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Experimental cage culture of snow trout, *Schizothorax richardsonii* (Gray) and golden mahseer, *Tor putitora* (Hamilton) fry and fingerling in a sub-Himalayan lake Bhimtal, India

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ABSTRACT

Trials were conducted to ascertain the potential of cage culture in a sub- Himalayan lake for commercially important indigenous upland fishes. Growth performances of different grow-out stages, namely fry and fingerlings of snow trout, *Schizothorax richardsonii* and golden mahseer, *Tor putitora* were assessed for 3 months. Fishes were stocked @ 20 fish/ m^3; one set of fishes (experimental) were fed a 40% crude protein (CP) extruded pelleted feed, while the other set (control) thrived on natural food present in the lake. Rate of survival, net weight gain, per cent weight gain, specific growth rate (SGR) and gross yield of snow trout and golden mahseer fry and fingerlings were significantly higher in experimental group compared to the control. Feed conversion ratio (FCR) was calculated only for the experimental groups. Thus, this simple practice offers the possibility of rearing fry and fingerlings of snow trout and golden mahseer in floating cages in the sub-Himalayan lakes by using extruded pelleted feed.

Key words: Cage culture, Golden mahseer, Growth, Snow trout, Survival, Sub-Himalayan region

Snow trout (*Schizothorax richardsonii*) and golden mahseer (*Tor putitora*) showed drastic declines due to anthropogenic activities like introduction of exotics, damming and overfishing, and are therefore assessed as vulnerable (Vishwanath 2010) and endangered (Jha and Rayamajhi 2009), respectively, in the IUCN Red List of Threatened Species, Version 2011.1.Geographically they are native of Himalayan mountain streams, rivers and lakes of India, Afghanistan, Pakistan, Bhutan, Nepal and Bangladesh. Strategies for preservation of existing stock by habitat conservation, development of seed production technology for restocking and culture were undertaken to promote the population (Petr and Swar 2002). In India network of streams/ rivers (10 000 km) and open water bodies (natural lakes 20 500 ha and reservoirs 50 000 ha) in the Himalayan mountain region hold a tremendous potential for ranching (Vass and Gopakumar 2002). *In situ* production of fingerlings in cages offers opportunity for supplying stocking materials, a vital input for enhancing fish production from open waters (Das *et al*. 2009).Cage aquaculture in Indian freshwaters is limited to experimental trials mostly conducted for the warm water fishes (James *et al.* 1986). In the present study possibilities of cage culture were explored for culture of commercially important snow trout and golden mahseer of sub-Himalayan region, in an open water body.

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MATERIALS AND METHODS

Bhimtal is a subtropical freshwater lake located in the Kumaon sub-Himalayan region, District Nainital, Uttarakhand, India at an elevation of 1331 m above MSL between the latitude 29°20’35’’N and longitude 79°33'33’’E. The total water surface area of lake Bhimtal is 72.3ha and is surrounded by mountainous catchment area of 975.4ha. The lake has a moderate level of nutrients and is mesotrophic (Raina and Petr 1999). It is one of the largest lakes (Petr and Swar 2002) among the 11 lakes situated, within a short distance from each other.

The experiment was conducted using 16 cages (3.0 m × 3.0 m × 3.0 m) made up of HDPE knotless webbing of 4 mm mesh size floated over the water surface with GI pipe frame and 200 litre capacity synthetic barrels. Fry and fingerlings of snow trout and golden mahseer were collected from different locations of River Kosi, the main river of Kumaon

Himalayan region, District Nainital. The fry and fingerlings of snow trout and golden mahseer were distributed randomly at a density of 20 fish/m^3, keeping duplicate cages for each treatment. Fish under experimental group were fed 7 days a week, twice a day to their apparent satiation, with formulated extruded fish feeds having 40% crude protein (CP), while fish under control group thrived on natural food present in the lake.

Water temperature was recorded twice daily in morning and evening. Water samples were collected from inside of all the cages and from 2 different points in the lake on either side of the cage unit's. Transparency, pH, dissolved oxygen, free carbon dioxide, total alkalinity, conductivity, ammonia, nitrate and phosphate were analyzed at fortnightly intervals (APHA 1998). Plankton were collected and enumerated fortnightly by filtering 50 liters of water from different locations of each cage and from 2 locations in the lake through plankton net (No. 25 bolting silk cloth; mesh size 68 μ) and counted using Sedgewick Rafter plankton counting cell (Adoni 1985).

The trial lasted for 90 days (3 months). At the end of experiment fish survival, final weight, net weight gain, per cent weight gain, specific growth rate (SGR=ln final weight-ln initial weight/days × 100, %/day) and gross yield (kg/cage) for each cage and treatment were calculated. Feed conversion ratio (FCR=weight of feed/gain in wet weight of fish) was ascertained for experimental groups only. Through one-way analysis of variance (ANOVA) analyzed the difference between treatment means for fish growth parameters, survival, feed conversion ratio and gross yield at 5% level of significance.

RESULTS AND DISCUSSION

Water quality parameters monitored, inside the different experimental cages and at 2 locations in the lake, did not exhibit any significant difference. Mean values and ranges

Table 1. Water quality parameters in cages during the experimental period

Physico-chemical parameters	Mean values and ranges
Water temperature (°C)	24.4±0.39 (21.2–26.4)
Transparency (m)	2.00±0.04 (1.71–2.24)
pH	7.77±0.13 (6.9–8.7)
Dissolved oxygen (mg/l)	6.45± 0.18 (5.2–7.6)
Free carbon dioxide (mg/l)	1.40±0.11 (0.9–2.1)
Total alkalinity (mg/l)	95.75±3.84 (69–116)
Conductivity (μ mhos)	307.92±7.20 (251–342)
Ammonia (mg/l)	0.0063±0.001 (0–0.02)
Nitrate (mg/l)	2.04±0.17 (1.0–3.0)
Phosphate (mg/l)	0.06±0.01 (0–0.15)

Values are mean ±SE and range. No significant differences among treatments were observed and data from different treatments were pooled to give an overview.

Table 2. Plankton abundance (cells/l) in cages during the experimental period

Plankton	Mean values and ranges
Phytoplankton (*cells/l*)	
Bacillariophyceae	16711±3752 (7590–28814)
Dinophyceae	12826±2966 (5881–22658)
Chlorophyceae	17988±7080 (7862–30938)
Cyanophyceae	1975±717 (537–4594)
Total	49598±8006 (27358–72643)
Zooplankton (*cells/l*)	
Protozoa	7774±2126 (2358–14382)
Cladocera	31170±6083 (15322–49735)
Copepoda	3957±1260 (1326–8452)
Rotifera	4098±1166 (1854–8452)
Total	48534±7463 (26215–68434)

Values are mean ±SE range. No significant differences among treatments were observed and data from different treatments were pooled to give an overview.

of water quality parameters observed during study period in the cages are presented in Table 1. As natural food, the total plankton assemblages comprised phytoplankton and zooplankton. The abundance of plankton in all control and experimental cages and in the open lake did not present any significant difference during the study. Mean values and ranges of plankton abundance observed during study period in the cages are presented in Table 2.

Water quality parameters are critical for fish culture system; optimum water quality ensures maximum survival and growth of fish (Gomes *et al*. 2006, Silva *et al.* 2007). In open water bodies as the control and management of water quality is impossible; it becomes essential to select a suitable site for cage aquaculture of fishes. For the present study lake Bhimtal appeared appropriate, since it is approachable, has less human interference and also inhabits golden mahseer and snow trout (Basade 2005). During the study period the water quality parameters were within the optimum range for farming of snow trout and golden mahseer (Jhingran and Sehgal 1978). Plankton biomass, a biological correlate of fish yield was observed to be adequate for rearing of the fishes (Melack 1976).

The net weight gain, per cent weight gain, SGR, survival and gross yield of fry and fingerlings of snow trout and golden mahseer during the 90 days rearing period are presented in Table 3. Survivability of stocked species was low and most of the mortality occurred during the initial phase of rearing. The reasons of mortality can be ascribed to various stress related factors such as handling, transportation, change of environment, etc. For both the species survivability was better in the experimental groups and was considerably higher in fingerlings (snow trout 70%; golden mahseer 67%). Likewise, Kohli *et al.* (2005) obtained an overall survival rate of about 70% in cage culture of 2 species of mahseer,

Table 3. Growth performances, survival, feed utilization and gross yield of snow trout and golden mahseer fry and fingerlings reared in floating cages

	Snow trout				Golden mahseer			
	Fry		Fingerling		Fry		Fingerling	
Parameters	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental
Initial weight (g)	3.07±0.02	3.38±0.02	5.23±0.04	5.88±0.03	3.28±0.06	3.91±0.05	6.12±0.04	6.30±0.02
Initial biomass (kg)	1.07±0.01	1.18±0.01	1.83±0.01	2.06±0.01	1.15±0.02	1.37±0.02	2.14±0.01	2.21±0.01
Final weight (g)	4.78±0.02	5.92±0.07*	7.17±0.04	8.95±0.06*	6.79±0.05	13.81±0.02*	10.42±0.03	19.25±0.06*
Net weight gain (g)	1.71±0.04	2.54±0.05*	1.95±0.08	3.07±0.03*	3.51±0.02	9.90±0.03*	4.31±0.01	12.95±0.04*
Weight gain (%)	55.55±1.50	75.14±1.03*	37.24±1.69	52.25±0.29*	106.90±2.41	253.56±3.69*	70.40±0.48	205.56±0.02*
SGR (%/day)	0.49±0.01	0.63±0.01*	0.35±0.02	0.47±0.01*	0.79±0.00	1.41±0.01*	0.59±0.00	1.24±0.01*
FCR		6.98±0.35		7.39±0.28		5.77±0.24		5.55±0.23
Gross yield (kg/cage)	0.86±0.002	1.43±0.02*	1.35±0.01	2.20±0.01*	1.03±0.01	2.95±0.00*	1.80±0.02	4.52±0.01*
Survival (%)	51.7±0.10	69.1±0.05*	53.7±0.08	70.3±0.03*	43.4±0.04	61.1±0.07*	49.7±0.05	67.1±0.04*

Values are means (± SE); experimental means with * are significantly different ($p<0.05$) from their control means.

Tor putitora and *Tor khudree* in Walwhan lake, a non-sub-Himalayan lake located at about 625 m above MSL. While survival of snow trout fry (52–69%) and fingerling (54–70%) in cages was higher to the one observed (30–50%) for fish reared in running water cemented raceways under similar sub-Himalayan climatic condition (Mohan and Basade 2008). Various other studies of cage culture undertaken in India for rearing carp fishes, namely Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrihnus mrigala*) as well common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*), in reservoirs of tropical regions using similar procedures had reported that the fingerling recovery rate of at least 70% can be achieved (Das *et al*. 2009).

Weight gain, specific growth rate and gross yield in snow trout and golden mahseer fry and fingerlings were significantly ($P<0.05$) higher in the experimental groups over the control. Feed conversion ratio in the experimental groups was found to correspond with growth of the fish. FCR of golden mahseer fry and fingerlings was better than that of snow trout. Better growth performance in experimental groups can be attributed to feed. Feed used in the study was formulated extruded feed with 40% protein content. In previous studies too feed protein levels of 40% for mahseer and snow trout had been adjudged optimal (Oglae 2002, Mohan and Basade 2008).

By and large a slow growth rate was observed in fry and fingerlings of both the species during the trial. This may be due to the fact that snow trout and golden mahseer are inherently slow growing fishes (Pathak 1991, Sunder 2007, Mohan and Basade 2008). However, Oglae (2002) in case of golden mahseer cultured in floating cages of similar size (3 m×3 m×3 m) in lake Walwhan (about 625 m above MSL) obtained relatively better growth performance. In his study the fingerlings (35–40g) stocked @ 450 / cage in January 2001 and fed with pelletized feed twice a day grew to about 170g in 5 months. This infers that the prevailing climatic conditions of a region, which varies with the altitude, greatly influence fish growth. Furthermore, some researchers in the course of pond culture of fishes in sub-Himalayan region had described that the growth performances of fish are invariably related to prevailing water temperatures (Jhingran and Sehgal 1978). Fish showed considerable growth only in the summer (May to September) when water temperature ranged from 18.6–27.4°C. While in autumn and spring (October-November and March-April) at 12–18°C water temperature fish showed no growth. However, in winter (December-February) when water temperature falls (5.3–15.8°C) loss of weight occurs. Water temperature was reported to be a major decisive factor responsible for fish growth in the sub-Himalayan region (Anonymous 2001).

The growth performance achieved for snow trout and golden mahseer in this study are comparable to those attained from pond culture system under similar sub-Himalayan climatic conditions (Mohan and Basade 2008). The results indicated that in the sub-Himalayan region different grow-out stages of snow trout and golden mahseer can be reared in floating cages by using extruded feed. This opens the possibilities of cage farming of these species and may elude the requirement of ponds and tanks for their aquaculture.

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