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## Studies on Indoor Culture of Indus Golden Mahseer (*Tor macrolepis*) in Central Punjab, Pakistan

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**Abstract:** Studies were conducted to investigate the survival and growth performance of hatchery reared, semi-cold water, Indus golden mahseer (*Tor macrolepis*) fingerlings in indoor cemented tanks on different feed rations in Central Punjab. There were three ration levels; 4, 5 and 6% of live body weight of fish, designated as treatment 1 (T<sub>1</sub>), treatment 2 (T<sub>2</sub>) and treatment 3 (T<sub>3</sub>), respectively. Each treatment was run in triplicate. Fish were housed in 9 indoor cemented tanks of 6 m<sup>3</sup> each and experiment was continued for 150 days from October to March. Ninety fingerlings of uniform size were stocked in each tank at 15 fish/m<sup>3</sup>. Feed prepared from locally available ingredients, containing 43% crude protein was offered to all treatments with different ration levels mentioned earlier. Temperature (°C), dissolved oxygen (mg/l) and pH were monitored on daily basis twice a day and kept within optimal ranges required for fish culture through aeration and partial exchange of water. The results reveal that this game fish, *Tor macrolepis* can survive successfully and grow comfortably under monoculture in Central Punjab. The difference in ration size however, influenced the growth of fingerlings but not the survival. Maximum final weight i.e., 15.52±0.448 g was observed in T<sub>3</sub> that significantly differed from T<sub>2</sub> (13.60±0.368 g) and T<sub>1</sub> (12.97±0.367 g). Net weight gain increased significantly with the increase in ration rate. PWG and SGR were higher in T<sub>3</sub> as compared to T<sub>2</sub> and T<sub>1</sub> at p<0.05. T<sub>2</sub> and T<sub>3</sub> had high values of FCR than T<sub>1</sub>, while FCE was significantly high in T<sub>1</sub>, followed by T<sub>2</sub> and T<sub>3</sub>. So, ration rate was directly related to NWG, PWG, SGR and FCR and had inverse relation to FCE.

**Key words:** *Tor macrolepis*, semi-cold water, survival, growth, indoor culture, artificial feed

### INTRODUCTION

Mahseer is considered an important food and sport fish (Singh *et al.*, 2009) due to its nutritional value and high market price. This fish inhabits semi-cold waters of foot hills and has a wide distribution in sub-continent (Shrestha *et al.*, 1990; Talwar and Jhingran, 1992; Chatta and Ayub, 2010). At early stages of its development it is carnivorous (Froese and Pauly, 1999) and later on diverts to omnivore when approaches adulthood. Sometimes it becomes opportunistic feeder and also feeds on larvae, small mollusks and algal coating on rocks (Shrestha, 1997). Unfortunately natural stocks of mahseer are severely thinning all-around from its natural trans-Himalayan habitats due to indiscriminate fishing, industrial pollution, population pressure, introduction of exotic fish species and low fecundity (Rahman *et al.*, 2005).

In Pakistan only two valid species of mahseer named zhobi mahseer and the golden Indus mahseer are found. The name, *Tor putitora* (Hamilton) has wrongly been used in literature for golden mahseer of Indus river system. Actually, the golden mahseer found in the Ganges-Brahmaputra river system of India is *Tor putitora* while mahseer of Indus river system of Pakistan is *Tor macrolepis* (Mirza, 2004; Pervaiz *et al.*, 2012). Indus mahseer population is drastically depleting from

natural habitats of Pakistan (Mirza, 1994; Mirza *et al.*, 1994) Like other culturable fish species it can be successfully cultured in captivity because it readily accepts artificial diet, shows good growth and can be used to control tilapia (Shrestha, 2000). Its growth rate is comparatively lower than cultured carps however; growth rate of adult mahseer can be enhanced by providing artificial feed containing primarily animal products with minor contribution from plant by products (Bista *et al.*, 2000).

This species has been successfully induced bred at Fish Nursery Hattian, district Attock, Punjab, Pakistan (Ayub *et al.*, 2007). Now the Department of Fisheries, Punjab has planned to rehabilitate its natural stocks and also introduce this species in existing aquaculture system in Punjab province due to its peculiar qualities. The objective of this study was to determine growth and survival of advanced stage fry of this species under monoculture on locally formulated artificial diet on different ration sizes in indoor cemented tanks.

### MATERIALS AND METHODS

**Study site and experimental design:** The experiment was conducted at Fisheries Research and Training Institute Manawan, Lahore, for a period of 150 days from October to March in indoor cemented

tanks having size 3 x 2 x 1.5 m (length x width x depth) each. Water however, was filled up to 1 m only to avoid jumping and escape of fish so the total water volume remained 6 m<sup>3</sup>. There were three treatments with three replicates of each. Ninety fingerlings were stocked in each tank at 15 fish/m<sup>3</sup>.

**Feed preparation and administration:** Pelleted Feed was prepared from locally available ingredients containing 43% crude protein using soybean and fish meal as major ingredients along with maize gluten meal (Table 1). The crude protein level of feed ingredients was determined by Kjeldahl method. The obtained values of nitrogen were multiplied by factor 6.25 to get crude protein level each ingredient following AOAC (1995). Three samples of each of the feed ingredients were analyzed to get mean crude protein percentage. Feed was administered to fish; daily (once a day) at 4, 5 and 6% of live body weight to T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively. The daily feed ration for each tank was adjusted on fortnightly basis at the time of fish sampling with proportionate increase in live fish weight. Feed formula and chemical composition is given below in Table 1.

Table 1: Crude protein level and %age contribution of different feed ingredients

Ingredient	Crude protein (%age <sup>*</sup> )	Percent age used in feed formula	Crude protein contribution (%age)
Soybean (extruded whole)	45.00±1.50	68.94	31.00
Fish meal	45.00±1.79	20.00	9.00
Maize gluten meal	30.00±2.69	10.00	3.00
DL-Methionine	-	0.26	-
L-Lysine	-	0.10	-
Vitamin and mineral premix	-	0.70	-
Total	100.00	43.00	

\*Crude protein % age Mean±SD, n = 3

**Water quality parameters and sampling:** To keep the water quality at optimal levels of fish culture, temperature (°C), dissolved oxygen (mg/l) and pH were regularly recorded twice a day at 08.00 am and 02.00 pm. Water was aerated when and where required. Water tanks were cleaned weekly and one third water of each tank was replenished with fresh tube well water. Ten fish from each tank were randomly sampled after each 15 days, weighed individually and released back. At the end of experimental trial, all the fish were harvested, counted to determine survival rate and weighed to assess growth increment.

**Determination of growth indices:** Percentage survival and growth indices such as average final weight, net weight gain (NWG), percentage weight gain (PWG), specific growth rate (SGR), food conversion ratio (FCR) and food conversion efficiency (FCE) were determined at the end of experiment from the data using standard methods.

**Statistical analysis:** Data collected were subjected to one-way analysis of variance (ANOVA). Statistical analysis was performed using SPSS17.0. Differences among treatments means were distinguished by Least Significant Difference (LSD) test and were considered significant at p<0.05.

## RESULTS

Fingerlings of *Tor macrolepis* successfully and uniformly survived in all the three treatments in spite of different feeding rations with percentage survival of 95.93±1.33, 96.70±1.10 and 97.07±1.68% in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively (Table 2). The initial average weights of fingerlings of mahseer were 6.80±0.157, 6.93±0.178 and 7.38±0.265g in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively with no significant difference. While at the end of the experiment maximum weight i.e., 15.52±0.448 g was observed in T<sub>3</sub> (feeding at 6%), followed by 13.60±0.368 g in T<sub>2</sub> (feeding at 5%) and 12.97±0.367 g in T<sub>1</sub> (feeding at 4%). The mean final weight of fingerlings in T<sub>3</sub> was significantly higher than T<sub>1</sub> and T<sub>2</sub> but mean final weight of T<sub>2</sub> in spite of slight increase did not differ significantly from T<sub>1</sub> (p<0.05). The percentage weight gain (PWG) and specific growth rate (SGR%/day) under different treatments also followed the same trend (Table 3).

The mean net weight gain (NWG) of fingerlings fed on varying rations was 6.17±0.12, 6.67±0.14 and 8.13±0.30 g in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively showing significant difference in all treatments. T<sub>3</sub> showed significantly higher weight gain followed by T<sub>2</sub> and T<sub>1</sub>. Similarly food conversion ratio (FCR) was significantly lower in T<sub>1</sub> (10.41±0.254) than T<sub>2</sub> (12.88±0.268) and T<sub>3</sub> (13.50±0.597), but in spite of lower value the FCR of T<sub>2</sub> did not differ significantly from T<sub>3</sub>. Thus FCR has shown an increasing trend with the increase in ration size. On the other hand food conversion efficiency (FCE) was observed significantly higher in T<sub>1</sub> than T<sub>2</sub> and T<sub>3</sub> exhibiting no significant difference between T<sub>2</sub> and T<sub>3</sub>. When fortnight growth increments of fingerlings in terms of weight were statistically analyzed; it revealed that growth of fish in T<sub>3</sub> became significantly higher than T<sub>1</sub> (p<0.05) from 2nd to the last fortnight, while T<sub>3</sub> differed with T<sub>2</sub> from 8th fortnight and the same significant difference continued till the last fortnight (Table 4). Overall ration rate showed a direct relation with NWG, PWG, SGR and FCR and inverse relation with FCE.

Among water parameters, temperature ranged from 12.48±0.42 to 26.78±0.81°C, throughout the 150 days experiment; lowest in January and highest in October. Similarly dissolved oxygen and pH ranged from 4.62±0.18 to 8.73±0.55 mg/l and 8.12±0.20 to 8.37±0.30, respectively (Table 5). This was the first ever attempt to rear this fish in soil less indoor tanks under monoculture in warm water of Central Punjab. These results revealed that fingerlings of this semi-cold water fish can survive uniformly irrespective of the difference

Table 2: Percentage survival of Mahseer fingerlings in different treatments

Replicate	Treatment 1			Treatment 2			Treatment 3		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
Initial stocking (n)	90	90	90	90	90	90	90	90	90
Final harvesting (n)	87	85	87	86	88	87	87	86	89
Percent age survival	96.7	94.4	96.7	95.6	97.8	96.7	96.7	95.6	98.9
Mean±SD (% age survival)	95.93±1.33 <sup>a</sup>			96.70±1.10 <sup>a</sup>			97.07±1.68 <sup>a</sup>		

\*Means of percentage survival across the row are not significantly different (p = 0.619)

Table 3: Net weight gain, percentage weight gain (%WG), SGR, FCR and FCE of Mahseer fingerlings in different treatments

Replicate	Net weight gain (gm)	Percentage weight gain (%WG)	Specific growth rate (%)	Food conversion ratio	Food conversion efficiency	
						Treatment
Treatment -1 (feeding at 4% body weight)	1	6.10	91.04	0.432	10.333	9.678
	2	6.10	88.41	0.422	10.692	9.353
	3	6.30	92.65	0.437	10.200	9.804
	Mean±SD	6.17±0.12 <sup>a</sup>	90.70±2.14 <sup>a</sup>	0.430±0.007 <sup>a</sup>	10.41±0.254 <sup>a</sup>	9.61±0.233 <sup>a</sup>
Treatment -2 (feeding at 5% body weight)	1	6.75	98.54	0.457	12.661	7.898
	2	6.50	92.86	0.438	13.177	7.589
	3	6.75	97.12	0.452	12.794	7.816
	Mean±SD	6.67±0.14 <sup>b</sup>	96.17±2.96 <sup>a</sup>	0.449±0.01 <sup>a</sup>	12.88±0.268 <sup>b</sup>	7.77±0.160 <sup>b</sup>
Treatment -3 (feeding at 6% body weight)	1	8.45	119.86	0.525	12.866	7.772
	2	7.85	105.37	0.480	14.050	7.117
	3	8.10	105.88	0.481	13.594	7.356
	Mean±SD	8.13±0.30 <sup>c</sup>	110.37±8.22 <sup>b</sup>	0.495±0.026 <sup>b</sup>	13.50±0.597 <sup>b</sup>	7.42±0.331 <sup>b</sup>

Figures with different superscript letters <sup>a,b,c</sup> across the column are significantly different (p<0.05)

Table 4: Fortnightly increase in weight of mahseer fingerlings during experimental period

	Treatment-1	Treatment-2	Treatment-3
Initial	6.80±0.157 <sup>a</sup>	6.93±0.178 <sup>a</sup>	7.38±0.265 <sup>a</sup>
1	8.73±0.274 <sup>a</sup>	9.53±0.180 <sup>a</sup>	9.43±0.409 <sup>a</sup>
2	10.03±0.303 <sup>a</sup>	10.68±0.230 <sup>ab</sup>	10.97±0.252 <sup>b</sup>
3	10.38±0.352 <sup>a</sup>	11.23±0.252 <sup>ab</sup>	11.77±0.365 <sup>b</sup>
4	10.87±0.284 <sup>a</sup>	11.63±0.211 <sup>ab</sup>	12.18±0.351 <sup>b</sup>
5	11.27±0.298 <sup>a</sup>	12.20±0.266 <sup>b</sup>	13.52±0.417 <sup>c</sup>
6	11.70±0.367 <sup>a</sup>	12.57±0.354 <sup>ab</sup>	13.67±0.466 <sup>b</sup>
7	12.07±0.353 <sup>a</sup>	13.05±0.283 <sup>ab</sup>	13.83±0.449 <sup>b</sup>
8	12.40±0.341 <sup>a</sup>	13.20±0.335 <sup>a</sup>	14.30±0.459 <sup>b</sup>
9	12.70±0.343 <sup>a</sup>	13.40±0.346 <sup>a</sup>	14.85±0.488 <sup>b</sup>
Final	12.97±0.367 <sup>a</sup>	13.60±0.368 <sup>a</sup>	15.52±0.448 <sup>b</sup>

Figures with different superscript letters

<sup>a,b,c</sup> across the row are significantly different (p<0.05)

in feed rations, however it can be assumed that variation in growth increments among treatments was attributed to differences in ration sizes.

## DISCUSSION

In present study fingerlings of *Tor macrolepis* uniformly survived in all the three treatments in spite of different feeding rations with survival rate above 95%. This indicates that this semi-cold water fish is well capable to survive in central Punjab and ration size does not affect survival of the fish. This survival rate is compatible to the findings of Mohan and Basade (2005) and Misieng *et al.* (2011). Mohan and Basade (2005) reported 96-99% survival of golden mahseer, *Tor putitora* with no statistically significant difference among different diets. Similarly Misieng *et al.* (2011) worked on dietary protein requirements of Malaysian mahseer (*Tor tambroides*) fingerlings and reported very high survival rates from 91-100% observing no significant difference (p<0.05) under diets of varying protein levels. This indicates that

mahseer can survive equally good at diverse feed rations and dietary protein levels.

The golden mahseer fry and fingerlings have carnivorous feeding habit (Nautiyal, 1994), which suggests their higher protein requirements at early stages of life. In this experiment crude protein level (43%) was very near to Sunder *et al.* (1998) who reported better growth and survival of golden mahseer fed 45.4% crude protein. Mohan and Basade (2005) conducted growth experiment on *Tor putitora* juveniles fed on three different diets containing crude protein 30, 47.47 and 51.65% and reported better growth in fish fed with 47.47%. However, Joshi *et al.* (1989) reported 35% crude protein best for its growth while Islam (2002) reported lower growth performances in supplementary feed containing 20.3-29.5% crude protein. Among other common culturable freshwater fishes, crude protein requirement have been recorded for fry of grass carp 45.6% by Dabrowski (1977) for fry of Nile tilapia 40% by Siddiqui *et al.* (1988) and AlHafedh (1999).

The major growth indices like Mean Final Weight, Mean Weight Gain, Percentage Weight Gain and Specific Growth Rate (SGR%/day) of *Tor macrolepis* fingerlings were monitored. Fish showed increasing trend in growth, with the increase in feed from 4 to 6% of fish biomass. Growth was comparatively higher in T<sub>3</sub> where feeding %age was maximum (6% of body weight) compared to those of T<sub>1</sub> (4%) and T<sub>2</sub> (5%). The causes of less growth in first two treatments might be food competition due to less feed availability (Haque *et al.*, 1993; Kohinoor *et al.*, 1994). In the present study, the mean weight gain of fingerlings fed on varying rations was 6.17±0.12, 6.67±0.14 and 8.13±0.30 g in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively showing significant difference in all

Table 5: Mean ranges of water quality parameters during experimental months

Month	----- Water temperature -----		----- Dissolved oxygen -----		----- pH -----	
	Morning	After noon	Morning	After noon	Morning	After noon
Oct	24.23±0.47	26.78±0.81	6.52±0.26	8.73±0.55	8.14±0.13	8.16±0.07
Nov	20.08±0.41	21.13±0.73	5.23±0.58	6.16±0.64	8.24±0.05	8.32±0.23
Dec	15.13±0.42	17.14±0.62	6.44±0.30	6.70±0.31	8.37±0.30	8.41±0.04
Jan	12.48±0.42	13.10±0.52	5.35±0.13	5.39±0.17	8.19±0.02	8.20±0.02
Feb	16.10±0.58	17.50±1.03	5.46±0.05	5.24±0.10	8.15±0.08	8.20±0.04
Mar	17.35±0.79	19.55±1.01	4.62±0.18	6.06±1.83	8.12±0.20	8.23±0.34

treatments. The increase in PWG and SGR was proportional to the increase in ration size. The highest SGR was observed in T<sub>3</sub> fed with 6% of body weight (0.495±0.026%) which is similar to the studies on other mahseers viz, on *Tor tor* by Sehgal (1999) and on *Tor khudree* by Ogale (2002). The value of SGR of *Tor macrolepis* in present study was much lesser than other culturable fish species like tilapia (1.400%) and common carp (1.280%), reported by Kaushik (1998) and *Labeo rohita* (1.060%) and *Cirrhinus mrigala* (1.080%), reported by Parveen *et al.* (2012) but comparatively higher than the studies of Islam (2002), who reported GSR of *Tor putitora* ranged between 0.280-0.330%/day in indoor cemented tanks and 0.550-0.750%/day in earthen ponds. However Sawhney and Gandotra (2010) reported highest and lowest SGR of *Tor putitora* fed with 45 and 30% protein diet (0.719%) and (0.364%), respectively which is higher than the present findings.

FCR in this study was significantly lower in T<sub>1</sub> (10.41±0.254) than T<sub>2</sub> (12.88±0.268) and T<sub>3</sub> (13.50±0.597) which is close to Sawhney and Gandotra (2010). They reported average FCR of *Tor putitora* 13.393 at 30% protein feed. In spite of significantly higher weight gain in T<sub>3</sub>, the FCR showed increase with the increase in ration size from 4-6% body weight. Reddy and Katro (1979), Ghosh *et al.* (1984) and Das and Ray (1989) also reported the increase in FCR value with the increase in ration size while working on cat fish (*Heteropneustes fossilis*), rohu and common carp, respectively. The possible cause of increasing FCR may be the feed digestibility competence of fish as De Silva and Davy (1992) opinioned that digestibility has an imperative role to lower the value of FCR by efficient food utilization. Sawhney and Gandotra (2010) observed FCR of *Tor putitora* fry ranged from 6.91-13.39 with varying protein diets while Islam (2002) also reported high FCR of this fish (5.28-9.55). However Misieng *et al.* (2011) obtained reasonably low FCR of Malaysian mahseer, *T. tambroides* (2.19) using 5% semi-purified diet containing 40% dietary protein. Similarly, the food conversion efficiency (FCE) was significantly higher in T<sub>1</sub> than T<sub>2</sub> and T<sub>3</sub> indicating decrease in FCE with the increase in ration size. Low FCR and high FCE can be achieved by high digestibility, smaller ration size and proper use of feed (Misieng *et al.*, 2011). Fortnightly growth increments of fingerlings in terms of weight when

statistical analyzed; it revealed that growth of fish in T<sub>3</sub> became significantly higher than T<sub>1</sub> and T<sub>2</sub> (p<0.05) from 2nd and 8th fortnight, respectively. This indicates that ration size influenced fish growth even from the start of experiment.

This was the first ever attempt made, to culture the fingerlings of this endemic semi-cold water fish of Pakistan in monoculture under indoor tanks rearing system. Fish survived uniformly at different feed rations. The better growth was observed feeding fish at 6% body weight. However more specific studies on its stocking density and optimization of dietary protein requirements are required to bring this high prized fish in commercial aquaculture.

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