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STUDIES ON SURVIVAL OF ENDANGERED INDUS GOLDEN MAHSEER (*TOR MACROLEPIS*) AND ITS IMPACT ON GROWTH OF OTHER CARPS

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ABSTRACT

To observethe survival and growth of golden mahseer *(Tor macrolepis)*and its impact on other traditionally cultured carps in pond polyculture, a study was conducted at Fisheries Research and Training Institute, Manawan, Lahore. Fish fingerlings in equal densities, i.e. 2000 ha^{-1}were stocked with two combinations(i.e. two treatments) in triplicate and fed with supplementary feed containing 25% crude protein @ 3%of live body weight. Fortnightweights, net weight gains (NWG), percentage weight gain (PWG), specific growth rate (SGR),gross and net fish productions/ha/year were calculated. Comparison through multivariate analysis of variance (MANOVA) showed that final weights of *Labeorohita*, *Catlacatla* and *Ctenopharyngodonidella* were significantly higher in T_1 ($P < 0.05$) than in T_2, while of *Cirrhinusmrigala* and *Hypophthalmichthesmolitrix* did not varied statistically ($P > 0.05$).The inclusion of mahseer in 2nd treatment did not affect the survival rate of experimental fish species.It can be concluded that endemic Indus mahseer can survive and grow under warm water polyculture, however it has significant negative effects on growth of *Labeorohita*, *Catlacatla* and if prolonged on*Ctenopharyngodonidella* and also on overall per unit fish production.

Key words: *Tor macrolepis*, major carps, fortnight growth, semi-intensive, polyculture.

INTRODUCTION

Indus Golden Mahseer, an important game and appetizing food fish (Basade and Mohan, 2009) is among bigger sized species of Cyprinids (Thapa, 1994) and may grow beyond 50kg in weight and 2.75m in length (Dhu and Shene, 1923). Disappointingly over decades, the natural stocks of this fish are diminishing all along its distribution range (Gupta and Khan, 1994;Bista *et al*, 2006) due to worsening environment, anthropogenic activities and unsystematic fishing (Mohan and Bassde, 2005). The fish is now considered endangered in most of the inhibiting countries (Hossain*et al.*, 2002; Ayub *et al*, 2007). Golden mahseer possessing many qualities like omnivorous feeding habit, preferred consumers acceptability, acceptance of artificial diet and development of seed production techniques (Shreshtha, 1994; Basade and Kohli, 2011) can be a looming candidate for recruitment as aquaculture species (De Silva *et al*,2004).

Mahseer is present in both, the Ganga-Brahmaputra River System of India and the Indus River System of Pakistan. The golden mahseer of Ganga-Brahmaputra River System is *Tor putitora* while of Indus River System;varying in different features is *Tor macrolepis* (Mirza, 2004; Pervaiz *et al*, 2011). During recent years, many fisheries researchers have focused their attention to explore the aquaculture prospective of *Tor putitora* and worked on its survival, growth, optimum dietary protein requirements, FCR and SGR (Islam *et al*, 2002; Rahman*et al*, 2005; Sawhney and Gandotra, 2010) while very little work has yet been done on Indus golden mahseer (*Tor macrolepis*). Some studies include those on induced spawning (Ayub *et al*, 2007), weight-length relationship (Chatta and Ayub, 2010), indoor culture (Chatta *et al*, 2015); while studies on its growth potential and cultural aspects are presently lacking in Pakistan.

Keeping in view the rehabilitation and conservation of endemic Indus mahseer in natural waters andto explore the prospects of this high priced food fish for commercial aquaculture, Indus mahseer fingerlings were cultured with other major carpsunder semi-intensive pond polyculture. The basic objectives of this study were to assess the survival and growth of this endangered fish in local warm water polyculture and its effects on growth of locally cultures, Indian major carps and Chinese carps.

MATERIALS AND METHODS

a. **Experimental site, pond preparation and stocking:**The experiment was conducted on hatchery reared fingerlings of Indus golden mahseer and five Indian and Chinese major carps *viz.*, *Labeorohita*, *Cirrhinusmrigala*, *Catlacatla*, *Hypophthalmichthesmolitrix* and *Ctenopharyngodonidella* at Fisheries Research and Training Institute,Manawan, Lahore for a period of 75 days. Six earthen ponds of equal size (0.05 ha each)were sun-dried and treated with quicklime i.e. calcium oxide @ 300 kg ha^{-1}.A week after liming, the ponds weremanuredwith cow dung @ 6000 kgha^{-1}, fertilized with dye-ammonium phosphate (DAP) and urea @ 100 and 50 kg ha^{-1},respectively and filled with tube well water, following Rahman*et al*. (2007). All ponds were left un-stocked for further seven days for plankton productivity to be used as natural fish food.

Fish seed of uniform size for same species, with slight variations among different species was stocked at equal densities, @ 2000ha^{-1} in each pond as per recommendations of the Departmentof Fisheries Punjab. Two treatments in triplicate were designed for the experiment as given below in Table1.

Table 1. Seed stocking of different fish species in two treatments

Species	Treatment 1 (T-1)		Treatment 2 (T-2)	
	Stocking %age	No of fish stocked ha^{-1}	Stocking %age	No of fish stocked ha^{-1}
C. catla	25	500	21	420
L.rohita	30	600	26	520
C.mrigala	15	300	11	220
C. idella	15	300	11	220
H. molitrix	15	300	11	220
T.macrolepis	-	-	20	400
Total:	**100%**	**2000**	**100%**	**2000**

b. **Feeding and fertilization of ponds:** The natural pond productivity in both the treatments was maintained by fortnight application of manure (cow dung) @ 1200 kg ha^{-1} and inorganic fertilizers (DAP and Urea) @ 22.5 kg and 5 kg ha^{-1}, respectively throughout the experiment. Pelleted feed, containing 25% crude protein was prepared from locally available ingredients usingrice polish, maize gluten meal and soybean as major feed ingredients along with fish meal and wheat bran (Table-2). Feed was given to fish, daily (once a day) @ 3% of live body weight both in $T_1$and T_2.Crude protein of all feed ingredients in triplicate was analyzed by Kjeldahl method and calculated using given formula following AOAC, 2006.

$$\text{Nitrogen (\%)} = \frac{\text{Volume} \times \text{Normality} \times 0.014 \times 250 \times 100}{\text{Weight of sample} \times 10}$$

Where,
Volume = Volume of H_2SO;
Normality = Normality of H_2SO_4

The daily feed ration was adjusted fortnightly based on estimated fish biomass. Water quality parameters like temperature (°C), dissolved oxygen (mg/l) and pH were monitored on daily basis. The required water level of 1.5 meter was maintained by addition of fresh tube well water as and when needed.

Table 2:Crude protein level and percentage contribution of different feed ingredients

Sr. No.	Ingredient	Crude protein %age*	%age used in feed formula	Crude protein Contribution(%age)
1.	Rice Polish	12.6 ± 0.80	35	4.41
2.	Maize gluten meal	30.00 ± 2.69	35	10.5
3.	Soybean	45.00 ± 1.50	14	6.3
4.	Fish meal	46.00 ± 1.81	5	2.3
5.	Wheat bran	14.9 ± 1.38	10	1.49
6.	DI-Methionine	-	0.2	-
7.	I-Lysine	-	0.1	-
8.	Vitamin and mineral premix	-	0.7	-
	Total		**100.00**	25 %

***** Crude protein %age Mean ± SD, n = 3

c. Fish sampling and statistical analysis: Ten fishes of each species from each pond were sampled after every fortnight, weighedindividually and released back. All six ponds were harvested at the end of experiment; required fish samples were weighed and measured and total fish were counted to evaluate survival, growth and production. Data was statistically analyzed by SPSS-20. Growth indices were compared by T-test and multivariate analysis of variance (MANOVA) was applied to statistically test the effect of two treatments on the weight of experimental carps and separate univariate ANOVAs were done as a “step down analysis” after MANOVA.

RESULTS

The growth in terms of final weight, weight gain and SGR of mahseer in T_2 remained 46.60g ± 10.51, 37.60 ± 4.06g and 1.09 ± .076, respectively (Table-3). Final weights of *Catlacatla, Labeorohita, Cirrhinusmrigala, Ctenopharyngodonidella* and *Hypophthalmichthysmolitrix* remained 341.55±38.07 and 258.07±39.27 g; 246.21±32.81 and 201.07±32.71 g; 156.23±28.22and 147.87±30.03 g; 288.03±60.90 and 245.99±27.93 g and276.52±50.21 and 275.04±34.65gin $T_1$and T_2respectively (Table-4).Finalweights of *Labeorohita, Catlacatla* and *Ctenopharyngodonidella* were significantly higher inT_1 ($P < 0.05$) than in T_2, while of *Cirrhinusmrigala* and *Hypophthalmichthysmolitrix* did not varied statistically ($P > 0.05$).When fortnightly weight increments were compared through multivariate analysis of variance (MANOVA) and separate univariate ANOVAs (Table-5); *Labeorohita* and *Catlacatla* showed significant growth variations from the day 16 (2nd fortnight) onward, while *Ctenopharyngodonidella* started significant growth variation from day 46 (4th fortnight). These fortnightly growth variations among treatments have clearly been depicted in figure, 1, 2, 3, 4 and 5.

Table 3:Fortnightly weight increments of *Tor macrolepis* in Treatment 2.

Weight of Fish (g)	Fortnights					
	1	2	3	4	5	6
Mean	9.16	15.75	26.84	31.53	43.5	46.75
SEM	0.081	0.865	1.171	2.120	1.924	1.987
SD	0.624	4.750	6.410	11.610	10.540	10.510

Table-4:Mean (±SD) growth performance of different fish species in two treatments over75 days experiment.

Species	Treatment	Initial Weight	Final Weight	Net weight gain (gm)	Percentage weight gain (%WG)	Specific growth rate (%)
C. catla	T1	3.75±.7310^a	341.55±38.07^b	337.8±5.80^b	9026.0±438.33^b	3.01±.027^b
	T2	3.87±.7245^a	258.07±39.27^a	254.2±5.44^a	6586.5±457.14^a	2.80±.044^a
L. rohita	T1	7.70±.9768^a	246.21±32.81^b	238.5±9.09^b	3096.2±157.92^b	2.31±.035^b
	T2	7.73±.7520^a	201.94±23.70^a	194.2±6.83^a	2513.6±129.06^a	2.18±.029^a
C. mrigala	T1	7.82±.7959^a	156.23±28.22^a	148.4±1.53^a	1897.8±22.01^a	2.00±.006^a
	T2	7.64±.9988^a	147.87±30.03^a	140.2±7.69^a	1836.3±70.21^a	1.98±.025^a
C. idella	T1	3.98±.8120^a	288.03±60.90^b	284.0±28.83^a	7130.9±1055.66^a	2.85±.095^a
	T2	3.84±.6366^a	245.99±27.93^a	242.1±7.18^a	6300.3±452.16^a	2.77±.050^a
H. molitrix	T1	3.84±.8593^a	276.52±50.21^a	272.7±24.13^a	7094.9±736.13^a	2.85±.070^a
	T2	3.53±.7116^a	275.04±34.65^a	271.5±8.07^a	7684.3±458.17^a	2.90±.040^a
T.macrolepis	T2	9.0±0.624	46.60±10.51	37.60±4.06	417.8±56.60	1.09±.076

Figures for same species with different superscript letters "a,b" across the column are significantly different (p <.05).
T1: carps; T2: carps + mahseer

As shown in Table-6, the net weight gain (NWG), percentage weight gain (PWG) and specific growth rate (SGR) of *Labeorohita* and *Catlacatla* were also significantly higher in T_1 than in T_2, while these growth indices did not showed any significant variation for *Ctenopharyngodonidella*, *Hypophthalmichthys molitrix* and *Cirrhinusmrigala*in both treatments. The survival rate of all fish species in both the treatments remained same i.e. 100% and was not affected by any change in fish combinations. The growth rate of mahseer was very slow as compared with other carps (Figure 6). Gross and net fish productions/ha/year (2602.39 and 2547.93 kg; 1845.48 and 1784.38 kg) when calculated and statistically analyzed, were also significantly higher in T_1 than in T_2 ($P < 0.05$). The physico-chemical parameters *viz.*, temperature, dissolved oxygen (DO) and pH of water remained within suitable range of fish culture, without any significant difference among treatments ($P > 0.05$) (Table-7).

Table 5:Multivariate analysis of variance (MANOVA) results of fortnightlyincrease in weight of Carps in T1 and T2.

Fortnight	Dependent Variable	F-Value	Multivariate Tests of Significance †	Significant Univariate F-Test *	Difference
Initial	*C. catla*, *L. rohita*, *C. mrigala*, *C. idella*, *H. molitrix*	.620	p = .685	-	-
1	*C. catla*, *L. rohita*, *C. mrigala*, *C. idella*, *H. molitrix*	2.064	p = .084	-	-
2	*C. catla*, *L. rohita*, *C. mrigala*, *C. idella*, *H. molitrix*	170.12	p = .000	*C. catla* (p = .000) *L. rohita*(p = .000)	$T_1 > T_2$ $T_1 > T_2$
3	*C. catla*, *L. rohita*, *C. mrigala*, *C. idella*, *H. molitrix*	40.43	p = .000	*C. catla* (p = .000) *L. rohita*(p = .000)	$T_1 > T_2$ $T_1 > T_2$
4	*C. catla*, *L. rohita*, *C. mrigala*, *C. idella*, *H. molitrix*	20.80	p = .000	*C. catla* (p = .000) *L. rohita*(p = .000) G. carp (p = .000)	$T_1 > T_2$ $T_1 > T_2$ $T_1 > T_2$
5	*C. catla*, *L. rohita*, *C. mrigala*, *C. idella*, *H. molitrix*	23.52	p = .000	*C. catla* (p = .000) *L. rohita*(p = .000) G. carp (p = .001)	$T_1 > T_2$ $T_1 > T_2$ $T_1 > T_2$

* p<.05

T1: carps; T2: carps + mahseer.

† Multivariate tests of significance include tests of Pillais, Wilks, Hotellings, and Roys. The value of Wilks' Lambda was used as the F-ratio.

Table 6:Gross and net fish productions in two treatments over 75 days experiment.

Parameters	Treatment	
	T_1	**T_2**
Gross Production(kg/ha/yr)		
C. catla	831.11	527.49
L. rohita	718.94	511.05
C. mrigala	228.10	158.32
C. idella	420.52	263.37
H. molitrix	403.72	294.48
T. macrolepis	-	90.77
Total Gross Production(kg/ha/yr)	**2602.39[b]**	**1845.48[a]**
Net Production(kg/ha/yr)		
C. catla	821.98	519.58
L. rohita	696.45	491.50
C. mrigala	216.68	150.14
C. idella	414.71	259.25
H. molitrix	398.11	290.70
T. macrolepis	-	73.20
Total Net Production(kg/ha/yr)	**2547.93[b]**	**1784.38[a]**

Figures with different superscript letters "a,b,c" across the row are significantly different (p < .05)

T1: carps; T2: carps + mahseer

Table 7:Fortnightly mean and ranges of temperature and DO of ponds.

T1	Fortnight	Temperature (°C)		DO		pH	
		Mean ± SEM	Min - Max	Mean ± SEM	Min - Max	Mean ± SEM	Min – Max
	1	29.44±.1736	28.0 - 31.5	3.17±.238	2.5 - 4.8	7.8±.0894	7.5 - 8.3
	2	29.88±.2002	27.5 - 31.0	3.38±.376	2.8 - 5.4	7.6±.1528	7.3 - 8.4
	3	28.35±.3289	26.0 - 31.0	4.08±.296	2.8 - 6.8	7.7±.2758	7.4 - 8.6
	4	28.85±.0975	28.0 - 30.0	4.40±.260	3.0 - 7.4	8.0±.2135	7.4 - 8.7
	5	26.41±.1456	25.0 - 28.0	4.82±.095	3.4 - 8.4	7.9±.0112	7.6 - 8.4
	1	29.26±.1986	28.0 - 31.0	3.19±.263	2.6 - 5.4	7.5±.2778	7.1 - 7.8
	2	29.94±.1911	27.5 - 32.0	3.42±.365	2.8 - 6.6	7.7±.0982	7.2 - 8.2
T2	3	28.22±.3159	25.5 - 31.0	4.12±.284	3.2 - 6.7	7.8±.1345	7.4 - 8.3
	4	28.71±.1007	27.0 - 30.0	4.68±.253	3.2 - 7.8	7.6±.2201	7.2 - 8.2
	5	26.27±.1691	24.5 - 28.5	4.90±.103	3.5 - 6.4	7.8±.0791	7.5 - 8.4

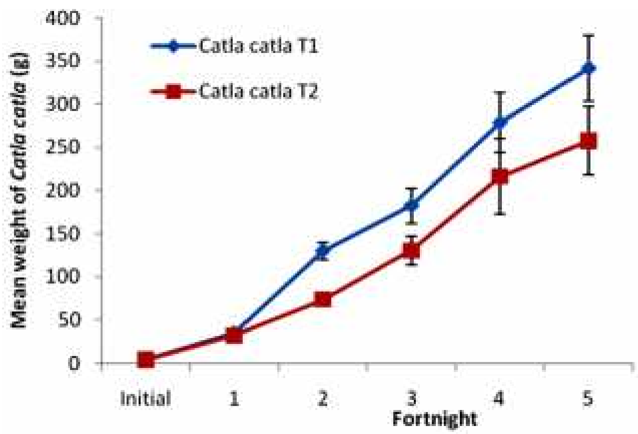

Fig. 1: Fortnight growth comparison of *Catlacatla* in both treatments

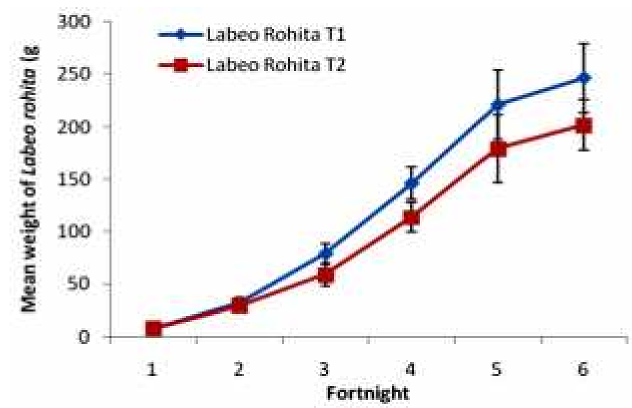

Fig. 2: Fortnight growth comparison of *Labeorohita* in both treatments

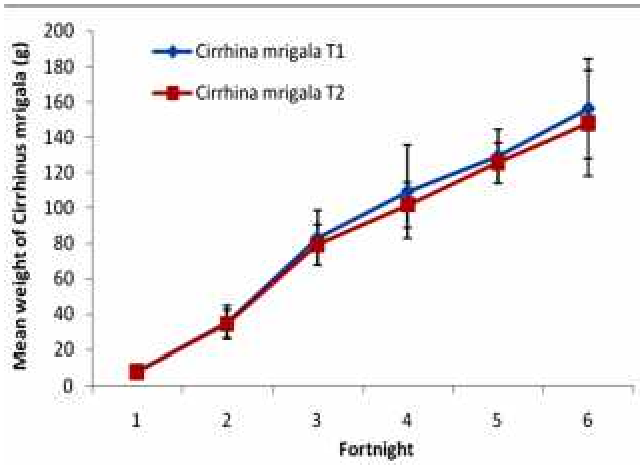

Fig. 3: Fortnight growth comparison of *Cirrhinamrigala* in both treatments

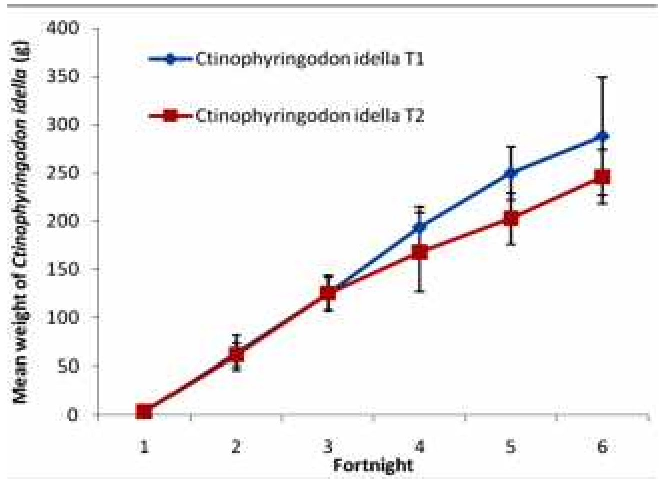

Fig. 4:Fortnight growth comparison of*Ctinophyringodonidella* in both treatments

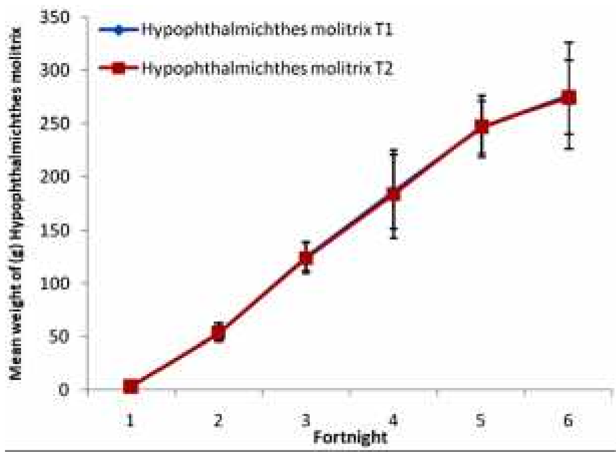

Fig. 5: Fortnight growth comparison of *Hypophthalmichthys molitrix* in both treatments

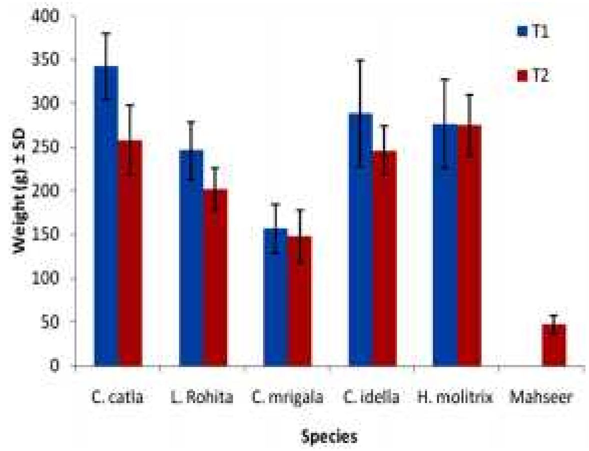

Fig. 6: Growth comparison of cultured fish species in both treatments

DISCUSSION

Survival of this semi-cold water fish, *Tor macrolepis* in warm water ponds was 100%, which was very encouraging and almost similar to the findings of Mohan and Basade (2005) and Chatta *et al*. (2015) who also reported very high survival rates of masheer. This reflects that this semi-cold water species can equally survive in warm water pond polyculture. Growth performance of mahseer in terms of final weight, weight gain and SGR is very low when compared with other carps. Rahman*et al.* (2007) findings are almost in agreement with the present study.

Growth in terms of final weight of *Labeorohita*, *Catlacatla*, and *Ctenopharyngodonidella* and in terms of weight gain of *Labeorohita* and *Catlacatla*, *were* significantly higher in T_1 than in T_2 which suggest that mahseer has some food overlapping with *Labeorohita* and *Catlacatla* in natural plankton pond food and mahseer might has pulled its share (Haque *et al.*, 1993). *Ctenopharyngodonidella*, which basically eats macrophytes also interestingly showed significantly higher growth in T_2in spite of different food habits. This might had happened after consistent change in pond primary productivity patterns due to addition of mahseer. The *Cirrhinusmrigala* and *Hypophthalmichthys molitrix* did not showed any significant difference in growth in both the treatments, which indicates that mahseer did not share natural food with *Cirrhinusmrigala* and *Hypophthalmichthys molitrix*. Tripathi (1995) reported same results with *Cyprinuscarpio* and *Cirrhinusmrigala.* While Rahman *et al.* (2007) reported same with *Cirrhinusmrigala.*

In fortnightly weight increments *Labeorohita* and *Catlacatla* showed significant growth variations among T_1 and T_2 from the 2^{nd} fortnight which confirms the food overlapping of masheer with *Labeorohita* and *Catlacatla*, while *Ctenopharyngodonidella* showed growth variation from 4^{th} fortnight which might be attributed to change in pond productivity patterns due to masheer. Mean SGR of *Labeorohita*, *Cirrhinusmrigala*, *Catlacatla*, *Hypophthalmichthysmolitrix* and *Ctenopharyngodonidella* remained 2.31 and 2.18; 2.00 and 1.98; 3.01 and 2.80; 2.85 and 2.77; 2.85 and 2.90 in T_1 and T_2 respectively. Bandari (1998) reported SGR of *Labeorohita*, *Catlacatla* and *Cirrhinusmrigala*, 2.40, 3.00 and 2.56 respectively, which was little closer to the present study.

Food combinations, fish growth and production are normally governed by some physic-chemical factors (Brett, 1979). The optimal and acceptable range of water temperature for fish ponds as suggested by Haque *et al*. (1993) and Rahman*et al.* (2005) is 29.1-32.4^{o}C. In this experiment water temperature ranged 24.5-32^{o}C which is similar to the observations recorded by Azim*et al*. (1995) and Kohinoor *et al.* (1998).The DO levelsare similar to the findings of Wahab *et al.* (1995) while pH values in the present study fluctuated between 7.1-8.7, which was suitable and in agreement with the pH values suggested by Hora and Pillay (1962) andRahman*et al.*(2007).

Conclusion: It can be concluded that this semi-cold water, endemic Indus golden mahseer cancomfortably survive and grow in warm water pond polyculture with relatively slower growth rate when compared with other cultured carps. It might has some food overlapping with*Labeorohita* and *Catlacatla* and if prolonged, also with*Ctenopharyngodonidella*.*Tor macrolepis* has no effect on growth of *Cirrhinusmrigala* and *Hypophthalmichthysmolitrix.* However, further investigations are required done to be in correlation with pond primary plankton productivity and food preferences toconfirm these food overlapping.

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