The Journal of Animal & Plant Sciences, 25(2): 2015, Page: 561-566
ISSN: 1018-7081

A STUDY ON GROWTH PERFORMANCE AND SURVIVAL OF INDUS GOLDEN MAHSEER (*TOR MACROLEPIS*) WITH INDIAN MAJOR CARPS IN SEMI-INTENSIVE POLYCULTURE SYSTEM

A. M. Chatta[1], A. M. Khan[2], M. N. Khan[2] and M. Ayub[3]

[1]Fisheries Research and Training Institute Manawan, Post office Batapur (53400), G. T. Road Lahore, Pakistan.
[2]Department of Zoology, University of the Punjab, Lahore, Pakistan, PO box 54590.
[3]Department of Fisheries**,** Government of the Punjab, 2- Sanda Road Lahore, Pakistan**.**
Corresponding Author E-mail: majid.zool@pu.edu.pk

ABSTRACT

Studies were conducted to explore the survival and growth potential of *Tor macrolepis* in existing polyculture system when cultured with Indian major carps *viz, Labeo rohita* (Rohu), *Catla catla* (Thaila) and *Cirrhinus mrigala* (Mrigal). There were two treatments and a Control, with three replicates each. Fish stocking density in all the treatments was kept 2000 fish/ha. Control contained only *Tor macrolepis* (100%); Treatment-1 (T_1) stocked with *Labeo rohita* 60%, mrigal 25% and *Catla catla*15%; while Treatment- 2 (T_2) with *Tor macrolepis* 20%, *Labeo rohita* 50%, *Cirrhinus mrigala* 20% and *Catla catla*10%. Fish was fed daily, @ 5% of its body weight and studies were continued for 120 days. Among treatments, *Tor macrolepis* gained slightly higher weight in T_2 than Control; *Labeo rohita* gained significantly higher in T_1 than T_2; *Cirrhinus mrigala* gained slightly higher weight in T_2 than T_1 and *Catla catla* gained similar weight in both, T_1 and T_2. Overall *Catla catla* gained maximum weight while *Tor macrolepis* gained minimum. The survival rate and feed conversion ratio (FCR) of *Tor macrolepis* was significantly higher in T_2 than Control. It is observed that *Tor macrolepis* has some food overlapping with *Labeo rohita*.

Key words: Semi-intensive, polyculture, Mahseer, Rohu, Mrigal, Thaila, FCR, SGR.

INTRODUCTION

Mahseers (Tor species) are distributed in South-east Asian and Himalayan regions including trans-Himalayan countries like Pakistan, India, Nepal, Myanmar and South-east Asian countries like Malaysia, Thailand, Cambodia, Lao-PDR, Vietnam etc. (De Silva *et al*.,2004). Golden mahseer is known as a high valued game and food fish (Ayub *et al*., 2007). This popular game fish is amongst the largest species of family Cyprinidae and attains weight, over 50 kg and is called as the pride of Anglers (Mirza and Bhatti, 1996). The golden mahseer in Indus River System is *Tor macrolepis*, found in four ichthyo-geographic provinces of Pakistan (Pervaiz *et al*., 2012). Unfortunately natural mahseer populations are declining throughout its geographic distribution. The fish has now been identified as a critically endangered in many countries ~~and~~ depletion of mahseer populations is reported from various parts of Pakistan, Bangladesh and India (Mirza *et al*., 1994; Kulkarni, 1991; Dubey, 1994; IUCN, 1998; Hussain and Mazid, 2001; Shrestha, 1994). To protect mahseer from elimination and to conserve its natural stocks, the development of breeding, rearing and culture techniques of this fish are very essential (Rahman *et al*., 2007).

The available studies on mahseer primarily focus on taxonomy, morpho-metery and breeding (Chaturvedi, 1976; Chandra and Haque, 1982; De Silva *et al*., 2004; Brett *et al*., 2005; Naeem *et al*., 2010). A few publications are available on growth and cultural aspects of mahseer (Shrestha, 1994; Rahman *et al*., 2007; Debajit and Jha, 2010). After successful production of seed of *Tor macrolepis* in Punjab, on mass scale; techniques and methods need to be developed for its successful culture and sustainability of stocks. Indian major carps are successfully cultured on low-cost conventional supplemental diets under semi-intensive pond polyculture in Punjab, Pakistan. Previously some experiments on polyculture of mahseer with Indian major carps have been conducted in Bangladesh (Rahman *et al*., 2007). The present study is an attempt to monitor survival and growth rate of mahseer, when cultured with these commercial fish varieties on low cost diets under locally existing culture system, to explore the aquaculture potential of this fish species.

MATERIALS AND METHODS

Experimental station and design: Experiment was conducted at Fish Seed Nursery Kotli Araian, district Sialkot, in nine rectangular earthen ponds of identical size i.e. 0.227 ha each, (225′ ×110′) having average 4′ water depth, for a period of 120 days from 4th May to 31st August. There were two experimental treatments and a Control with three replicates in each. All ponds were stocked according to the ratios as described in table-1,

following instruction of the Department of Fisheries, Punjab prepared for fish farmers. (www.punjabfisheries.gov.pk).

Table 1. Species combination used in different treatments

Treatment	Species Combination	Species ratio (%)	Stocking density/ha
Control	Mahseer	100	2000
	Total	**100**	**2000**
Treatment 1 (T_1)	*Labeo rohita*	60	1200
	Cirrhinus mrigala	25	500
	Gibelion catla	15	300
	Total	**100**	**2000**
Treatment 2 (T_2)	Mahseer	20	400
	Labeo rohita	50	1000
	Cirrhinus mrigala	20	400
	Gibelion catla	10	200
	Total	**100**	**2000**

All the experimental fishes were procured from Fish Nursery Kotli Araian and held there in cemented tanks for acclimatization for ten days. Before stocking, ten fish samples of each species were collected randomly from the bulk, weighed and measured for baseline data (Table-2). On termination of feeding trial all the fishes were harvested, weighed and measured for growth comparisons.

Pond preparation: Pond preparation was done following Rahman *et al*., (2005). Before start of experiment all ponds were drained and sun-dried till cracking of the bottom soil. Quick lime (calcium oxide @ 300 kg / ha) was spread on the dried pond bottom. Ponds were manured with cow dung @ 4000 kg / ha, fertilized with Di Ammonium Phosphate (DAP) and Urea @ 100 and 50 Kg /ha and filled with tube well water. After five days acclimatized fish seed was stocked in each pond.

Fertilization of ponds and Feeding: For natural productivity of fish ponds, fortnightly, applications of manure (cow dung) @ 800 kg/ ha and inorganic fertilizers (DAP and Urea) @ 25 kg and 10 kg/ ha respectively were done throughout the experiment in all nine ponds. Low cost (12.5% protein feed) was prepared with a combination of rice polish and wheat bran (2:1 ratio), fortified with1% vitamin premix. Prepared feed was offered to all the dietary treatments in mash form @ 5% of fish wet biomass, twice a day at 8.00 am and 5.00 pm. Daily feed ration was adjusted after every 30 days of fish sampling.

Physico-chemical parameters: Temperature was recorded by ordinary thermometer, pH by digital pH meter (VSI pH 100), D.O. by YSI DO Pro-20, water transparency by Secchi's disc, total alkalinity and total hardness with Hach Model 16800, once a day on daily basis.

Sampling and statistical analysis: Ten fishes of each species from each pond were sampled after every 30 days, weighed individually and released back. All 9 ponds were harvested at the end of experiment and fish were weighed for estimation of growth increments and counted to determine survival of fishes in each pond. Data collected were statistically analyzed by SPSS (version 18). Growth rate, Survival, Food Conversion Ratio (FCR), Specific Growth Rate (SGR) were determined at the end of experiment from the data using standard methods following Sawhney and Gandotra (2010) and for physico-chemical parameters, one way ANOVA was applied.

RESULTS AND DISCUSSION

Physico-chemical parameters: Fortnightly variations were observed in all parameters in all treatments (Table-4). Among treatments, morning and noon temperature, total alkalinity and total hardness were not significantly different in Control, T_1 and T_2. Water transparency was significantly higher in Control than $T_1$and T_2 while DO of morning and noon and pH, both were significantly lower in T_1 than T_2. In general all the water quality parameters remained within the acceptable limits for fish culture, throughout the experimental period. All the physic-chemical parameters recorded during the entire experiment were comparable to the studies of Wahab *et al*., (1995) and Kohinoor *et al*., (1998) who had similar observations.

Survival and Growth Performance: The survival in different fish species under different treatments ranged from 70.93% to 100% (Table-3). The significantly low survival of mahseer was observed in Control than T_2 might be a cause of reduction in natural food due to stress on production of zooplanktons because of monoculture and better interaction of mahseer in polyculture. The survival of *Catla catla* was 100% in both treatments which attributes to large stocking size. This also

advocates the recommendations of stocking fish seed of large size to get better growth. The overall survival of T_1 and T_2 was closer to Rahman *et al*., (2007) findings in polyculture.

Table-4. Mean values (± S.D) and ranges of water quality parameters in different treatments.

Parameters	Control	Treatment-1	Treatment-2
Water temperature (ºC)			
Morning	24.56 ± 2.12[a]	25.30 ± 2.76[a]	25.50 ± 2.82[a]
	(21.00-30.20)	(19.60-28.50)	(20.50-29.50)
Noon	29.48 ± 2.62[a]	30.30 ± 2.72[a]	31.00 ± 2.42[a]
	(26.00-39.00)	(26.50-38.20)	(27.00-38.50)
Water transparency (cm)	35.30 ± 4.82[a]	30.07 ± 5.86[b]	30.48 ± 5.99[b]
	(26.00-48.00)	(20.00-48.00)	(20.00-48.00)
Dissolved Oxygen (mg/l)			
Morning	4.35 ± 0.76[a]	3.31 ± 0.81[b]	3.46 ± 1.02[b]
	(3.60-6.00)	(2.60-6.00)	(2.60-6.20)
Noon	8.81 ± 1.58[a]	5.58 ± 1.57[b]	5.55 ± 1.69[b]
	(6.80-9.30)	(3.60-8.50)	(3.60-8.60)
pH	8.22 ± 0.29[a]	8.44 ± 0.30[b]	8.46 ± 0.28[b]
	(7.50-8.60)	(7.60-8.60)	(7.60-8.60)
Total alkalinity (mg/l)	228.30 ± 35.47[a]	242.55 ± 28.25[a]	238.00 ± 33.86[a]
	(170.00-350.00)	(195.00-340.00)	(218.00-360.00)
Total hardness (mg/l)	255.40 ± 32.26[a]	72.28 ± 38.34[a]	267.62 ± 24.18[a]
	(200.00-380.00)	(212.00-368.00)	(220.00-380.00)

Values with the same superscript letters across the row "a.b.c." are not significantly different (P>0.05).

Mean initial and final weights and weight gain by all species are given in Table-2. Intra-species growth didn't vary considerably except *Labeo rohita*. Weight gain in mahseer in T_2 (97.73 ± 2.13 g) was though statistically non-significant but was slightly higher than in Control (88.53 ± 2.89 g). This indicates that mahseer performs equally in mono and polyculture with these stocking ratios and can be comfortably cultured in semi-intensive pond polyculture with Indian major carps even with low protein supplementary feed. However the growth rate was slow due to low protein diet as Islam, (2002). Low percentage of protein in this experimental diet however did not affect much the health, survival and growth of *Tor macrolepis* possibly due to high performance of natural planktonic food than that of supplementary feed as reported by Haque *et al*., (1993); Haque *et al*., (1994), and Rehman *et al*., (2007).

Among Treatments mean weight gain of *Labeo rohita*, in T_1 (489.06 ± 6.28 g) was significantly higher ($p < 0.001$) than T_2 (411.73 ± 3.67 g) which indicates that there was some food overlapping between *Labeo rohita* and *Tor macrolepis* particularly in planktonic food in ponds where mahseer pulled its share. This contradicts with the findings of Rahman *et al*., (2007), who reported that the growth of *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* was not affected when cultured with mahseer. This may be due to variation in stocking ratio or compulsion in utilization of same natural food produced by manuring and fertilization. Weight gains of *Cirrhinus mrigala* in $T_1$and T_2 were almost similar. This indicates that mahseer does not share natural planktonic food with *Cirrhinus mrigala* and mahseer, *Cirrhinus mrigala* combination, growing in same pond has least negative effect on each other which is in line with the findings of Rahman *et al*., (2007). Tripathi, (1995) also stated that mahseer did not compete with *Cirrhinus mrigala* and common carp. The *Catla catla* also grew unaffected showing very little difference in weight gain in both treatments. This was perhaps due to proper utilization of food and less competition for space and habitat (Islam, 2002 and Islam *et al*., 2002).

Inter species growth performance varied considerably except *Labeo rohita* and *Cirrhinus mrigala*. Growth rate among fishes was highest in *Catla catla* and lowest in mahseer. Final weight of mahseer was significantly lower than *Labeo rohita*, *Cirrhinus mrigala* and *Catla catla* ($P < 0.001$). *Labeo rohita* showed significantly higher final weight than mahseer and lower than *Catla catla* but no significant difference was observed when compared with *Cirrhinus mrigala*. The highest growth of *Catla catla* was because of four possible reasons including stocking of big size seed, low stocking density, less food competition (Rahman *et al*., 2007) and fast growing nature of *Catla catla*. The similar growth of *Labeo rohita* and *Cirrhinus mrigala* with almost half stocking density of *Cirrhinus mrigala* indicates relatively slow growth rate of *Cirrhinus mrigala* than *Labeo rohita*. The slowest growth of semi-cold water mahseer, (±90g) was due to slow growth rate of genus Tor.

Table-2. Mean (± S.D) growth performance of fishes in different treatments.

Parameters		Control	Treatment-1	Treatment-2
Survival (%)				
a)	**Mahseer**	70.93 ± 6.05[a]	-	90.84 ± 1.68[b]
b)	***Labeo rohital***	-	82.35 ± 5.19[a]	81.06 ± 4.04[a]
c)	***Cirrhinus mrigala***	-	87.43 ± 5.36[a]	77.29 ± 2.77[b]
d)	***Catla catla***	-	100.00 ± 0.00[a]	100.00± 0.00[a]
Initial weight (g)				
a)	**Mahseer**	1.27 ± 0.05[a]	-	1.22 ± 0.05[a]
b)	***Labeo rohita***	-	6.37 ± 0.21[a]	6.30 ± 0.18[a]
c)	***Cirrhinus mrigala***	-	3.68 ± 0.61[a]	3.65 ± 0.16[a]
d)	***Catla catla***	-	170.23 ± 4.46[a]	172.73 ± 4.56[a]
Final weight (g)				
a)	**Mahseer**	89.80 ± 3.21[a]	-	98.73 ± 2.13[a]
b)	***Labeo rohita***	-	495.43 ± 6.40[a]	418.03 ± 3.92[b]
c)	***Cirrhinus mrigala***	-	442.63 ± 5.17[a]	498.20 ± 5.98[a]
d)	***Catla catla***	-	1333.63 ± 16.30[a]	1276.20 ± 15.12[a]
Weight gain (g)				
a)	**Mahseer**	88.53 ± 2.89[a]	-	97.51 ± 2.19[a]
b)	***Labeo rohita***	-	489.06 ± 6.28[a]	411.73 ± 3.67[b]
c)	***Cirrhinus mrigala***	-	438.95 ± 4.92[a]	494.55 ± 5.87[a]
d)	***Catla catla***	-	1163.40 ± 16.30[a]	1103.47 ± 12.68[a]

Values with the different superscript letters across the row "a.b.c." are significantly different (P<0.05).

Specific Growth Rate (SGR), FCR and Production: The specific growth rate (SGR%/day) of mahseer, *Labeo rohita*, *Cirrhinus mrigala* and *Catla catla* was significantly different among different treatments showing difference in response of same fish in different combinations. Among fishes, SGR (%/day) of mahseer, *Labeo rohita*, *Cirrhinus mrigala* and *Catla catla* was 1.54, 1.51, 1.73 and 0.72. SGR of mahseer and *Labeo rohita* was almost similar, which again advocates some food overlapping among these. SGR was highest in *Cirrhinus mrigala* indicating a positive co-response among mahseer and *Cirrhinus mrigala*. The lowest SGR in *Catla catla* was probably due to its least interaction with other species due to considerably stocking ratio. Bandari, (1998) noted SGR of *Labeo rohita*, *Cirrhinus mrigala* and *Catla catla* 2.40, 2.56 and 3.00, which are considerably higher than present study. This overall low SGR might be attributed to the use of low protein supplemental diet in the present study.

The FCR of mahseer in Control (2.74±0.01) was significantly higher than T_2 (2.505 ± 0.005); of *Labeo rohita* and *Cirrhinus mrigala* in T_1 (3.13 ± 0.13 and 2.95 ± 0.001) was also significantly higher than in T_2 (2.7 ± 0.01 and 2.79 ± 0.01). However for *Catla catla*, the case was reversed and FCR for T_1 (3.29 ± 0.003) was significantly lower than T_2 (3.35 ± 0.002) indicating efficient feed utilization by *Catla catla* in T_1 than T_2. Among fishes (Table-3) the FCR was the lowest in mahseer and highest for *Catla catla* having a significant difference among each other except between *Labeo rohita* and *Cirrhinus mrigala*. Thus FCR has shown a kind of correlation with size. Smaller fish showed lower FCR while the bigger fish showed higher FCR. The possible causes are, ration size, digestibility and utilization of feed. Reddy and katro, (1979) and Das and Ray, (1989) reported increasing FCR value with increasing ration size in growth experiments of catfish *Heteropneustes fossilis* and *Labeo rohita*. Ghosh *et al.*, (1984) also found increasing FCR values for common carp when increasing ration.

Among the three treatments, the highest total (Gross and Net) production of fish was recorded in the order of T_1, T_2 and Control (Table-3). The lowest production in T_1 can be attributed to considerably slow growth rate of mahseer as compared to Indian major carps. This indicates that monoculture of mahseer in earthen ponds is un-economical and hence is not advisable. Similarly among treatments, low production of T_2 than T_1 was probably also due to introduction of mahseer. The maximum gross fish production seen in T_2 (3249 kg) is closer to the gross production reported by Mazid *et al*., (1997). They got 3600 kg /ha/yr from polyculture of carps.

Table-3. Mean (± S.D) Survival, SGR, FCR and production of fishes in different treatments.

Parameters		Control	Treatment-1	Treatment-2
Specific growth rate (SGR) (%/day)				
a)	Mahseer	1.54 ± 0.001[a]	-	1.59 ± 0.002[b]
b)	*Labeo rohital*	-	1.57 ± 0.003[a]	1.52 ± 0.001[b]
c)	*Cirrhinus mrigala*	-	1.73 ± 0.001[a]	1.78 ± 0.001[b]
d)	*Catla catla*	-	0.74 ± 0.001[a]	0.72± 0.00[b]
Food convertion ratio (FCR)				
a)	Mahseer	2.74 ± 0.01[a]	-	2.51 ± 0.01[b]
b)	*Labeo rohital*	-	3.13± 0.13[a]	2.70 ± 0.01[b]
c)	*Cirrhinus mrigala*	-	2.95 ± 0.001[a]	2.79 ± 0.01[b]
d)	*Catla catla*	-	3.29 ± 0.003[a]	3.35 ± 0.002[b]
Gross production (kg/ha/year)				
a)	Mahseer			
b)	*Labeo rohital*	381.00	-	108.00
c)	*Cirrhinus mrigala*	-	1467.00	1017.00
d)	*Catla catla*	-	583.00	463.00
Total gross production (kg/ha/year)		-	1199.00	759.00
		381.00[a]	**3249.00[b]**	**2347.00[c]**
Net production (kg/ha/year)				
a)	Mahseer	375.00	-	107.00
b)	*Labeo rohital*	-	1448.00	1001.00
c)	*Cirrhinus mrigala*	-	578.00	460.00
d)	*Catla catla*	-	1043.00	658.00
Total Net production (kg/ha/year)		**375.00[a]**	**3069.00[b]**	**2226.00[c]**

Values in same row with same superscript "a.b.c." are not significantly different (P>0.05).

Conclusion: This is the first ever successful attempt to culture endangered mahseer, a semi-cold water fish in conventional warm water polyculture system in Pakistan. Fish survival was very encouraging; however its growth ~~is~~ was relatively slow when compared with other Indian major carps. *Tor macrolepis* probably has some food overlapping with *Labeo rohita*. Further experimentation on mixed polyculture of Indian major carps with *Tor macrolepis* with special focus on interspecific feeding competition may help in resolving the growth related issues of *Tor macrolepis.*

Acknowledgements: The fish seed and pond facilities for the present study were provided by Punjab Fisheries Department, Government of the Punjab. The authors are thankful to the fisheries department and staff of Fish Nursery Kotli Araian, district Sialkot.

REFERENCES

Ayub, M., I. Ahmad and K. Pervaiz (2007). Breeding of Tor putitora with and without Hypophysation at Hattian Nursery Unit District Attock, Punjab-Pakistan. Mahseer: The Biology, Culture and Conservation. Proc. International Symposium on the "Mahseer 2006", Kuala Lumpur, Malaysia. 99-106.

Bandari, R.K. (1998). Optimization of supplementary feeding rate for the composite carp culture in Bangladesh. M.S. Thesis. Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. 67 pp.

Brett, I., S. Sungan, G. Gooley, S.Y. Sim, D. Tinggi, and S.S. DeSilva (2005). Induced spawning, larval development and rearing of two indigenous Malaysian mahseer, Tor tambroides and T. douronensis. Aquaculture Research. 36: 1001-1014.

Chandra, K.J. and A. Haque (1982). Studies on the biology of Tor spp. in natural and artificial waters of Bangladesh: II-Taxonomy, Bangladesh. J. Fish. 2-5: 59-64.

Chaturvedi, S.K. (1976). Spawning histology of Tor mahseer, Tor tor (Ham.). J. Bombay Nat. Hist. Soc. 73: 63-73.

Das, I. and A.K. Ray (1989). Growth performance of Indian major carps *Labeo rohita* (Ham.) on duckweed incorporated pelleted feed: a preliminary study. J. Inland Fish. 21: 1-6.

De Silva, S.S. Brett, I. Stephen, S. David, T. Geoff and S.Y. Sim (2004). Artificial propagation of indigenous tor species, empurau (T. tambroides) and semah (T. *douronensis*), Sarawak, East Malaysia. Research and farming techniques IX. 4: 15-20.

Debajit, S. and G.N. Jha (2010). Effect of Spirulina Fortified Diets on growth and survival of chocolate mahseer (Neolissochilus hexagonolepis). Ind. J. Anim. Nutri. 27(4):441-446.

Dubey, G.P. (1994). Endangered, vulnerable and rare fishes of West Coast river system of India. Threatened Fish of India. Proceedings of the National Seminar on Endangered Fishes of India Held at National Bureau of Fish Genetic Resources, Allahabad, India, (1992). Nature Conservators. 77-95.

Fish Farming manual. Accessed online from www.punjabfisheries.gov.pk, pp 1-7.

Ghosh, S.K., B.K. Mandaland, D.N. Borthakur (1984). Effects of feeding rates on production of common carp and water quality in paddy cum fish culture. Aquaculture 40: 97-101.

Haque, M.Z. Rahman, M.A. Hossain, M.M. and M.A. Rahman (1994). Effect of stocking densities on the growth and survival of mirror carp, Cyprinus carpio var. specularis in rearing ponds. Bangladesh J. Zool. 22: 109-116.

Haque, M.Z., M.A. Rahman, and M.M. Hossain (1993). Studies on the effect of stocking densities on the growth and survival of *Cirrhinus mrigala* fry in rearing ponds. Bangladesh J. Zool. 2 (1): 51-58.

Hussain, M.G. and M.A. Mazid (2001).Genetic improvement and conservation of carp species in Bangladesh. Bangladesh Fisheries Research Institute and International Center for Living Aquatic Resources Management. 74 pp.

Islam, M.S. (2002). Evaluation of supplementary feeds for semi-intensive pond culture of mahseer, Tor putitora (Ham.). Aquaculture. 212: 263-276.

Islam, M.S., S. Dewan, M.G. Hussain, M.A. Hossain, and M.A. Mazid (2002). Feed utilization and wastage in semi-intensive pond culture of mahseer, Tor putitora (Ham.). Bangladesh J. Fish Res. 6:1-9.

I.U.C.N. Bangladesh (1998). List of threatened animals of Bangladesh Paper presented in the special workshop on Bangladesh Red Book of Threatened Animals, 22 February (1998), Dhaka. 13 pp.

Kohinoor, A.H.M., M.L. Islam, M.A. Wahab, and S.H. Thilsted (1998). Effect of mola (Amblypharyngodon mola Ham.) on the growth and production of carps in polyculture. Bangladesh J. Fish. 2 (2): 111-126.

Kulkarni, C.V. (1991). Mahseer, the mighty game fish of India. Fish Chimes. 11(3): 43-49.

Mazid, M.A., M. Zaher, N.N. Begum, M.Z. Ali, and F. Nahar (1997). Formulation of cost effective feeds from locally available ingredients for carp polyculture systems for increased production. Aquaculture. 151:71-78.

Mirza, M.R. and M.N. Bhatti (1996). Systematics and Biology of the Golden Mahseer of the Indus River system. Biologia (Pakistan) 42(1-2): 31-35.

Mirza, M.R., M.N. Javed, M. Tariq (1994). A note on the fish of the river Zhob, Pakistan. Pak. J. Biol. Sci. 26:189 pp.

Naeem, M., A. Salam, M. Khalid, and M. Ashraf (2010). Effect of body size and condition factor on whole body composition of immature population hatchery reared mahseer from Pakistan. 2nd Int. Con. Nov. 2-4 on Chemical, Biological and Environmental Engineering (ICBEE). 286-289.

Pervaiz, K., Z. Iqbal, M.R. Mirza, M.N. Javed, and M. Naeem (2012). Meristic and Morphometric studies of Indus mahseer *Tor macrolepis* (Heckel) (Teleostei: Cyprinidae) from Attock Pakistan. Int. J. Agric. Biol. Sci. 14: 169-175.

Rahman, M.A., M.A. Mazid, M.R. Rahman, M.N. Khan, M.A. Hossain and M.G. Hussain (2005). Effect of stocking density and growth of critically endangered mahseer, Tor putitora (Hamilton), in nursery ponds. Aquaculture 249 (1-4): 275-284.

Rahman, M.A., M.R. Rahman, and M.S. Rahman (2007). Evaluation of growth and production of mahseer, Tor putitora (Ham.) in polyculture with indigenous major carps. Mahseer: The Biology, Culture and Conservation. Proc. International Symposium on the "Mahseer 2006", Kuala Lumpur, Malaysia. 161-175.

Reddy, S.R., S. Katro (1979). Growth rate and conversion efficiency of air breathing catfish, Heteropneustes fossilis in relation to ration size. Aquaculture 18: 35-50.

Sawhney, S. and R. Gandotra. 2010. Growth Response and Feed Conversion Efficiency of *Tor putitora* (Ham.) Fry at Varying Dietary Protein Levels. Pak. J. Nutr. 9 (1): 86-90.

Shrestha, T.K. (1994). Migration and spawning of golden mahseer in Himalayan waters of Nepal. J. Freshwater. Biol. 6: 71-77.

Tripathi, S.D. (1995). Summary of Proceedings of 4th Workshop on Conservation of Mahseer.

Wahab, M.A., Z.F. Ahmed, M.A. Islam, and S.M. Rahmatullah (1995). Effect of introduction of common carp, Cyprinus carpio (L) on the pond ecology and growth of fish in polyculture. Aquaculture Res., 26: 619-628.