Aquaculture*, 11: 329-334.

Refstie, T. and Kittelsen, A. 1976. Effects of density on growth and survival of artificially reared Atlantic salmon. *Aquaculture*, 8: 319-326.

Smith, D.W. 1985. Biological control of excessive phytoplankton growth and the enhancement of aquacultural production. *Can. J. Fish. Aquat. Sci.*, 42: 1940-1945.

Smith, D.W. 1988. Phytoplankton and catfish culture: a review. *Aquaculture*, 74: 167-189.

Vijayan, M.M. and Leatherland, J.F. 1988. Effects of stocking density on the growth and stress-response in Brook Charr, *Salvelinus fontinalis. Aquaculture*, 75: 159-170.