academicJournals

Vol. 5(11), pp. 278-285, November, 2013
DOI: 10.5897/IJFA2013.0374
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/IJFA

International Journal of Fisheries and Aquaculture

Full Length Research Paper

Effect of varying stocking density of bottom feeder fish *Cirrhinus mrigala* and *Cyprinus carpio* on growth performance and fish yield in polyculture system

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Accepted 18 November, 2013

The present project was planned to study gradual replacement of *Cirrhinus mrigala* with *Cyprinus carpio* and its impact on pond ecosystem. A total of 900 fishes belonging to six species viz. *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Ctenopharyngodon idella*, *Hypophythylmichthys molitrix* and *Cyprinus carpio* were stocked in four earthen ponds. The dimensions of each pond were 220 × 198 × 7 feet length, breadth and depth. The stocking density in pond 1 (T1) was *C. catla* 150, *L. rohita* 200, *C. mrigala* 200, *C. idella* 150, *H. molitrix* 150 and *C. carpio* 50. The stocking density of *C. mrigala* and *C. carpio* in pond 2 (T2) was 150 and 100, in pond 3 (T3), 100 and 150 and in pond 4 (T4) it was 50 and 200, respectively while the stocking density of all the other four fish species remained constant in all the four ponds. All the fish were fed with a diet of 25.16% crude protein at 2% body weight. *C. idella* and *C. mrigala* showed maximum growth in T1, *C. catla* and *H. molitrix* in T2, *L. rohita* and *C. carpio* in T3. Maximum growth was observed in T3 followed by T4, T1 and T2. Among fish species *C. idella* and *C. carpio* showed higher growth rates than the rest of fish species. Our results reveal that in polyculture system stocking density of *C. mrigala* and *C. carpio* in a ratio of 1: 1.5 gives better results.

Key words: Aquaculture, freshwater, phytoplankton, zooplankton, exotic fish.

INTRODUCTION

One of the major issues of serious concern which directly influences human life is the availability of quality protein. Human population is increasing day by day and the situation puts more pressure on the existing resources for food supply. The problem can be resolved by using fish as a quality protein supplement in human diet (Sheikh and Sheikh, 2004). With the increase in fish demand trend, measures have developed to culture fish more intensively to enhance the present level of fish production (Hussein, 2012). The productivity of the aquatic system is thus increased by more efficiently utilizing ecological resources within the environment. Stocking two or more complimentary fish species can increase the maximum standing crop of a pond by allowing a wide range of available food items and the pond volume to be utilized (Hassan, 2011). Aquaculture is working as economic stimulant and has a great potential to be a major-income generating component, poverty alleviation and employment generation ultimately leading to sustainable rural pond fish farming (Sheikh and Sheikh, 2004). Aquaculture provides almost 50% of the total inland fish production. During the last two decades,

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Table 1. Stocking ratios of six fish species in treatment ponds.

Fish species	T1	T2	T3	T4
Labeo rohita	200	200	200	200
Ctenophyarngodon idella	150	150	150	150
Cyprinus carpio	50	100	150	200
Hypopthalmichthys molitrix	150	150	150	150
Catla catla	150	150	150	150
Cirrhinus mrigala	200	150	100	50
Total	**900**	**900**	**900**	**900**

inland freshwater aquaculture production grew more than 10% annually, relying mainly on polyculture of native and exotic carp species in ponds (DOF, 2005). In Asia, carp culture grew on 12% annually during the last two decades (Dey et al., 2005). Carp contribute more than 70% of the inland aquaculture production in Asia and the world and considered as the major provider of fish protein through aquaculture (Acosta and Gupta, 2005). *Cyprinus carpio* is extensively cultured all over the world due to its fast growth, omnivorous feeding nature and tolerance to wide water quality and temperature ranges. It can feed in any part of fish pond (Jain, 2002). *C.carpio* enhanced aerobic decomposition of organic matter at the pond bottom and suspended bottom nutrients into the water column, there by stimulating natural food production. However, not only increased food availability but also changes in behavior of rohu when common carp is introduced in the pond might have affected rohu's feeding behavior and food intake (Takamura et al., 1993; Anras et al., 2001). Polyculture of compatible fish species is the most favored fish culture practice because this facilitates efficient utilization of all ecological zones within pond environment enhancing the maximum standing crop (Lutz, 2003). In some cases, one species enhances the food availability for other species and thus increases the total fish yield per unit area (Miah et al., 1993; Azad et al., 2004). Selection of species plays an important role for any culture practices. For efficient utilization of different strata and zones of a pond, three or more species need to be stocked. In current fish culture set up three Indian carps *Catla catla, Labeo rohita*, *Cirrhinus mrigala* and two Chinese carps, silver and grass carp are considered the best combination (Chakrabarti, 1998; Rahman et al., 2006).

Currently farming depends mainly on the application of organic fertilizers and to some extent on inorganic fertilizers. Fertilization increases the productivity of phytoplankton in breeding and storage ponds (New and Fedoruk, 2003; Bhakta et al., 2004, 2006). Because composite diets are not available and the farmers often use fertilizers (compost or animal droppings) or inorganic fertilizers with cheap feed. Current farming practices depending on regular input of organic and inorganic fertilizers. The recycling of these organic wastes and proper exposure to light for their inclusion phytoplankton is very important for their legitimate use. Fertilizers are often used, cow manure (Ansa and Jiya, 2002; Terziyski et al., 2007). Time and dosage of organic manuring significantly affect the ecological processes of pond ecosystem. It encourages the organic loading and anaerobic conditions, which reduces the heterotrophic activities. Nitrogen microbial destabilization declines gradually with the passage of time and increases with the manuring rate. Common carp is more responsive to feed supplied as it is a bottom feeder. Naturally pond primary productivity (zooplankton) in earthen pond enhances the fish production with increase the growth rate of carp species by using the fertilizer (Jha et al., 2006). Utilization of homestead organic waste, in carp polyculture proves to be the harmless for physico-chemical properties of water. *Cirrhinu mrigala* and *C. carpio* responded best in manured ponds with homestead organic wastes while *Ctenopharyngodon idellus* did not show any marked response (Parvez et al., 2006). In the present study native and exotic fish species were cultured in polyculture system and the effect of replacement of native fish species *C. mrigala* with exotic fish species *C. carpio* is observed.

MATERIALS AND METHODS

The present study was conducted in earthen fish ponds at Department of Fisheries and Aquaculture, University of Veterinary and Animal Sciences, Ravi campus. Four ponds were chosen for the task that were drained, dried, disinfected by liming and well prepared before the start of research trial. A total of 900 fishes belonging to six fish species were stocked in different stocking combinations and *C. mrigala* were gradually replaced by *C. carpio* as both are bottom feeder (Table 1). All four ponds were considered as four treatments and were labeled as T1, T2, T3 and T4. Before filling water, ponds were manured at 1000 kg manure per acre. Inorganic fertilizers that is, nitrophos, ammonium sulfate, urea, diammonium phosphate and single super phosphate were added to all the four ponds in equal quantity. Fish were fed twice a day with a diet of 25.16% crude protein at 2% body weight. The fish samples were weighed and measured at the time of stocking; and thereafter every fortnight ten fish samples of each species were captured through drag. They were weighed and measured and released back in their respective ponds. Water quality parameters viz. dissolved oxygen and water temperature was taken by using DO meter

Table 2. ANOVA of different treatments.

Treatment	Body weight (Mean ±S.E)	Body length (Mean ±S.E)
3	416.88±18.892[a]	32.27±0.634[a]
4	410.07±18.828[a]	32.05±0.650[a]
1	391.02±19.235[a]	31.20±0.560[a]
2	341.49±19.269[b]	29.47±0.650[b]

Mean with same Superscript letter are not significantly different at p≤0.05.

(YSI 55 Incorporated, Yellow Springs, Ohio, 4387, USA), pH by pH meter (LT-Lutron pH-207 Taiwan) while electrical conductivity, salinity and total dissolved solids were taken through electrical conductivity meter (Condi 330i WTW 82362 Weilheim Germany) on daily basis. The obtained data statistics was analyzed by using SAS 9.1 version statistical packages (Table 2).

RESULTS

Fortnightly increase in body weight and length of fish in all the four treatment ponds is given in Table 3. *Catla catla, Ctenopharyngodon idella, C. carpio, Labeo rohita, C. mrigala* and *Hypophthalmichthys molitrix* attained significantly higher body weights and fish length in treatment IV ponds while the same was minimum for all the fish species in treatment 1 which clearly indicates that replacement of *C. mrigala* with *C. carpio* has effective role in growth of all the cultured fish species in poly-culture system. Statistically significant variations in weight gain and increase in fish length was observed for *C. catla* in all the four treatments. Non-significant variations in weight gain and increase in fish length was observed between *C. idella*, *C. carpio*, *C. mrigala* and *H. molitrix* while significantly lower weight gain was recorded in *C. catla* and *L. rohita* (Table 4).

In treatment 1 pond higher SGR 0.552% was observed in *H. molitrix* and lower 0.238 in *C. carpio*. Similarly, in T2 pond maximum SGR 0.703% was observed in *H. molitrix* and minimum 0.260% in *C. idella*. Maximum SGR 0.409% was observed in *H. molitrix* in on T3 pond while it was minimum 0.153 in *C. mrigala*. In T4 pond maximum SGR 0.322% was observed in *L. rohita* while it was minimum 0.139 in C*. idella* (Table 5).

During present study major water quality parameters remained in the favorable range for fish culture, average value of temperature remained in the range 27.08 to 28.66°C, salinity 0.86 to 0.99 ppt, DO 5.15 to 5.91 mg/L, EC ranges from 2.23 to 2.32 Ms/cm and pH ranges from 8.04 to 8.23 were observed within the optimum range throughout the experiment. Statistically significant variations in nitrate content of water were observed in T1 and T4 ponds while non-significant differences for nitrates were recorded in T2 and T3 ponds. Similarly, phosphates in water showed significant differences in T1 as compared to T3 and T4 ponds while T2, T3 and T4 showed non-significant differences for phosphates. Light penetration varied significantly between T1, T2 and T4 ponds and its values varied from minimum 18.17±0.946 cm in T4 to maximum 25.50±1.057 cm in T1 ponds.

DISCUSSION

Among bottom feeders, *C. carpio* grows better than *C. mrigala* probably due to their superior feed utilizing capability (Sinha and Saha 1998). Moreover, faster growth rate of bottom dwellers is attributed to effective utilization of ecological niches and rich detritus food web that is maintained through periodic manuring, liming and fertilization (Mohanty, 1995). These findings are in line with Milstein et al. (2002) who reported that farmers prefer to stock *C. carpio* as a bottom feeder instead of *C. mrigala* because *C. carpio* grows faster than *C. mrigala* and the overall production is higher when combined with *L. rohita* and *C. catla* in poly-culture ponds.

In the present study, *C. catla* showed maximum weight gain in treatment 2 (T2) ponds, *C. idella* showed maximum weight gain in treatment T1, *H. molitrix* showed maximum weight gain in T2 ponds, *C. carpio* showed maximum weight gain in T3, *C. mrigala* showed maximum weight gain in T1, but amongst all the fish species *H. molitrix* showed maximum weight gain. According to Sumaira et al. (2010) *C. catla* showed maximum growth followed by *L. rohita* in decreasing order while *C. carpio* showed the lowest body weight in poly-culture system.

In the present study, *L. rohita* showed maximum weight gain in the presence of *C. carpio* in T3 ponds. Wahab et al. (2002) reported a 1.6 times higher *L. rohita* yield in the presence of *C. carpio* while Rahman et al. (2006) reported that *L. rohita* and total production of pond increased almost twice in the presence of *C. carpio*, as bottom dwelling fish.

Many abiotic and biotic components of aquatic ecosystem directly and indirectly influence water quality. Measurements of these components also reflect the dynamics of the living organisms such as metabolic and physiological behavior of aquatic ecosystems. pH, temperature and dissolved oxygen have great influence on fish growth (Ali et al., 2000; Ahmad et al., 2008; Noor et al., 2010). In the present study major water quality parameters remained in the favorable range for

Table 3. Fortnightly increase in body weight and fish length in all the four treatment ponds.

Species	Treatment 1		Treatment II		Treatment III		Treatment IV	
	Weight gain (g) (Mean ±S.E)	Length (cm) (Mean ±S.E)	Weight gain (g) (Mean ±S.E)	Length (cm) (Mean ±S.E)	Weight gain (g) (Mean ±S.E)	Length (cm) (Mean ±S.E)	Weight gain (g) (Mean ±S.E)	Length (cm) (Mean ±S.E)
C. catla	241.68±16.050[d]	25.66±0.680[c]	295.22±6.564 [c]	27.82±0.236[bc]	357.58±20.283[b]	29.79±0.590[b]	453.82±23.931[a]	32.96±1.252[a]
C. idella	349.63±27.000[c]	29.45±1.731[b]	439.52±26.009[b]	34.13±0.655[a]	459.82±20.217[b]	34.34±0.802 [a]	553.85±17.138[a]	36.19±0.712[a]
C. carpio	327.33±23.280[c]	28.32±1.041[b]	414.12±25.146[b]	31.76±0.607[a]	466.70±24.165[b]	32.16±0.573 [a]	554.17±21.336[a]	34.08±0.766[a]
L. rohita	200.28±12.288[d]	25.53±0.540[d]	248.85±3.037[c]	27.40±0.219[c]	294.47±10.092[b]	28.83±0.296[b]	354.42±17.515[a]	30.68±0.429[a]
C.mrigala	309.78±28.145[c]	29.09±1.305[c]	387.37±15.670[b]	32.30±0.769[b]	431.58±14.284[b]	33.59±0.664[b]	501.02±16.277[a]	36.25±0.534[a]
H.molitrix	241.03±21.883[d]	26.40±1.392[c]	387.73±37.978[c]	31.64±1.296[b]	489.93±21.075[b]	34.27±0.860[ab]	596.85±30.605[a]	37.20±0.406[a]

Means with similar letters in a row are statistically non-significant.

fish culture. Average temperature ranged between 27.08 to 28.66°C, salinity from 0.86 to 0.99 ppt, DO 5.15 to 5.91 mg/L, EC from 2.23 to 2.32 Msm/cm and pH from 8.04 to 8.23. All these parameters remained within optimum range throughout the experiment. Ghazala et al. (2011) observed variations in water temperatures from 29.66 to 30.0°C, pH from 8.32 to 8.55, dissolved oxygen 6.31 to 6.60 mg/L which are close to the values recorded during present study. The findings of present work are quite in line with those of Abbas (2010). Chandra et al. (2005) observed in their studies that variations in fish growth depended on electrical conductivity, pH, and total alkalinity and phosphorus contents of rearing water. Growth performance of fish was not limited by any of water quality parameters during present study. Statistically significant variations in nitrate content of water were observed in T1 and T4 ponds while non-significant differences for nitrates were recorded in T2 and T3 ponds. Similarly, phosphates in water showed significant differences in T1 as compared to T3 and T4 ponds while T2, T3 and T4 showed non-significant differences for phosphates. Light penetration varied significantly between T1, T2 and T4 ponds and its values varied from minimum 18.17±0.946 cm in T4 to maximum 25.50±1.057 cm in T1 ponds (Table 6). Similar, results were obtained by Hussein (2009). The values of physico-chemical characteristics of water ponds during the experimental period were within the acceptable limits for carps as indicated by Miranda-filho et al. (1996).

In Table 7, maximum weight gain (548.3 g) was observed in *H. molitrix* while the same was recorded minimum (133 g) for *L. rohita*. Average initial weight was highest (278.5) for *C. idella* and lowest (166.5 g) for *H. molitrix* while average final weight was highest that is, 714.8 g for *H. molitrix* and lowest that is, 308.5 g was recorded for *L. rohita* in treatment 2 ponds. Kang'ombe et al. (2006) verified that poultry manure mainly donates nitrogen and phosphates to pond water which boosts pond productivity (natural food of fish) which in turn enhances the weight increment in fish. According to Hussain et al. (2011) decrease in water temperature also reduces fish growth. Garg and Bhatnagar (2000) reported in their investigative work that phosphorus is a key metabolic nutrient in fish ponds which promotes planktonic production. However, decline in dissolved oxygen can be expected during night due to eutrophication and consumption oxygen by phytoplankton in the absence of light if excessive doses of organic manure are used (Chandra et al., 2005).

In pond water the most important natural food materials are phytoplankton, zooplankton, benthic macro-invertebrates and detritus and phytoplankton. Zooplanktons are the first link in food chain within pond water and are the indicators of production level in ponds. Fish ponds with a high Plankton abundance characterized as highly eutrophic systems, primary productivity and promote the growth of fish in polyculture system. Fertilization increases primary productivity with careful management and a continuous and controlled addition of inorganic and organic fertilizers to produce autotrophic organisms. Organic fertilizers act as an energy source for bacterial growth, but the aerobic decomposition of organic matter by bacteria was an important drain of oxygen supplies in ponds (Boyd, 1982). During present study Chlorophytes were the dominant phytoplankton group followed by the Cianophytes and Bacillariophytes. Same was observed by Ponce Palafox (2010). *C. carpio* density affects

Table 4. Body Weight (Mean ±S.E) and Body Length (Mean ±S.E)

Species	Body weight (Mean ±S.E)	Body length (Mean ±S.E)
C. idella	450.70±18.533[a]	33.53±0.720[a]
C. carpio	440.58±20.370[a]	31.58±0.562[a]
C. mrigala	407.44±17.072[a]	32.81±0.673[a]
L. rohita	274.50±13.103[c]	28.11±0.434[b]
H. molitrix	428.89±30.473[a]	32.38±0.966[a]
Catla catla	337.07±18.452[b]	29.06±0.667[b]

Means with similar letters in a column are statistically non-significant.

Table 5. Percent Specific growth rate (%SGR) in all the six fish species from 1st April 2012 to June 30, 2012.

SGR	*C. catla*	*C. idella*	*L. rohita*	*H. molitrix*	*C. carpio*	*C. mrigala*
T1	0.369	0.292	0.279	0.552	0.238	0.380
T2	0.493	0.260	0.272	0.703	0.343	0.323
T3	0.316	0.228	0.409	0.459	0.325	0.153
T4	0.273	0.139	0.322	0.284	0.238	0.216

Table 6. Physic-chemical parameters of 4 treatments (Mean ±S.E).

Variable	Treatment 1	Treatment 2	Treatment 3	Treatment 4
	(Mean±S.E)	(Mean±S.E)	(Mean±S.E)	(Mean±S.E)
DO (mgL^{-1})	5.15±0.166[b]	5.73±0.163[a]	5.87±0.227[a]	5.91±0.086[a]
EC ($mScm^{-1}$)	2.23±0.0194[b]	2.32±0.018[a]	2.26±0.014[b]	2.29±0.017[ab]
pH	8.17±0.050[a]	8.10±0.100[a]	8.23±0.087[a]	8.04±0.031[a]
Salinity (PPT)	0.99±0.088[a]	0.86±0.006[a]	0.89±0.014[a]	0.88±0.019[a]
Temp. (ºC)	27.08±0.306[b]	28.42±0.404[a]	28.54±0.391[a]	28.66±0.125[a]
TDS (mgL^{-1})	1019.64±6.521[a]	1187.43±141.806[a]	1121.88±50.352[a]	1170.31±19.420[a]
Nitrate (mgL^{-1})	16.67±3.333[b]	21.67±4.773[ab]	23.33±4.943[ab]	35.00±5.627[a]
Phosphate (mgL^{-1})	1.83±0.307[b]	3.33±0.494[ab]	2.67±0.333[a]	3.83±0.477[a]
Light penetration (cm)	25.50±1.057[a]	21.67±1.429[b]	20.50±0.428[bc]	18.17±0.946[c]

Means with similar letters in a column are statistically non-significant.

Table 7. Weight gain of different species in 4 treatment ponds.

Parameter	*C. cattla*	*C. idella*	*L .rohita*	*H. molitrix*	*C. carpio*	*C. idella*
T1	243	253	167.5	407.2	235.5	297.5
T2	319	199.2	133	548.3	254.1	212.3
T3	251.4	223	232.5	400.4	285	145
T4	182.4	148.4	163.6	250.9	238	186.1

plankton and benthic macro-invertebrate availability in pond water. In poly-culture system fish species combinations, fish stocking density ratio and nutrient input quality and quantity are the management factors that predisposed the amounts of these natural foods in ponds (Milstein, 1992). The feeding behavior of fish has a significant influence on natural food quantity. In present study, results show that *C. carpio* presence increased phytoplankton and zooplankton. *C. carpio* enhances the production of phytoplankton and zooplankton by grazing or indirectly by nutrient re-suspension, to a large extent water column control phytoplankton and zooplankton biomass. Positive effects were observed in ponds stocked with *C. carpio* in excess numbers (200). But higher *C. carpio* density reduces light penetration in water due to which photosynthesis reduced which in turn reduce phytoplankton and zooplankton production it is all due to more sediment particles in the water column by *C. carpio* (Roberts et al., 1995; Parkos III et al., 2003). Present study revealed that *C. carpio* density above 150 individuals in poly-culture system with other five major carps mainly affected the phosphorus accessibility for primary production. But increasing the stocking density more than 200 *C. carpio* had a negative effect on fish production, pond dynamics and plankton availability. Artificial feed has two main functions in aquaculture especially in semi-intensive systems first it is directly eaten by fish and second it supplies nutrients to the ambient environment enhancing primary productivity and natural food availability. The major portion of artificial feed is lost as uneaten feed and feces (Daniels and Boyd, 1989; Siddiqui and Al-Harbi, 1999). Lost artificial feed in the aquatic system has pronounced effect on water quality through decomposition (Horner et al., 1987; Poxton and Allouse, 1987; Poxton and Lloyd, 1989). Starch and proteins present in feed have a decomposition rate of about 0.8 day^{-1} (van Keulen and Seligman, 1987) providing nitrogenous and phosphorus compounds but the same is also responsible for greater CO_2 concentration and lowering dissolved oxygen (DO) concentration.

C. carpio density also influences nutrient accumulation, its presence in pond just about double the nitrogen and phosphorus withholding efficiency in fish biomass due to which smaller amount of nutrients accumulated in the sediment and more nutrients pass through the pond's food web. Nitrogen and phosphorus accumulation were reduced in the sediment by 17-22% and 34-36%, respectively in the presence of *C. carpio* (Rahman, 2006). During present study it was observed that all the six fish species viz. *C. catla, C. idella, C. carpio, L. rohita, C. mrigala* and *H. molitrix* attained significantly higher body weights and fish length in treatment IV ponds in which the *C. mrigala* was replaced by *C. carpio*. A higher percentage of the input nutrients ended up in plankton and detritus.

Benthivorous fishes play a vital role in productivity a large number of benthivorous fish species are cultured including *C. carpio* (Spataru and Saha 1980; Hepher and Pruginin, 1981; Spataru et al., 1983), *C. mrigal* (Milstein et al., 2002), *Labeo calbasu* (Milstein et al., 2003), and white bream *Blicca bjoerkna* (Lammens, 1984; Rask, 1989). Most of fish species are specialized to feed on benthic organisms and have a great affect on the abundances of phytoplankton, zooplankton, water transparency, nutrient cycling, macrophyte, and benthic macroinvertebrate (Northcote, 1988). Chironomid larvae one of the important benthic food sources chironomid larvae dwell from a few millimeters to several centimeters deep in the sediment this depending on their size, species and sediment type, (Winkel, 1987). Due to their dwelling habits specialized techniques requires separating Chironomids from the sediments for their predation (Hyslop, 1982; Robotham, 1982; Sibbing, 1988). Benthivorous fishes enhance oxygen availability in the sediment and cause re-suspension of bottom particles by digging and sieving of sediments which has a large impact on the abiotic and biotic properties of the overlying water column of the pond.

C. carpio affected nutrient concentrations in the water column four different densities of *C. carpio* were added to ponds stocked with other five fish species. Water quality parameters changed with addition of *C. carpio* although in all treatments water quality remained favorable for fish growth. The highest total nitrogen and total phosphorus concentrations were observed in treatments 4 with 200 *C. carpio* followed by treatments 3 with 150 and 50 *C. carpio*. This effect was more pronounced when artificial feed was given. We concluded that the key factors controlling nutrient concentrations in the water column included *C. carpio* presence, *C. carpio* density, and nutrient availability in the sediment resulting from nutrient input. Obviously, these factors are interrelated because the effects of *C. carpio* on nutrients availability in the water column were influenced by artificial feed and *C. carpio* density. Among these three factors, presence of *C. carpio* can be considered as the most important factor and relatively independent because *C. carpio* had significant effects on nutrients availability in the water column in fed ponds, even in both higher and lower *C. carpio* density. Higher sediment nutrients (fed ponds) helped only to increase the effect of *C. carpio*. The effects of *C. carpio* on increase of nutrient availability at the water column have been well documented by many authors (Rahman, 2006; Milstein et al., 2002).

In the present study, the effects of sediment nutrients on nutrients concentration in the water column were greatly dependent on *C. carpio* presence. The effects of *C. carpio* density on nutrients concentrations in the water column were only pronounced in presence higher nutrients in the sediment. These mean, the effects of *C. carpio* density and nutrients availability in the sediment on the nutrients concentration in the water column were very depend on another factor. On the other hand, the effects of *C. carpio* on nutrients availability in the water column are relatively independent. However, if consider the effects of *C. carpio* biomass on the effects of nutrients concentration in the water column, the present result in a way contradictory with Parkos III et al. (2003). They observed higher total phosphorous concentration in presence of higher *C. carpio* biomass in enclosure experiment without adding additional nutrients inputs. The most credible reasons of contradiction are: difference in nutrient input (feed and fertilizer *vs.* no addition input), difference in experimental system (pond *vs* enclosures) and difference in culture system (polyculture *vs.* monoculture).

For present study a combination of planktivorous and benthic feeding fish species were used as experimental animals. These include *C. mrigala,* local fish species of Pakistan and *C. carpio,* exotic fish species. Both the species are amongst the important commercial aquaculture fish species. Moreover, *C. carpio* is found in almost all the countries of the world, and now prefer common carp above any other benthivorous species due to its fast growth. In the experiment it was determined that *Cyprinus carpio* affects nutrient dynamics. During the study period, common carp predisposed water quality and nutrient dynamics, changed phytoplankton biomass and composition and decreased submerged macrophyte biomass independently of sediment access, indicating that nutrient excretion was the primary mechanism for the carp effects. With the increased concentration of suspended solids Secchi depth decreased when carp access to the sediments was allowed, suggesting that bioturbation by carp influenced water transparency. Increase in phytoplankton (dominated by cyanobateria) and suspended solids resulted in reduced submerged macrophyte biomass through reduction of light availability. Zooplankton, numerically dominated by rotifers, increased in ponds with higher carp density. In addition, benthic macro invertebrates decreased in carp enclosures, regardless of the presence and absence of the netting. Because direct predation effects were not evident, carp probably affected benthic macro invertebrates through reduction of submerged macrophytes. These results indicate that carp can have dramatic direct and indirect impacts on nutrient dynamics and littoral community structure through excretion and bioturbation. Ecosystem engineering by carp may therefore trigger a shift from a clear water state dominated by submerged macrophytes to a turbid water state dominated by phytoplankton.

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