

Strategy of mahseer fish (Actinopterygii: Cyprinidae) conservation: A case study in Arunachal Pradesh, India

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Introduction

Coldwater Fishes refer to those members of the family Cyprinidae which inhabit head waters, upland lakes and reservoirs having water temperature below 25°C (Morrow and Fischenich, 2000). Indian uplands in the Himalayas and Peninsular Plateau harbor incredible coldwater fish community. The mahseer is one of the important coldwater fish groups that inhabit the pristine streams with high dissolved oxygen and comprise of around fifteen species (Jayaram, 1999; Menon, 1999). Mahseer are appraised for delicious food and are mostly sought-after by the hobbyist anglers because they provide thrills while angling (Ogale, 2002). In nature, mahseer grow large (25-30 Kg) and considered the largest among the cyprinids (Thomas 1897). Several studies on mahseer are undergoing elsewhere. As inherent to the majority of fish species, the possibility of artificial seed production of mahseer is strenuous. Meanwhile, the dry stripping technique of artificial seed production for golden mahseer has been standardized and practicing, yet meagerly, by the Directorate of Coldwater Fisheries Research (Indian Council of Agricultural Research). Many of the mahseer in India as well as in other Asian regions

have been facing severe threats due to habitat loss (particularly spawning habitat), indiscriminate killing, etc. leading to an unprecedented reduction of population in the natural distribution areas, and consequently recognized under various threat statuses in the IUCN Red List (IUCN 2011). Eventually, the Indian golden mahseer (*Tor putitora*) and the chocolate mahseer (*Neolissochilus hexagonolepis*) are declared respectively as the flagship species (State Fish) of the states Arunachal Pradesh and Nagaland in North-East India. Although in India, the Wild Life (Protection) Amendment Act, 2002 redefined the term 'Animal' including fishes, but, existing protected areas are not taking additional protection measure and scientific management for the freshwater fishes. Further, there is lack of information from many confined water bodies regarding the existing fish diversity, and prospects and feasibility for sustainable introduction of threatened/ endangered fish species.

On the backdrop, there is paramount demand of population rehabilitation and restocking of mahseer in safe and suitable water bodies, especially Lake, for the establishment of germplasm as treasure trove (Sarkar *et al.* 2005). This would augment conservation effort and allows long run conservation in the

way of consequential recruitment into connecting streams/ rivers through outlet after natural reproduction. Nevertheless, mahseer being the sought after sport fish, the development of sport fishery would bring forth tourism importance. Yet, it is often difficult to search out potential water bodies for the purpose.

The Mehao Lake in Lower Dibang Valley District of Arunachal Pradesh was thought to be important with regard to long run conservation of endangered Mahseer fish. The lake was selected for the study as because there is information of vastness of the water body which has not been scientifically explored (<http://roing.nic.in/tourism.htm>). Further, it is known to few, although not in document, that seeds of common carp and brown trout were introduced in the lake by the then education minister of state (Late Dera Natung) in association with the then forest minister (Shri Mukut Mithi, Ex-Chief Minister of the state) in the year 1993-94. In fact, the motto behind stocking of these two species in the lake is still unknown. Obviously, the effort was not for germplasm conservation, where both the introduced species were exotic in nature. Yet, if the trout fishery had established then it could have envisaged the tourism avenue there. Therefore, a feasibility study was carried out during 2003 to 2010 in the lake on whether mahseer fishery can be established in the lake.

The study was aimed to investigate its water quality and biotic status of the lake through stan-

dard methods. The status of the two historically introduced exotic species, viz., brown trout and common carp was evaluated. The study also corroborated the hitherto unknown naturally existing fish fauna in the lake.

Together, the study explored the possible existence of any higher aquatic vertebrates other than fish. The ultimate objective was to establish Mahseer fishery in the lake for conservation and eco-tourism development. The result of trial rehabilitation of chocolate mahseer is successful; hence, the introduction of seeds of golden mahseer is accomplished recently. At the present time, the chocolate mahseer has established natural population and is expanding through recurrent wild breeding in the lake.

Materials and Methods

Study site

The Mehao Lake is an upland lake (elevation 1656m asl) situated at $28^{\circ}8'48.51''N$ and $95^{\circ}56'29.33''E$. The lake is situated as a bowl on the hill top, said to be of glacial origin, vast and very deep, and comprised of rocky substratum. The source of large volume of water in the lake is purely reaped from rainwater as there is no inlet. The lake comprises of two unequal segments, both connected through a 'link-stream' of length around 200m, bigger one flows into smaller. The only outlet sweeps out from the smaller segment (Fig. 1).

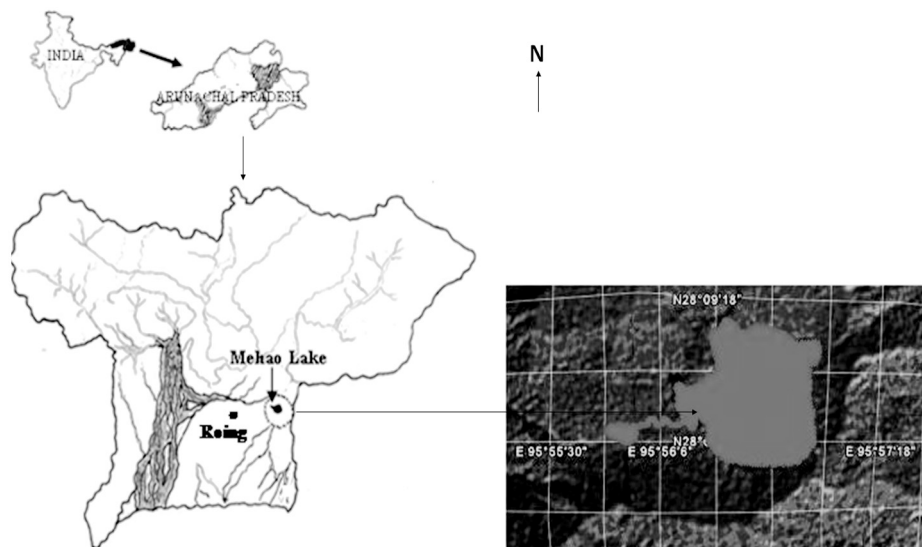


Fig. 1. Map showing the location of the Mehao Lake in Lower Dibang Valley District of the state Arunachal Pradesh in North East India.

General features of the lake

The water area of the important lake was studied by importing the toposheets in ILWIS 3.4 GIS platform, and the area was calculated from the digital polygon map. It confirmed that the lake covers water area of 95.27ha, with periphery of 4748.33m. The depth of the lake at a distance of 30m from shoreline was measured to be 10.4m; however, the maximum depth as recorded by the District Fishery Development Office is 65m. During daytime, the light transparency of the water is very high and so do the pristine clarity. The upper surface of the lake water is total open and there is no floating vegetation in the lake. In total, the lake is more aesthetic hence attracts many nature lovers. The lake is also a dwelling ground for few aquatic local and migratory birds.

Sampling

A total of seven samplings in the lake was accomplished during 2004 to 2009. In the first phase there were three samplings from Feb 2004 to Nov 2005, while in second phase there were four samplings from Dec 2008 to 2009. The sampling times correspond to four in winter (Nov-Dec), two in pre-monsoon (Feb) and one in summer (Jul). Although in Feb 2010, only vigilance was made but no sampling done. The samplings of plankton were done through sieving of water for five times using approximately 2 liters capacity of jar into standard plankton collection net, periphyton were collected after scrapping 1x1 inch on surface of submerged cobbles, benthos were collected from bottom side of submerged stones after taking out from water and washing the mud surface in a bucket, and fishes were collected using drag nets (80m-110m length X 10m height; 7-10cm mesh/ mosquito net mesh), and cast net. Three replicates at each sampling for plankton, periphyton and benthos were sampled from randomly selected sites at the littoral zone. The specimens other than fish were preserved in 70% alcohol, while fishes were preserved in 4% formalin. Identification of fishes was done following Talwar and Jhingran (1991) and Jayaram (1999); the other biotic specimens were identified with the help of Edmondson (1992). The water quality parameters were recorded on the spot using portable tools, while dissolved oxygen was fixed in the dark bottle using alkaline iodide and manganese sulphate and measured through Winkler's titration method in the laboratory.

Rehabilitation of Mahseer

The living seeds of chocolate mahseer were accumulated through multiple attempts from the natural spawning areas in the nearby rivers. During the early period of the study, the seeds were released into a pit on the periphery of the lake at the onset of monsoon in March, and were monitored until the water level had raised enough after rain water harvest and swept the seeds into the main lake. The stocks of the introduced mahseer have been protected from killing by visitors through display of notice for awareness on the lake site. Time to time explorations encountered no classes of higher aquatic vertebrates other than fish and few birds; hence, found safe against predation on the experimental stocking.

Results

Water quality

Studied water parameters in the lake are recorded in the range of highest to lowest from 17°C (Jul) through 14 °C (Feb) to 8-9 °C (Nov-Dec) as water temperature, 7.2 to 6.8 as pH, 9.5 mg/L to 8 mg/L as DO, 60 mg/L to 40 mg/L as TA, 6 to 5 m as Light transparency.

Biotic composition

Organisms floating free or attach to submerged substratum both under the broad category named Plankton have been identified mostly at genus level, and found belonging to three classes, viz., Bacillariophyceae comprising 11 species, Chlorophyceae comprising 12 species, and Cyanophyceae comprising 3 species (Table 1). Macro-invertebrate (Benthos) identified comprising mainly of early life stage of flies and insects, like, Nymph of damsel fly, Nymph of may fly, Nymph of damsel fly, Nymph of dragon fly, Nymph of stone fly, Nymph of *Heptagenia* sp, Larvae of Coleoptera, and Larvae of Chironomids.

Fishery status

The fishery status is presented in Table 2. The samplings revealed that *Cyprinus carpio* were comprised of mixed size classes. This species was found in first sampling with established population. The further samplings also encountered the influx of population. *Salmo trutta fario* was present only in third sampling, but, none other specimen of this species was

Table 1. Plankton composition in Mehao lake revealed through preliminary investigation from seasonal sampling and identified following Edmondson (1992). Most of collected samples are yet to be thoroughly identified.

| Class→ | Bacillariophyceae | Chlorophyceae | Cyanophyceae |
|-------------------|-------------------------|-------------------------|---------------------|
| Identified taxa → | <i>Cyclotella</i> | <i>Closterium</i> | <i>Microcystis</i> |
| | <i>Encyonema</i> sp.1 | <i>Scenedesmus</i> | <i>Oscillatoria</i> |
| | <i>Frustulia</i> | <i>Sphaeroszoma</i> | <i>Phormidium</i> |
| | <i>Gomphonema</i> | <i>Staurastrum</i> sp.1 | |
| | <i>Navicula</i> sp.1 | <i>Staurastrum</i> sp.2 | |
| | <i>Navicula</i> sp.2 | <i>Staurastrum</i> sp.3 | |
| | <i>Nitzschia</i> | <i>Staurastrum</i> sp.4 | |
| | <i>Pinnularia</i> | <i>Staurastrum</i> sp.5 | |
| | <i>Surirella</i> | <i>Staurastrum</i> sp.6 | |
| | <i>Synedra</i> sp.1 | <i>Staurastrum</i> sp.7 | |
| | <i>Tabellaria</i> | <i>Staurastrum</i> sp.8 | |
| | <i>Staurastrum</i> sp.9 | | |

encountered in consecutive sampling. Although, the only observed specimen of this species was gravid female. The sampling in the 'link-stream' revealed the presence of a good number of *Exostoma labiatum*. The second phase of sampling after a lapse of three years revealed that seeds of *Neolissochilus hexagonolepis* were present in large number (Fig. 2). The sampling in pre monsoon further revealed a good population of this species. During summer, the sampling in the lake was unsuccessful due to full storage of water. However, *E. labiatum* was collected yet again from the 'link-stream'. The ultimate sampling in December 2009, revealed established population of *C. carpio* and *N. hexagonolepis* in the lake, while *E. labiatum* was sustained in the 'link-stream'. The vigilance at later phase of the study further unveiled that the sport fishery has been successfully established in the lake.



Fig. 2. Congregation of different life stages of chocolate mahseer in Mehao Lake.

Discussion

The physicochemical condition of water as depicted above suggests suitability of production of various plankton, periphyton and benthic macro invertebrates which have been sustained in the lake. The fishery status of common carp and chocolate mahseer can be said well established, rather best evaluated through observation. The existing good status of carp fishery in the lake is primarily credited to the biotic and abiotic condition of the valued ecosystem. However, the fish species present in the lake are mostly introduced, except *E. labiatum* which could only immigrate into the lake. The probable reasons of impossible upward migration by other fish species may relate to the cascading outlet of the lake. Further, during water recession period the head of the outlet dries out, although the seepages from the lake discharge water into the outlet. However, the study fails to encounter no other than single individual of the introduced brown trout which concludes that the species might not able to establish through natural propagation.

As a general fact, the mahseer feeds on diverse items including plankton, algae, crustaceans, aquatic macrophytes etc., and attains sexual maturity at the age between 3 to 4 years (Rai and Swar, 1989; Nautiyal and Lal, 1985; Ogale, 2002). The introduced mahseer has therefore been thriving well in the ecological condition of the lake along with the already established common carp population. The chocolate mahseer adapts readily in stagnant water and grow well (Laskar *et al.* 2009). The mahseer is also said to be migratory spawner who breed on gravel substratum in the headwater (Nautiyal, 1984). The physical

condition of 'link-stream' in the lake composing of gravels and boulders as substratum, medium to turbulent water flow, etc. along with suitable ecological condition have met the congenial breeding platform for the mahseer species. The presence of a large quantity of seeds of chocolate mahseer in December 2008 (around 4½ years after the introduction) suggests that the species has been persisting wild breeding in the lake; resultant population influx led to establish sustainable chocolate mahseer fishery there. Till the end of the study, the vigilance is profoundly encouraging the conservation endeavor that schools of mixed size classes of chocolate mahseer at the littoral and limnetic zones are abundantly present and visible from the periphery. Based on the profound success of first introduction of chocolate mahseer as well the establishment of natural population of the species in the lake, subsequent stocking of golden mahseer seeds also performed in the recent (Fig. 3) as per the rehabilitation strategy mentioned in methodology.

The study encourages the scope and potential of

such undisturbed and vast water bodies to be useful for long-run conservation of threatened/ endangered fishes particularly the indigenous Mahseer, through rehabilitation. The strategy of rehabilitation explained in the paper would be useful to conserva-



Fig. 3. Stocking of seed of Golden mahseer in Mehao Lake on 14th October 2011 with the aid of The Rufford Foundation London and The Directorate of Coldwater Fisheries Research (ICAR), India.

Table 2. Fishery status in Mehao lake revealed from seasonal samplings during the period of six years. The table focuses the establishment of Mahseer fishery in the lake through introduction and rehabilitation.

| Sampling No. | Sampling month (Year in parenthesis) | Fishes (common English name in parenthesis) | Size range of fishes caught (wt. in Kg); No. in parenthesis | Remarks |
|--------------|--------------------------------------|---|---|--|
| 1. | Feb (2004) | <i>Cyprinus carpio</i> (Common carp) | 1.1-1.3 (6) | Established population present with mixed size classes. |
| 2. | Dec (2004) | <i>C. carpio</i> | 0.6-1.56 (27) | -Do- |
| 3. | Nov (2005) | <i>C. carpio</i> <i>Salmo trutta fario</i> (Brown trout) <i>Exostoma labiatum</i> | 0.25-1.0 (13) 1.65 (1) 0.002-0.003 (17) | -Do- Stock declined; Many efforts ruined but lead to catch single. Present only in 'link-stream' between the lake segments. |
| 4. | Dec (2008) | <i>Neolissochilus hexagonolepis</i> (Chocolate Mahseer) | 0.0002-0.0005 (c7000-8000) | Natural breeding exhibited. |
| 5. | Feb (2009) | <i>C. carpio</i> <i>N. hexagonolepis</i> | 0.8 (1) 0.3-0.5 (23) | As above Established population present with mixed size classes |
| 6. | July (2009) | <i>E. labiatum</i> | 0.002-0.0025 (29) | Full storage level of water unsuited fishing in the lake. |
| 7. | Dec (2009) | <i>C. carpio</i> <i>N. hexagonolepis</i> <i>E. labiatum</i> | 0.9-1.3 (4) 0.5-0.6 (7) - | Clear water displayed bountiful schools of mixed size classes of both the carp species as evident by necked eye. |

tion planners. The results of the study provoke the recognition of the lake as 'Mahseer reserve' in order to pay management attention in the Lake. There is need of further management of the lake as it has been assumed that increasing rate of tourist's visits at the lake may cause some ecological problem if not managed from the beginning. From the study, it is proposed that the lake may be considered to declare as 'Mahseer Reserve' in order to pay attention for the scientific management and conservation of the important threatened mahseer fishes of India. The studied lake would be utilized for rehabilitation of other species of native mahseer in the near future. The strategy of rehabilitation explained in the paper would be useful to conservation planners. The lake at its present condition is a sustainable reserve for chocolate mahseer; while the newly released seeds of golden mahseer are also expected to achieve natural population therein. The study of bioecological conditions in the lake is a paramount need.

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