The Endangered Mighty Mahseer (*Tor putitora*) in the Himalayan Waters

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Abstract

Golden mahseer (*Tor putitora*), also called "mighty mahseer," is a prime fish species in the temperate Himalayas. It plays an important role in the socioeconomic upliftment of the local people in the hill region through fish-based ecotourism and sport fishery. However, due to indiscriminate exploitation and other anthropogenic pressure, the wild stocks of golden mahseer have dwindled significantly in the past, and eventually, it has been declared an "Endangered Species" by the International Union for Conservation of Nature. Therefore, there is an urgent need to conserve and rehabilitate this prime and priced fish species of the temperate Himalayas through different strategies and action plans. The development of breeding technology of golden mahseer helps to provide seeds for stocking in natural and man-made water bodies assuring the conservation of this magnificent fish. The present book chapter briefly describes golden mahseer status, and conservation approaches, emphasizing its captive breeding and seed production.

Keywords

Golden mahseer · Ranching · Angling · Captive breeding · Fish-based ecotourism

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6.1 Introduction

The *Tor* spp., the most magnificent fish group found in many rivers and streams of the Himalayas, is collectively called "mahseer." Taxonomically, mahseer is an iconic group of game fishes belonging to the family Cyprinidae, mostly to the genus *Tor*, but also includes certain species of the genera *Neolissochilus* (e.g., chocolate mahseer, *Neolissochilus hexagonolepis*) and *Naziritor* (e.g., dark mahseer, *Naziritor chelynoides*). Despite some phenotypic similarities, only members of the genus *Tor* are regarded as "true mahseers" (Desai 2003; Nguyen et al. 2008), and this chapter mainly focuses on the *Tor putitora* (Hamilton, 1822), a "flagship" species of the Indian subcontinent. Golden mahseer, king mahseer, mighty mahseer, the tiger of waters, and the king of game fishes (Fig. 6.1) are all common names for *Tor putitora*. The big size, appealing golden color, culinary quality, and fighting abilities of the fish have piqued the interest of the human population, fishermen, and researchers (Bhatt and Pandit 2016). Mahseer has always offered fishermen better sports than salmon (Thomas 1897). There have been reports of 275-cm-long and 54 kg fish in Indian lacustrine waters (Everard and Kataria 2011; Nautiyal et al. 2008). Numerous vernacular names, such as mahseer (big head), mahasaul (huge body), and mahasalka (large scale), are derived from these characteristics (Nautiyal 2014). In addition, mahseers have been revered as "God's fish" for ages over their entire geographic range. Sacred and masculine depictions of fish similar to mahseers may be found in Hindu holy scriptures, symbols, motifs, sculptures, and ancient literature (Jadhav 2009; Nautiyal 2014). At several temple ponds, there is a substantial population of mahseer, and these "temple sanctuaries" or "temple pools" are protected because of the social ideals and feelings of devotees, in addition to the involvement of communities and temple officials (Pinder et al. 2019).

Fig. 6.1 A golden mahseer (*T. putitora*)

6.2 Geographical Distribution

T. putitora (golden mahseer) is found in many Southeast Asian countries including India, Afghanistan, Bangladesh, Pakistan, Nepal, Bhutan, and Myanmar. This species is naturally distributed (Fig. 6.2) throughout the rivers of the South Himalayan drainage (specifically the Indus, Ganges, and Brahmaputra) from Pakistan in the west, all the way through India, Nepal, Bhutan, and Myanmar, with its range extending throughout the Eastern Brahmaputra catchments comprising the north-eastern states of India and Bangladesh (Rahman 1989). In India, golden mahseer primarily inhabits the Himalayan rivers in the foothills, and its range extends from Hindukush-Kabul-Kohistan in the Northwest Himalaya to Sadiya (Brahmaputra) in the Northeast Himalaya. Golden mahseer is a rheophilic species that enjoys rocky/stony/sandy substrates in hill streams (Nautiyal 2014). It also thrives well in semi-lacustrine waters of the Himalayas (Bhatt and Pandit 2016). The mighty mahseer's cylindrical body, muscular tail, and hypertrophied lips enable it to survive in rapidly flowing streams. The temperature range of 15–25 °C is considered optimal for golden mahseer. The species is potamodromous and performs extensive upstream spawning migrations (Bhatt and Pandit 2016).

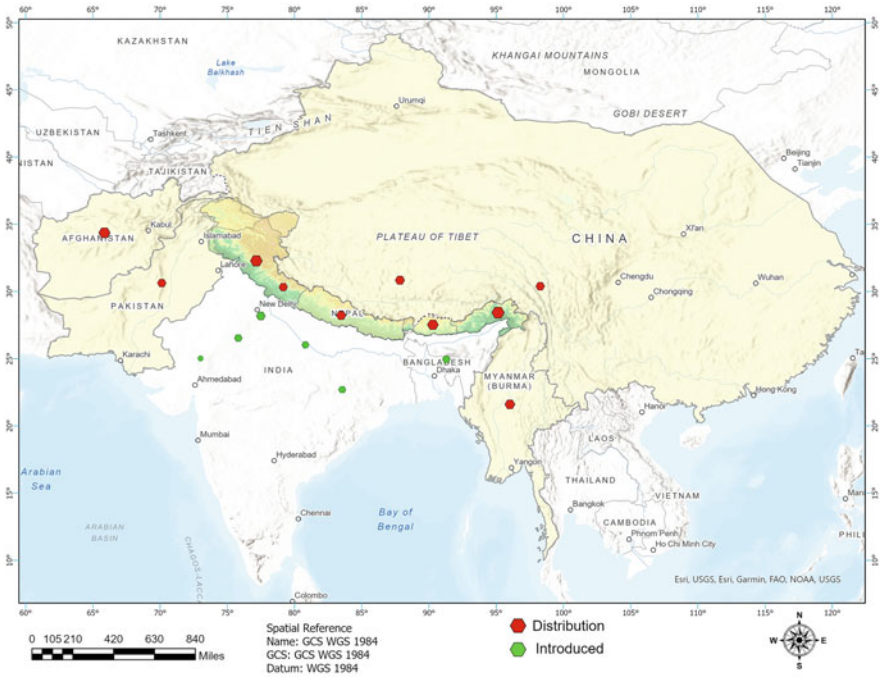


Fig. 6.2 Distribution of golden mahseer (*T. putitora*) across the temperate Himalaya (Map courtesy: Dr. Ravindra Posti)

6.3 Major Threats and Population Status of Golden Mahseer

Mahseer, *T. putitora*, formed a substantial natural fishery in the major riverine and lake ecosystems of the Indian Himalayas. The mahseer population in natural waters has decreased in size and quantity despite once being abundant. The unprecedented population pressure and decline are attributed to anthropogenic activities such as habitat fragmentation, environmental degradation and declining water quality, drainage basin alteration and deforestation, pollution, overexploitation, invasive species, and indiscriminate and destructive fishing (Nautiyal 1994; Sehgal 1999; Dinesh et al. 2010; Akhtar et al. 2017). Inherent biological traits such as delayed maturity, low fecundity, and slow growth rate have also contributed for its population decline over time (Akhtar et al. 2018). Consequently, it is now classified as an endangered species (IUCN 2014) due to the decrease in *T. putitora* populations in several Asian regions (Hussain and Mazid 2001). Females do not attain sexual maturity until they reach 4 years or older (Nautiyal 1994). However, sexually mature males are usually spotted even at 2+ years of their age. The age classes of *T. putitora* most frequently harvested are 2+ to 4+ years. Consequently, catching a significant number of fish before they reach sexual maturity reduces population size (Bhatt and Pandit 2016). Furthermore, *T. putitora*, threatened by overfishing, habitat loss, and degradation, has led to the destruction of its reproductive habitats across the water bodies. It is anticipated that the current proliferation of dams in the Himalayan region, either already built or scheduled to be built, will have a domino effect on the breeding migrations of the species. Because of its economic, sporting, and cultural significance, the golden mahseer has been designated as the "state fish" of four Indian Himalayan states (Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, and Uttarakhand). Numerous organizations are working to prevent its further decline (Bhatt and Pandit 2016) through various conservation strategies.

6.4 Food and Feeding Habits

Due to the large mouth opening and size of the golden mahseer, it was once believed that it was a carnivorous fish. Later, studies indicated that food preference varies with age and size (Nautiyal and Lal 1984). For example, hatchlings prefer planktonic food that is abundant in their natural environments, while as fish grows larger, their feeding habit shifts toward carnivory. However, they are opportunists who feed on a variety of plant and animal items. Mahseer has been reported to consume green filamentous algae, small mollusks, insect larvae, and algal coatings on rocks. It was observed that the diet of mahseer fingerlings in the wild comprised of insect matter (81.4%), plant matter (15.9%), and other foods such as fish (1.6%) (Nautiyal and Lal 1984). Hence, the eating preferences of golden mahseer are highly dependent on availability of food. Consequently, several studies classified the species as insectivore, carnivore, herbi-omnivore, and carni-omnivore (Nautiyal and Lal 1984; Das and Pathani 1978; Badola and Singh 1980). In general, the mahseer is a carnivorous fish during its early stage and an omni-herbivore during its adult phase.

6.5 Reproductive Biology

The golden mahseer is a batch spawner, producing eggs intermittently (different size groups of eggs can be seen in the ovary; Fig. 6.3), during its extended breeding season, with the majority of spawning occurring between May and August (monsoon season). No strong sexual dimorphic character is evident in *T. putitora*, although a few secondary sexual characteristics have been documented in hatchery stocks (Fig. 6.4) during the breeding season. Males have bright coloration and an elongated body with rough pectoral fins, whereas females have a dull coloration and a deep body (Arjamand et al. 2013). During spawning season, the ripeness of the female mahseer can be noted by feeling the softness of the abdomen and the pink coloration of the vent. It has a preference for clean water with sandy or gravelly bottoms for breeding and performs potamodromous upstream spawning migrations. It is believed that spawning migration is triggered by turbid waters and elevated

Fig. 6.3 Ovary of golden mahseer containing eggs of different sizes

Fig. 6.4 Captive-reared female (upper) and male (lower) brooders of golden mahseer

water temperatures (Nautiyal 1994; Bhatt et al. 2004). Consequently, during floods, the mahseer ascends to the river's higher reaches, travelling great distances in search of suitable breeding grounds or substratum. They typically lay their eggs in shallow (0.5–3.5 m) streams, containing pebbles, gravel, sand, and silt (Pathani 1994). Suitable spawning environments include riverbanks, where fishes dig nests to lay eggs (Nautiyal 1994). One batch of eggs is released at a time, and the process is repeated numerous times during the breeding season. The fecundity of golden mahseer is very low, ranging from 7 to 25 eggs per gram of body weight (Pathani 1981; Nautiyal and Lal 1985; Nautiyal 2014). The fertilized eggs require 58–192 h to hatch, and because they are demersal, they may sink and die on the muddy riverbeds (Johnsingh et al. 2006). Additionally, their extended developmental period leaves them susceptible to predation. The optimal conditions for egg hatching are high turbidity and temperatures between 16 °C and 25 °C (Johnsingh et al. 2006). In the Indian subcontinent, the predominant spawning grounds of *T. putitora* are distributed throughout the Himalayan river systems (Joshi 1988; Bhatt et al. 2004; Atkore et al. 2011; Shrestha 2002; Dasgupta 1991a, b; Zafar et al. 2001).

6.6 Captive Breeding Technology and Seed Production

After the inclusion of the golden mahseer in the *IUCN Red Data Book* as an endangered species (Jha and Rayamajhi 2010), biologists, conservationists, and policymakers became very concerned about preserving and increasing the existing stock through technological solutions and other conservation methods. Artificial propagation and seed production have been regarded as the most viable strategy for rehabilitating this valuable fish. The production of large quantities of seeds from captive broodstocks, followed by the release of healthy fry into their natural habitat (stock enhancement) has been promoted as one of the possible and pragmatic ways for stock replenishment and conservation (Akhtar et al. 2020). Numerous studies have investigated the reproductive biology/behavior and approach for captive propagation of golden mahseer in numerous Trans-Himalayan nations over the years (Ingram et al. 2005; Sarma et al. 2010; Ismail et al. 2011; Akhtar et al. 2013; Sharma et al. 2016). Unfortunately, golden mahseer fails to complete ovarian development and maturity in captivity due to oxidative stress induced endocrine dysfunctions (Akhtar et al. 2017). Therefore, gravid female brooders, collected from the wild, were exploited in the development of golden mahseer seed production and hatchery technologies in the recent past (Sehgal and Malik 1991; Sunder et al. 1993; Sehgal 1999; Ogale 2002; Sarma et al. 2016). This practice of wild collection of gravid brooders for stripping and artificial fertilization has been demonstrated to be non-sustainable, as gravid wild brooders, collected through gill nets die after stripping (Fig. 6.5). Furthermore, the huge demand of stocking material cannot be achieved from wild brooders. Consequently, the paucity of mature golden mahseer brooders in captivity significantly hindered its large-scale seed production for conservation and rehabilitation.

Fig. 6.5 A trapped golden mahseer brooder in a gillnet (destructive fishing)

Numerous scientists and researchers have attempted captive breeding of golden mahseer using pituitary extract or synthetic hormones during the past four decades with minimal success (Tripathi 1978; Pathani and Das 1979; Pandey et al. 1998; Sehgal 1991). Thus, the lack of mature female golden mahseer brooders in captivity has been a significant barrier to producing seeds on a large scale. ICAR-Directorate of Coldwater Fisheries Research (ICAR-DCFR), Bhimtal, India, the only premier research institute engaged in the research and development of fisheries and aquaculture in the temperate Himalayas, has developed an indoor technology for captive maturation and year-round multiple breeding of golden mahseer (Fig. 6.6) by manipulating different environmental cues (Akhtar et al. 2018, 2020, 2021b). This invention includes a system and method for year-round multiple breeding of golden mahseer to produce fry (Akhtar et al. 2021a, c). Using a unique indoor maturation unit, separate egg incubators, modifying water quality, and simulating breeding and grazing grounds during hatchery operation increased the fertilization, hatching, and fry survival. More than 72% of golden mahseer females were found to respond to egg stripping with the current technology, and a single female brooder was found to breed a maximum of four times and a minimum of two times annually. The average annual relative fecundity of each responding female brooder was calculated to be 9680±811 eggs/kg body weight. As a conservation and rehabilitation measure, hatchery-produced advance fry are now routinely ranched into open water bodies (the temperate Himalayan lakes and rivers), following a 6- to 7-month raising period in nursery tanks.

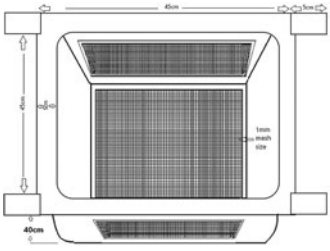
6.7 Mahseer Conservation Strategies

The population of golden mahseer in India is expected to have decreased by more than 50% in the past, and it may reduce by as much as 80% in the future, primarily as a result of the construction of dams across the Himalayan rivers (IUCN 2015;

Captive maturation unit

Golden mahseer brooders

Stripping of captive-matured brooder



Golden mahseer egg incubator

Fertilized eggs of golden mahseer matured in captivity

Golden mahseer fry produced from captive-matured brooders

Fig. 6.6 Some important components of the captive maturation and multiple breeding technology of golden mahseer

Sharma et al. 2015). Therefore, the conservation of golden mahseer in the rivers of the Himalayas presents a big challenge for those who work in the conservation field and those who formulate public policy and manage fisheries. To begin the process of recovering golden mahseer, the first thing that needs to be done is to use this species as a "flagship" species to educate people about its positive effects on the environment and the ecosystem (Laskar et al. 2013; Gupta et al. 2014). For the purpose of mounting a mahseer conservation effort that is both effective and focused on achieving particular objectives, recent years have seen the launch of programs like "Project Mahseer," which is analogous to "Project Tiger" (Nautiyal 2011; WWF 2013). Without stringent protection measures such as the restoration of river connectivity to enable spawning migration, habitat restoration, strict enforcement of rules and regulations (complete fishing ban during monsoon, mesh/equipment size restriction, and penalty for catching/landing small size groups), the establishment of protected areas, etc., conservation and rehabilitation of mahseer may fail. It is possible for various stakeholders, including recreational fisheries groups, to play an important part in the protection of mahseer by practicing catch-and-release fishing. This recreational fishing helps to protect mahseer while also providing employment opportunities and economic benefits to the local fishermen (Bhatt and Pandit 2016; Pinder et al. 2019). It is also recommended that the key sections of the Himalayan rivers be designated as important habitats for the golden mahseer so that it can be protected and brought back to its former glory.

The establishment of hatcheries for ex situ conservation of mahseer is a technique that would be effective over the long run (Bhatt and Pandit 2016). Despite this, there is less number of operational hatcheries in India, dedicated to *T. putitora*. Flow-through mahseer hatcheries have been developed by the ICAR-Directorate of Coldwater Fisheries Research at the Iduli fish farm in Roing, Arunachal Pradesh; the Eco-camp, ABACA, Nameri National Park in Tezpur, Assam; and the Bagua fish farm in Sikkim. If the environment in which we release the fry is fragmented, it is imperative that we adhere to the recommendations made by the IUCN regarding the release, site selection, and longitudinal connectivity (IUCN/SSC 2013). Only then we will be able to successfully disperse hatchery-produced fry into natural water bodies. Ranching operations, in which hatchery-produced healthy juveniles are reintroduced into various temperate Himalayan lakes and rivers, are being carried out on a regular basis by the ICAR-DCFR, Bhimtal, a leading research institute in cold-water fisheries. These ranching operations are being carried out as a step toward mahseer restoration (Fig. 6.7) and rehabilitation.

6.8 Recreational Fishing and Ecotourism Prospects

Ecotourism is a sustainable form of resource use that contributes to the preservation of the natural environment and offers socioeconomic benefits to the people who participate in it. These benefits come from the ecotourism industry's utilization of natural or biological resources in ways that do not involve direct consumption. Fishery-based ecotourism is growing and has the potential to create new jobs.

In Naukuchiatal Lake, Nainital, Uttarakhand

Kosi river at Ramnagar, Nainital, Uttarakhand

Nainital Lake, Nainital, Uttarakhand

Fig. 6.7 Some glimpses of golden mahseer ranching programs taken up by ICAR-DCFR

Anglers from all over the world travel to the temperate Himalayan rivers to catch the mighty mahseer since sport fishing is quite popular in the Indian Himalayas (Fig. 6.8). About 3800 km lengths of river and stream stretch in the Indian uplands hold sizeable mahseer for angling.

The revenues generated through the sale of fishing licenses help manage fish and wildlife, while the money spent by anglers and tourists on recreational fishing and other logistics generates employment for the locals. Among the Himalayan streams and rivers, river Beas and its tributaries in the foothill region and the river Giri (Himachal Pradesh); Yamuna between Tajwala (Haryana) to Dhak Pathar; Ganga between Rishikesh to Tehri and its tributaries; the Kali, Saryu, East and Western Ramganga, East and Western Nayar, Song, Kosi (Uttarakhand), river Chenab and its tributaries, and rivers Jia-bhoroli, Dibang, Subansiri and Manas (North Eastern Himalayan region) are important fishing sites for mahseer. Apart from these, the lakes of Kumaon (Bhimtal, Naukuchiatal, Nal Damyanti Tal, and Sattal) contribute substantially to mahseer fishery and provide ample scope for fish sports. Besides natural water bodies, the suitable ponds and pools available along the scenic valleys, mountains, or riverbanks in the region could be used to develop mahseer-based sport fishery units with the development of infrastructural facilities. This will help in the overall conservation and management of golden mahseer in the Himalayan waters.

Fig. 6.8 Golden mahseer angling in the North Eastern Himalayan region. (Photo courtesy: Mr. Nausad Ali)

6.9 Conclusion

Golden mahseer has been one of the prides of the temperate Himalayan waters. Therefore, it is the moral duty of all the stakeholders, from researchers to policymakers, to safeguard its population. Dedicated efforts are required to conserve mahseer fishing resources and promote their sustainable development successfully. The conservation initiatives must integrate its capture and culture fisheries with environmental protection programs. Environmental regulations with stringent enforcement mechanisms must be implemented to manage mahseer fisheries effectively. The sustainable development of the golden mahseer fishery would require the intervention of policy and governance from various stakeholders and fisheries researchers. Perhaps, we may have to incorporate our policy research for mahseer into our research initiatives as soon as the program is initiated. There are many identified potential areas in the Himalayan states which can be developed for mahseer-based ecotourism/eco-parks.

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