Pak. J. Agri. Sci., Vol. 48(4), 321-326; 2011
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

COMPARATIVE STUDY OF REPLACEMENT OF MAIZE GLUTEN WITH RICE BRAN (3:1 AND 1:3) FEED SUPPLEMENT: EFFECT ON FISH GROWTH IN COMPOSITE CULTURE

Majid Hussain[1,*], Syed Makhdoom Hussain[2], Muhammad Afzal[1], Syed Aoun Raza[3], Nasir Hussain[1] and Muhammad Samee Mubarik[1]

[1]Department of Zoology & Fisheries, University of Agriculture, Faisalabad, Pakistan; [2]Department of Wildlife and Fisheries, Government College University, Faisalabad, Pakistan; [3]Fish Biodiversity Hatchery, Chashma, Mianwali, Department of Fisheries, Pakistan
[*]Corresponding author's e.mail: chmajidhussain@hotmail.com

The experiment was conducted to examine the effect of mixed feeding schedule with varying dietary protein levels on the growth performance of fishes in composite culture, using two earthen ponds. Both the ponds were stocked with 100 *Labeo rohita*, 50 *Cirrhinus mrigala* and 25 *Ctenopharyngodon idella* each. In pond-1 (T_1) and pond-2 (T_2) the fish was supplemented with maize gluten (30% protein) and rice bran (8% protein) with 3:1 and 1:3 ratio, respectively. The fish was fed once daily at the rate of 1% of body weight. Due to high protein contents of feed, comparison of means showed significantly increased average body weight, average standard length, average fork length and average total length in T_1 than T_2. The gross (6373.20 kg) and net (2587.67 kg) fish production was also higher in T_1 than gross (4499.38 kg) and net (2042.18 kg) fish production in T_2 per hectare per year, respectively. In conclusion, *Ctenopharyngodon idella* performed better in both experimental ponds as compared to indigenous *Labeo rohita* and *Cirrhinus mrigala* while 3:1 ratio of maize gluten and rice bran showed better results over 1:3 ratio due to difference in overall protein contents of feed.
Keywords: Growth performance, maize gluten, rice bran, composite culture

INTRODUCTION

Fish is an important dietary animal protein source in human nutrition. Production of aquatic species through freshwater fisheries and aquaculture for protein supply is being encouraged throughout the world. According to nutritionists, fish is an excellent substitute of protein for red meat. Fish flesh contains all the essential amino acid and minerals viz., iodine, phosphorus, potassium, iron, copper and vitamin A and D in desirable concentrations (Sandhu, 2005). It serves as valuable source of protein to a healthy diet because of its low carbohydrate and unsaturated fat, especially Omega 3 contents (Razvi, 2006). Asian aquaculture is dominated by semi-intensive freshwater, earthen pond culture systems. In these systems natural productivity is enhanced with fertilizers and the fishes are provided with supplemental feeds (De-Silva and Hasan, 2007). In the South Asian subcontinent even after decades of rapid growth in fish culture, only 10 % of its potentials have been exploited (Bhatta, 2001).

Specific interactions among fish species are also important in the sustenance of any composite culture system (Sahu *et al*., 2007). Suitable selection of fish can boost nutrient flux and is very important in maximizing the productivity, both in terms of quantity and quality (Rahman, 2006). Exotic species are introduced along with the existing indigenous fishes to increase species diversity, improve fish yield and fill an apparent vacant niche (Okemwa and Ogari, 1994). Therefore polyculture concept is largely based on the principle that each stocked species has its own feeding niche without entirely overlapping with the feeding niches of other species. Often some species improve the food availability for other species and thus enhances the overall per unit area production (Azad *et al*., 2004). But fish culture on a small-scale basis has often failed due to inadequate knowledge regarding ideal stocking density of fish (Osofero *et al*., 2009). Semi-intensive production in ponds using fertilizers and supplementary feeding is a mean of producing low-cost fish in developing countries (Chakraborty and Banerjee, 2009). Sustainable and successful freshwater fish culture on scientific basis principally depends upon the use of adequate, economically viable and environment friendly artificial feeds. Since the feed costs vary between 40 to 60% of the total managerial expenditure in fresh water fish culture system, provision of artificial feed increases the fish growth and production in the fertilized ponds and results in higher growth rates and yields than fertilization alone (Diana *et al.,* 1994; Lupatsch *et al*., 2003; Shahzadi *et al*., 2006). It is noted that fish supplemented with more crude protein in feeds showed significantly better growth as compared to that supplemented with low crude protein feeds (Abbas *et al*., 2004). Rice bran is one of the most commonly employed agriculture by-product in fish culture as it is higher in protein and carbohydrates and lower in fat and fiber (Jhingran and Pullin, 1985). Maize gluten is also one of the important by-products of the starch industry, available in substantial amount in most of the countries including Pakistan, which can be used as fish feed. It is a good dietary protein source and has a significant positive impact on fish growth (Ahmed *et al*., 2005). The nutritive value of rice bran has been observed to be relatively low as compared to maize gluten (Tekchandani *et al*., 1999).

The concept of composite culture of fish rests on the idea that when compatible fish species of different feeding habits are cultured in the same pond, the maximum utilization of all the fish food of different pond columns is established. Therefore the present project was planned to study the effect of mixed feeding schedule with varying dietary protein levels on the growth performance of *Labeo rohita*, *Cirrhinus mrigala* and *Ctenopharyngodon idella*.

MATERIALS AND METHODS

The following line of work was adopted to achieve the objectives defined for the study. The experiment was conducted by using two earthen ponds, each having dimensions of 30 × 16 × 1.5m located at Fisheries Research Farms, University of Agriculture, Faisalabad. The inlets of the ponds were properly screened with gauze of fine mesh to avoid the entry of any intruder into or exit of fish from the ponds. Both the ponds were filled with tube-well water up to the level of 1.5m and this level was maintained throughout the experimental period. Before stocking, both ponds were sun dried for fifteen days. For the purpose of disinfection and the stabilization of pH, liming with CaO was applied at the rate of 2.5 kg per pond with dusting method (Wahab *et al*., 2002). The fishes *Labeo rohita, Cirrhinus mrigala* and *Ctenopharyngodon idella* were stocked at a ratio of 100:50:25; respectively in both the ponds. Two diets, one of high protein (30% maize gluten) and the other of low protein (8%, Rice bran) were used in ratio of 3:1 and 1:3 in experimental ponds T_1 and T_2, respectively. The fishes were fed at the rate of 1% total wet body weight daily. Growth and limnological parameters were also monitored on fortnightly basis from October 15, 2009 to April 14, 2010. At the time of stocking, the morphometric characteristics of fish i.e. body weight, total length, fork length and standard length were measured and recorded. A sample containing 10 fish of each species was captured by random sampling after each fortnight from these ponds using nylon drag net. Their body weight, total length, fork length and standard length were recorded and then fishes were released into their respective ponds. After every fortnight physico-chemical parameters of water such as temperature, light penetration, dissolved oxygen, pH and electrical conductivity were estimated in each pond for the whole study following the standard methods of APHA (1998). At the end of the experiment, total harvested fishes of three fish species were counted and weighed to calculate the survival rate and total fish production.

$$\text{Survival rate (\%)} = \frac{\text{Number of fishes recovered} \times 100}{\text{Number of fishes stocked}}$$

Statistical analysis: The data recorded was subjected to statistical analysis by using CoStat computer package (Version 6.303, PMB 320, Monterey, CA, 93940 USA). The comparison of mean values for various parameters was computed by using Duncan's Multiple Range (DMR) at 5% interval with repeated sampling (Steel *et al.,* 1996).

RESULTS

Physico-chemical parameters: Main parameters investigated during the study period were temperature, light penetration, dissolved oxygen, pH and electrical conductivity. Table 1 explains the comparison of means for said physico-chemical parameters. The mean values for temperature in T_1 and T_2 were 18.38±1.44 °C and 18.46±1.26 °C, for light penetration were 18.66±1.01 cm and 18.15±1.14 cm, for dissolved oxygen were 7.93±0.36 mg/L and 7.68±0.28 mg/L, for pH were 8.12±0.07 and 8.18±0.08 and for electrical conductivity were 3.31±0.10 ds/m and 3.25±0.09 ds/m, respectively. Table 2 shows the analysis of variance for above physico-chemical parameters. Effect of duration (fortnights) towards change in water temperature, light penetration, pH and electrical conductivity was highly significant ($p<0.01$) but for dissolved oxygen it was significant at ($p<0.05$). However, analysis of variance showed statistically non-significant interaction between two treatments for above mentioned physico-chemical parameters.

Fish growth: The growth parameters studied were the increase in body weight, standard length, fork length and total length. The data presented in Table 1 shows comparison of means for said growth parameters. The mean values for wet body weight in T_1 and T_2 were 853.37±43.71 kg and 625.60±35.11 kg, for standard length were 37.19±1.19 cm and 30.70±1.03 cm, for fork length were 39.77±1.26 cm and 32.61±1.02 cm and for total length were 43.25±1.02 cm and 36.86±1.07 cm, respectively. The analysis of variance on wet body weight, standard length, fork length and total length of fish explains that fish species, treatments and fortnights showed highly significant ($p<0.01$) differences in term of wet body weight standard length, fork length and total length. However, the interaction between treatments and fortnights was statistically non-significant for wet body weight standard length and total length, but for fork length it was significant at ($P<0.05$).

Fish production: Final results of this experiment clarifies in Table 4 that after six months the survival rate in both experimental ponds was 100%. Gross production of the

Table 1. Comparison of means for physico-chemical and growth parameters of two treatments (mean±*SE*)

Parameters	T_1	T_2
Temperature (°C)	18.38^{bc}±1.44	18.46^{ab}±1.26
Light Penetration (cm)	18.66^{ab}±1.01	18.15^{bc}±1.14
Dissolved Oxygen (mg/L)	7.93^{ab}±0.36	7.68^{bc}±0.28
pH	8.12^{bc}±0.07	8.18^{ab}±0.08
Electrical Conductivity (ds/m)	3.31^{ab}±0.10	3.25^{bc}±0.09
Body weight (g)	853.37^{a}±43.71	625.60^{b}±35.11
Standard length (cm)	37.19^{a}±1.19	30.70^{b}±1.03
Fork length (cm)	39.77^{a}±1.26	32.61^{b}±1.02
Total length (cm)	43.25^{a}±1.02	36.86^{b}±1.07

Table 2. Analysis of variance for physico-chemical parameters of two treatments

Source of Variation	D.F	F. values				
		Temperature	Light Penetration	Dissolved Oxygen	pH	Electrical Conductivity
Treatments	1	0.07^{NS}	2.04^{NS}	0.59^{NS}	5.43^{NS}	3.47^{NS}
Fortnights	11	71.49^{**}	35.60^{**}	3.12^{*}	31.60^{**}	31.60^{**}
Error	11					

Table 3. Analysis of variance for various growth parameters of two treatments

Source of Variation	D.F	F. values			
		Body weight	Standard length	Fork length	Total length
Fish species	2	1128.154^{**}	3013.6546^{**}	5432.0549^{**}	1120.0586^{**}
Treatments (T)	1	151.7178^{**}	1681.7654^{**}	3505.5528^{**}	698.8183^{**}
Fortnights (F)	11	16.638^{**}	179.5566^{**}	324.2344^{**}	63.1136^{**}
T x F	11	0.2034^{NS}	0.9205^{NS}	3.072^{*}	0.9490^{NS}
Error	46				

Table 4. Comparison of fish production in T_1 and T_2

	T_1			T_2		
	C. idella	***L.rohita***	***C. mrigalla***	***C. idella***	***L.rohita***	***C. mrigalla***
No. of fishes stocked	25	100	50	25	100	50
Survival rate %	100	100	100	100	100	100
Initial average weight (g)	1148	413.40	395.20	961	237	211.30
Final average weight (g)	1887	679.90	720.40	1574	443.30	461.10
Gain in average weight (g)	739	266.50	325.20	613	206.30	249.80
Fish biomass at stocked (kg)	28.700	41.340	19.760	24.025	23.700	10.565
Gross fish production/pond/6 month (kg)	47.175	67.990	36.020	39.350	44.330	23.055
Gross fish production/acre/6 month (kg)	397.730	573.220	303.682	331.757	373.744	194.375
Gross fish production/acre/year (kg)	795.460	1146.440	6073.64	663.514	747.488	388.750
Gross fish production/ hectare/year (kg)	1988.650	2866.100	1518.410	1658.785	1868.720	971.875
Net fish production/pond/6month (kg)	18.475	26.650	16.260	15.325	20.630	12.490
Net fish production/pond/year (kg)	36.950	53.300	23.520	30.650	41.260	24.980
Net fish production/acre/year (kg)	311.523	449.369	274.174	258.408	347.860	210.605
Net fish production/hectare/year (kg)	778.809	1123.422	685.435	646.020	869.650	526.512

Fishes, i.e. *Ctenopharyngodon idella, Labeo rohita* and *Cirrhinus mrigala* was 47.18kg, 67.99kg and 36.02kg for T_1 and 39.35kg, 44.33kg and 23.06kg for T_2, respectively. Gross fish production of individual said species per hectare per year in T_1 was 1988.65kg, 2866.10kg and 1518.41kg, and for T_2 was 1658.79kg, 1868.72kg and 971.88kg, respectively. Net fish production per pond per 6 month remained 18.48kg, 26.65kg and 16.26kg in T_1 and 15.33kg, 20.63kg and 12.49kg for *Ctenopharyngodon idella, Labeo rohita* and *Cirrhinus mrigala* in T_2, respectively. Net fish production per hectare per year for *Ctenopharyngodon idella, Labeo rohita* and *Cirrhinus mrigala* calculated as

778.81kg, 1123.42kg and 685.44kg in T_1 and 646.02kg, 869.65kg and 526.51kg in T_2, respectively. Gross fish production per hectare per year of all fish species was calculated as 6373.20kg in T_1 and 4499.38kg in T_2. Whereas, net fish production per hectare per year of all fish species was calculated 2587.67kg and 2042.18kg for T_1 and T_2, respectively.

DISCUSSION

In aquaculture, the ultimate aim is not to achieve the highest mean weight (De-Silva *et al*., 1989) but especially, in the current context practices, the emphasis is on a low environmental burden and the cost effectiveness. In present study fish showed better growth performance, gross fish production and net fish production with the addition of supplementary feeding in both experimental ponds. Such type of results were also obtained by Nazish and Mateen (2011) who reported that supplementary feeding is known to increase the carrying capacity of culture system and can enhance fish production by several folds. Kabir *et al.* (2009) also reported that net fish production of treatment with supplementary feed was 7.7 times greater than the treatment without feed in conducting the experiment in polyculture system. During the comparative study of ponds maximum gain in net fish production and gross fish production was obtained in T_1 which was provided with maize gluten and rice bran in 3:1 ratio. Weight gain and production was higher in T_1 due to higher crude protein content of feed than in T_2 receiving lower protein content feed. Comparison of means showed significant difference in average weight, average standard length, average fork length and average total length. Better performance of supplementary feeds with higher crude protein content than that of lower protein content was also reported by (Shankar, 1988; Joshi *et al*., 1989; Sunder *et al*., 1998). Analysis of variance in Table 3 showed that fortnights significantly ($p<0.01$) increased body weight, standard length, fork length and total length of fish species. These results fully substantiate the findings of Hussain *et al.* (2010) who reported that duration had statistically significant effects on growth performance of fish in terms of weight, fork and total length increments.

In aquaculture the physico-chemical conditions of water and presence of different types of biotic flora and fauna have an effective control on productivity. Water quality is determined by ecological parameters. Important ecological parameters are temperature, pH, dissolved oxygen, electrical conductivity and light penetration. A proper range of these factors is necessary for fish culture. These properties were recorded at fortnight intervals and the results obtained as a consequence of this investigation are presented in Tables 1 and 2. It is obvious from the results that air and water temperature of all ponds varied throughout experimental period. Maximum weight gain in T_1 and T_2 was noted in March and April which was due to high water temperature. The minimum growth was observed in both ponds when temperature was lower. Similar results were also reported by Ahmad *et al.* (2008) who observed that planktonic biomass and fish production depend highly on water temperature. Alliot *et al.* (1983) also opined that the fish activities including growth greatly depend upon temperature. Okpokwasiti and Obah (1991) reported highly significant seasonal variations in water temperature, EC, pH, dissolved oxygen, alkalinity and light penetration of ponds. The results of the present investigation also revealed that fortnights exerted significant effect on temperature, dissolved oxygen, pH, electrical conductivity and light penetration of both experimental ponds.

Water pH plays an important role in maintenance of the homeostasis in aquatic animals. Fish can tolerate pH 5-6 but suffer slow growth at these conditions. The 6.5–9.0 range of water pH is usually suggested for fish culture, but the optimum range may differ for different species. In present study pH varied from of 7.53-8.76 which was in optimal range. Afzal *et al.* (2008) also found in their study that pH remained in the range of 6.88-8.61 which was considered best for all fish species. Visual clarity impacts the behavior of fishes that rely on sight for feeding and to catch their prey. Limnologists have long used the Secchi´s disc to measure water clarity. The variation in light penetration ranged from 12.2 to 23.7 cm during the experimental period. Such variations may be due to many factors, e.g. observer, time of the day, season and weather during the experimental period. Rahman (1992) also reported in his experiment on water quality management that values of transparency varied fortnightly.

CONCLUSION

Finally, the results of this study lead to the conclusion that due to high protein content, maize gluten is more suitable and acceptable ingredient than rice bran. Growth potential of exotic species, *Ctenopharyngodon idella* is higher than indigenous species *Labeo rohita* and *Cirrhinus mrigala* which both have approximately similar potential for growth.

REFERENCES

A.P.H.A. 1998. Standard Methods for the Examination of Water and Wastewater. 20th ed. American Public Health Association, Washington, USA.

Abbas, K., I. Ahmed, M.H. Rehman and S. Kanwal. 2004. Effect of rice bran and maize gluten on the growth performance of major carps in fertilized ponds. Indus J. Plant Sci. 3: 391-395.

Afzal, M., A. Rub, N. Akhtar, I. Ahmad, M.F. Khan and M. Qayyam. 2008. Growth performance of big head carp *Aristichthys nobilis* (Richardson) in monoculture system with and without supplementary feeding. Pak. Vet. J. 28: 57-62.

Ahmad, N., I. Ahmed, M. Saleem and M. Ashraf. 2008. Effect of different levels of mineral phosphorus with and without nitrogen on the dry weight of planktonic biomass, increase in fish production and biomass conversion efficiencies. Pak. J. Agri. Sci. 45: 122-128.

Ahmed, I., K. Abbas and M.H. Rehman. 2005. Growth performance of major carp in semi intensive ponds supplemented with rice polishing. Pak. Vet. J. 25: 59-62.

Alliot, E., A. Pastoureaud and H. Thebault. 1983. Influence of temperature and salinity on the growth and body composition of sea bass fingerlings, *Dicentrachus lebrak.* Aquaculture 31: 181-194.

Azad, M.A.K., M.R. Rahman, Z. Rahman, M.A. Kader, M.M. Haque and M.J. Alam. 2004. Polyculture of carp, tilapia and pangas using low cost inputs. Pak. J. Biol. Sci. 7: 1918-1926.

Bhatta, R. 2001. Production, accessibility and consumption patterns of aquaculture products in India. Production, Accessibility, Marketing and Consumption Patterns of Freshwater Aquaculture Products in Asia: A Cross-Country Comparison. p. 275. FAO Fisheries Technical Paper No. 973, Rome.

Chakraborty, S.B. and S. Banerjee. 2009. Culture of monosex Nile tilapia under different traditional and non-traditional methods in India. World J. Fish Marine Sci. 1: 212-217.

De-Silva S.S., R.M. Gunasekara and D. Atapattu. 1989. The dietary protein requirements of young tilapia and evaluation of the least cost dietary protein levels. Aquaculture 80: 271-284.

De-Silva, S.S. and M.R. Hasan. 2007. Feeds and fertilizers: the key to long-term sustainability of Asian aquaculture. In: Study and Analysis of Feeds and Fertilizers for Sustainable Aquaculture Development. Ed. M.R. Hasan, T. Hecht, S.S. De-Silva and A.G.J. Tacon), p. 19-48 FAO Fisheries Technical Paper No. 497, Rome.

Diana, J.S., C.K. Lin and K. Jaiyen. 1994. Supplemental feeding of tilapia in fertilized ponds. J. World Aquacult. Soc. 25: 497-506.

Hussain, S.M., M. Javed, S. Asghar, M. Hussain, S. Abdullah, S.A. Raza and A. Javid. 2010. Studies on growth performance of metals mixture stressed *Cirrhina mrigala* in earthen ponds. Pak. J. Agri. Sci. 47: 263-270.

Jhingran, V.G. and R.S.V. Pullin. 1985. A Hatchery Manual of Common, Chinese and Indian Major Carps, ICLARM Studies and Reviews, p. 191. Asian Development Bank and International Center for Living Aquatic Resources Management. Manila, Philippines.

Joshi, C.B., K.L. Sehgal and K.C. Malkani. 1989. Experimental trials on feeding of *Tor putitora* with formulated diets at Bhimtal in Kumaon Himalayas. Indian J. Anim. Sci. 59: 206-209.

Kabir, A.N., M.A. Hossain and M.S. Rahman. 2009. Use of duckweed as feed for fishes in polyculture. J. Agric. Rural. Dev. 7: 157-160.

Lupatsch, I., G.W. Kissil and D. Sklan. 2003. Comparison of energy and protein efficiency among three fish species gilthead sea bream *(Sparus aurata*), European sea bass (*Dicentrarchus labrax*) and white grouper (*Epinephelus aeneus*): energy expenditure for protein and lipid deposition. Aquaculture 225: 175-189.

Nazish, N. and A. Mateen. 2011. Winter growth of carps under different semi-intensive culture conditions. Pak. Vet. J. 31: 134-136.

Okemwa, E. and J. Ogari. 1994. Introductions and extinctions of fish in Lake Victoria. In: I.G. Cowx, Ed. Rehabilitation of Fresh Water Fisheries. Oxford: Fishing News Books, Ltd. London. p. 326-337.

Okpokwasiti, G.C. and O. Obah. 1991. Relationship between the water quality and bacteria associated with the brown patch disease of Tilapia fingerlings reared in tropical fresh water culture ponds. J. Aqua. Trop., 6: 157-172.

Osofero, S.A., S.O. Otubusin and J.A. Daramola. 2009. Effect of stocking density on tilapia (*Oreochromis niloticus*) growth and survival in bamboo-net cages trial. Africal J. Biotech 8: 1322-1325.

Rahman, M.M. 2006. Food Web Interaction and Nutrients Dynamics in Polyculture Ponds. Ph.D Thesis, Wageningen University, Netherlands, p.157.

Rahman, M.S. 1992. Water Quality Management in Aquaculture. BRAC Prokashana, Dhaka, Bangladesh, p. 84.

Razvi, M. 2006. Lahore-Absolutely Fishy: Nutritional Value, The Review, Dawn, Lahore, Pakistan, p. 12-13.

Sahu, P.K., J.K. Jena, P.C. Das, S. Mondal and R. Das. 2007. Production performance of *Labeo calbasu* (Hamilton) in polyculture with three Indian major carps *Catla catla* (Hamilton), *Labeo rohita* (Hamilton) and *Cirrhinus mrigala* (Hamilton) with provisions of fertilizers, feed and periphytic substrate as varied inputs. Aquaculture 262: 333-339.

Sandhu, G.S. 2005. A Textbook of Fish and Fisheries. 1st ed. Dominant Publishers and Distributors, New Delhi, India, p. 39-40.

Shahzadi, T., M. Salim, U. Kalsoom and K. Shahzad. 2006. Growth performance and feed conversion ratio (FCR) of hybrid fingerlings (*Catla catla* X *Labeo rohita*) fed on cottonseed meal, sunflower meal and bone meal. Pak. Vet. J. 26: 163-66.

Shankar, T.J. 1988. Effect of dietary protein level on the growth of Decan mahseer fry *Tor khudree* (Sykes). J. Ind. Fish Assoc. 18: 135-140.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1996. Principles and Procedures of Statistics, 3rd Ed. McGraw Hill International Book Co., New York. p. 336-352 USA.

Sunder, S., H.S. Raina and U. Naulia. 1998. Preliminary feeding trials on juveniles of golden mahseer, *Tor putitora* (Ham.) at different stocking densities with artificial dry pellet feeds. Ind. J. Ani. Sci. 68: 410-416.

Tekchandani, H.K., F.F. Dias and D. Mehta. 1999. Maize wet milling co-products as feed additives: perspectives and opportunities. J. Sci. Indust. Res. 58: 83-88.

Wahab, M.A., M.M. Rahman and A. Milstein. 2002. The effect of common carp, *Cyprinus carpio* (L.) and mrigal, *Cirrhinus mrigala* (Hamilton) as bottom feeders in major Indian carp polycultures. Aquacult. Res. 33: 547-556.