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Growth Performance of Carp Species Fed on Salt-Tolerant Roughages and Formulated Feed in Brackish Water Under Polyculture System

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Abstract.- A study was carried out to assess the growth performance of four fish breeds suitable for saline environments: *Catla catla* (Thaila), *Hypophthalmichthys molitrix* (Silver carp), *Ctenopharyngodon idella* (Grass carp) and *Cyprinus carpio* (Common carp) in a semi-intensive integrated pond system. The experiment was conducted in earthen ponds with brackish groundwater (electrical conductivity 4.7 dS m^{-1}, pH 8.6 and residual sodium carbonate 21.3 meq L^{-1}) for a period of 11 months. Feed with crude protein 20% was prepared by using different ingredients, i.e. rice polish, maize gluten, sunflower meal and fish meal. The feeding treatments were formulated feed at 3% body weight alternated with salt-tolerant roughages (T_1) or only roughages (T_2) including *Leptochloa fusca* (kallar grass), *Brachiaria mutica* (para grass) and *Kochia indica* (kochia). Fertilization of all ponds was done with goat droppings at 6000 kg ha^{-1}. Results indicated that all four fish species were well adapted to formulated feed and roughages in saline environment. However, significant differences ($p \leq 0.05$) were observed in growth parameters under two feeding regimes. *C. catla* produced maximum weight (986 g) and net production (1721 kg ha^{-1} $year^{-1}$), followed by *H. molitrix* (955 g and 1638 kg ha^{-1} $year^{-1}$), *C. idella* (806 g and 1459 kg ha^{-1} $year^{-1}$) and *C. carpio* (745 g and 1219 kg ha^{-1} $year^{-1}$) in T_1. Survival rate was maximum in *C. idella* (93%) and minimum in *C. carpio* (84%). It may be concluded that the salt-tolerant roughages alternate with formulated feed of 20% protein can be used for optimal fish production by reducing feed cost in saline environments.

Key words: Fish breeds, polyculture, supplemental feed, brackish water, condition factor

INTRODUCTION

The climate of Pakistan is arid and semi-arid with scarce and irregular rainfall. Much of its land is affected with salinity and water-logging and the underlain water is brackish. Such areas can be used for fish culture which will act as a tool for rehabilitation and desalinization of the soil through flushing and will also provide fish meat. Traditionally, Indian major and Chinese carps are cultured under polyculture system. These fish breeds fall under stress in brackish water as salinity affected ecological factors and natural food production (Mateen *et al*., 2004).

Fish growth is inconstant process which can be changed considerably in response to internal factors such as age, size and feeding habit of fish and external factors like water quality, food supply and management practices (Weisberg *et al.*, 2010). Intensive and semi-intensive fish farming is gaining more importance in Pakistan. To get maximum fish production, it is essential to use supplemental feed along with organic and inorganic fertilizers to improve the planktonic life. Supplemental feed increases the carrying capacity of the culture system which ultimately enhances the fish production (Shahzadi *et al*., 2006).

Water quality is one of the most important factors in fish production. It varies with time, season, weather, source, soil type, stocking density, feeding rate and culture systems. For a successful aquaculture, the management of water quality is most important (Davies and Ansa, 2010). In Pakistan, there is a tremendous scope of fish culture in saline environments by managing levels of inputs and monitoring the water quality (Chughtai and Mahmood, 2012). Nutrition represents 40-50% of production costs in commercial fish culture (Craig and Helfrich, 2002). It is necessary to formulate a suitable and compatible inexpensive feed combination. Fish meal is extensively used due to palatability and compatibility with the protein requirements of the fish but its increasing cost has restricted its use (Watanabe *et al*., 1997).

Plant material can be considered as an alternative protein source to replace fish meal for economic fish production. Plants can be directly use as supplemental feed or through different cereals,

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byproducts and meal of oilseeds like rice polish, sunflower meal, etc. for partial replacement of fish meal. The use of these less expensive plant proteins in fish feed can reduce production (Tahir *et al*., 2008). Improper combinations of ingredients may lead to the formulation of feeds with low water stability and high percentage of leachates (Nwanna, 2003). Feed costs can be reduced by developing management strategies and improving husbandry techniques (Abid and Ahmed, 2009).

Keeping in view the utilization of saline waste resources and economic importance of supplemental feed, the present study was carried out to determine the growth response of four fish breeds in saline environments under two feeding regimes for the optimal production.

MATERIALS AND METHODS

The experiment was conducted in three earthen ponds, each with dimensions 25 m × 13 m × 1.5 m located at Bio-saline Research Station (BSRS), Pakka Anna at a distance of 50 km in South-West of Faisalabad, Pakistan (Lat. 31^{o}.24' N and Long. 73^{o}.05' E). The climate is semi-arid with an annual average rainfall of 325 mm and evaporation exceeds 1600 mm. The annual average temperature in the area is 32^{o}C.

The experiment was performed for the period of 11 months. The inlets of the ponds were properly screened with gauze of fine mesh to avoid the entry of any intruder into or the exit of the experimental fish from the ponds. All the ponds were filled with tube-well water up to 1.5 m which was maintained throughout the study period. After the preliminary preparation, the ponds were stocked with selected fish breeds at a density of 3000 ha^{-1} with a ratio of 25% *Catla catla* (Thaila), 25% *Hypophthalmichthys molitrix* (Silver carp), 35% *Ctenopharyngodon idella* (Grass carp) and 15% *Cyprinus carpio* (Common carp) in a composite culture.

Feed containing 20% protein was prepared following Pearson's square method (Rath, 2000) using different feed ingredients including rice polish, gluten, sunflower meal and fish meal purchased from the local market. The feeding treatments were formulated feed at 3% body weight alternated with salt-tolerant roughages (T_1) and only roughages (T_2) including *Leptochloa fusca* (Kallar grass), *Brachiaria mutica* (Para grass) and *Kochia indica* (Kochia) on daily basis. All ponds were fertilized using goat droppings at 6000 kg ha^{-1}. Supplemental feed ingredients and roughages were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash by standard analytical methods (AOAC, 1990) and metabolizable energy (ME) was calculated by using a formula as described by Menke and Steingass (1988).

Soil and water analysis was performed before the start of the experiment. During the experiment, water analysis was done on monthly basis by using methods of the USDA Handbook-60 (Richards, 1954). At 30 day intervals, a sample of 10 fishes of each cultured breed was captured randomly from each of the treatment ponds and the body weight and length was recorded. After obtaining the data, the fish were released back into their respective ponds. The data was subjected to analysis of variance to determine any statistical significance of the results using MSTATC program (version 2.10).

RESULTS AND DISCUSSION

Results of the water analysis indicated that the water temperature ranged from 16.2^{o}C to 32.9^{o}C throughout the growing period. The light penetration was observed maximum up to 25.9 cm in August. Light penetration is one of the limiting factors for the primary productivity of any water body. The pH and electrical conductivity remained in the range of 8.27 to 8.70 and 5.43 to 6.13 dS m^{-1}, respectively. The pH of water in different months except February and December was within the WHO (1995) standard of 6.5-8.5. Electrical conductivity fluctuates due to total dissolved solids and salinity (Boyd, 1981). Dissolved O_2 ranged from 5.43 to 7.27 mg L^{-1} and free CO_2 ranged from 8.93 to 11.6 mg L^{-1}. High dissolved O_2 is an indication of healthy aquatic ecosystem (Chattopadhyay and Banerjee, 2007). Total solids were observed maximum 4008 mg L^{-1} in August and minimum 2750 mg L^{-1} in November. The RSC ranged from 15.1 to 21.3 me L^{-1} and the planktonic biomass ranged from 2741 to 3996 mg L^{-1}.

Biological productivity of pond is a measure of planktonic biomass that is affected by the light availability, water temperature and presence of essential nutrients (Liti *et al.*, 2006). The results of correlation among all studied physio-chemical parameters of the pond water are presented in Table I.

The results of proximate composition and metabolizable energy of various roughages and supplemental feed concentrates are shown in Table II. Overall, the nutritive analysis indicated that the salt-tolerant roughages are less protein source i.e. 6.2% (*Brachiaria mutica*) to 10.9% (*Kochia indica*) while the feed concentrates having much more up to 54.8% (fish meal). So, the combination of these ingredients and salt-tolerant roughages as supplemental feed can fulfill the protein requirement of fish. Khanum *et al.* (2007) carried out the nutritional evaluation of salt tolerant plants and reported high fiber (19.5 to 28.4%) and low crude protein level (8 to 11%) which is low for fish body requirement. Jayasuriya (2000) also concluded that these roughages are deficient in fermentable carbohydrates with relatively low organic matter digestibility. The use of waste material of plant origin as fish diet can promote growth rate, decrease mortality rate and increase the antioxidant activity in fish (Metwally and El-Gellal, 2009).

The initial mean weights of cultured breed's fingerlings at stocking time were as *C. catla* (41.0±5.68 g), *H. molitrix* (24.9±4.52 g), *C. idella* (29.7±4.27 g) and *C. carpio* (44.3±5.41 g). After 335 days of growth period, different parameters including weight, length, survival rate, condition factor and production were calculated to compare the four experimental Carp species against two types of supplemental feeds.

The comparison for monthly gain in weight and length among cultured species was made and presented in Table III. Results indicated that *C. catla* gained maximum weight (137.8 g) in October and minimum (51.4 g) in April in T_1 while in T_2; *C. catla* gained maximum weight (92 g) in November and minimum (26.4 g) in May. *H. molitrix* gained maximum weight (155.5 g) in November and minimum (55.9 g) in June in T_1 while in T_2; *H. molitrix* gained maximum weight (145.1 g) in December and minimum (26.8 g) in June. *C. idella* gained maximum weight (121.5 g) in October and minimum (31.1 g) in April in T_1 while in T_2; *C. idella* gained maximum weight (110.6 g) in September and minimum (32.7 g) in June. *C. carpio* gained maximum weight (161.7 g) in December and minimum (35.2 g) in May in T_1 while in T_2; *C. carpio* gained maximum weight (101.6 g) in January and minimum (28.2 g) in April.

In *C. catla*, the gain in length was ranged from 1.2 cm (June) to 5.3 cm (August) in T_1 and 1.1 (May) to 2.5 (October) in T_2. In *H. molitrix*, the gain in length was ranged from 1.7 cm (November) to 3.4 cm (May) in T_1 and 0.8 (December) to 4.4 (September) in T_2. In *C. idella*, the gain in length was ranged from 1.8 cm (September) to 3.3 cm (April) in T_1 and 1.2 (June) to 2.8 (May) in T_2. Similarly; in *C. carpio*, the gain in length was ranged from 1.5 cm (May) to 3.8 cm (November) in T_1 and 1.1 (May) to 2.3 (December) in T_2 as shown in Table III.

Average daily gain (ADG) in cultured species against first supplemental feed (T_1) showed significantly higher values than the second feed (T_2). In T_1, ADG was observed maximum (5.20 g day^{-1}) in *H. molitrix* in October and minimum (1.17 g day^{-1}) in *C. carpio* in June while in T_2, maximum (4.05 g day^{-1}) in *C. idella* in December and minimum (1.04 g day^{-1}) in *C. catla* in April. However, survival rate was recorded as mean percentage of each species in both treatments and found maximum 93% in *C. idella*, followed by 89% in *C. catla*, 87% in *H. molitrix* and 84% in *C. idella*.

In present study, the condition factor increased with the increase in weight and length and its values were more than one in all cultured species which indicates the availability of adequate feed for fish. Condition factor gives information about feeding source whether it is good or not (Bayhan *et al.*, 2008) and it varies when average weight of fish does not increase in direct proportion to the cube of its length (Naeem *et al.*, 2010). In T_1, maximum net and gross fish production was calculated as 1721 and 1891 kg ha^{-1} year^{-1} in *C. catla* and minimum 1219 and 1401 kg ha^{-1} year^{-1} in *C. carpio*, while in T_2, *C. idella* produced maximum 1190 kg ha^{-1} year^{-1} and *C. carpio* produced minimum 714 kg ha^{-1} year^{-1} (Table IV).

Table I.- Correlations among physico-chemical parameters of brackish pond water.

Correlation matrix	Photoperiod	Humidity	Water Temperature	Light Penetration	Density	Specific gravity	Turbidity
pH	-0.004^{NS}	-0.227^{NS}	-0.020^{NS}	-0.316^{NS}	-0.139^{NS}	0.033^{NS}	-0.200^{NS}
EC	0.048^{NS}	-0.162^{NS}	-0.255^{NS}	-0.250^{NS}	-0.442^{NS}	-0.266^{NS}	0.217^{NS}
Dissolved O_2	-0.761**	-0.61*1	-0.411*	-0.354^{NS}	0.763**	0.661*	0.309^{NS}
Free CO_2	0.667*	0.702*	0.895**	0.561^{NS}	-0.046^{NS}	0.068^{NS}	-0.584^{NS}
CO_3^{--}	0.074^{NS}	0.288^{NS}	0.275^{NS}	0.269^{NS}	0.405^{NS}	0.356^{NS}	0.049^{NS}
HCO_3^-	0.213^{NS}	0.172^{NS}	0.468^{NS}	0.277^{NS}	0.025^{NS}	0.283^{NS}	-0.029^{NS}
Acidity	-0.805**	0.740**	-0.547^{NS}	-0.415^{NS}	0.706*	0.561^{NS}	0.795**
Hardness	0.305^{NS}	0.285^{NS}	0.476^{NS}	-0.132^{NS}	-0.068^{NS}	-0.019^{NS}	-0.395^{NS}
Alkalinity	0.628*	0.488^{NS}	0.302^{NS}	0.473^{NS}	-0.545^{NS}	-0.642*	-0.247^{NS}
Total solids	0.542^{NS}	0.654*	0.347^{NS}	0.498^{NS}	-0.214^{NS}	-0.240^{NS}	-0.007^{NS}
RSC	0.004^{NS}	-0.007^{NS}	0.289^{NS}	0.085^{NS}	0.084^{NS}	0.335^{NS}	-0.051^{NS}
Planktonic Biomass	0.542^{NS}	0.653*	0.346^{NS}	0.498^{NS}	-0.214^{NS}	-0.240^{NS}	-0.006^{NS}

NS = Non significant ($p \geq 0.05$), * = Significant ($p<0.05$), ** = Highly significant ($p \leq 0.001$)

Table II.- Chemical composition and metabolizable energy of feed sources on DM basis.

Feed Sources	Dry matter (%)	Ash (%)	Crude fiber (%)	Crude protein (%)	Ether extract (%)	Metabolizable energy (MJ kg^{-1})
Feed ingredients						
Rice polish	91.5±0.6	10.8±0.6	5.1±0.3	12.0±0.6	13.9±1.5	7.79±0.1
Maize Gluten	92.2±0.9	7.8±0.2	1.2±0.2	22.3±0.6	3.0±0.3	9.06±0.2
Sunflower meal	88.6±1.0	6.1±0.6	13.7±0.6	38.3±1.5	7.1±0.9	9.27±0.1
Fish meal	91.4±1.2	20.1±2.9	1.82±.0.5	54.8±1.9	10.2±1.5	17.1±0.6
Roughages						
Kallar grass (*Leptochloa fusca*)	32.2±0.8	10.0±0.5	28.0±1.3	8.2±0.6	1.6±0.2	6.54±0.1
Para grass (*Brachiaria mutica*)	34.4±1.0	9.6±0.5	27.4±0.6	6.2±0.5	1.9±0.4	6.23±0.5
Kochia (*Kochia indica*)	19.8±0.7	21.8±0.9	18.8±0.9	10.9±0.8	1.6±0.2	6.51±0.3

Values are averages of three replicate measurements ± standard deviation

Table III.- Comparison for monthly gain in weight and length among Carp species grown in brackish water under two feeding regimes.

Months	Mean Weight gain (g)								Mean Length gain (cm)							
	C. catla		*H. molitrix*		*C. idella*		*C. carpio*		*C. catla*		*H. molitrix*		*C. idella*		*C. carpio*	
	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2
Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar	55.3	38.1	22.3	18.2	23.1	17.1	44.2	19.4	3.1	1.2	3.1	1.3	2.5	1.9	2.1	1.5
Apr	51.4	31.1	59.0	40.6	31.1	34.0	42.0	28.6	2.6	2.2	2.7	2.3	3.3	2.2	1.8	1.6
May	59.6	26.4	72.3	40.9	47.7	35.2	36.4	38.2	2.7	1.1	3.4	1.7	2.6	2.8	1.5	1.1
Jun	88.9	28.7	55.9	26.8	62.5	32.7	35.2	32.8	1.2	2.2	3.0	2.2	2.3	2.2	2.1	1.3
Jul	93.1	33.8	127.3	34.4	106.0	48.3	41.5	38.5	1.8	2.1	2.6	1.7	3.1	1.2	1.6	2.1
Aug	111.3	84.2	110.2	43.0	79.2	71.3	54.8	32.5	5.3	1.5	2.7	2.1	2.1	2.7	1.8	1.4
Sep	108.3	73.2	62.2	73.4	80.3	110.6	69.1	66.6	2.3	2.2	2.8	4.4	1.8	1.2	1.8	2.0
Oct	137.8	66.5	125.9	92.6	121.5	85.0	102.4	41.8	3.3	2.5	2.6	2.3	2.3	2.7	2.4	1.3
Nov	118.4	92.0	155.5	62.0	114.3	91.5	113.0	69.0	3.2	2.3	1.7	1.9	2.4	1.8	3.8	1.8
Dec	121.3	91.8	140.3	145.1	116.9	101.4	161.7	73.2	2.0	2.3	2.6	0.8	1.8	2.3	3.5	2.3
Jan	130.1	86.5	122.7	115.7	120.2	110.4	125.4	101.6	2.5	2.1	2.5	1.2	2.0	1.7	3.2	2.0

Table IV.- Cumulative growth parameters of Carp species grown in brackish water under two feeding regimes

Fish breeds	Treatments	Survival rate (%)	Weight gain (g)	Length gain (cm)	Condition factor (k)	Gross production (kg ha^{-1} year^{-1})	Net production (kg ha^{-1} year^{-1})
C. catla	T_1	91	945.4	27.5	2.67	1891	1721
	T_2	88	565.8	19.6	2.56	1132	996
H. molitrix	T_1	88	930.9	27.2	2.24	1862	1638
	T_2	86	567.0	20.7	2.07	1185	975
C. idella	T_1	94	776.3	24.2	1.88	1553	1459
	T_2	92	647.1	21.0	1.68	1294	1190
C. carpio	T_1	87	700.3	22.4	1.81	1401	1219
	T_2	81	440.6	16.4	1.73	881	714

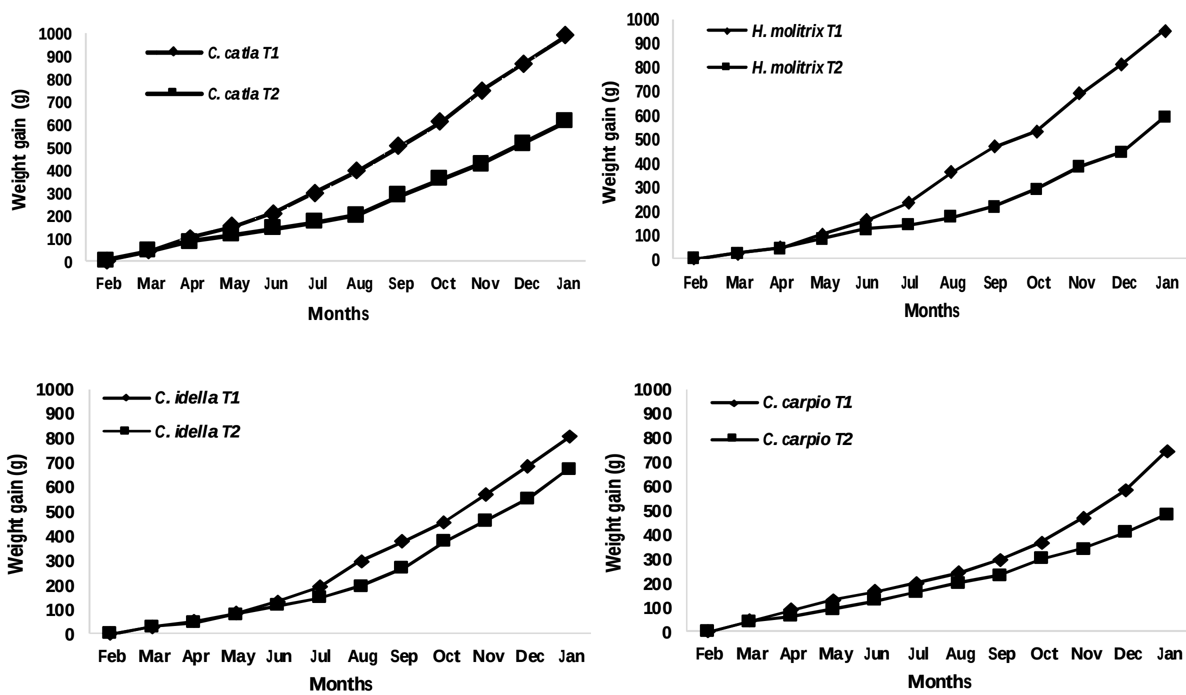

Fig. 1. Comparison for increase in weight of *C. catla, H. molitrix, C. idella* and *C. carpio* grown in brackish water ponds under two feeding regimes.

The results of the experiment revealed that average increase in body weight and length of four fish species varied significantly from one another under two feeding regimes. In first feeding regime (T_1), *C. catla* showed the maximum increase in weight as 986 g followed by *H. molitrix* (955 g), *C. idella* (806 g) and *C. carpio* (745 g) while in second feeding regime (T_2), *C. idella* increased maximum weight 677 g. Similarly in T_1, increase in length was observed maximum in *H. molitrix* as 40.3 cm and minimum in *C. carpio* (34.5 cm) while in T_2, maximum (32.8 cm) in *C. idella* and minimum (28.2 cm) in *C. carpio*. The monthly increase in weight of four experimental Carp species in comparison to treatments is shown in Figure 1.

Feed of plant origin has a good potential in fish feed industry because of cheaper protein source as compared to animal sources proteins and limited application due to lack of some essential amino acids and palatability (Stankovic *et al.*, 2011).

Chughtai and Awan (2011) studied the growth of Tilapia fish against salt-tolerant roughages (Kallar grass, Para grass, Kochia) as supplementary food and reported that feed with more than 20% protein level must be used along with these roughage to get optimal fish production in brackish water. Iqbal *et al.* (2015) also evaluated growth potential of carp fish against supplemental feed of plant origin as replacement of expensive fish meal and reported significant increase in weight and length parameters, high feed conversion ratio (FCR) and 100% survival rate in *Labeo rohita* while feeding on soybean meal. The results of the present study reveals that plant protein can efficiently replace high cost fish meal in herbivorous fishes partially because salt-tolerant plants has high fiber content and low crude protein level for fish requirement.

CONCLUSIONS

It is need to reduce the current dependency on costly fish meal as fish feed represents 40-50% of production costs. Inexpensive salt-tolerant roughages used for rehabilitation and reclamation of salt-affected lands and some other low-cost locally available alternative feed ingredients can be a partial or complete substitute for fish meal in commercial rations for semi-intensive polyculture system. So, the utilization of on-farm resources can play a central role in sustainability of saline aquaculture and poverty alleviation of small-scale fish farmers.

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REFERENCES

ABID, M. AND AHMAD, M.S., 2009. Growth response of *Labeo rohita* fingerlings fed with different feeding regimes under intensive rearing. *J. Anim. Pl. Sci.*, **19**: 45-49.

AOAC, 1990. *Official methods of analysis. Association of Official Analytical Chemists*, Washington, DC, USA.

BAYHAN, B., SEVER, T.M. AND TASKAVAK, E., 2008. Length-weight relationships of seven flatfishes (Pisces: Pleuronectiformes) from Aegean Sea. *Turk. J. Fish. aquat. Sci.*, **8**: 377-379.

BOYD, C.E., 1981. *Water quality in warm water fish ponds*. Craftmaster Printers Inc., Opelika, Alabama.

CHATTOPADHYAY, C. AND BANERJEE, T.C., 2007. Temporal changes in environmental characteristics and diversity of net-phytoplankton in a freshwater lake. *Turk. J. Bot.*, **31**: 287-296.

CHUGHTAI, M.I. AND AWAN, A.R., 2011. Growth performance of monosex and mixed-sex tilapia (*Oreochromis niloticus*) in brackish water by using salt-tolerant roughages as supplementary food. *Pakistan J. Zool.*, **43**: 596-599.

CHUGHTAI, M.I. AND MAHMOOD, K., 2012. Semi-intensive carp culture in saline water-logged area: A multi-location study in Shorkot (District Jhang), Pakistan. *Pakistan J. Zool.*, **44**: 1065-1072.

CRAIG, S. AND HELFRICH, I.A., 2002. *Understanding fish nutrition, feeds and feeding*. Department of Fisheries and Wildlife Sciences, Virginia Tech, pp. 420-256.

DAVIES, O.A. AND ANSA, E., 2010. Comparative assessment of water quality parameters of freshwater tidal earthen ponds and stagnant concrete tanks for fish production in Port Harcourt, Nigeria. *Int. J. Sci. Nature*, **1**: 34-37.

IQBAL, K.J., ASHRAF, M., QURESHI, N.A., JAVED, A., ABBAS, F., HAFEEZ-UR-REHMAN, M., RASOOL, F., KHAN, N. AND ABBAS, S., 2015. Optimizing growth potential of *Labeo rohita* fingerlings fed on different plant origin feeds. *Pakistan J. Zool.*, **47**: 31-36.

JAYASURIYA, M.C.N., 2000. *Principles of ration formulation of ruminants*. Proceeding of the final review and planning meeting of an IAEA Technical Cooperation Regional AFRA Project organized by Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Cairo, Egypt, 25-29.

KHANUM, S.A., YAQOOB, T., SADAF, S., HUSSAIN, M., JABBAR, M.A., HUSSAIN, H.N., KAUSAR, R. AND REHMAN, S., 2007. Nutritional evaluation of various feedstuffs for livestock production using in vitro gas method. *Pakistan Vet. J.*, **27**: 129-133.

LITI, D.M., MUGO, R.M., MUNGUTI, J.M. AND WAIDBACHER, H., 2006. Growth and economic performance of Nile tilapia (*Oreochromis niloticus* L.) fed on three brans (maize, wheat and rice) in fertilized ponds. *Aquacult. Nutr.*, **12**: 239-245.

MATEEN, A., AFZAL, M., AHMAD, I. AND HAFEEZ-UR-REHMAN, M., 2004. Salinity tolerance of rohu (*Labeo rohita*) and its hybrid under different temperature regimes. *Int. J. Agric. Biol.*, **6**: 1030-1032.

MENKE, K.H. AND STEINGASS, H., 1988. Estimation of the energetic feed value from chemical analysis and in vitro gas production using rumen fluid. *Anim. Res. Dev.*, **28**:

7-55.

METWALLY, M.A.A. AND EL-GELLAL, A.M., 2009. Used of some plant wastes for fish feeding with reference on its impact on growth performance and body composition. *World appl. Sci. J.*, **6**: 1309-1313.

NAEEM, M., SALAM, A., ISHTIAQ, A. AND SHAFIQUE, S., 2010. Length-weight and condition factor relationship of farmed hybrid (*Catla catla* ♂ x *Labeo rohita* ♀) from Multan, Pakistan. *Sindh Univ. Res. J. (Sci. Ser.)*, **42**: 35-38.

NWANNA, L.C., 2003. Risk management in aquaculture by controlled feeding regimes. *Pakistan J. Nutr.*, **2**: 324-328.

RATH, R.K., 2000. *Freshwater aquaculture*, 2nd Ed., Scientific Publishers, Jodhpur, India.

RICHARDS, L.A., 1954. *US Salinity Lab. Staff. Diagnosis and improvement of saline and alkali soil. USDA Handbook 60*. Washington, DC, USA.

SHAHZADI, T., SALIM, M., UM-E-KALSOOM AND SHAHZAD, K., 2006. Growth performance and feed conversion ratio (FCR) of hybrid fingerlings (*Catla catla* × *Labeo rohita*) fed on cottonseed meal, sunflower meal and bone meal. *Pakistan Vet. J.*, **26**: 163-166.

STANKOVIC, M.B., DULIC, Z.P. AND MARKOVIC, Z.Z., 2011. Protein sources and their significance in carp (*Cyprinus Carpio* L.) nutrition. *J. agric. Sci.*, **56**: 75-86.

TAHIR, Z.M.I., AHMAD, I., MATEEN, A., ASHRAF, M., NAQVI, Z.H. AND ALI, H., 2008. Studies on partial replacement of fish meal with oilseeds meal in the diet of major carps. *Int. J. Agric. Biol.*, **10**: 455-458.

WATANABE, T., VERAKUNPIRIYA, V., WATANABE, K., KIRON, V. AND SATOH, S., 1997. Feeding in rainbow trout with non-fish meal diets. *Fish. Sci.*, **63**: 258-266.

WEISBERG, S., SPANGLER, G. AND RICHMOND, L.S., 2010. Mixed effects models for fish growth. *Can. J. Fish. aquat. Sci.*, **67**: 269-277.

WHO, 1995. *Guideline for drinking water*. World Health Organization, Geneva.

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