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Effect of stocking density on the survival and growth of tank-reared Deccan mahseer *Tor khudree* (Sykes, 1849)

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ABSTRACT

Deccan mahseer, *Tor khudree* (Sykes, 1849) is the most popular mahseer species of the Western Ghats. However, information on optimising stocking density for fingerling rearing is not available for *T. khudree*. A study was undertaken to evaluate the effect of stocking density on the growth and survival of the blue-fin mahseer, *Tor khudree* in fry to fingerling rearing. Fish were reared for 90 days at stocking densities of 15, 25, 35 and 45 fish m⁻² in soil-based 24 m² masonry tanks. The tanks were fertilised initially with cow dung at 3 t ha⁻¹ and were stocked with fry of *T. khudree* (mean length 1.31±0.09 cm; weight 9.49±0.12 mg) after a week of manuring. A mixture (1:1) of powdered groundnut oil cake and rice bran was fed at 10% of body weight to the fish during the first month. Subsequently, fish were fed to satiation with a fishmeal-based sinking pelleted feed (3 mm, 35% crude protein). The length of fish at harvest ranged from 5.03 to 6.43 cm and weight from 1.39 to 3.47 g. The mean final length, weight, specific growth rate and condition factor were the highest (p<0.05) under 15 m⁻² and lowest under 45 m⁻² stocking density. The condition factor remained above 1 under all the treatments. No significant (p>0.05) difference in the survival of fish at harvest was recorded. Fish biomass estimates were higher (p<0.05) at higher stocking densities. The similar (p>0.05) final length and condition factor between the stocking densities of 15, 25 and 35 m⁻² and the highest fish biomass at 35 m⁻² indicate a stocking density of 35 fry m⁻² as optimal for fry to fingerling rearing of *T. khudree*.

Keywords: Blue-fin mahseer, Peninsular carp, Seed rearing, Stocking density

The Deccan mahseer *Tor khudree* (Sykes, 1849) is the most popular mahseer species of the Western Ghats. The distribution range of the species was limited to eastward flowing Krishna river system including its tributaries, the Indrayani, Mula-Mutha, Koyna, Krishna, Tungabhadra and Panchaganga of Northern and Central Western Ghats (Hora, 1943). However, the species is currently known to be distributed throughout peninsular India, including the westward flowing river systems originating from the southern Western Ghats (Jayaram, 2005). This fish is reported to grow as high as 1.2 m and up to 50 kg in the wild (Froese and Pauley, 2019) and is an important species for recreational as well as aquaculture purposes. According to Goonatilake *et al.* (2020), local populations of the species have significantly declined both in their native range as well as in their type locality. Surveys of local fishers in the region have indicated that catches of *T. khudree* have declined drastically in the last few years and only smaller juveniles appear in the nets, compared to large adults that were frequently caught in the 1980s (Minimol, 2000). ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFG) has identified *T. khudree* as a potential cultivable species. Karamchandani (1972) opined that though *T. khudree* is an inhabitant of hill streams, it

thrives well in waters with high-temperature ranges also. Ogale (2002) reported that in village ponds near Lonavala, Maharashtra, *T. khudree* has grown between 600-900 g in one year and in Bhatnagar Reservoir near Pune the fish has been reported to have grown even faster. Kohli *et al.* (2002) carried out its culture trials in floating cages in open water and reported better growth as compared to earlier trials of pond culture or flow-through system.

Captive breeding of *T. khudree* was first carried out in 1970 by Kulkarni (1971) at Lonavala, followed by the distribution of thousands of seeds to various State Fisheries Departments and other stakeholders throughout India, primarily for stock enhancement in natural waters (Ogale, 2002). Presently, the technique for breeding and artificial propagation is available for *T. khudree* (Ogale, 2002) including pond-reared broodstock (Keshavanath *et al.*, 2006). Though considerable information has been generated in recent years on the spawning season and habits, methods of artificial propagation and hatchery management (Kulkarni and Ogale, 1986), published information on optimising stocking density for fingerling rearing is not available for *T. khudree*. The present work was therefore taken up to evaluate the effect of different

stocking densities on the growth and survival of Deccan Mahseer during fry to fingerling production in nursery tanks.

This 90-day growth trial was conducted in cement tanks (6 x 4 x 1.2 m) having 10 cm soil bottom with water spread area of 24 m². The source of water for the experimental tanks was from a nearby bore well. Tanks were fertilised using cow dung at 3 t ha⁻¹, a week before stocking (CIFA, 2009). Soap-oil emulsion was applied to the tanks a day before stocking, to eradicate the predatory insects (CIFA, 2009). The floating dead insects if any, were netted out the next day before stocking. Evaporation loss of water in the tanks was compensated at fortnightly intervals. Fry of mahseer, produced by induced breeding at our centre with an initial weight of 9.49±0.87 mg and 1.31±0.09 cm were stocked at 15, 25, 35 and 45 fish m⁻². For each experimental group, three tanks were maintained. During first month of rearing, a 1:1 mixture of groundnut oil cake powder and rice bran was provided as feed at 10% of fish biomass (CIFA, 2009). Subsequently, the experimental fish were fed to satiation with a fishmeal-based sinking pelleted feed with 35% crude protein (Barlaya *et al.*, 2021). Feeding was done once a day in the morning hours. While the rice bran-groundnut oil cake mixture was broadcasted in powdered form, the pelleted feed was given in plastic trays, suspended in the water column. Before feeding, the un-consumed feed of the earlier day in the trays was removed and the trays cleaned. Ingredient proportion and proximate composition of pelleted feed used for feeding are given in Table 1. Feed was prepared as follows: All the ingredients were sieved through a 0.5 mm screen and weighed quantities were mixed with hot water to make a dough, which after cooling and addition of vitamin and mineral mixture was passed through a hand pelletiser to obtain 3 mm pellets. The pellets were sun dried and packed in air-tight bags.

Pelleted feed was subjected to proximate analysis (AOAC, 1995). Water samples were collected between 08.30 and 09.00 hrs for analysis of dissolved oxygen, total alkalinity and hardness through standard procedures

(APHA, 2005) and pH and temperature using a probe. This was done at monthly intervals. Fish body weight was also measured at monthly intervals. At the end of rearing period, fingerlings were collected by repeated netting, followed by draining of tanks and handpicking. Final length and weight measurements of individual fish were recorded. Condition factor was determined using the following formula (Ricker, 1975):

$$K = 100 W/L^3$$

where K = Condition Factor, W = Weight in g and L = Length in cm

Duncan's multiple range test was used to rank the treatment means tested for significance ($p < 0.05$) employing analysis of variance (ANOVA) for the different parameters (Duncan, 1955; Snedecor and Cochran, 1968).

Water quality data of experimental tanks is given in Table 2. The parameters did not differ significantly ($p > 0.05$) during the study period. Temperature ranged between 22.87 and 23.13°C. The tank water was alkaline in nature with pH ranging from 8.59 to 8.89 and total alkalinity from 293.91 to 339.38 ppm. Water was slightly harder with hardness ranging from 192.12 to 223.33 ppm. Karamchandani (1972) opined that though *T. khudree* is an inhabitant of hill streams, it flourishes well in waters with high-temperature ranges also. Water quality parameters recorded in the present study were within the acceptable range for nursery rearing of fry and fingerlings of carps (Rahman *et al.*, 2005).

The length of fish at harvest ranged from 5.03 to 6.43 cm and weight from 1.39 to 3.47 g (Table 3). The mean final length, weight, specific growth rate (SGR) and condition factor were the highest ($p < 0.05$) under 15 m⁻² and lowest under 45 m⁻² stocking density (Fig. 1). In a similar study conducted for 90 days with another medium carp, *Hypselobarbus pulchellus*, Barlaya *et al.* (2021) recorded final length and weight ranging from 5.73 to 6.11 cm and 1.97 to 2.68 g respectively, for stocking

Table 1. Ingredient proportion (%) and proximate composition (mean±SD) of the formulated diet

Feed ingredient	%	Proximate parameters	
Fish meal	22	Moisture (%)	4.50±0.21
Rice bran	38	Crude protein (%)	34.89±0.35
Groundnut cake	30	Fat (%)	10.31±0.02
Finger millet flour	8	Ash (%)	8.93±0.12
Vitamin and mineral mixture*	2	Crude fibre (%)	10.69±0.19
		NFE (%)	30.64
		Gross energy (kJ g ⁻¹)	17.17

*Each kg has calcium - 25.5%; Phosphorus-12.75%; Manganese-6,000 mg; Sulphur-0.72%; Sodium-5.9 mg; Potassium-100 mg; Copper-1,200 mg; Cobalt-150 mg; Zinc-9,600 mg; Iron-1,500 mg; Iodine-325 mg; Selenium-10 mg; Manganese-1,500 mg; Vitamin A-7,00,000 IU; Vitamin D3-70,000 IU; Vitamin E-250 mg; Nicotinamide-1000 mg; DLmethionine-1,929 mg; L-lysine-4,400 mg; *Lactobacillus* sp. 1.5 × 1,011 CFU; *Saccharomyces cerevisiae* -30,000 million CFU

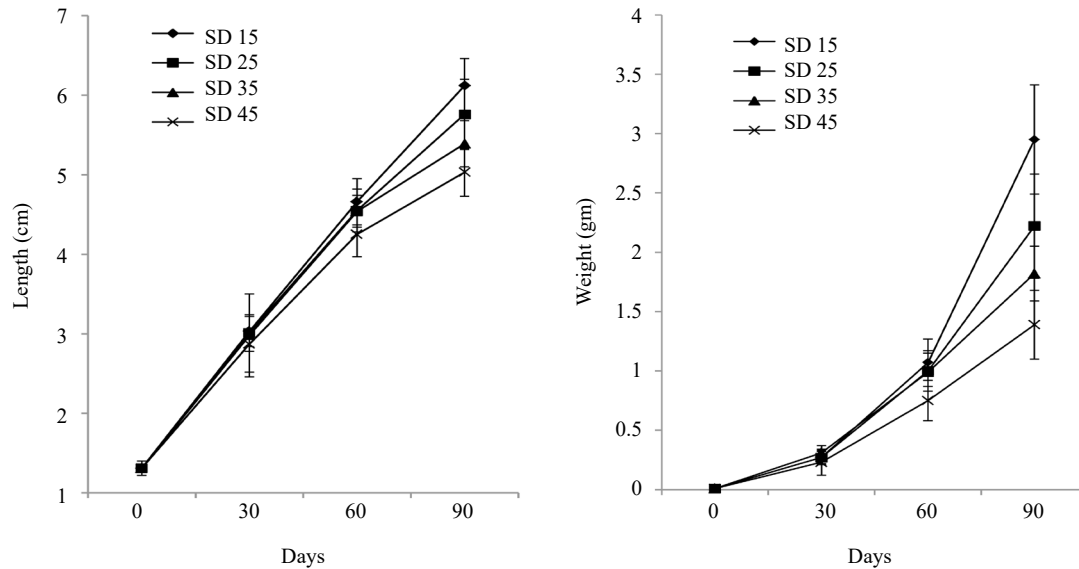
Table 2. Water quality analysis results (mean $\pm$ SD) of rearing tanks

Stocking density	Temperature ($^{\circ}$ C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Hardness (ppm)
SD 15	22.87 $\pm$ 0.75	8.89 $\pm$ 0.41	7.20 $\pm$ 0.63	331.41 $\pm$ 23.58	221.33 $\pm$ 6.11
SD 25	23.13 $\pm$ 0.81	8.59 $\pm$ 0.09	6.36 $\pm$ 0.25	339.38 $\pm$ 8.28	223.33 $\pm$ 7.57
SD 35	22.87 $\pm$ 0.75	8.74 $\pm$ 0.36	6.67 $\pm$ 0.92	322.68 $\pm$ 6.81	204.11 $\pm$ 4.42
SD 45	23.03 $\pm$ 0.83	8.67 $\pm$ 0.17	6.73 $\pm$ 0.99	293.91 $\pm$ 14.6	192.12 $\pm$ 4.01

Table 3. Final growth parameters and survival (mean $\pm$ SD) of *T. khudree*

Stocking density	Length (cm)	Weight (g)	Specific growth rate (% day $^{-1}$)	Condition factor	Survival (%)	Fish biomass (g tank $^{-1}$)
SD 15	6.43 $\pm$ 0.74 ^b	3.47 $\pm$ 0.60 ^c	6.37 $\pm$ 0.30 ^c	1.27 $\pm$ 0.09 ^b	84 $\pm$ 6 ^a	890.90 $\pm$ 48.67 ^a
SD 25	5.76 $\pm$ 0.44 ^{ab}	2.22 $\pm$ 0.44 ^b	5.96 $\pm$ 0.19 ^b	1.16 $\pm$ 0.15 ^{ab}	81 $\pm$ 8 ^a	1081.14 $\pm$ 84.57 ^b
SD 35	5.39 $\pm$ 0.29 ^{ab}	1.82 $\pm$ 0.23 ^{ab}	5.76 $\pm$ 0.12 ^b	1.16 $\pm$ 0.09 ^{ab}	82 $\pm$ 6 ^a	1252.16 $\pm$ 61.25 ^c
SD 45	5.03 $\pm$ 0.30 ^a	1.39 $\pm$ 0.29 ^a	5.49 $\pm$ 0.20 ^a	1.09 $\pm$ 0.12 ^a	77 $\pm$ 9 ^a	1156.48 $\pm$ 57.84 ^c

The means with different superscripts differ significantly in a column ($p < 0.05$).

Fig. 1. Length and weight (mean $\pm$ SD) increment of *T. khudree* during the rearing period

densities ranging from 15 to 45 m $^{-2}$. Rahman *et al.* (2005) evaluating the effects of stocking densities in *Tor putitora* fingerlings also observed an inverse relationship between stocking density and length, weight and survival. Growth and survival of fry and fingerlings depend on factors like stocking density, type and quantity of fertilisers and feeds provided. Growth was higher in the lowest stocking density treatment compared with that of higher density treatments in studies conducted earlier with pearl spot (*Etroplus suratensis*), rohu (*Labeo rohita*), reba carp (*Cirrhinus reba*), common carp (*Cyprinus carpio*) and fathead minnows (*Pimephales promelas*) (Smith *et al.*, 1978; Rahman *et al.*, 2009; Biswas *et al.*, 2013; 2015; Samad *et al.*, 2016). Several factors have been attributed to the slower growth of fish at higher stocking density, which includes: increased competition for food and space (Chakraborty and Mirza, 2007), social stress (Zen *et al.*, 2010) and social interaction (Irwin *et al.*, 1999). However,

in the present study, increased competition for food is not expected since fish in all the treatment tanks were fed to satiation. Smith *et al.* (1978) reported that the growth of fathead minnows halted at high densities despite food abundance. A stressful situation is caused mainly due to the inorganic nitrogenous metabolites accumulated as a result of excess unconsumed feed in the rearing tanks with a high density of fish (Rahman *et al.*, 2005). Further, high stocking density can also lead to stress through competitive inter-individual interactions (Chakraborty and Mirza, 2007). Stocking density as high as 1000 per m 2 is recommended for fingerling production of *T. putitora*, in ponds/tanks with continuous water renewal facilities (flow rate 4-6 l min $^{-1}$), where inorganic nitrogenous metabolites are not expected to be accumulated (Sarma *et al.*, 2010).

The condition factor (CF) ranged between 1.09 and 1.27, with the highest ($p < 0.05$) value recorded under the

lowest density and the lowest ($p < 0.05$) under the highest density (Table 3). The values for the stocking densities 25 and 35 m^{-2} were, however, comparable ($p > 0.05$) with those recorded for the rest of the densities. Studies by Varma *et al.* (2020) and Barlaya *et al.* (2021) indicated that high-density rearing does not, negatively affect the body condition of *T. khudree* and *H. pulchellus*, respectively. In general, adequately fed fish will be in good growth, having a CF larger than 1 (Jisr *et al.*, 2018). The CF of above 1 recorded in our study indicates adequate feeding, good condition and health of the fish.

Survival of mahseer varied between 71% (45 m^{-2}) and 84% (15 m^{-2}) with no significant difference ($p > 0.05$) between the stocking densities. Stocking density did not influence survival in another peninsular carp species *H. pulchellus* reared at 15, 30, 45, 60, 75, 90, 105 and 120 fish m^{-3} in tanks (Barlaya *et al.*, 2021) and rainbow trout juveniles reared at 10, 40 and 80 kg fish m^{-3} in flow-through tanks (North *et al.*, 2006).

Though the stocking density of 15 m^{-2} recorded the highest final weight among all the treatments, the final length, condition factor and survival under 35 m^{-2} were similar to those obtained for the density of 15 m^{-2} . Further, the fish biomass was highest at 35 m^{-2} . Jena *et al.* (2011) in a fingerling rearing study of three minor carps viz., *Labeo fimbriatus*, *Labeo gonius* and *Puntius gonionotus* along with the Indian major carp *L. rohita* carried out in similar outdoor concrete tanks for 90 days at four densities viz., 10, 20, 30 and 40 m^{-2} opined that number of fingerlings harvested is important factor ahead of growth attainment in a seed rearing system. It is obvious that significantly higher number of *T. khudree* fingerlings are produced at 35 m^{-2} (2870 per 100 m^2) compared to 15 (1260 per 100 m^2) and 25 m^{-2} (2025 per 100 m^2) densities. Considering these factors, it is concluded that a stocking density of 35 m^{-2} is ideal for rearing the fry of *T. khudree* in soil-based nursery tanks.

Acknowledgements

The authors are grateful to the Director, ICAR-CIFA, Bhubaneswar, India for the encouragement and facilities.

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