ICAR

HIMALAYAN MAHSEER

HIMALAYAN MAHSEER

H.S. Raina
Shyam Sunder
C.B. Joshi
Madan Mohan

Himalayan Mahseer

Published by : The Director NRCCWF, Bhimtal (Nainital), U.P.

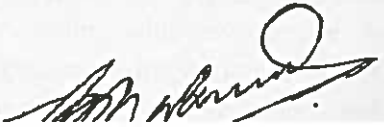
FOREWORD

The Golden putitor mahseer, *Tor putitora* is the most prized, delicious sport fish. *T. putitora* is distributed all along the Himalaya hence also known as himalayan mahseer. The golden mahseer is the most perferred sport fish and attracts anglers even from abroad. It is basically an inhabitant of the lotic system waters.

The mahseer was abundantly distributed in all the Himalayan waters before the advent of current century. But due to its declining trend in many river stretches, streams and lakes along the Himalayan ranges, the mahseer is designated as "Threatened/Endangered". Similar concern was expressed during a National Seminar on Endangered Fishes of India held in 1992.

It is under this scenario that the National Research Centre on Coldwater Fisheries has attempted to develop necessary technology for artificial propagation of this important indigenous fish with a view to restore the population in the depleted waterbodies through ranching of artificially produced seed. This will help the conservation efforts of this species in big way.

This valuable document "Himalayan Mahseer" summarizes the research highlights of the NRCCWF, covering all aspects of habitat variable, brood stock selection, stripping operation, hatchery rearing and nursery management in order to produce the mahseer seed under controlled conditions. The coverage of this publication is ample testimony to the untiring efforts of the group of scientists and other categories of staff of NRCCWF who undertook the arduous task of working in the remote hilly regions of Kumaon Himalaya. This bulletin will go a long way in promoting the mahseer fishery in upland regions.



PREFACE

The golden mahseer-*Tor putitora* (Ham.), a fish of rapids, rocks and pools occurring along the Himalayan belt is very much sought after for sport and adventure apart from being an important food fish in hill regions. Of late, a significant decline in its catches has been reported from various upland ecosystems. Industrialization, urbanization and related developmental activities, although a sign of prosperity of a nation, have resulted in an adverse impact on the fragile mountain ecosystems in the Himalayas. Environmental stresses coupled with increased fishing activity has reduced the abundance and availability of this species to very low level. The indiscriminate killing using destructive methods and large scale juvenile fishing has also contributed to a significant damage to natural stocks. In view of these anthropogenic changes and population decline, the fish has recently been declared as threatened/endangered. The situation demands urgent attention towards its rehabilitation in natural waters.

Besides adopting *in-situ* conservation measures for its protection, it is necessary to propagate the species under controlled conditions and produce the seed in hatchery for ranching in depleted natural waters and also promote its farming. The National Research Centre on Coldwater Fisheries has taken an initiative to develop and standardize the technology to propagate this species under controlled conditions. The sustained efforts of the scientists at the institute have borne fruits and the hatchery seed is being regularly produced.

The present publication is an attempt to make available to various users the mahseer seed production technology in a simple manner. It gives a succinct account on the status, bionomics and farming aspects of golden mahseer alongwith general view on the conservation and management strategies. The document will be useful to a cross-section of persons concerned with development and conservation of mahseer fishery in upland regions. The authors having wide experience in coldwater fishery have done a wonderful job and deserve appreciation. I am hopeful that the document will receive adequate response from researchers and

CONTENTS

INTRODUCTION

The etymology of mahseer is highly controversial and so about the number of valid species. Amongst the six valid species of mahseers (Sen and Jayaram, 1982), golden mahseer (*Tor putitora)* is the largest in size attaining the length upto 270 cm and 170 lbs in weight (Misra, 1962). Hamilton (1822) was the first taxonomist who described golden mahseer under the name *Cyprinus* (*Cyprinus putitora)* McClelland (1839) recorded it as *Barbus putitora*. Finally, it was Hora (1939) who revised the systematic position of golden mahseer by recognising *Tor* as a subgenus under *Barbus (Tor putitora)*. Since then, in almost all published records, the species is known as *Tor putitora* (Hamilton). Thomas (1897), Dhu (1923) and McDonald (1948) brought out detailed account on the important sport fish - the mahseer.

The mahseers, which belong to one of the groups among Indian carps (Cyprinidae) are clad in the largest shining scales recorded in freshwater fishes and are also referred to as large scaled carps in India. Among the mahseers, the putitor mahseer or the common himalayan mahseer or the golden mahseer, is one of the widely distributed species of genus *Tor* extending from Hindukush-Kabul-Kohistan in the North-West to Sadiya in the North-East. Besides, the species is also reported from Afghanistan, Bangladesh, Myanmar, Nepal, Pakistan, Sri Lanka and even from Thailand and Ningpo in China (McClelland, 1844). According to Cordington

Tor putitora primarily being denizen of rocks, rapids and pools - a common feature of himalayan rivers having steep gradient, high current velocity, voluminous discharge and coldwaters has successfully established and flourished in lentic waters(lakes, reservoirs) too. In these waters, the species is considered to be one of the most reputed sport delight as no other game fish affords such a thrill and excitement. From the ancient times, it has been a constant source of unparallel recreation to innumerable sportsmen from home as well as from abroad. The fish has been of significant importance because of its large size and durability after catch. Their hard scales normally protect the fish from spoilage when long travel is involved.

1. STATUS AND PROBLEMS

1.1 Status

Exact numerical assessment of the catches of mahseer particularly from lotic systems is not available due to difficult hilly terrains, absence of proper landing/ assembly centres, lack of organised fishery and species-wise statistics of inland fish landings in our country. For proper comparison, whatever figures are available from a few isolated surveys as well as observations by anglers and fishery biologists indicated serious decline of mahseer fishery.

A haul of himalayan mahseer

1.2 Problems

prevailing ecological conditions of aquatic ecosystems, construction of dams, barrages, weirs etc. under river valley projects, inorganic and organic pollution etc. Among the various species, *T. putitora* is perhaps the worst affected both by the natural and man-made factors. The waters which were once used to be highly populated with this sport wealth are, of late, reported to be almost barren especially in the himalayan belt. Literally the species is presently confined in certain isolated pockets of the himalayan region. Even in these pockets the catches are on a sharp decline. The situation of legendry mahseer in North-East himalayan region is not very encouraging. As per recent records, the decline is to the level of 45-60%. Tribal people and new illegal migrants have started even netting the fish less than 100 g in the Hans and Kameng (Bhorelli and Assam) and in the upstreams of Kopil river which once used to have fish specimens upto 25 kg.

The situation of golden mahseer in reservoirs of Himachal Pradesh and lakes of Kumaon (Central Himalaya) is equally disappointing. Both in Pong and Gobindsagar reservoirs, the population of the species has declined considerably not only in catches but in its sizes also (Kumar, 1988). In Gobindsagar reservoir, the catches have come down from 40% recorded in 1960 to 0.5% in 1980 in total fish landings. The impact of construction of a dam at Pandoh on R. Beas under the Beas-Sutlej Link Project adversely affected the catches of *T. putitora*. These investigations indicated that the Juni stream which once drained the south eastern ranges of the middle Himalaya into the R. Beas near Pandoh has stopped flowing due to dumping of debris as a result of digging of nearly 13 km long tunnel. This stream has rich spawning grounds for *T.putitora*. The golden mahseer which used to migrate as far as Kulu is not able to do so due to a dam at Pandoh. The fish ladders provided in headwaters of irrigation projects were also ineffective and acted as traps rather than fish passes. The case study made by Khan (1940) on golden mahseer in R. Yamuna at Tajewala headwaters revealed that this species started ascending in April-May and its passage is obstructed by the weir at Tajewala. During the last week of September, the fish from upper reaches descended with diminishing volume of water after the monsoon precipitation. Simultaneously the sluices and the weir shutters at Tajewala headworks have completely closed and hardly any water escaped into the river below the weir. The desceding or spent *T.putitora* consequently found their way into the canals. After having entered the canals, the

reported on Chenab at Salal; Bhagirathi at Tehari and proposed Ganga barrage at Lachmanjhula. Corbett caught a 22.50 kg mahseer from Nainital lake (Rai,1947) where it has almost been exterminated now. In District Nainital (UP), the golden mahseer catches declined from 8.92 quintals in 1982-83 to 4.16 quintals in 1989-90. Inspite of restocking of young mahseer,the situation has not yet improved to a sustainable level in majority of Kumaon lakes due to one or other reason. Shreshtha (1994) has also reported considerable depletion of himalayan mahseer in streams and rivers of Nepal.

The National Commisssion on Agriculture (1976) in its report on fisheries stated that ''there was general decline in the mahseer fishery due to indiscriminate fishing of brood and juvenile fish and adverse effect of river valley projects''. Later, in the recommendations and Proceeding of Workshop on Research and Development Needs On Coldwater Fishes held at NRC-CWF, Haldwani in 1989 and at National Seminar On Endangered Fishes of India held at NBFGR, Allahabad in 1992, most of the concerned authorities had common concensus about himalayan mahseer and designated as 'Threatened / Endangered' species of special concern in some himalayan zones. The present unabated downward trend in commercial catches and sport fishing of this species warrants continuous transplanting programme on a mass scale and conservation by proper legislations. The legislative measures include regulation of mesh size and observance of close season etc. The rehabilitation programme in open waters will include production of stocking material on a mass scale through establishment of hatcheries and fingerling production units.

1.3 Research and Development Initiative

In seventies, initial success was achieved in breeding wild stocks of golden mahseer through stripping in Kumaon region (Tripathi, 1977 and Joshi, 1982, 1988). However, Pathani and Das (1978) did not get much success in breeding the species through the administration of pituitary hormones. In 1989, after the establishment of NRC on Coldwater Fisheries, top priority was given to establish a mahseer hatchery to standardize technologies on induced breeding, hatchery and nursery management of *Tor putitora* at Bhimtal Research Unit of NRC-CWF. The chief objective of mahseer culture at NRC-CWF is the production of healthy

2. BIOLOGICAL CHARACTERISTICS

2.1 Food and Feeding

The golden mahseer is a sight feeder and can be categorised as column feeder which at some stages resorts to bottom feeding as well. Depending upon the availability of food, the fish consumes a wide spectrum of dietary items varying from microscopic organisms and macrophytes to large number of insects and even the small fishes. The youngones are voracious feeders with a special preference towards zooplankton mainly crustaceans and various stages of aquatic insects. The feeding intensity intends to lessen with the increase in fish size (Nautiyal, 1994).

The food consumed by *Tor putitora* in the streams revealed herbivore nature. Joshi and Kumar (1980) while observing the food spectrum of mahseer recorded that the juveniles of this species mainly subsists on the aquatic insects and planktonic algae.

2.2 Breeding periodicity

The study on the maturity and fecundity of golden mahseer has shown that the species has multi-model ova. The eggs mature in batches (Dunsford,1911). Khan (1939) on basis of examination of ovaries, observed that *Tor putitora* breeds in N.W. Himalayas three times in a year *viz*; winter (December-January); summer, when the snow-melt water swells up the streams and monsoon (July-October) when the streams are flooded from heavy precipitation in catchment areas. The observations of actual spawning of *T.putitora* in streams of Himachal Pradesh and lakes of Kumaon himalaya revealed two distinct spawning periods; first in May-June when flooded conditions appear due to influx of snowmelt water and second in monsoon (July-October). The male fishes generally attain maturity at a relatively [illegible] and smaller size (around 225 mm) mainly due to high growth

fishes tend to lay eggs. The fecundity of *T.putitora* generally fluctuates between 2500-6000 eggs / kg body weight/brust.

2.3 Spawning behaviour

Tor putitora migrates annually to the mountaineous regions for feeding and spawning. In himalayas, elevation of 2000 m asl has been reported the upper limit for the migration of fish during S.W. monsoons (July-September). The fish lays eggs during the low phase of floods in shallow areas on the gravel, shingles, sand and debris (*lithopilus*). The newly emerged fry prefer marginal areas among stones constantly being flushed by the flow of the stream. The eggs are demersal and very adhesive in nature. However due to flash floods, the shifting substratum of the hill streams may envelop the newly laid eggs/hatchlings which have a long incubation period causing asphyxiation due to low oxygen levels resulting in heavy mortality.

2.4 Sexual diamorphism

It is problematic to segregate the specimens of golden mahseer into different sexes by observing their external morphology, except during breeding season and that too with some difficulty. This aspect is important and essential during artificial fecundation of brood fishes. During peak breeding months, the male mahseer are generally bright coloured with thicker and protruded lips, thick dorsal spine, bright orange pectoral fins and bright orange to reddish anal fins; whereas the female mahseer are dull coloured with less protruded lips, thin and short dorsal spines, slightly pink pectoral fins and pinkish anal fin. The presence of few tubercles on the snout of male specimens are rarely developed.

Apart from these characteristics which many a times may not be very sharp and contrasting and may be confusing rather, the spawners are examined for their readiness prior to stripping in the field by well experienced hands. The ripeness of the female fish can be noted by feeling the softness of abdomen, pink colouration of vent and its gravidness by exerting a slight pressure on the belly to confirm free release of eggs. In the male fish, its readiness is confirmed by the jet flow of milt with gentle pressure near the vent.

3. HATCHERY PRE-REQUISITES

The success of a aquaculture programme depends to a large extent on the proper selection of site for developing a fish hatchery or farm. For selecting a site, following aspects should be kept in mind.

3.1. Water supply

The site should be elevated with abundant facilities of freshwater renewal. The preference should be given to a site where gravity water supply can be provided in the hatchery and farm. Chemically the water should be pure and fresh having sufficient oxygen contents (7.5 to 9.0 mg/1) at all times and in all seasons. Temperature between 20.0-25°C is found to be more congenial for hatchery operation and fish rearing of this species.

The source of water may either be rheocrene or limnocrene type of springs or from a stream/brook having low silt load and other nutrients. The site of hatchery and farm must be protected from the flash floods from catchment. The water supply to the farm should not be contaminated by pollutants or toxic substances detrimental to fish life.

The ideal requirement of water in terms of quantity at various stages of mahseer rearing should be as :

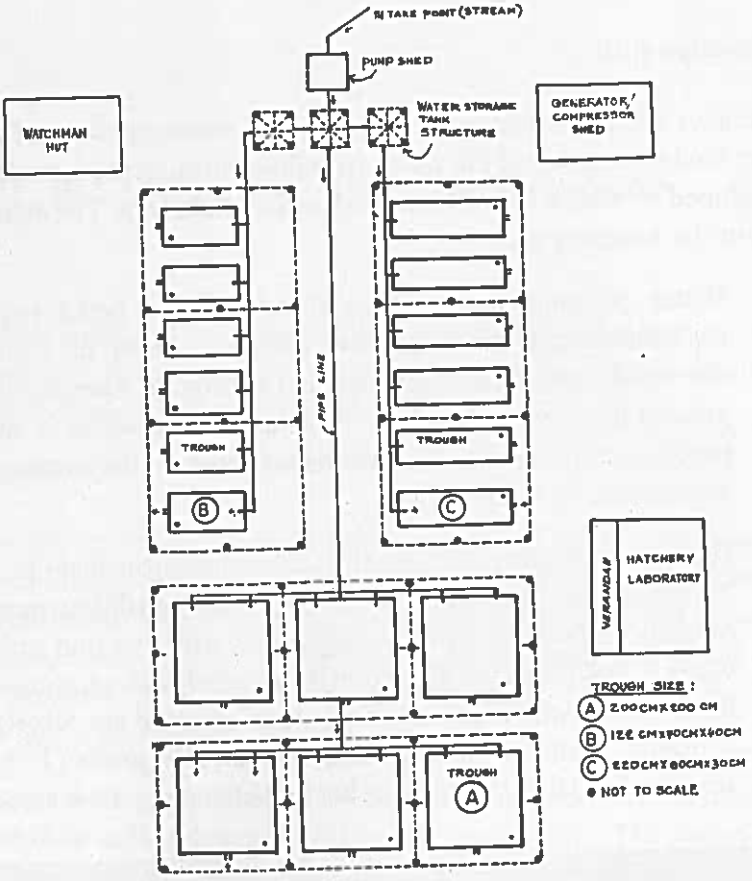
Water flow	Rearing capacity
1.0- 1.5 1/minute	for incubation and rearing 2000 eggs/ hatchlings at 20-25°C
3.0-4.0 1/minute	for rearing 2000 fry (0-3 month old) at

3.2 Production unit

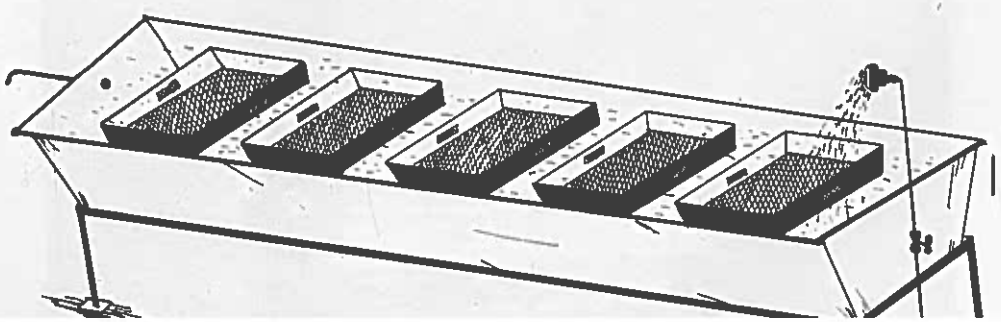
To achieve a high percentage of egg hatching, better survival of hatchlings and augument seed production of *Tor putitora*, a flow-through seed production unit has been developed at NRC-CWF, Bhimtal in Kumaon himalaya. The main components involved in the hatchery are:

Water pumping unit and overhead storage tanks supplying clear, oxygenated and silt free water with a capacity of 1000ℓ each. The overhead storage tanks are installed approx. at a height of 5 m from the ground level where hatchery is installed. The water is supplied to the hatchery at a level of 0.25 m from the bottom of the storage tank to allow sedimentation of silt, if any.

Hatchery troughs made of either galvanised iron sheet or fibre glass of 220x60x30 cm size with separate inflow and outflow arrangements. The outflow from the hatchery trough is so arranged that only the bottom water is first removed. Each unit is provided with aerating devices in the form of showers. Hatchery trays made of wood are 50x30x10 cm with a plastic synthetic netting cloth of suitable mesh (1 mm) properly stretched and fixed to form the bottom of the tray. Five wooden trays can



Layout plan of mahseer hatchery



be arranged and kept floating in a hatchery trough. About, 5000-6,000 eggs can be conveniently stocked in each tray.

Nursery tank units made of either fibre glass or PVC (120 x70x40 cm) having a capacity to raise 10,000-15,000 swim-up fry/tank with proper water adjustment and with individual shower arrangements to ensure supply of well oxygenated water.

Rearing tanks made of either fibre glass or GI sheet having an area of 2.0 sqm with a depth of 0.45 m for rearing 5,000-10,000 fry or advance fry per tank. For proper supply of water, showers are provided in each tank.

The flow through hatchery at Bhimtal has a capacity to hold about 0.25-0.30 million fertilized eggs and can raise 0.20-0.25 million fry/advanced fry.

All the rearing units are installed on the iron stands about 0.25-0.5 m above the ground level for proper working. The hatchery is housed under a PVC shed to protect from the vagaries of weather. The whole hatchery system devised is on turn-key basis and hence can be operated with minimum manpower. The continuous water flow can be regulated as per the requirement of each unit. To combat the shortage of water supply during dry spells, one artison tubewell has been installed. The water from the natural source and/or tubewell is air-lifted through interconnected pipelines to overhead tanks and distributed to various hatchery components. In addition, a small shed is provided to house a generator.

4 CULTURE PRACTICES

4.1 Artificial propagation

Success in artificial fecundation of golden mahseer collected from wild waters has been achieved at Bhimtal Research Centre of NRC-CWF (Joshi 1982, 1988; Sehgal 1991; Sehgal and Malik 1991, 1992; Sunder *et al.*, 1993 and Mohan *et al.*, 1994) without administration of pituitary gland extract or any other hormone. The principal operations involved for artificial breeding of golden mahseer includes: collection of brood stock of the requisite type; artificial fecundation and fertilization; incubation and hatching until yolk-sac is completely absorbed; production of fry and advance fry etc.

4.1.1 Collection of brood stock

Unlike salmonids, which are domesticated, the availability of brood stock of golden mahseer from the wild waters is a pre-requisite for mass scale seed

production. The species is said to have multiple spawning periodicity. The fish in the spawning run either from stream, lake or reservoir are gilled in the nets and employed for stripping operation. The species is completely amenable to egg taking and artificial fecundation, hatching and fry and fingerling rearing etc. under controlled conditions.

The deep pools in the mountaineous gorges, the rivers in the foothills, fish sanctuaries, man-made reservoirs and some uplands lakes are the congineal abodes for himalayan mahseer and can be dependable sources for the brood stock. The use of pond reared brood stock met with little success in induced breeding. It is, therefore, desirable that induced breeding of natural stocks be resorted to. With the onset of breeding season, the mature fish normally leave their safe haunts in deep river pools and ascend unprotected shallow streams to spawn from where the ripe spawners can be collected easily. The collection of brood fish from the deep pools, lakes and reservoirs can generally be done by gill nets of different dimension (37.5x8.0 to 75.0x10.0 m depth) and mesh sizes (75-125) mm. The nets in the above mentioned ecosystems are mostly fixed during the night hours and removed in the morning. Each mahseer specimen gilled in the nets is released carefully or sometimes even by cutting some meshes of nets to avoid any damage to the brood fish and are examined for marking the ripe females and males which are utilized for artificial fecundation. Even the ripe spawners can be stripped while they are still gilled to avoid any damage to the gonads.

4.1.2 Stripping operation

Himalayan mahseer is easily amenable to egg taking. Only live specimens are used for stripping and fertilization. The eggs are fertilized by 'dry method' to ensure high rate of fertilization. The artificial fecundation is generally done by *two men method* i.e. one man grips the fish in an inclined position holding caudal peduncle with one hand and by pectoral region with the other with the fish in tail end down position over a clean and dry plastic/ enamel receptacle. The second man or the egg-taker who sits at the opposite end gently pushes out the eggs using his thumb and index finger exerting gentle pressure over the swollen belly and descends over the lower end of the body down to genital vent. The fully ripe eggs generally flow out under slight pressure which is continued to be applied till all the ripe eggs come out. Sometimes oozing blood during stripping operation may be

brust. Soon after the eggs are stripped, the gravid male is stripped of the free flowing milt by similar manipulation and spread over the eggs. The mixing of sex products is gently done by moving the container sideways or with the help of bird's feather. One tea spoon of milt would be sufficient to fertilize large quantity of eggs squeezed from 2-3 female specimens. The fertilization takes place instantly after mixing the two sex products. The eggs are allowed to remain in this condition for sometime by adding a small quantity of water for ascertaining complete fertilization. After about 2-3 minutes, the eggs are washed and excessive milt and other

Stripping operation

extraneous particles, if any, are removed completely by changing the water repeatedly. The newly taken eggs are adhesive in nature till, they become water hardened. For this clean water is added to the basin so as to keep the eggs submerged and placed aside under shade for 40-45 minutes. The colour of mahseer eggs ranges from pale yellow to bright orange having a diameter of 2.5-3.6 mm which after fertilization and water hardening swells upto 3.0.-3.6 mm. The rate of fertilization

4.1.3 Quantification of eggs

It is customary for a hatchery operator to estimate the total number of fertilized eggs to maintain proper records for the computation of survival rates at various developmental and rearing stages. The eggs of mahseer are vulnerable to physical stimulii at this stage, so reasonable care must be exercised in handling for their numerical estimation. For mahseer egg counts, volumetric or gravimetric methods are best suited. In the former case, a sub-sample of fertilized eggs are poured in a known quantity of water filled in a measuring cylinder and counted. Three such samples are taken to minimise the error and their average counts can give the number of eggs/ml by volume. Based on this, the total number of fertilized eggs could be computed by estimating their volume. In gravimetric method as well, three egg samples of known weight are counted and averaged. Then the total weight of fertilized eggs is taken and their total number is computed based on the average counts of the sub-samples. Normally the number of golden mahseer egg/ml ranges between 30-36 by volume and 60-110 eggs/g by weight.

After complete water hardening and the numerical estimation of mahseer eggs, they are transferred to the flow-through hatchery complex for incubation, hatching and further rearing.

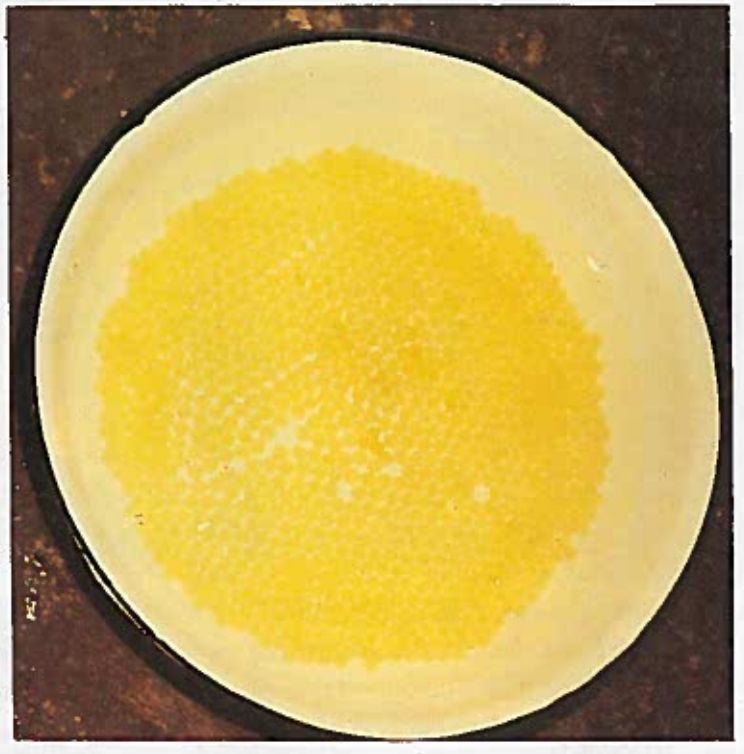
4.1.4 Incubation and hatching

The fertilized eggs of *Tor putitora* brought from the breeding sites are kept in hatching trays @5000-6000 eggs/tray in a single layer having running water facilities and continuous sprinkling of water through the showers for higher oxygenation. The rate of water flow is maintained 1-2 l/min. It should be ensured that all the hatchery components are disinfected properly with 5% potassium permagnate solution before use. The non-viable eggs are culled daily after second day of fertilization, taking every possible precaution to avoid injury/disturbance to the neighbouring stock. Occasional flushing of hatching stocks with malachite green @1:2,00,000 for about 30 minutes is done as prophylaxis against fungal attacks which helps in checking mortality during incubation period.

The incubation period ranges from 80-120 hours at a temperature of 20-25^{0}C

in water temperature; c) sudden incursion of silt-laden water; d) white-spot disease; e) egg cleavage and f) egg clumping.

When the hatching of the livestock is near completion, the egg shells are removed with glass dropper or siphoned through a flexible plastic tube of small diameter ensuring that the newly emerged hatchlings are least disturbed. The hatchlings at this stage remain almost semi-quiscent measuring about 7.5-8.0 mm and lie at the bottom sideways. The percentage of hatching ranges between 85-97%. The overall survival from fertilized eggs to swim-up fry normally varies from 70-78% under controlled conditions.



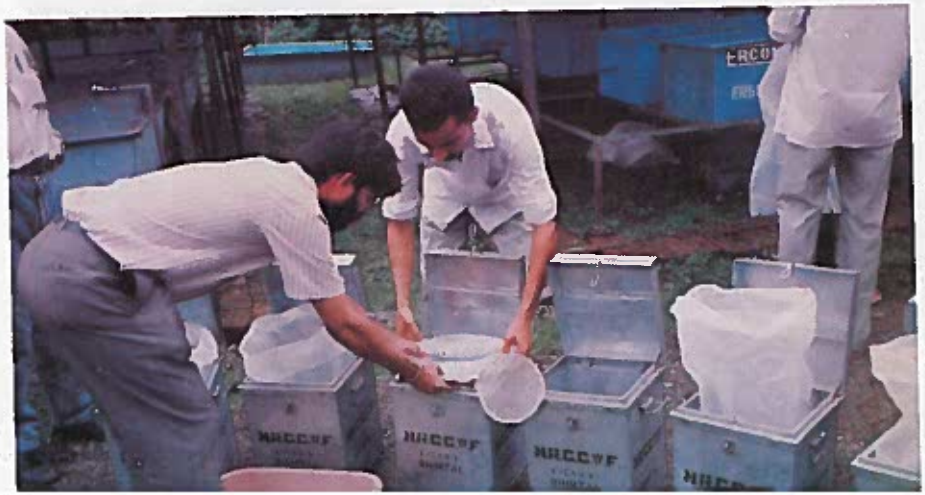
Fertilized eggs of mahseer

4.1.5 Rearing of stocks

Once the yolk-sac is completely absorbed and newly emerged swim-up fry

Young fry of golden mahseer

one month. The mash consists of soybean powder, fish oil, vegetable starch, gelatin, casein fortified with vitamins and minerals. The young fry attain a size of 15-20 mm with a survival rate varying from 80-85%. The young fry can be



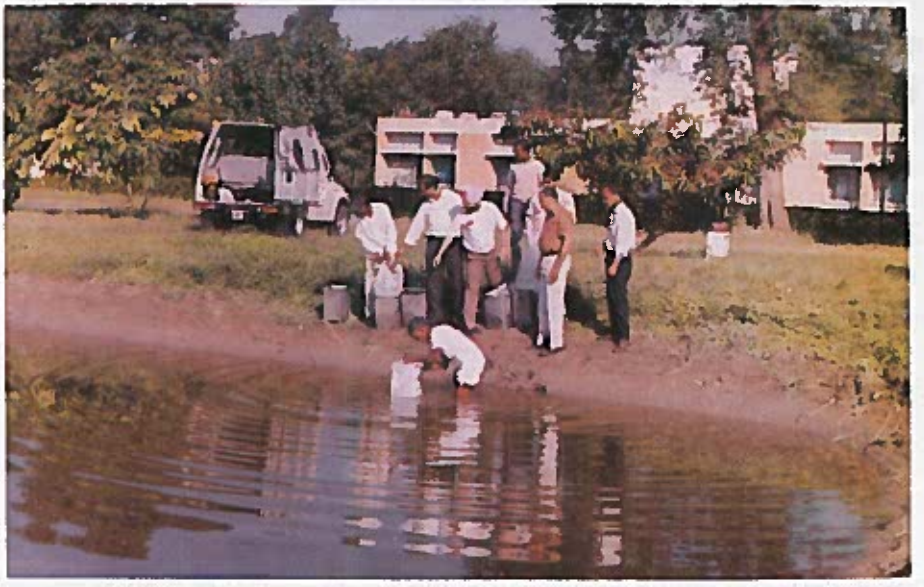
observed to grasp the floating feed particles and sometimes seen congregating at the spot where the feed is broadcasted. The dead fry are siphoned out with plastic tube alongwith the excessive unutilized feed every morning to avoid putrification. The major causes accounted for the mortality during fry rearing phase are : a) injury caused during shifting or sampling; b) weak progeny; c) incoming of heavy muddy or silty water due to flash rains in the catchment; d) body deformities; and e) abrupt fluctuations in water temperature.

The young fry of golden mahseer after size grading are stocked in flow-through rearing tanks @ 5,000-10,000/ tank (approx. 2 m^2). The water flow is maintained @ 3-4 l/ min. The fry at this stage are very active and are fed regularly on dry artificial diets having 30-45% protein content.

4.2 Artificial diets

The principal ingredients used to formulate the diet of putitora mahseer mainly are soybean meal, silk-worm pupae, rice starch, yeast extract, feeding oil, casein fortified with vitamins and mineral pre-mix. The various feed components in required proportions are crushed, powdered and sieved before mixing. The mixture @ 10-15% body weight of fish stocked is soaked in water to make small dough balls which are kept in clean dishes at 2-3 different places in each rearing tank. The daily

ration is splited in 3-4 diets to avoid wastage and putrification. In a rearing period of 3-4 months, the fry could grow to a size of 40-50 mm with a survival rate of 60-70% (Raina *et al.*, 1993; Sunder *et al.*, 1995 and 1998). The constraint of nutritive pelletized diet to raise fingerlings is being tackled by experimental trials on different artificial diets made from locally available feed ingredients.



Rearing of mahseer under pond environment

4.3 Advantages of hatchery design

The flow-through hatchery designed has a great impact on the building up of healthy and disease resistant stocking material of golden mahseer on mass scale under controlled conditions for rehabilitating the natural waters on required basis and for aquaculture purposes. This can prove a beneficial model for other upland regions of the country from various angles *i.e.* i) rate of survival during incubation and hatching of fertilized mahseer eggs is observed 2-3 times more as compared to conventional methods; ii) due to prolonged breeding periodicity (May to

4.4 Prospects of farming

With a view to build up the brood stock in farms for future progeny, the hatchery reared putitora mahseer fry can be stocked in a nursery pond having running water facilities for further rearing. The growth of 150-180 g (185-220 mm) with a survival rate of about 55% in a period of one year has been obtained through phased manuring of the pond and supplementary feeding on conventional diets (rice polish and mustard oil cake 1:1) fortified with essential minerals and vitamins. In an experimental trial to rear mahseer fry in cages at Bhimtal for a duration of 30 days revealed that the survival can be achieved to the tune of 80.0-98.0%, however, depending upon the stocking density, water temperature and artificial feeds. The preliminary culture experiment conducted is just a beginning, the basic idea of which was to observe the behaviour of growth and survival of mahseer fry in captivity (Sunder *et al.*, 1995). Hence, at this stage, it would be premature to comment on any production or economic strategies. However, there appears to be bright possiblities that aquaculture of mahseer can be taken up in captivity through careful scientific stocking cum farm management techniques in near future. This would go a long way in i) raising brood stock for intensive seed production and to conserve the germplasm of depleting golden mahseer; ii) effective utilization of coldwater ecosystems by increasing fish biomass per unit water area for cheap protein source as well as for sport; iii) production of table delight; and iv) exploiting the possibilities to culture mahseer in combination with other carps *viz;* exotic carps and even the Indian major carps.

It may be stated that the efficient breeding and rearing technologies developed so far to meet the challenge of raising golden mahseer seed on intensive basis is just a beginning towards the restoration of vanishing wild stocks and improving the present fish yields of this species in the himalayan belt.

5. REHABILITATION AND CONSERVATION

Since conservation and rehabilitation of endangered golden mahseer is a problem of national importance, thus production of stocking material through artificial propagation of this species and ranching in their natural habitats is the only solution to save its germplasm from extinction. In this direction, aquaculture of golden mahseer commenced in the early ninetees on intensive seed production and to establish flow- through hatchery by this Institute and the efforts of NRC on Coldwater Fisheries are worthy of national recognition. At Bhimtal mahseer hatchery, every year thousands of advanced fry of this species are produced and are being provided to Uttar Pradesh State Fisheries Department for ranching the depleted waterbodies in Kumaon and Garhwal himalayas. Even seed of this fish is also provided to neighbouring States holding this species and to SAUs and other concerned agencies in the himalayan region for culture purposes.

All the States holding this fishery should take serious note of the threatened existence of golden mahseer and encourage similar efforts for establishing mahseer hatcheries on the sites of the main waterbodies/reservoirs for intensive production of stocking material and for directly replenishing them and for aquaculture purposes.

The conservation and management of himalayan waters is a very difficult task as presently these waters are utilized for multiple uses and are under control of different agencies.The successful implementation of any conservation strategy is possible through harmonious and integrated approach. Therefore, socio-political, legal and economic aspects alongwith a number of alternatives have to be considered before executing the plans for conservation and management of, not only golden mahseer but entire group *(Tor)* in himalayan and Peninsular waters. Based on the evaluation and assessment of the existing resources of mahseers and available scientific data base following strategies are suggested. This will go a long way in achieving the desired objectives.

5.1 Generation of database

For evolving sound rehabilitation policy for himalayan eco-systems (rivers, streams, lakes and reservoirs), a complete information on fish resources, stock structure, production trends/levels and patterns of exploitation should be collected based on which separate plans and models for mahseers recruitment, harvest and stock management can be formulated.

5.2 Legal initiative

Protection to juveniles and brood stock of this group/species is pre-requisite by legislations or other possible means. The revision of this act to meet the present political and social challenges has not been undertaken. In some States like Uttar Pradesh, certain fishery waters in the hill districts are under the administrative control of Forest Department. Such anomalies probably are existing in other States too, which poses hinderances in operating the legislations properly.

fishes are mostly in a tamed condition. To name a few, Andhreta machhal on Awakhad near Panchrukhi Village; Nagachula in Mandi, Owa khud, Mamta and Samtole sanctuaries in district Kangra of H.P.; areas adjacent to Baijnath of R. Gomti (Distt. Almora), Nal Damyanti Tal (Distt. Nainital), Rishikesh and Haridwar temples in Central Himalaya and Corbett Park (U.P.) It is basic fact that if some productive waters are banned completely for mahseer fishing; the fish can be saved to an extent for growing a healthy population in that particular area. During the breeding periods, the fishes undergo ascending and descending migrations to far off places and in the side channels where it becomes practically difficult to check the fishing and hence not only the brood stocks even the juveniles are trapped.

Nal Damyanti Tal sanctuary

Moreover, innumerable newly hatched and advanced fry get entrapped in the boulder pools formed as a result of low water levels in the streams which ultimately get perished during dry spells and for want of proper salvation thus resulting in poor recruitment in the water body. Fish sanctuaries afford only limited protection (Kulkarni, 1986; Kulkarni and Ogale, 1995).

of adequate watch and ward staff in the field have encouraged such fishing activities like the use of explosives, poisons, spears and spurious local methods etc. Even the basic principles of mesh size to protect juveniles from mass killing are not being observed. The observation of close season during breeding period is also not practiced. Attempts have, however, been made by the States of Jammu & Kashmir and Himachal Pradesh to formulate their fishing regulations to conserve the fish stocks in sport and commercial fishing waters.

5.5 Water abstraction

The river valley projects constructed in different river systems have affected the catches of coldwater fishes. The impoundments created through river valley project, no doubt, have provided a resource to raise fish in the area. But at the same time reduced down stream outflow of the river has affected the move of fish stocks for spawning and feeding especially (mahseers and schizothoracids). Since majority of the river-valley projects have multiple benefits to society, it is difficult to reduce environmental stress. The fishery agencies have to take corrective measures including rehabilitation of the affected species by establishing seed production units to meet the stocking requirements in artificially created impoundments.

5.6 Mass awareness

Prevention of environmental degradation can be achieved through mass awareness programmes and people participation. Of late, efforts have resulted in the Karnataka Forest Department (Wildlife) leasing out about 23 Km. of R. Kauveri stretch holding mahseer to Wildlife Association of South India (WASI) which has been protecting it with military discipline by hired guards. Right now WASI, CWA and the Karnataka Tourism Department have been granted leases on the long stretches of the river which are run efficiently to allure the anglers even from U.K., Europe and Japan (Allen, 1993). Such type of leasing programmes in other areas of the country could pay fruitful results in the long run. During the past two and a

anglers; ii) protecting the fish habitats; iii) controlled harvest; and iv) arranging angling competitions from time to time to promote sport fishing. Such more voluntary and local organisations could play a great role in the conservation of the depleting fish stocks especially the splendid himalayan mahseer-one of the biggest tourist attraction for anglers both from home and abroad.

6. RECOMMENDATIONS

Under productive phase, intensive stock development programme has to be attempted to:

i) Large scale hatcheries for golden mahseer (*Tor putitora*) at selected sites along the himalayan waterbodies (lakes, reservoirs, rivers, streams) should be established for repopulating the natural systems to have a high yield of this group.

ii) Raising of brood-stock for artificial propagation and intensive production of stocking material of this species in captivity

iii) Research may be reinforced on evolving complete supplementary diets under farm conditions.

iv) Aquaculture in enclosures by adopting modern scientific culture practices can be taken up.

v) Selective breeding and stock improvement of golden mahseer may be undertaken in near future.

From the resource point of view, it is clear that the potentials of golden mahseer in himalayan uplands are very high but due to environmental degradation and unmanaged fisheries development policies, the ecosystems holding this species are heading towards its extinction. In order to make systems ideal, conservation deserves due consideration to ensure proper utilization of resources over a long periods.

REFERENCES

Allen, J, Meldonca, 1993. Lions in the rivers. *Indian Express* 25th July, 1993.

Cordington, K. De. B. 1939. Notes on Indian mahseers. *Off Print* 1993.

Dhu, Skere, 1923. The anglers in India or the mighty mahseer (*Off print* 1993).

Dunsford, H.S. 1911. The report of fish and fisheries of Pubjab. *Govt. Press, Lahore*. 23 pp.

Hamilton, B. 1922. An cccount of fishes found in R. Ganges and its branches. *Off Print* 1981. Bishan Singh Mahendra Pal Singh, Dehradun : 541 pp.

Hora, S.L. 1939. Game fishes of India VIII. The mahseer of the large scale barbels of India I. The putitor mahseer *Barbus (Tor) Putitora* (Ham.). J. Bombay Nat. Hist. Soc. **4**. 272-85.

Jhingran, V.G. and K.L. Sehgal, 1978. Coldwater fisheries of India. *Inland Fish. Soc. India* : 239 pp.

Joshi, C.B. 1982. Artificial breeding of golden mahseer *Tor putitora (Ham.) J. Inland Fish. Soc. India.* **13** (2) : 73 - 74.

Joshi, C.B. 1988. Induced breeding of mahseer, *Tor putitora* (Ham.). *J. Inland Fish. Soc. India.* **20** (1) : 66 - 67.

Joshi, C.B. and K. Kumar, 1980. Food spectrum of juveniles of golden mahseer, *Tor putitora* collected from streams of Jammu province. *J. Inland Fish.*

Khan, Hamid, 1940. Fish ladders in Punjab. *J.Bombay Nat. Hist. Soc.* **41** (3) : 551 - 62,

Kulkarni, C.V. 1986. Methods of conservation of mahseer resources. *Pb. Fish. Bull. X* (2) : 33 - 35.

Kulkarni, C.V. and S.N. Ogale, 1995. Conservation of mighty mahseer in India. *Tata Electric Companies, Bombay House* 38 pp.

Kumar, K. 1988. Gobindsagar reservoir, a case study on the use of carp stocking for fisheries enhancement. *FAO Fish Rep.* 405 (Suppl.) : 46 - 70.

McClelland, J. 1839. Indian Cyprinidae. *Asiat. Res., Calcutta* **19** (2) : 262 - 450.

McClelland, J. 1844. On the freshwater fishes collected by William Griffith. *J. Nat. Hist. Calcutta.* **2** : 560 - 89.

McDonald, A. St. J. 1948.Circumventing the mahseer and other sporting fishes in India and Burma. (Off print 1992). Natraj Publishers, Dehradun : 306 pp.

Misra, K.S. 1962. An aid to the identification of commercial fishes of India and Pakistan. *Rec. Indian Mus.* **57** (1-4). 320 pp.

Mohan, M; Shyam Sunder and H.S. Raina, 1994. A modern cost efficient hatchery for mahseer aquaculture in the himalayan region. *Proceedings of National Symposium 'Aquacrops'*, CIFE, Bombay (18-19 Nov., 1994) : 18.

National Commission on Agriculture, 1976. Report on National Commission on Agriculture. *Govt. of India, New Delhi.* III Fisheries: 8-10.

Nautiyal,P., 1994. Mahseer, the game fish (Natural History, Status and Conservation practices in India and Nepal). *Akashdeep Printers, New Delhi.*

Raina; H.S.; Shyam Sunder and Uma. Naulia, 1993. Nutritional requirements for the juveniles of golden mahseer; *Tor putitora* (Ham.). *The Third Fisheries Forum Proceedings, Pantnagar* (11-14, October, 1993) : 5-8.

Sehgal, K.L. 1991. Artificial propagation of golden mahseer, *Tor putitora* (Ham.) in the Himalaya. *NRC-CWF sp. Publ. 2*: 12 pp.

Sehgal, K.L and D.S. Malik, 1991. Efficiency of flow-through system for seed production of *Tor putitora* (Ham.) at Bhimtal, Kumaon Himalaya. *Indian J. Fish.* **38** (2): 134-37.

Sehgal, K.L. and D.S. Malik, 1992. Aquaculture of *Tor putitora vis-a-vis* stock enhancement and management of fisheries in the himalayas. *Pb. fish. Bull.* **16** (1) : 55-63.

Sen, T.K. and K.C. Jayaram, 1982. The mahseer fishes of India a review. *Rec. Zool. Surv. India. Publ. Occasional paper* 39 : 38 pp.

Shrestha, T.K. 1994. Eco-status of mahseer in the rivers of Nepal. *In Mahseer, the game fish. (ed.P.Nautiyal). Rachna Publ. (U.P.)* : 3 - 9.

Sunder, Shyam; Madan Mohan; H.S. Raina; B. Singh and R.S.Haldar, 1993. Culture of golden mahseer *Tor putitora* (Ham.) in Kumaon himalaya 1. Mass scale seed production of stocking material. *The Third Indian Fisheries Forum Proceedings, Pantnagar* (11-14, October, 1993) : 45 - 48.

Sunder, Shyam; H.S. Raina; M. Mohan and C.B. Joshi, 1995. Cultural possibilities of golden mahseer, *Tor putitora* (Ham.) in himalayan uplands. *Uttar Pradesh J.Zool. :* 177-81.

Sunder, Shyam; H.S. Raina and Uma Naulia. 1998 Preliminary feeding trials on the juveniles of golden mahseer, *Tor putitora* (Ham.) at different stocking densities with artificial dry feeds. *Indian J. Anim. Sci.* **68** (4) : 410 -16