



Review

The mighty mahseers of the genera *Tor*, *Neolissochilus* and *Naziritor*: A review on resource distribution, biology, ecotourism and conservation

DEBAJIT SARMA, DINESH MOHAN, RAVINDRA POSTI, MUKUL ARYA AND
PARVAIZ AHMAD GANIE

ICAR- Directorate of Coldwater Fisheries Research, Bhimtal - 263 136, Uttarakhand, India
e-mail: dsarma_sh@yahoo.co.in

ABSTRACT

Mahseers belonging to genus *Tor*, *Neolissochilus* and *Naziritor*, comprise important groups of food and sport fishes in the freshwater eco-systems. *Tor* mahseers being potential game fish are recognised as cultural icon in the pristine waters across the globe. They also have high nutritional value with high content of DHA, EPA and amino acids which are important to human health. Presently, 17 species of *Tor*, 25 species of *Neolissochilus* and 2 species of *Naziritor* have been reported and validated throughout the world. However, due to several anthropogenic and natural activities, their population is dwindling across most of the natural ecosystems and IUCN has categorised the group as endangered. Change in temperature and monsoon floods triggers the act of migration and spawning behaviour of mahseers in their respective ecological conditions. There are 47 species of mahseers in the world, out of which India harbours fifteen species. These species widely occur in the rocky and pristine fast flowing streams of India, China, Nepal, Sri Lanka, Myanmar, Malaysia, Thailand, Vietnam, Pakistan and Bangladesh. The present paper embodies the status of mahseers under the genera *Tor*, *Neolissochilus* and *Naziritor* to understand this magnificent group of fishes having extraordinary importance in terms of balancing aquatic biodiversity sustainability, creating opportunities for increasing livelihood though utilising this fish in sports (angling and ecotourism) and draws immediate attention for its conservation in inclusive and responsible manner.

Keywords: Conservation, Ecotourism, GIS, Mahseer, Resource mapping

Introduction

Mahseers commonly known as “tiger of water” belonging to the order Cypriniformes and family Cyprinidae are considered as bio-indicator species of freshwater ecosystems (Everard and Kataria, 2011; Gupta *et al.*, 2014, Sarma *et al.*, 2016). This group of game and sport fishes comes under the genera, *Tor*, *Neolissochilus* and *Naziritor* (Sarma *et al.*, 2016). Being a potential game fish, mahseer is recognised as a cultural icon in the pristine waters across the world and its flesh has high nutritional value (Islam and Tanaka, 2004, Gupta *et al.*, 2014, Sarma *et al.*, 2016). However, the population of mahseers in terms of size and species is declining due to various natural and anthropogenic factors (Sarma, 2009). Stone (2007) stated that mahseer is considered as one among the 20 mega fishes of the world. Because of its extraordinary fighting spirit and sensitivity for thriving in aquatic ecosystems, mahseer is declared as “state fish” in seven states in India (Sarma *et al.*, 2016). In South-east Asia, 13 valid *Tor* species have been reported by various authors (Hamilton, 1822; Wei and Cui, 1996; Monkolprasit *et al.*, 1997; Roberts, 1999; Oo, 2002; ZiMing and JunXing, 2004; Hoang *et al.*, 2015; Walton *et al.*, 2017; Qin *et al.*, 2017; Anabella *et al.*, 2020) viz., *Tor putitora*, *Tor tor*,

Tor khudree, *Tor mosal*, *Tor dongnaiensis*, *Tor douronensis*, *Tor laterivittatus*, *Tor mekongensis*, *Tor sinensis*, *Tor soro*, *Tor tambra*, *Tor tambroides* and *Tor yingjiangensis*. *Tor progenius* and *Tor barake* have also been described as valid species by Vishwanath (2011) and Laskar *et al.* (2013) respectively. The group of fishes which has been termed as Mahseer in the recent past by the anglers of North-eastern Himalayan region belongs to the genus ‘*Neolissochilus*’ (Sarma *et al.*, 2018). The distribution of *Neolissochilus* is mostly restricted to the Brahmaputra River basin of North-eastern India and Himalayan region of Nepal and Bhutan, inhabiting from 500 to 1500 m asl and they are commonly called as chocolate mahseer or copper mahseer. Due to its strong fighting habits like a tiger and due to presence of large scale and mouth, chocolate mahseer is considered as iconic fish in the waters of North-east India (Rainboth, 1985). There are more than twenty valid species of *Neolissochilus* described across South-east Asia which are highly potential game and sports fishes and fetch high market price in an unorganised manner (Laskar *et al.*, 2009). Two species of *Neolissochilus* i.e., *N. thienemanni* and *N. sumatranus* are also widely distributed in Borneo, Java and Sumatra. *N. thienemanni* is placed in the vulnerable list of the IUCN category because of habitat destruction and indiscriminate fishing activities. Three *Tor*

species namely *T. tambra*, *T. tambroides* and *T. douronensis* as well as four *Neolissochilus* species (*N. thienemanni*, *N. soro*, *N. sumatranus* and *N. longipinnis*) have been reported from the coldwater streams of Indonesia (Kottelat *et al.*, 1993). Chocolate mahseer of *Neolissochilus* genus is an extremely important fish as source of nutrition, sport fishing and livelihood in hilly regions of Arunachal Pradesh, Assam and Meghalaya (Sahoo *et al.*, 2015; Sarma *et al.*, 2018). Because of various illegal fishing activities, the population of *N. hexagonolepis* has been declining in the rivers of Arunachal Pradesh and is currently designated as threatened species (Nath and Dey, 2002; IUCN, 2014). To revive back its fishery, attempts are being made for artificial breeding programmes and various conservation measures are planned (Menon, 1974; Sinha, 1994; Marwein, 2000; Mahapatra *et al.*, 2004b; Lakra *et al.*, 2010; Mahapatra and Vinod, 2011; Debajit *et al.*, 2015). The present paper is an attempt to assess the status of mahseers under the genera *Tor*, *Neolissochilus* and *Naziritor* to understand this magnificent group of fishes having extraordinary importance in terms of balancing aquatic biodiversity, sustainability, creating opportunities for increasing livelihood though utilising this fish in sports (angling and ecotourism) and also tries to draw immediate attention for its conservation in inclusive and responsible manner.

Taxonomy

Taxonomy and phenotypic studies of species play important role in assessment of fish genetics and resource management, however there are ambiguities in identification of species due to the morphological similarities among the species (Bagra *et al.*, 2009). The mahseer species was first described as *Cyprinus putitora* which was later placed under the genus *Tor* as *Tor putitora* (Gray, 1833-1834). Hora (1939) described it as *Barbus putitora* whereas Menon (1954) described it as *T. putitora* and restored its name proposed by Gray (1833-1834). Despite its morphological distinction from other mahseer species (Laskar *et al.*, 2013), its nomenclature and taxonomic position was viewed by several authors in different genera (Dinesh *et al.*, 2010; Pinder and Raghavan, 2013; Eschmeyer and Fong, 2014). Large head, body and scales are important morphological characteristic features of mahseers and various names such as mahseer (large head), mahasaul and mahasalka (large scale) are probably derived from these features (Nautiyal, 2014) and head length of the fish exceeds that of the body depth in *T. putitora* (Hora, 1939, Bhatt *et al.*, 1998). The fish having length and weight up to 275 cm and 54 kg respectively in Indian waters were reported by Nautiyal *et al.* (2008) and Everard and Kataria (2011). The name mahseer is often used for species belonging to genus

Tor as well as for other species of the genus *Neolissochilus* and single species of the genus *Naziritor* (Sati *et al.*, 2013). Among the Indian mahseers, only five valid species have been accepted based on morphological description (Dinesh *et al.*, 2010). Some of the newly reported species such as *Tor moyarensis*, *Tor remadevi* and *T. mosal* has been contemplated as a synonym of *T. putitora* (Eschmeyer *et al.*, 2013; Froese and Pauly 2013). *T. khudree* and *T. mussulah* are exclusively endemic to the rivers of Deccan Plateau and peninsular India (Jayaram, 2005). However, *T. khudree malabaricus* is listed as a separate species (David, 1953a, b; Silas *et al.*, 2005). Menon (1992) described *T. mosal mahanadicus* as *T. khudree mahanadicus* endemic to the Mahanadi River of the central plateau. RAPD profile of *T. mosal mahanadicus* described it to be more similar to *T. putitora* than other *Tor* species (Mohindra *et al.*, 2007). However, it is not quite possible to distinguish *T. khudree longispinus* from *T. khudree* on the basis of three mitochondrial genes (Nguyen *et al.*, 2006). This also shows that their number varies because of the taxonomic uncertainties (Siraj *et al.*, 2007; Froese and Pauly, 2013). It has been documented that there are only sixteen valid species of *Tor* and all have been listed in the IUCN Red List of Threatened Species TM (Version, 2018-20; Pinder *et al.*, 2019). Eschmeyer's Catalog of Fishes (2021) shows that only 17 out of 24 mahseer species are validated as *Tor* species. The genus *Neolissochilus* is very closely related to the genus *Tor* (Arunachalam *et al.*, 2017). However, the genus *Tor* is different from *Neolissochilus* in development of a lower lobe into fleshy lobe (Vishwanath, 2014; Sarma *et al.*, 2016). The genus *Neolissochilus* has no identical fleshy mandibular lobe and tubercles. It is an intermediate group between the two genera. The genus *Tor* has massive pharyngeal arches than *Neolissochilus*. There are several taxonomic position and nomenclature of *Neolissochilus* species which are reviewed by several authors (Dinesh *et al.*, 2010; Eschmeyer and Fong, 2014) despite being morphologically distanced than other mahseer species (Laskar *et al.*, 2013). *N. hexagonolepis* was initially included under the genus *Barbus* (McClelland, 1839), but it was again reclassified under genus *Lissochilus* (Weber and de-Beaufort, 1916). Later on, its taxonomic position was put forward in the genus *Acrossocheilus* (Oshima, 1919). Among the Cyprinidae family, genus *Neolissochilus* (Rainboth, 1985) consists of 25 species, out of which 22 species are recorded in South-east Asia (Kottelat, 2013) and seven in the Indian subcontinent. The species of *Neolissochilus* available in India are *N. hexagonolepis* (McClelland, 1839), *N. hexasticus* (McClelland, 1839), *N. stevensonii* (Day, 1870), *N. stracheyi* (Day, 1871), *N. wynaadensis* (Day, 1873) and *N. paucisquamatus* (Smith, 1945; Talwar and Jhingran, 1990; Vishwanath, 2011). Earlier *Naziritor* was proposed

to fit in with mahseer species (*Naziritor zhubensis*) in the Zhub River of western Pakistan (Mirza and Javed, 1985) and due to the taxonomic ambiguities, it was considered as the single species until Menon (1999) classified *Tor chelynooides* as *Naziritorchelynooides* (Talwar and Jhingran, 1991). Later Dahanukar (2010) and Froese and Pauly (2013) recognised this species as *Puntius chelynooides*. However, there is enough scientific evidence to consider this species as valid species. Mahseer species are among the most diversified of the *cyprinids* across their distribution in the world and due to their morphological variations, most of the taxonomists have different opinion concerning their nomenclature (Silas *et al.*, 2005).

Occurrence and distribution

Mahseers generally inhabit the pristine fast flowing and cold waters with a preference for rocky bottoms and deep pools (Ng, 2004; Dinesh *et al.*, 2010). These species widely occur in the rocky streams of India, China, Nepal, Sri Lanka, Myanmar, Malaysia, Thailand, Vietnam, Pakistan and Bangladesh (Sarma *et al.*, 2016). There are 47 species of mahseers in the world, out of which India harbours fifteen species (Baruah and Sarma, 2018). These 15 species of mahseers belongs to the genus *Tor* and *Neolissochilus i.e.*, Golden mahseer (*T. putitora*), Tor mahseer (*Tor tor*); Deccan mahseer (*T. khudree*), (*T. kulkarni*), Mosal mahseer (*T. mosal*), *T. remadevi*, Humpback mahseer (*T. mussullah*), *T. progenies*, Chocolate mahseer (*Neolissocheilus hexagonolepis*), *N. wynadensis* and *N. hexastichus*. A new species of *Tor i.e.*, *Tor remadevii*, was identified from Chinnar Wildlife Sanctuary, Kerala of Southern India (Kurup and Radhakrishnan, 2010). The Indian subcontinent in southern Asia possess the majority of *Tor* species, out of which seven species are distributed in central and Deccan plateaus (Desai, 2003; Jayaram, 2005). These are *T. putitora* (Hamilton), *T. khudree* (Sykes), *T. tor* (Hamilton), *T. mosal* (Sykes), *T. mussullah* (Sykes), *T. progeneius* (McClelland) and *T. kulkarni* (Menon). The North-eastern part of India harbours 11 species of mahseers *i.e.*, 6 species of *Tor* and 5 species of *Neolissochilus* (Vishwanath, 2014). One important species of mahseer *viz.*, *N. hexastichus* has been reported to be colonised in the Diyung River of Assam, India (Laskar *et al.*, 2018). It is also reported that the upper reaches of Manas River, Assam and its tributaries are specially inhabited by *T. putitora*, *T. tor* and *N. hexagonolepis*. Arunachalam *et al.* (2017) reported five species of *Neolissochilus* from the Periyar River of Western Ghats, India *viz.*, *N. minimus*, *N. capudelpinus*, *N. acutirostris*, *N. microphthalmus* and *N. tamiraparaniensis*. Another species namely *N. kaladanensis* (Lalramliana

and Singh, 2019) was described from the Kaladan River drainage of Mizoram. Also, *N. compressus* (Day, 1870) and *N. blythii* (Day, 1870) were recorded from Tenasserim Province, Myanmar. *N. hendersoni* (Herre, 1940) and *N. dukai* (Day, 1878) were validated from Malay Peninsula. *N. subterraneus* (Vidthayanon and Kottelat, 2003) was recorded from Tham Phra Wang Daeng cave in Thailand. *N. thienemannia* (Ahl, 1933) is distributed inlake Toba in Sumatra, Indonesia. *N. benasi* (Pellegrin and Chevey, 1936) is found in Vietnam and China. Two species of *Neolissochilus viz.*, *N. baoshanensis* (Chen and Yang, 1999) and *N. heterostomus* (Chen and Yang, 1999) were reported from Yunnan region of China. Kottelat *et al.* (1993) reported four species of *Neolissochilus* (*N. sumatranus*, *N. thienemanni*, *N. soro* and *N. longipinnis*) from Indonesia.

Tor barakae (Arunkumar and Basudha, 2003)

Arunkumar and Basudha (2003) described *T. barakae*, from the Barak River, India and Laskar *et al.* (2018) explained the validity of the species and distinguished it from co-occurring *T. putitora*. This species is endemic to the Barak River, Manipur and from Madhpur on the Manipur-Assam border.

Tor mosal (Hamilton, 1822)

It was first described as *Cyprinus mosal* (Hamilton, 1822) and now assigned to the genus *Tor*. This species is mainly distributed in the upper Ganges and upper Brahmaputra River basins (northern India and Nepal). *T. mosal* is listed as data deficient in the IUCN Red List (Dahanukar *et al.*, 2018).

Tor dongnaiensis and *T. mekongensis* (Hoang *et al.*, 2015)

T. dongnaiensis and *T. mekongensis* were described by Hoang *et al.* (2015) from the Krong No and Dong Nai basins of southern Vietnam. *T. dongnaiensis* has been evaluated as near threatened in the IUCN Red List due to its restricted distribution (Pinder and Harrison, 2018).

Tor khudree (Sykes, 1839)

Tor khudree was first described from the Mota Mola River in Pune, Maharashtra, India (Sykes, 1839). The first genetic interpretation of this species was done to resolve its identity by Nguyen *et al.* (2008). This species has been listed as 'Endangered' in IUCN Red List (Devi and Boguskaya, 2007).

Tor kulkarni (Menon, 1992)

Menon (1992) described *T. kulkarnii* from the Dharna River which is a tributary of the river Godavari in

Maharashtra, but subsequently considered as a synonym of *T. khudree* (Jayaram, 1999, 2005, 2010).

Tor musullah (Sykes, 1839)

It is mainly distributed in the freshwaters of peninsular India. The Krishna and Godavari rivers are its principal habitats.

Tor tambroides (Bleeker, 1854)

It is distributed mainly in Thailand, Indonesia, Cambodia and Malaysia (Moshin and Ambak, 1983; Roberts, 1989; Rainboth, 1996).

Tor malabaricus (Jerdon, 1849)

T. malabaricus also known as the Malabar mahseer was first described from the fast-flowing hilly streams of Malabar India (Jerdon, 1849). Some taxonomists also considered it as a synonym of Deccan mahseer, *T. khudree* (Menon 1992, 1999), while some believe it to be a valid sub-species, *T. khudree malabaricus* (Indra, 1993).

Tor putitora (Hamilton, 1822)

The ‘golden mahseer’ *T. putitora* was first described from eastern Bengal by Hamilton (1822). Golden mahseer is widely distributed in the cold-water rivers of the Himalayas viz., Ganges, Brahmaputra and Indus from Pakistan, through India, Nepal, Bhutan and Myanmar in west. Its distribution also exceeds the eastern Brahmaputra catchment areas of India and Bangladesh (Rahman, 1989).

Tor remadevii (Kurup and Radhakrishnan, 2010)

Kurup and Radhakrishnan (2010) described *T. remadevii* on the basis of nineteen juvenile specimens ranging from 114 to 332 mm from the Pambar, a tributary of the river Cauvery in Kerala. This species is also known as the hump-backed mahseer and it is also being listed as ‘Critically Endangered’ in the IUCN Red List (Pinder *et al.*, 2018; IUCN, 2019).

Tor progeniens (McClelland, 1839)

The junggha of Assamese, is distributed in the north-eastern Himalayas in Assam, Naga hills and Manipur.

Tor tor (Hamilton, 1822)

This species is often referred to as the ‘red-fin’ or ‘deep bodied’ mahseer and was described from the Mahananda, a tributary of the Ganges in the North-east Bengal, India (Hamilton, 1822). *T. tor* is reviewed as the most widely distributed species of mahseer (Lal *et al.*, 2013) extending from the southern Himalayas from Pakistan in the west to the east of Myanmar and southwards to the peninsular Indian rivers.

Tor sinensis (Wu, 1977)

T. sinensis was first described by Wu (1977) in the upper reaches of the Mekong of the Yunnan Province,

China. It is also known as red fish throughout Laos. Due to its fragmented population, restricted distribution and habitat destruction, *T. sinensis* is listed as Vulnerable (Vidthayanon and Pinder, 2018).

Tor tambra (Valenciennes, 1842)

This species is endemic in the freshwater areas of Java, Sumatra and Borneo (Kottelat *et al.*, 2018).

Tor tambroides (Bleeker, 1854)

This species is endemic in the freshwater areas of Java, Sumatra and Borneo (Kottelat *et al.*, 2018).

Tor douronensis (Valenciennes, 1842)

T. douronensis is widely distributed in the freshwater reaches of Java, Sumatra and Borneo (Kottelat *et al.*, 2018).

Neolissochilus acutirostris (Arunachalam *et al.*, 2017) (Fig. 1)

This species is widely scattered in the rivers of the Western Ghats and peninsular India.

Neolissochilus benasi (Pellegrin and Chevey, 1936) (Fig. 2)

The species is mainly distributed in the Tsang-Po River of China and also been reported from Vietnam.

Neolissochilus capudelphinus (Arunachalam *et al.*, 2017) (Fig. 3)

This species was first reported by Arunachalam *et al.* (2003) from the Periyar River of Western Ghats in India.

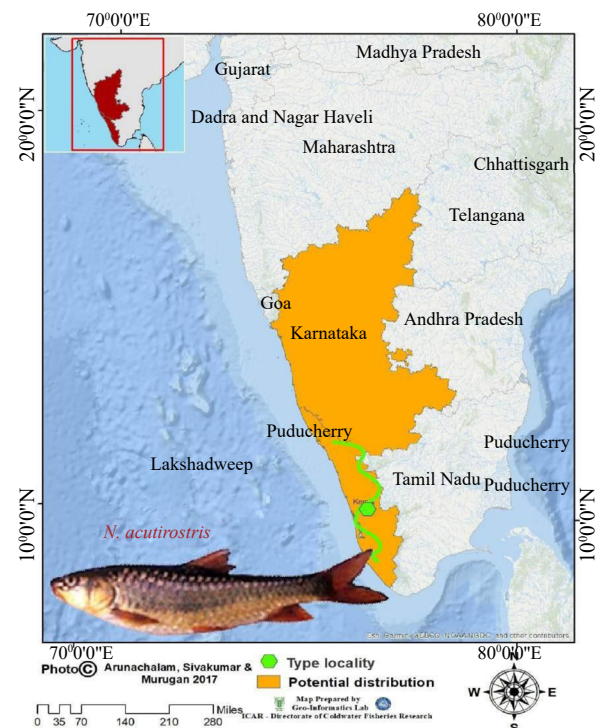


Fig. 1. Potential distribution and type locality of *N. acutirostris*

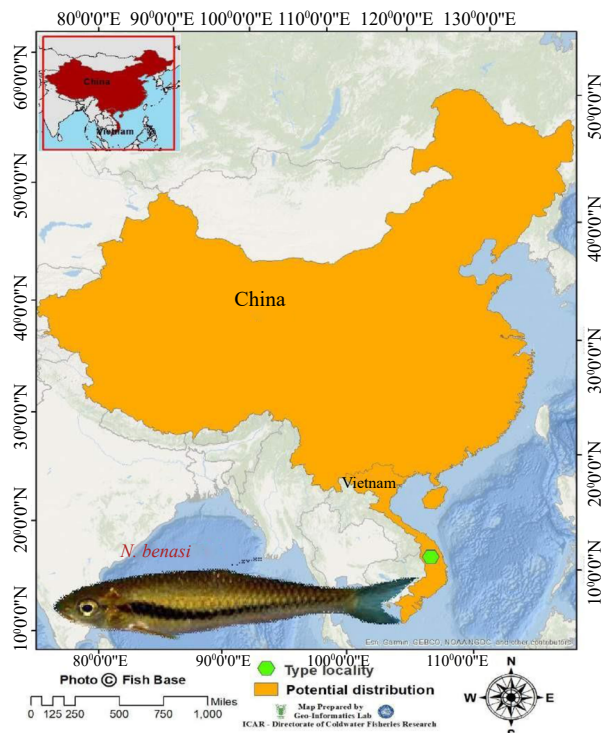


Fig. 2. Potential distribution and type locality of *N. benasi*

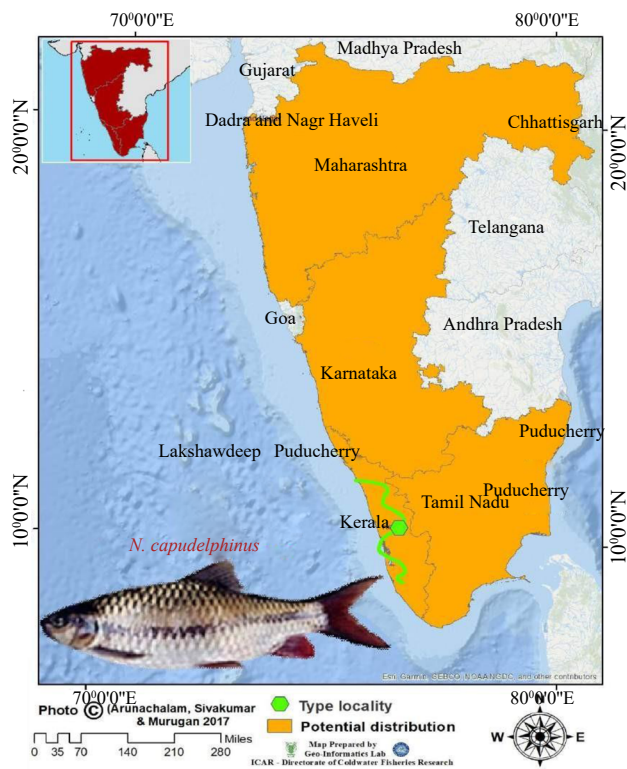


Fig. 3. Potential distribution and type locality of *N. capudelphinus*

Neolissochilus hendersoni (Herre, 1940) (Fig. 4)

Reported from the coldwater streams and rivers of Malay Peninsula.

Neolissochilus heterostomus (Chen and Yang, 1999) (Fig. 5)

This species is mainly distributed in the Longchuanjiang and Dayingjiang (upper Irrawaddy), Yunnan, China.

Neolissochilus hexagonolepis (McClelland, 1839) (Fig. 6)

N. hexagonolepis, commonly known as “chocolate mahseer” is an endemic species of the north-eastern states of India, particularly the Brahmaputra River basin (Sahoo *et al.*, 2015; Sarma *et al.*, 2016). This species inhabits in the clear, fast flowing streams and rivers with rocky and stony bottoms and is contemplated as a culture icon in the coldwater areas of North-eastern India (Sarma *et al.*, 2014). The species is mainly distributed in the Indian states of Arunachal Pradesh, Assam and Meghalaya. Due to habitat destruction and exploitation in the wild, it is assigned as nearly threatened species (IUCN, 2014).

Neolissochilus hexasticus (McClelland, 1839) (Fig. 7)

Hora (1921) reported three grown up specimens of this species as *Barbus hexasticus* from Karong, Manipur. This species is differentiated from *N. hexagonolepis* by the presence of a continuous labial fold of the lower lip while a widely interrupted labial fold is a significant feature of chocolate mahseer (Day, 1878).

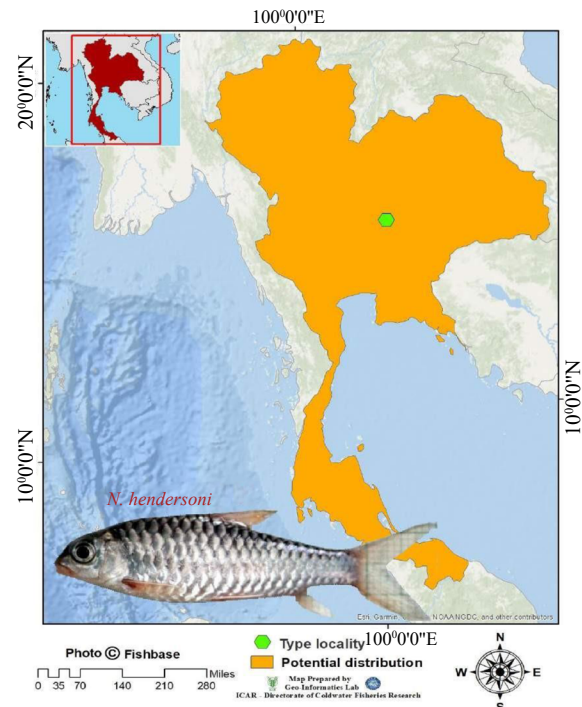


Fig. 4. Potential distribution and type locality of *N. hendersoni*

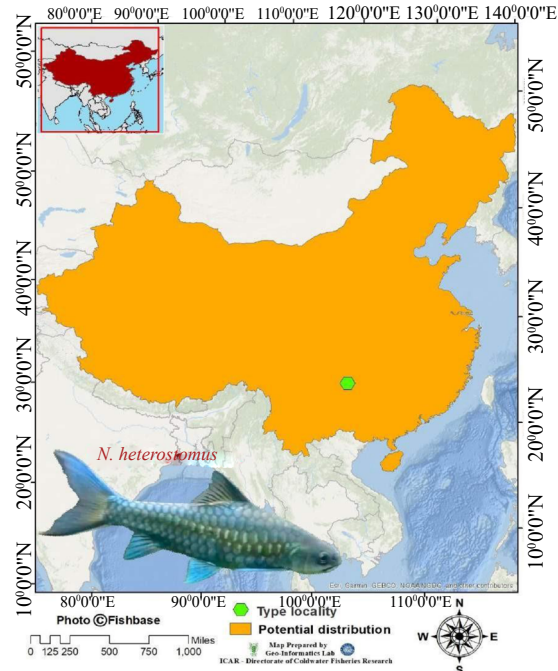


Fig.5. Potential distribution and type locality of *N. heterostomus*

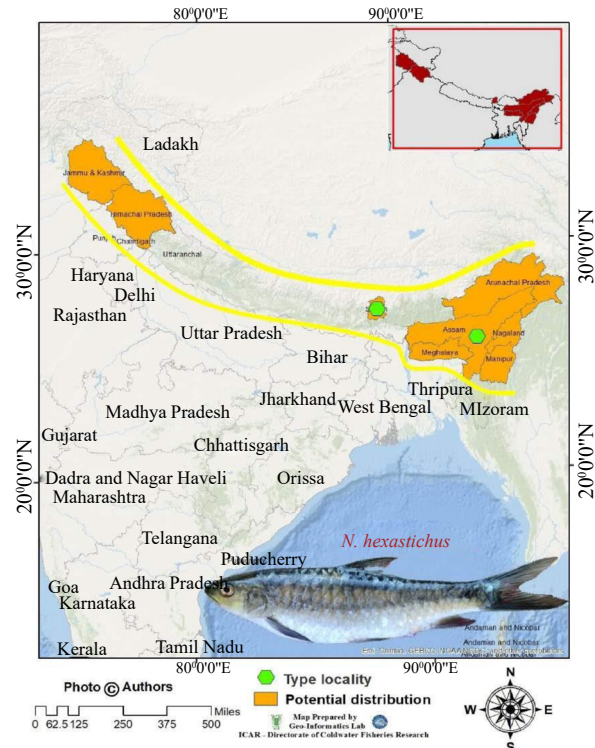


Fig. 7. Potential distribution and type locality of *N. hexastichus*

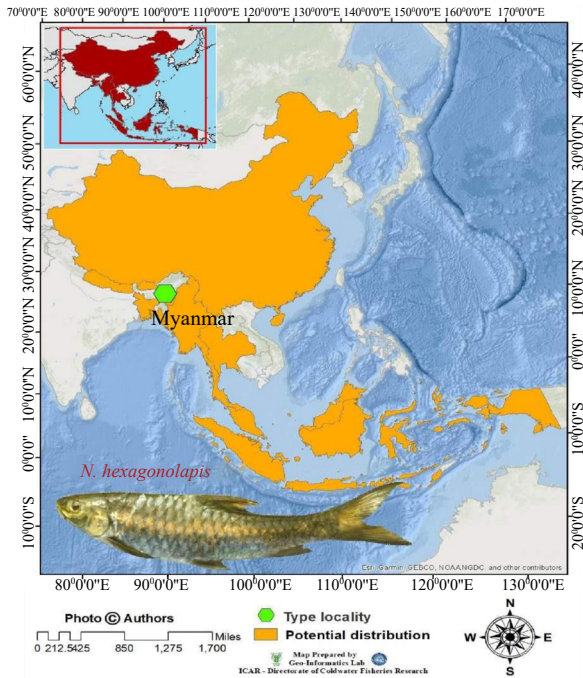


Fig. 6. Potential distribution and type locality of *N. hexagonolepis*



Fig. 8. Potential distribution and type locality of *N. Kaladanensis*

Neolissochilus kaladanensis (Lalramliana *et al.*, 2019) (Fig. 8)

This species is firstly identified from the Kaladan River of Mizoram.

Neolissochilus microphthalmus (Arunachalam *et al.*, 2017) (Fig. 9)

The species is distributed in the streams and rivers of the Western Ghats, peninsular India.

Neolissochilus minimus (Arunachalam *et al.*, 2017) (Fig. 10)

This species is widely distributed in the coldwater streams and rivers of the Western Ghats of India.

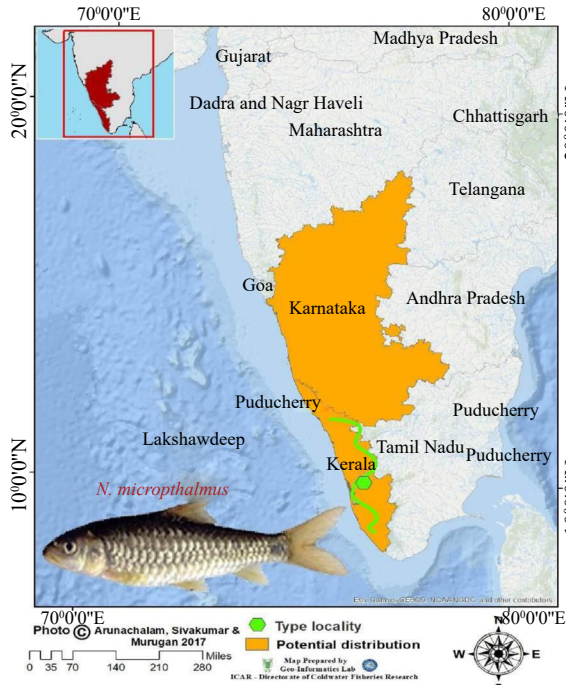


Fig. 9. Potential distribution and type locality of *N. microphthalmus*

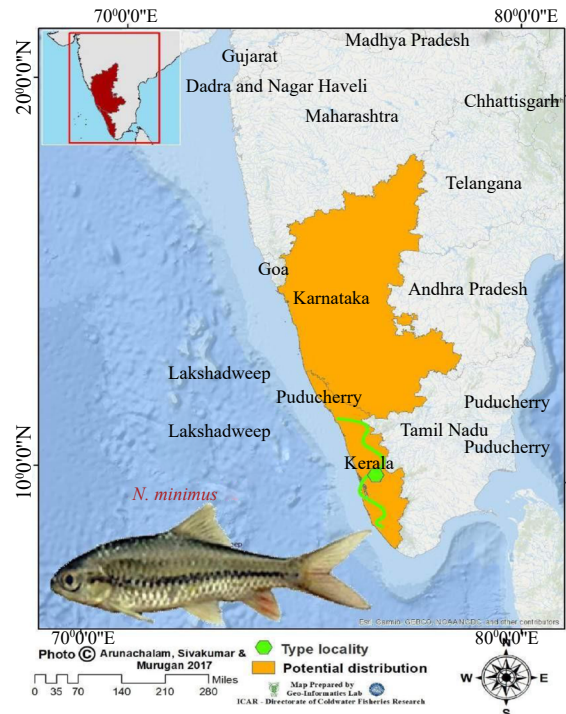


Fig. 10. Potential distribution and type locality of *N. minimus*

Neolissochilus pauciquamatus (Smith, 1945) (Fig. 11)

Smith (1945) described *Neolissochilus pauciquamatus* as *Puntius pauciquamatus* from Kaoluang, Thailand. Jayaram (1981) reported this species as *Puntius*

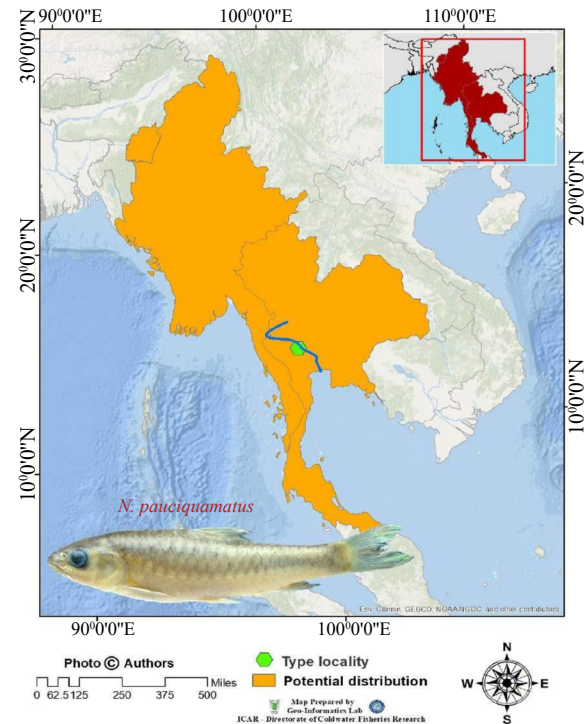


Fig. 11. Potential distribution and type locality of *N. pauciquamatus*

pauciquamatus from Burma. After a thorough review of the group, Rainboth (1985) proposed a new genus *Neolissochilus* for those cyprinoids of South-east Asia having a structural similarity with *Acrossochilus oshima* and placed *P. pauciquamatus* under the genus *Neolissochilus*.

Neolissochilus soroides (Valenciennes, 1842) (Fig. 12)

This species is mainly distributed in Indonesia, Malaya, Myanmar, Thailand and China.

Neolissochilus stevensonii (Day, 1870) (Fig. 13)

The species was first reported by Day (1870) from Akyab, Myanmar as *Barbus stevensonii*. Rainboth (1985) placed it under genus *Neolissochilus*. The species is presently distributed in hills near Akyab, Myanmar and Kolo River, Kaladan drainage, Mizoram, India.

Neolissochilus stracheyi (Day, 1871) (Fig. 14)

Selim and Vishwanath (1996) reported it for the first time from Manipur, India. It was also reported from Khuga River, Myanmar.

Neolissochilus subterraneus (Vidthayanon and Kottelat, 2003) (Fig. 15)

This species is mainly distributed in Tham Phra Wang Daeng cave in Thailand.

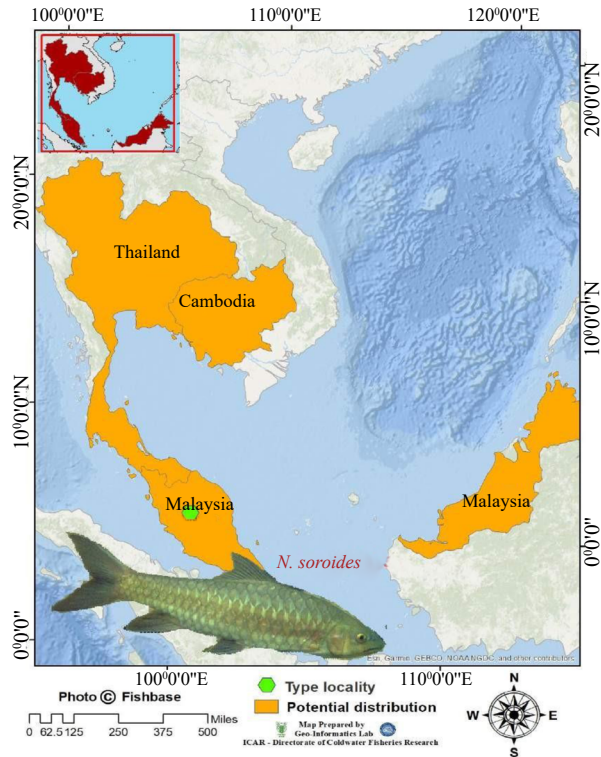


Fig. 12. Potential distribution and type locality of *N. soroides*

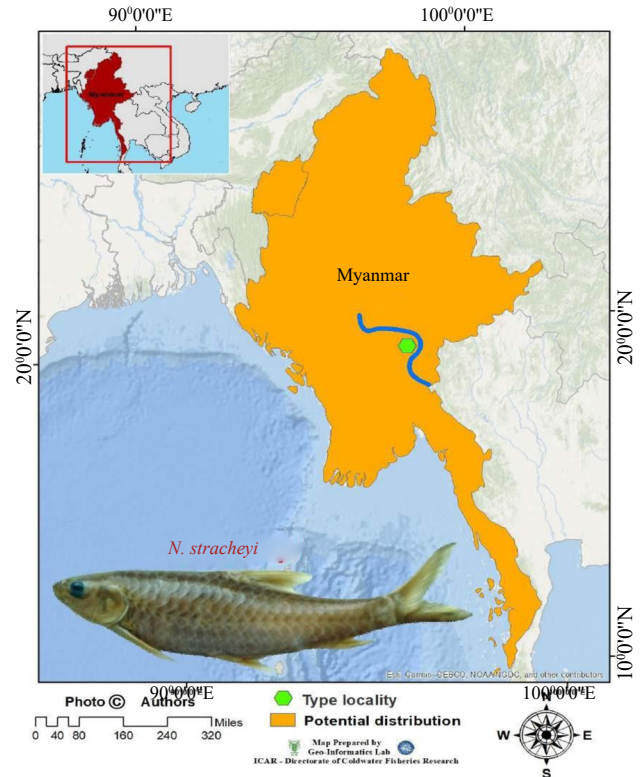


Fig. 14. Potential distribution and type locality of *N. stracheyi*

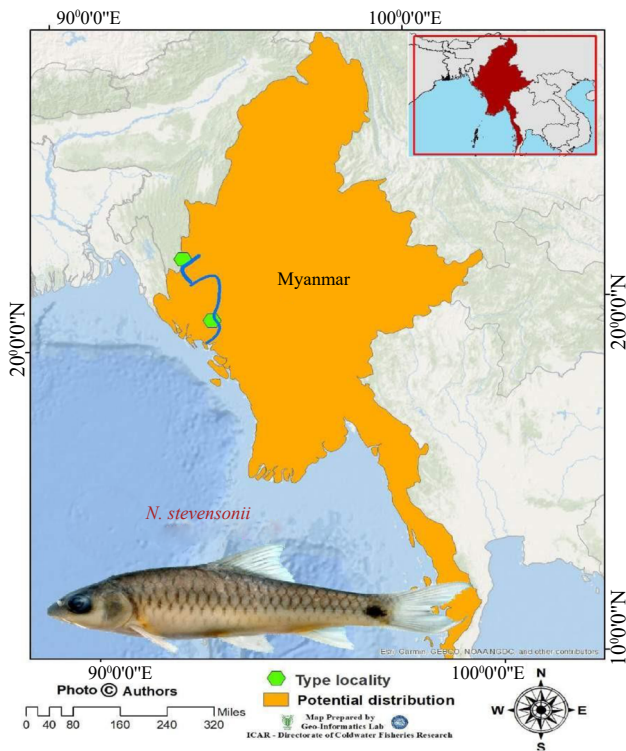


Fig. 13. Potential distribution and type locality of *N. stevensonii*

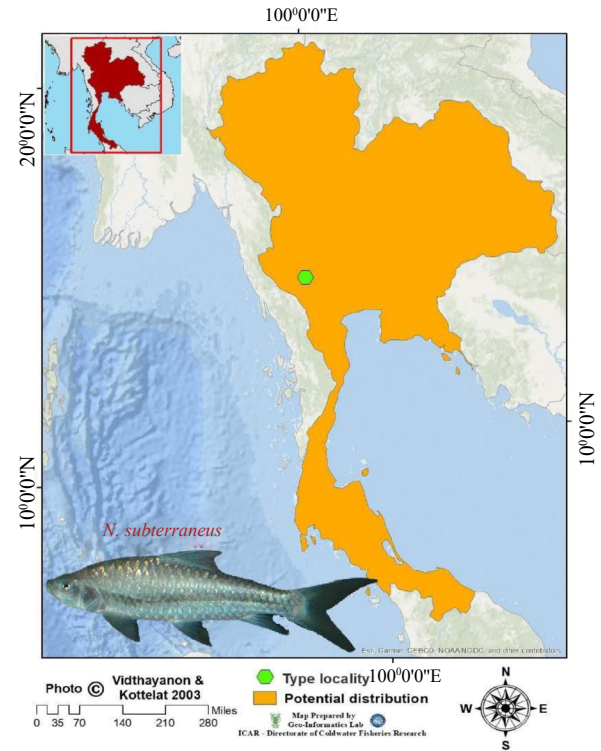


Fig. 15. Potential distribution and type locality of *N. subterraneus*

N. eolissochilus sumatranus (Weber and Beaufort, 1916) (Fig. 16)

This species is endemic to the coldwater areas of Sumatra (Kottelat *et al.*, 1993).

Neolissochilus tamiraparaniensis (Arunachalam *et al.*, 2017) (Fig. 17)

This species is distributed in streams and rivers of the Western Ghats, peninsular India.

Neolissochilus wynaadensis (Day, 1873) (Fig. 18)

The Wayanad mahseer, is one of two species that occurs in peninsular India and the other species *N. bovanicus* is found in the Bhavani River (Ali *et al.*, 2014). This species was described as *Barbus wynaadensis*, from Wayanad which was reported to be a common species of the larger streams in the region (Day, 1873). The species is particularly endemic in the Waynad region of Kerala but has also been recorded from Tamil Nadu and Karnataka (Manimekalan 1998, Yazdani *et al.*, 2001, Arunachalam *et al.*, 2005). In the IUCN Red List of Threatened Species *N. wynaadensis* has been listed as ‘Critically Endangered’ (Abraham, 2011).

Naziritor chelynooides (McClelland, 1839) (Fig. 19)

N. chelynooides, formerly known as *Tor chelynooides* and popular as “dark mahseer” is a rare coldwater fish distributed in Pakistan, north-east Baluchistan, north-

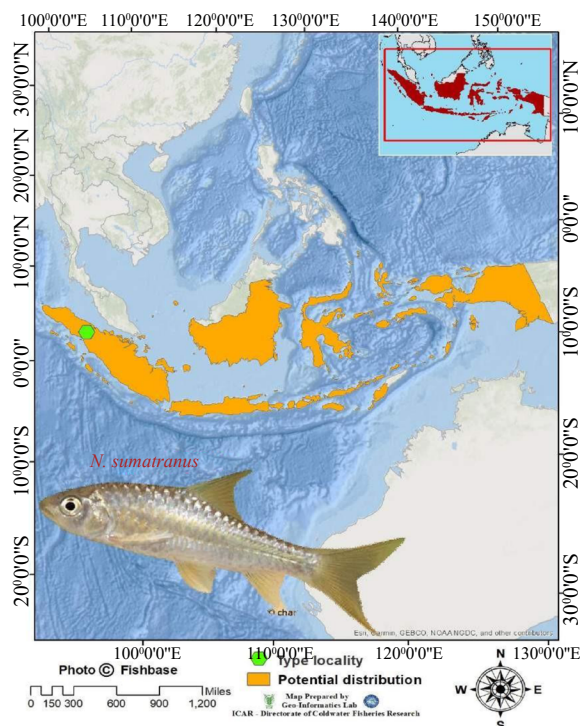


Fig. 16. Potential distribution and type locality of *N. sumatranus*

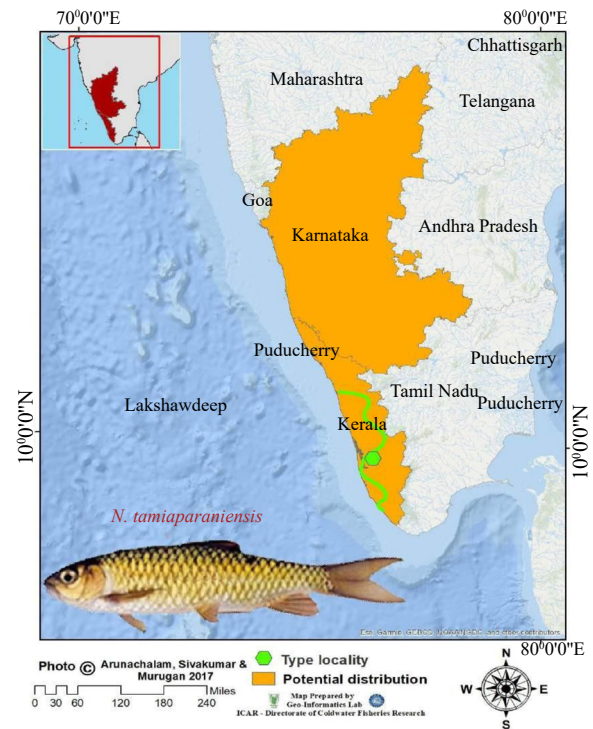


Fig. 17. Potential distribution and type locality of *N. tamiraparaniensis*

west frontier Province and in western Himalayan region (Talwar and Jhingran, 1991; Jayaram, 1999). In Kumaon Himalayas, *N. chelynooides* is reported from the rivers Kali, Gori, Saryu, east and west Ramganga, Kosi, Gaula, Gagas, Ladhiya, Gharhakiya and Lohawati (Joshi, 1999; 2007).

Naziritor zhobensis (Mirza, 1967) (Fig. 20)

The distribution range of *N. zhobensis* is Zhob, Gomal and the right bank tributaries of river Indus in Pakistan (Yousaf *et al.*, 2021).

Neolissochilus spinulosus (McClelland, 1845)

This species is distributed mainly in the Ganges and Yamuna rivers of India.

Neolissochilus blythii (Day, 1870)

This species is found only from Tenasserim Province, Myanmar.

Neolissochilus compressus (Day, 1870)

N. compressus is known only from Tenasserim Province, Myanmar.

Neolissochilus baoshanensis (Chen *et al.*, 1999)

This species is mainly reported from Nujiang and Longchuanjiang districts of Yunnan, China.

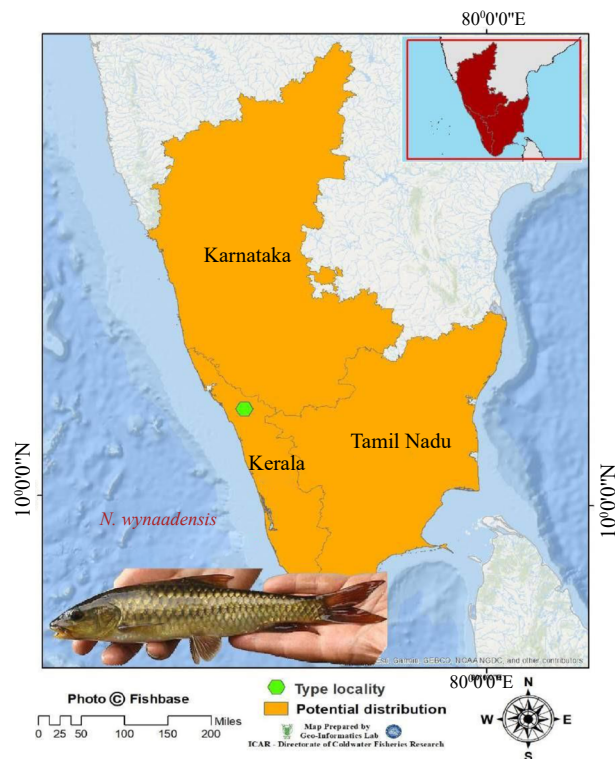


Fig. 18. Potential distribution and type locality of *N. wynaadensis*

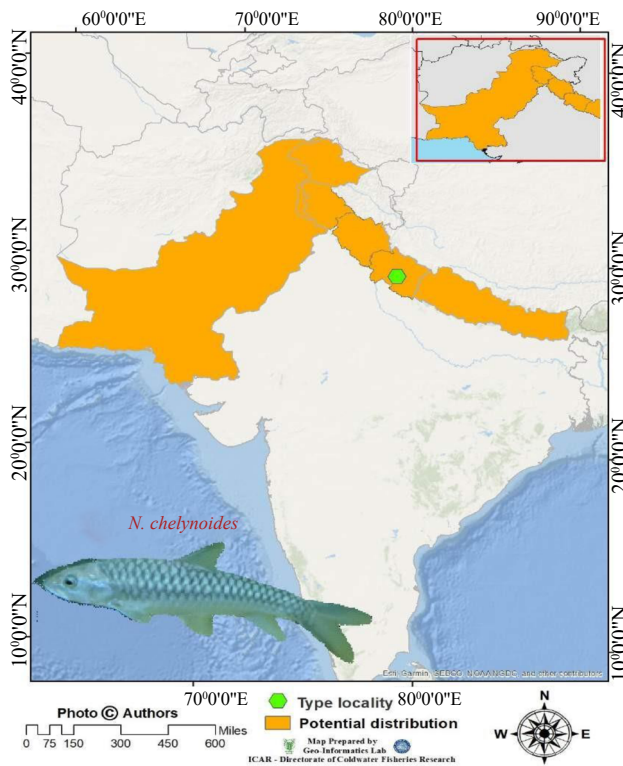


Fig. 19. Potential distribution and type locality of *N. chelynoides*

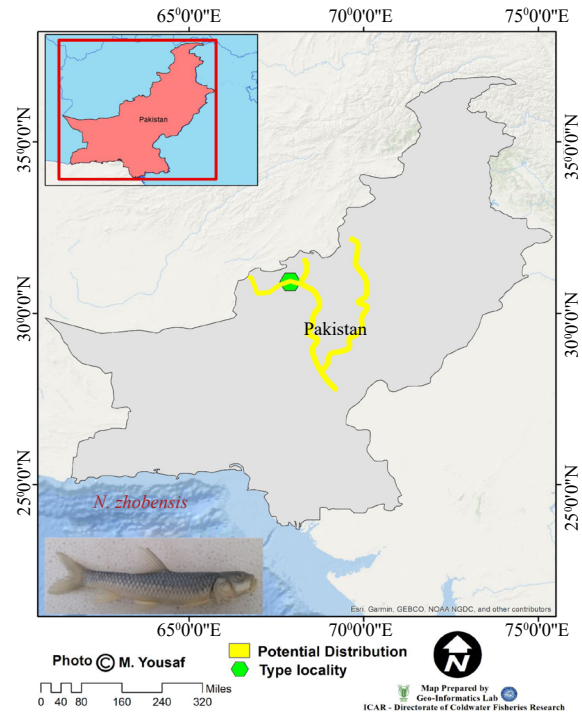


Fig. 20. Potential distribution and type locality of *N. zhobensis*

Nelissochilus dukai (Day, 1878)

N. dukai probably occurs in Mekong and Chao Phraya basins and Malay Peninsula.

Neolissochilus thienemanna (Ahl, 1933)

This species is distributed in Lake Toba in Sumatra, Indonesia.

Neolissochilus longipinnis (Weber and de Beaufort, 1916)

The species is mainly distributed in Sumatra (lake Kawar) and Java (Pangus river on Mt. Ungaran).

The GIS map of genus *Tor* has been prepared using ARC PRO (ESRI) software for describing the distribution and habitat of 19 *Tor* species worldwide (Fig. 21).

Reproductive biology

T. tor has been recorded to show sexual dimorphism during the spawning season from the Narmada River (Desai, 1973). The golden mahseer exhibits sexual morphism during the breeding season in Kumaon lakes (Pathani, 1978, Pathani and Das 1979). It is also observed that mahseer has relatively higher growth rate in male than female resulting in early maturity of males (Chaturvedi, 1976). The size at first maturity is also validated using condition factor (Nautiyal, 1985). The breeding season of golden mahseer was determined by calculating gonado-somatic Index (GSI) and condition factor (Kn) in Garhwal Himalayan

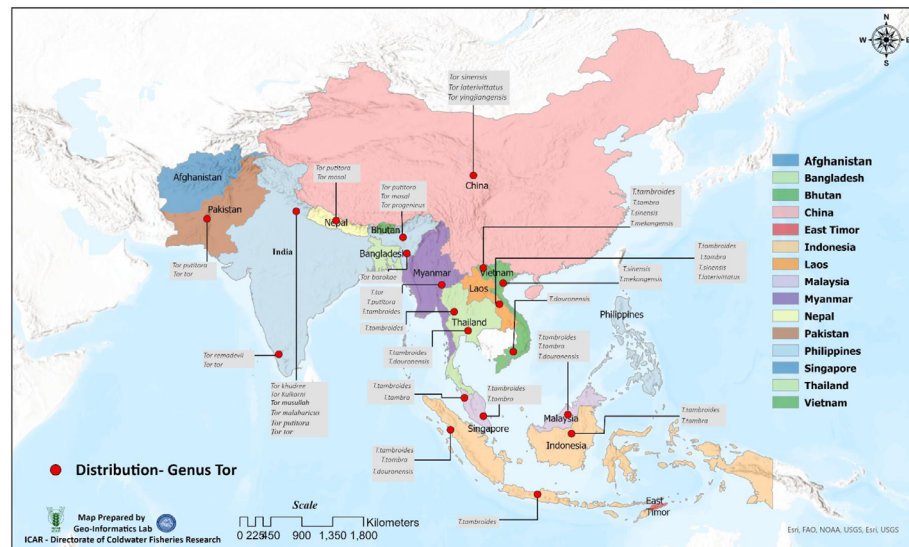


Fig. 21. Potential distributions of *Tor* species across the globe

region from Alaknanda and Nayar River (Nautiyal, 1984). It has also been recorded that mahseers spawn multiple times in a year (Dunsford, 1911; Nevill, 1915). Two peak breeding seasons of mahseers with one being minor breeding season in January-February and major breeding season in August has been observed on the basis of migration of mature fish in Indian mahseer (Cordington, 1946). Two breeding seasons have also been reported during the low flood phase *i.e.* May-June and August-September in Himachal Pradesh (Sehgal *et al.*, 1971, 1972; Karamchandani, 1972; Sunder and Joshi 1977; Pathani and Das, 1979). It was observed that spent gonads occur in golden mahseer after the second week of September and the ovaries possess three size classes of eggs, the proportion of which varied throughout the year (Shrestha, 1986). Some authors have also observed that spent phase occurs in the month of August (Johal *et al.*, 2000). It was stated that the mahseers are asynchronous spawners and spawn twice in a season (De Silva *et al.*, 2004). Breeding techniques and larval rearing of different species of mahseers (*T. putitora*, *T. khudree*, *T. tambroides* and *T. douronensis*) have been described by several authors (Kulkarni, 1971, 1980; Desai, 1972; De Silva *et al.*, 2004; Ingram *et al.*, 2005; Keshavanath *et al.*, 2006; Sarma *et al.*, 2009; 2010). Keshavanath *et al.* (2006) successfully induced maturity in Deccan mahseer (*Tor khudree*) under confinement and breeding was done successfully using carp pituitary and ovaprim. It was stated that change in the temperature and monsoon floods triggers the act of spawning (Thomas, 1897; McDonald, 1948). To understand the breeding biology of golden mahseer and to investigate the inability of the species to breed under captive

condition in Kumaon Himalayan region, a study was carried out by Shahi *et al.* (2014) on Kisspeptins. The peak spawning season of mahseer is observed during the month of May to August, which is the favourable time for the maturation of golden mahseer in natural water bodies of Garhwal Himalayan region (Bhatt and Pandit, 2015). The fecundity range of this fish varies from 3987 to 7320 eggs with a size ranging from 190 to 250 mm total length (Sarma *et al.*, 2016). Another study embodied that the peak breeding season of golden mahseer falls in the month of August when temperature ranges from 21.2-26.4°C, with absolute fecundity of 4217 to 8365 per kg body weight among the different-sized female fish (Joshi *et al.*, 2018). Akhtar *et al.* (2017) revealed certain limitations in attaining maturity of golden mahseer (*T. putitora*) in captivity and studies on hormone levels and stress biomarkers in wild and captive brooders were carried out. An experiment was successfully conducted using photo-thermal manipulation for inducing maturity and spawning of *T. putitora* under captivity at the mahseer hatchery of ICAR-Directorate of Coldwater Fisheries Research (ICAR-DCFR), Bhimtal (Akhtar *et al.*, 2018).

Captive breeding of *N. hexagonolepis* was successfully carried out in pond conditions (Sarma *et al.*, 2014) and was suggested a potential species for hill fisheries and aquaculture. Captive breeding of chocolate mahseer was also successfully carried out by Dash *et al.* (2021) achieving a fertilisation rate of 90.3, hatching rate of 82.8% and 97.4% free-swimming larvae. Earlier, artificial propagation of chocolate mahseer was carried out by Mahapatra and Vinod (2011). To achieve success in the artificial fertilisation of Thai mahseer, the use

of ovaprim at 0.5 ml per kg body weight was found to be the most successful hormone dose achieving 55% ovulation (Kunlapapuk and Kulabong, 2011). Broodstock management, induced spawning and larval rearing of two indigenous Malaysian mahseers *i.e.*, *T. tambroides* and *T. douronensis* was successfully carried out by Ingram *et al.* (2005). The biometry, condition factor, food and feeding habit, reproductive status, length-weight relationship, spawning habit, culture and larval development of chocolate mahseer were documented by several researchers around the world since 1822 to 2021 (Hamilton, 1822; McClelland, 1839; Hora, 1940; Langdale, 1944; Ahmed, 1948; Alikunhi, 1948; Dasgupta 1988 a,b,c; 1989; Ghosh and Zamadar, 2003; Sarma *et al.*, 2016, Dash *et al.*, 2021). The effect of temperature on incubation of eggs, standard metabolic rate (SMR), growth and thermal tolerance limit of chocolate mahseer was performed by Dash *et al.* (2021) as well. Sharma *et al.* (2016) evaluated the histomorphological changes of the embryo and larvae during ontogenesis of golden mahseer *T. putitora*. A study on growth performance, fatty acid profile, gut and muscle histo-morphometry was carried out in the post-larval stage of *T. tambroides*, using administration of short-term probiotic (Hossain *et al.*, 2022). In order to determine the immune systems of the offspring of wild-collected and captive-matured *T. putitora*, immune gene characterisation and expression comparison studies were conducted during ontogenetic developmental stages (Tripathi *et al.*, 2022). Melinda *et al.* (2022) analysed the genomic information of *T. tambroides* using the Illumina and Nanopore technologies which helps in species identification and analysis of various biological parameters. The information on reproduction-related seasonal changes in the fatty acid profile and nutritional status of male and female golden mahseer (*T. putitora*) is useful for managing the broodstock (Sharma *et al.*, 2022). *N. soroides* was shown to have two peaks in its fecundity, which coincided with heavy rainfall distribution (Khaironizam and Ismail, 2013). A macroscopic grading system for golden mahseer testes was developed by Shahi *et al.* (2015) which showed the testes development stages during the breeding season in Bhimtal and Sattal Lake.

Genetics and biotechnology

A new diploid cell line (TP-1) was developed for the first time from golden mahseer having immense potential in biodiversity conservation (Lakra *et al.*, 2006). It was observed that the cryopreservation of spermatozoa of Deccan mahseer (*T. khudree*) using different techniques increases the viability of spermatozoa (Basavaraja and Hegde, 2004; Basavaraja *et al.*, 2006). The phylogenetic relationship among the five Indian mahseer species was done using a ribosomal DNA sequence (45S rDNA)

which provided greater understanding of the taxonomic status (Kumar *et al.*, 2015). The karyotype and Nucleolar Organiser Regions (NORs) of golden mahseer (*T. putitora*) collected from different populations of Kosi and Beas rivers showed genetic polymorphism in the species (Barat and Ponniah, 1998). A study was carried out on characterisation and phylogenetic relationship of five mahseer species *viz.*, *T. tor*, *T. putitora*, *T. khudree*, *T. chelynooides* and *N. hexagonolepis* by partial sequencing of cytochrome oxidase I (COI) (Sati *et al.*, 2013). The cytogenetical studies on some of the closely related mahseer species such as *T. khudree*, *T. mosal mahanadicus*, *T. putitora* and *T. tor* were carried out earlier by several scientists (Khuda Bukhsh, 1980, 1982; Khuda-Bukhsh *et al.*, 1986; Barat and Ponniah, 1998). Comparative cytogenetic investigation of *T. khudree* and *T. mussullah* was undertaken using conventional staining and NOR banding by Kushwaha *et al.* (2001). Diploid chromosome number was found to be 100 in both the species; however, variation was observed in their karyomorphology. Silas *et al.* (2005) investigated the genetic identity of *T. malabaricus* using RAPD markers by comparing with *T. khudree* and the results showed that both the species are not under same gene pool and have to be treated as distinct species. Sequencing of 464 base pairs of the mitochondrial cytochrome c oxidase I (COI) gene and fifteen polymorphic microsatellite loci were examined for investigating the population genetic structure of *T. tambroides* (Esa and Rahim, 2013). The sequencing of mitochondrial genome and distinct genetic lineage of *T. tor* was investigated by Kumar *et al.* (2015). Random amplified polymorphic deoxyribonucleic acid (RAPD) markers confirmed the specific identity of *T. khudree malabaricus*, described by Silas *et al.* (2005). Mohindra *et al.* (2007) validated the genetic relationship between *T. tor*, *T. putitora*, *T. mosal mahanadicus*, *T. khudree* and *N. hexagonolepis* using RAPD markers. To study the simultaneous chromosomal localisation of 5S and 18S ribosomal genes in the genus *Tor*, the dual colour fluorescence *in situ* hybridization (FISH) was performed by Singh *et al.* (2009). Cytogenetic studies on endangered fish species and karyotypes of three species of mahseers *viz.*, *T. putitora*, *T. tor* and *T. khudree* was executed (Lakra, 1996). Based on the cytogenetic studies on *Tor* species, it was revealed that all the *Tor* species have 100 diploid chromosomes (Froese and Pauly, 2009). Furthermore, the chromosomal analyses of different species, populations and stocks revealed variations in karyomorphology in different species (Khuda-Bukhsh, 1982; Lakra and Rishi, 1991; Lakra, 1996; Barat and Ponniah, 1998; Kushwaha *et al.*, 2001). In a similar manner, detailed karyomorphological investigations was also carried out in seven species of mahseers *viz.*, *T. khudree*, *T. mussullah*, *T. putitora*, *T. tor*, *T. chelynooides*,

T. progneius and *N. hexagonolepis* (Mani *et al.*, 2009) using karyotyping, Ag-NOR and fluorescent staining techniques which showed 100 nos. of diploid chromosomes in all the species and the highest number of NORs was observed in *T. tor* i.e., four pairs of chromosomes. Khare *et al.* (2014) examined nine mahseer species of *Tor*, *Neolissochilus* and *Naziritor* with mtDNA data and indicated the need for integrating molecular and morphological tools for taxonomic revision of *Tor* and *Naziritor* genera. The phylogenetic analysis using the complete mitochondrial genome revealed that the chocolate mahseer belonged to same clade of mahseer group but different from genera, *Barbus* and *Acrossocheilus* (Sahoo *et al.*, 2015). Sharma *et al.* (2019) carried out a study to develop species-specific novel microsatellite markers using next-generation sequencing and to assess the genetic diversity of wild chocolate mahseer populations distributed throughout north-eastern India. The oxygen consumption, thermal tolerance and stress response in chocolate mahseer (*N. hexagonolepis*) illustrated the CTmax and LTmax that increased significantly with increasing acclimation temperature and water temperature of 31°C and beyond in natural water bodies might create physiological stress in chocolate mahseer, which may affect its reproductive performance (Majhi *et al.*, 2013).

Aquaculture potential

Due to the excellent flavour of the flesh and sporting quality, mahseer is considered as an important candidate species for aquaculture (Day, 1889). Pisolkar (2001) reported copper mahseer to be suitable for culture in ponds in Tamil Nadu. Ayyappan *et al.* (2001) listed *N. hexagonolepis* in the prioritised freshwater fish species to be considered for culture. Growth of *T. khudree* between 600 and 900 g in one year was reported by Ogale (2002) in village ponds near Lonavala, Maharashtra. Monoculture of *T. putitora* was also carried out at Lonavla with pellet feed prepared with rice bran, ground nut oil cake and fish meal (30:30:40) and mineral mix. Islam and Tanaka (2004) concluded *T. putitora* as a highly promising species for aquaculture by maintaining the proper dietary conditions. In floating cages, culture trials for *T. khudree* were carried out by Kohli *et al.* (2002) having initial length and weight of 100-140 mm and 5-25 g within a culture period of 356 days and survival of 68.89%. The slow growth of *T. khudree* in the ponds, reservoirs and floating cages in open waters was observed by Sharma and Parashar (2013). An experiment on polyculture of mahseer with Indian major carps in ponds was successfully carried by Rahman *et al.* (2007). Sawhney (2014) investigated growth response of mahseer, *T. putitora* fingerlings

to changed lipid levels in the diet and witnessed that a dietary lipid level of 6% was optimal for proper growth. Sarma *et al.* (2010) and Shahi *et al.* (2014) elaborated the culture potential of *T. putitora* in hill aquaculture. The increasing demand of chocolate mahseer for food as well as sport fish, especially in Indian uplands necessitates concerted attempts to produce seed for angling and for culture purposes using captive, pond reared broodstock (Sarma *et al.*, 2010). In pond culture system, growth performance of *N. hexagonolepis* (McClelland) in Arunachal Pradesh was studied by Laskar *et al.* (2009). Earlier the culture of *T. mosal mahnadicus* recorded a growth of 172-200 mm in four months, whereas Deccan mahseer reared in Odisha attained a growth increment of 107 mm in 254 days (Badapanda and Mishra, 1991). Thai mahseer (*T. tamboides*) is one of the high-value commercially cultured freshwater fish species, especially in Malaysia (Kunlapapuk and Kulabtong, 2011). The protocol for sperm cryopreservation of the critically endangered *T. tor* was developed by Kabir *et al.* (2022) which could be utilised for long-term preservation of genetic materials for effective breeding.

Angling and ecotourism

The International Ecotourism Society (TIES) defines ecotourism as a responsible travel to natural areas that endures the well-being of the local people, protects the environment and encompasses interpretation and education. One strategy for sustainable management of the ecosystem is to link the tourism through ecotourism and conservation activity (Kiper, 2013). In India, mahseer ecotourism is developed through a variety of activities like fish sanctuaries, mahseer watching and recreational fishing (Baruah and Sarma, 2018). Angling or sport fishing is one of the most interesting outdoor physical activities which offer diverse taste and pursuits. It includes the eco-tourism promoting sustainable form of resource utilisation and contributes to environmental conservation while ascertaining accrued socio-economic benefits to the society and provides high values to natural biological resources (Ditton *et al.*, 2002). The adventures and joy involved in entrapping of Indian mahseer is apparent since old age that has been acknowledged in many famous archives like “The rods in India” by Thomas (1873), “Anglers Handbook of India” by Lacy and Cretin (1905) and “Circumventing the mahseer and other sporting fish in India and Burma” by MacDonald (1948). Catch and release was emphasised as an angling ethic in the 1970s in an effort to regulate poaching actions after anglers noted a decline in the body size and rate of catch (Gupta *et al.*, 2015b). Various efforts are taken to reduce poaching and to mitigate

concerns surrounding the fishery for *e. g.*, anglers developed alliances and leased property along riverine sites, developing training programmes for guides and monitoring river activities (Everard and Kataria, 2011; Pinder and Raghavan, 2013; Gupta *et al.*, 2015a). Gupta *et al.* (2014) evaluated catch and release angling records of golden mahseer in the Ramganga and chocolate mahseer in the Jia-Bharali within two Indian reserves where catch data suggested these game fish populations are not negatively affected by angling activities. Due to the perceived economic benefits, conservation of fish and the protection of accompanying aquatic ecosystems, various stakeholders emphasised support for catch and release angling. A report describing the current status, challenges and evidence-based research agenda to support mahseer conservation was documented by WWF India in 2013. North-east India is bestowed with more than 33% of the total water bodies of India, 3800 km length of Himalayan river and streams hold the sizable mighty golden and chocolate mahseers along with 714 km of brown trout stream for angling purpose are offering an ample opportunity for angling tourism (Sarma *et al.*, 2016). In Vedic times, King Someswara (1127 AD) in his *Matsya Vinoda* has mentioned the existence of this mighty game fish in Indian waters with an account of angling of mahseer with rod and line (Hora, 1953). The British has also encouraged the anglers from around the world for angling activities in the country (Thomas, 1873, 1897; Beevan, 1877; Dhu, 1906, 1918, 1923; Sehgal, 1987). For sport fishing and eco-tourism, Sir H. Ramsay during 1858 has given his contribution by stocking a large number of mahseer fish in the lakes of Kumaun (Walker, 1888). The *Tor* genus accounts for majority of the mahseer species which is considered for recreational activities, economic livelihood and conservation regards (Baruah and Sarma, 2018). The anglers also contribute directly and indirectly for the conservation measures of this fish by restoration activities with generous donations. However, it is a prime concern to assess the post-release mortality and to understand the factors affecting the potential risk for their population depletion. It is also important to follow a proper management plan, as the advantage of angling for this endangered fish can outweigh the risk of this species (Cooke *et al.*, 2016). A study was carried out which demonstrates that angling can be used as a monitoring tool for data deficient fishes and can also be used to assess the population of large bodied fishes in rivers (Pinder *et al.*, 2020). It is estimated that over 10% of the population from transitioning and industrialised countries are engaged in recreational fishing activities (Arlinghaus *et al.*, 2015). It is also believed that the less

industrialised countries around the world are likely to be growing rapidly in these activities (Bower *et al.*, 2014).

Conservation measures: Protection and management

The freshwater ecosystems are in the verge of depletion and a report shows that almost 84% of the freshwater vertebrate populations have declined since 1970 (WWF, 2020). This has led to a steep downfall in the freshwater biodiversity of the world's lakes and rivers (Richter *et al.*, 1997) which is often not visible to the policy makers and general public (Dudgeon *et al.*, 2006; Reid *et al.*, 2019). The freshwater biodiversity has been jeopardising throughout the world (Cooke, *et al.*, 2012; Carrizo, *et al.*, 2013; Reid, *et al.*, 2013) with alarming decline of migratory fishes (Carrizo *et al.*, 2017; He *et al.*, 2017; WWF, 2021). However, more than half of world's population relies on the freshwater ecosystem for income, nutrition, cultural services and recreational activities (Youn *et al.*, 2014; Cooke *et al.*, 2016). But the current trend of misusing the freshwater resources and fisheries shows a failure in the protection and conservation of these resources. Mahseer serves as an important source of nutrition, livelihood for the local fisher-folk and the tribal people living along the banks of rivers. Despite being a threatened species, the various breeding technologies have benefitted the conservation of mahseer in the coldwater bodies in different parts of India (Sarma *et al.*, 2016). The protection and special ranking have been prescribed as conservation strategies in the historical and vedic times (1500 BC-800 AD) (Jayaram, 2005). Effective conservation strategies and management plans are surely lacking for the conservation of this species. Various small scale and effective initiatives should be followed for the catch and release angling activities and a suitable conservation area should be developed to identify potential habitat and fishery status of mahseers (Maskur, 2002). Jamuni *et al.* (2022) highlighted the potential of community-based fish sanctuaries and various conservation methods, such as temple-based fish sanctuaries and conservation-based fish reserves for *in situ* conservation of freshwater fishes, other aquatic biota and riparian habitats while providing socio-cultural benefits. The eco-region maps can be a significant resource for assisting regional and global conservation planning efforts for large-scale conservation strategies and for providing a global knowledge base to improve freshwater biogeographic literacy (Abell *et al.*, 2008). It is believed that for conservation and fisheries management, establishing fishing restrictions or regulations, habitat management through the restoration of habitat and connectivity for migratory fishes for completing the life cycle and contributing to innate ecological courses of action is crucial (Lothian, 2021).

Conclusion

In this review, an attempt was made to describe the taxonomical status and resource distribution of 17 *Tor*, 2 *Naziritor* and 25 *Neolissochilus* species. The description regarding reproductive biology, genetics and aquaculture potential of these fishes under 3 genera has been documented. The mahseer group of fishes is considered as one of the most important games and sports fishes across the world. However, due to several anthropogenic, environmental and biological factors, the population is declining over the period. Various efforts have been put forth for augmenting its population through *ex-situ* and *in-situ* conservation measures. This paper also provides innovative ideas for conservation and management of this group of fishes including the protection of its natural habitat to safeguard the mahseer, an important component of aquatic biodiversity.

Acknowledgements

The authors would like to thank the Director, ICAR-DCFR, Bhimtal, for his valuable support in preparing the manuscript. We also thank Dr. Neetu Shahi, Scientist, ICAR-DCFR for her valuable inputs. The authors also thank the anonymous reviewers for providing insightful comments for improving the manuscript.

References

- Abell, R., Thieme, M. L. and Revenga, C. 2008. Freshwater ecoregions of the world: A new map of biogeographic units for freshwater biodiversity conservation. *BioScience*, 58(5): 403-414. DOI:10.1641/B580507.
- Abraham, R. 2013. *Channa diplogramma*. IUCN 2013. IUCN red list of threatened species. <http://www.iucnredlist.org>.
- Ahl, E. 1933. About a small collection of fish from Lake Toba in Sumatra. *Proceedings of the meeting of the Society of Friends of Natural Sciences in Berlin 1932 (Nos. 8-10)*, p. 514-516 (In German).
- Ahmed, N. 1948. On the spawning habits and early development of the copper mahseer *Barbus (Lissocheilus) hexagonolepis* McClelland. *Proc. Natl. Inst. Sci.*, 14: 21-28.
- Akhtar, M. S., Rajesh, M., Ciji, A., Sharma, P., Kamalam, B. S., Patiyal, R. S. and Sarma, D. 2018. Photo-thermal manipulations induce captive maturation and spawning in endangered golden mahseer (*Tor putitora*): A silver-lining in the strangled conservation efforts of decades. *Aquaculture*, 497: 336-347. <https://doi.org/10.1016/j.aquaculture.2018.08.003>.
- Akhtar, M. S., Ciji, A., Sarma, D., Rajesh, M., Kamalam, B. S., Sharma, P. and Singh, A. K. 2017. Reproductive dysfunction in females of endangered golden mahseer (*Tor putitora*) in captivity. *Anim. Reprod. Sci.*, 182: 95-103. doi: 10.1016/j.anireprosci.2017.05.004.
- Ali, A., Dahanukar, N., Siby Philip, S., Krishnakumar, K. and Raghavan, R. 2014. Distribution, threats and conservation status of the Wayanad Mahseer, *Neolissochilus wynaadensis* (Day, 1873) (Teleostei: Cyprinidae): An endemic large barb of the Western Ghats, India. *J. Threat. Taxa*, 6(5): 5686-5699. DOI:10.11609/JoTT.o3901.5686-99.
- Alikunhi, K. H. 1948. On the spawning habits and culture of Katli, *Barbus (Lissocheilus) hexagonolepis* (McClelland) in the river Cauvery, Madras. In: *Proceedings of the 35th Indian Science Congress*, Patna University, Patna, Bihar, India.
- Anabella, N. A., Subagja, J., Arifin, O. Z., Muhiardi, I. and Arief, M. Z. 2020. The motility of *Tor soro* fish (Valenciennes, 1842) using post-cryopreservation sperm: The effect of grape juice (*Vitis vinifera*) as a natural antioxidant. *IOP Conference Series: Earth and Environmental Science*, 584 (1): 012063.
- Anon. 1997. *Features of indigenous fish species having potential for aquaculture*. Inland Fisheries Division, Department of Agriculture, Kuching, Sarawak, Malaysia, 49 pp.
- Arai, R. 2011. *Fish karyotypes: A check list*. Springer, Tokyo, Japan.
- Arlinghaus, R., Tillner, R. and Bork, M. 2015. Explaining participation rates in recreational fishing across industrialised countries. *Fish Manag. Ecol.*, 22: 45-55. <https://doi.org/10.1111/fme.12075>.
- Arunachalam, M., Muralidharan, M., Sivakumar, P., Soranam, R. and Murugan, M. 2005. New record of a rare barbin *Neolissochilus wynaadensis* (Day) from Abby Falls. Karnataka. *Zoos' Print J.*, 20(11): 2073-2074.
- Arunachalam, M., Sivakumar, P. and Murugan, M. 2017. Descriptions of five new species of *Neolissochilus* Rainboth, 1985 (Cypriniformes: Cyprinidae) from streams/ rivers of the Western Ghats, peninsular India. *Fish Taxa*, 2(1): 1-27.
- Arunkumar, L. and Basudha, C. 2003. *Tor barakae*, a new species of mahseer fish (Cyprinidae: Cyprininae) from Manipur, India. *Aquaculture*, 4: 271-276.
- Ayyappan, S., Raizada, S. and Reddy, A. K. 2001. *Captive breeding for aquaculture and fish germplasm conservation, NBFGR-NATP publication No. 3*, ICAR-National Bureau of Fish Genetic Resources, Lucknow, India, p. 1-20.
- Bagra, K., Kadu, K., Sharma, K. N., Laskar B. A., Sarkar, U. K. and Das, D. N. 2009. Ichthyological survey and review of the checklist of fish fauna of Arunachal Pradesh, India. *Check List*, 5: 330-350. doi: 10.15560/5.2.330.
- Barat, A. and Ponniah, A. G. 1998. Karyotype and nuclear organiser regions (NORs) of golden mahseer, *Tor putitora* from different populations of north-western Himalaya. In: Manna, G. K. and Roy, S. C. (Eds.), *Perspectives in cytology and genetics, vol 9. AICCG Publication*, University of Kalyani, West Bengal, India, p. 283-286.

- Baruah, D. and Sarma, D. 2018. Mahseer in recreational fisheries and ecotourism in India. *Aquaculture Asia Magazine*, 22(2): 3-10.
- Baruah, D. and Sarma, D. 2018. Mahseer in recreational fisheries and ecotourism in India. *NACA Newsletter*, 22(2): 1-10.
- Basavaraja, N. and Hegde, S. N. 2004. Cryopreservation of the endangered mahseer (*Tor khudree*) spermatozoa, I. Effect of extender composition, cryoprotectants, dilution ratio and storage period on post-thaw viability. *Cryobiology*, 49(2): 149-156. DOI: 10.1016/j.cryobiol.2004.05.007.
- Basavaraja, N., Hegde, S. N. and Palaksha, K. J. 2006. Cryopreservation of the endangered mahseer (*Tor khudree*) spermatozoa: Effect of dimethyl sulfoxide, freezing, activating media and cryostorage on post-thaw spermatozoa motility and fertility. *Cell Preservation Technology*, 4(1): 31-45. DOI:10.1089/cpt.2006.4.31.
- Beavan, R. 1877. *Handbook of freshwater fishes of India*, L. Reeve and Co., London, UK. 247 pp.
- Bhatt, J. P., Nautiyal, P. and Singh, H. R. 1998. Racial structure of Himalayan mahseer, *Tor putitora* (Hamilton) in the river Ganga between Rishikesh and Hardwar. *Indian J. Anim. Sci.*, 68: 587-590.
- Bhatt, J. P. and Pandit, M. K. 2016. Endangered golden mahseer *Tor putitora* Hamilton: A review of natural history. *Rev. Fish. Biol. Fish.*, 26: 25-38. DOI 10.1007/s11160-015-9409-7.
- Bleeker, P. 1854. Overview of the ichthyological fauna of Sumatra, with description of some new species. *Physica Magazine for the Dutch East Indies*, 7(1): 49-108 (In Dutch).
- Bower, S. D., Nguyen, V. M., Danylchuk, A. J., Beard, Jr. T. D. and Cooke, S. J. 2014. Inter-sectoral conflict and recreational fisheries of the developing world: Opportunities and challenges for co-operation. In: McConney, P., Medeiros, R. and Pena, M. (Eds.), *Enhancing stewardship in small-scale fisheries: Practices and perspectives*, *CERMES Technical Report No. 73*, p. 88-97.
- Carrizo, S. F., Jahng, S. C., Bremerich, V., Freyhof, J., Harrison, I. and He, F. 2017. Freshwater megafauna: Flagships for freshwater biodiversity under threat. *BioScience*, 1(10): 1-9. <https://doi.org/10.1093/biosci/bix099>.
- Carrizo, S. F., Smith, K. G. and Darwall, W. R. T. 2013. Progress towards a global assessment of the status of freshwater fishes (Pisces) for the IUCN Red List: Application to conservation programmes in zoos and aquariums. *International Zoo Yearbook*, 47(1): 46-64. <https://doi.org/10.1111/izy.12019>.
- Chaturvedi, S. K. 1976. Spawning biology of mahseer *Tor tor* (Hamilton). *J. Bombay Nat. Hist. Soc.*, 73: 63-73.
- Chen, X. Y., Yang, J. X. and Chen, Y. R. 1999. A review of the cyprinoid fish genus *Barbodes* Bleeker, 1859, from Yunnan, China, with descriptions of two new species. *Zool. Stud.*, 38(1): 82-88.
- Cooke, S. J., Allison, E. H., Beard, T. D., Arlinghaus, R., Arthington, A. H. and Bartley, D. M. 2016. On the sustainability of inland fisheries: Finding a future for the forgotten. *Ambio*, 45: 753-764. <https://doi.org/10.1016/j.biocon.2020.108932>.
- Cooke, S. J., Hogan, Z. S., Butcher, P. A., Stokesbury, M. J., Raghavan, R., Gallagher, A. J., Hammerschlag, N. and Danylchuk, A. J. 2016. Angling for endangered fish: Conservation problem or conservation action. *Fish Fish.*, 17(1): 249-265. <https://doi.org/10.1111/faf.12076>.
- Cooke, S. J., Paukert, C. and Hogan, Z. 2012. Endangered river fish: Factors hindering conservation and restoration. *Endangered Species Research*, 17(2): 179-191. <https://doi.org/10.3354/esr00426>.
- Cordington, K. D. B. 1946. Notes on the Indian mahseers. *J. Bombay Nat. Hist. Soc.*, 46: 336-344.
- Dahanukar, N. 2010. *Puntius chelynooides*. IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <http://www.iucnredlist.org>.
- Dahanukar, N., Pinder, A. and Harrison, A. 2018. *Tor mosal*. The IUCN Red List of Threatened Species. <http://www.iucnredlist.org>.
- Dasgupta, M. 1988a. A study on the food and feeding habits of the copper mahseer *Acrossocheilus hexagonolepis* (Mc Clelland). *Indian J. Fish.*, 35(2): 92-98.
- Dasgupta, M. 1988b. Fecundity of *Acrossocheilus hexagonolepis* (Mc Clelland) from Garo Hills, Meghalaya. *Uttar Pradesh J. Zool.*, 8(2): 159-167.
- Dasgupta, M. 1988c. Length-weight relationship and condition of the copper mahseer *Acrossocheilus hexagonolepis* (Mc Clelland). *Matsya*, 14: 79-91.
- Dasgupta, M. 1989. Biometry of the copper mahseer *Acrossocheilus hexagonolepis* (Mc Clelland) from the north eastern India. *Nova Serie*, 1(25): 361-374.
- Dash, P., Tandel, R. S., Bhat, R. A. H., Sarma, D., Pandey, N., Sawant, P. B. and Chadha, N. K. 2021. Spawning substrate preference and spawning behavior of chocolate mahseer, *Neolissochilus hexagonolepis*. *Animal Reproduction Science*, 106847.
- David, A. 1953a. On some new records of fish from the Damodar and the Mahanadi River systems. *J. Zool. Soc. India*, 5: 243-254.
- David, A. 1953b. Notes on the bionomics and some early stages of the Mahanadi Mahseer. *Journal of Asian Social Sciences*, 9: 197-209.
- Day, F. 1870. On the freshwater fishes of Burmah Part II. *Proc. Zool. Soc. London*, p 99-101.
- Day, F. 1871. Monograph of Indian Cyprinidae, Parts 1-3. *J. Asiat. Soc. Bengal*, v. 40: 95-143, 277-336, Pls. 9: 21-23.

- Day, F. 1873. On some new fishes of India. *J. Linn. Soc. London*, 11: 524-530. <http://dx.doi.org/10.1111/j.1096-3642.1873.tb01674.x>.
- Day, F. 1878. *The fishes of India; Being a natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon*. Part 4: i-xx + 553-778, Pls. 139-195.
- Day, F. 1889. Fishes. In: Blanford, W. T. (Ed.), *The fauna of British India, including Ceylon and Burma*, v. 1: i-xviii + 1-548. Taylor and Francis, London, UK.
- De Silva, S. S., Ingram, B., Sungan, S., Tinggi, D., Gooley, G. and Sim, S. Y. 2004. Artificial propagation of the indigenous *Tor* species, empurau (*T. tambroides*) and semah (*T. douronensis*), Sarawak, East Malaysia. *Aquaculture Asia*, 9(4): 15-20.
- Debajit, S., Akhtar, M. S., Partha, D., Ganesh, G., Ciji, A. and Mahanta, P. C. 2015. Observations on larval development of chocolate mahseer *Neolissochilus hexagonolepis* (McClelland, 1839). *Indian J. Fish.*, 62(1): 135-138.
- Desai, V. R. 1973. Studies on fishery and biology of *Tor tor* (Ham) from river Narmada. II. Maturity, fecundity and larval development. *Proc. Indian Natl. Sci. Acad.*, 39B: 228-248.
- Desai, V. R. 1972. Notes on the early larval stages of *Tor putitora* (Ham.). *J. Zool. Soc. India*, 24: 47-51.
- Desai, V. R. 2003. Synopsis of biological data on the *Tor* mahseer *Tor tor*, (Hamilton, 1822). *FAO Fisheries Synopsis*, 36, Food and Agriculture Organisation of the United Nations, Rome, Italy, 158 pp.
- Devi, R. and Boguskaya, N. 2007. *Tor khudree*. *IUCN 2010. IUCN Red List of Threatened Species, Version 2010.2* <http://www.iucnredlist.org/>.
- Dhu, S. 1906. *The mighty Mahseer and other fish*. 2nd edn. Higginbotham & Co., Madras, India, p. 240-241.
- Dhu, S. 1918. *The angler in North India*, 2nd edn. The Pioneer Press, Allahabad, India, 574 pp.
- Dhu, S. 1923. *The angler in India or the mighty Mahseer*, 3rd edn. The Pioneer Press, Allahabad, India, 786 pp.
- Dinesh, K., Nandeesha, M. C., Nautiyal, P. and Aiyappa, P. 2010. Mahseers in India: A review with focus on conservation and management. *Indian J. Anim. Sci.*, 80: 26-38.
- Ditton, R. B., Holland, S. M. and Anderson, D. K. 2002. Recreational fishing as tourism. *Fisheries*, 27(3): 17-24. [https://doi.org/10.1577/1548-8446\(2002\)027<0017:RFAT>2.0.CO;2](https://doi.org/10.1577/1548-8446(2002)027<0017:RFAT>2.0.CO;2).
- Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J. and Leveque, C. 2006. Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biol. Rev.*, 81(2): 163-182. doi: 10.1017/S1464793105006950.
- Dunsford, H. S. 1911. *The report on fish and fisheries of the Punjab*. Government Press, Lahore, Pakistan, 23 pp.
- Esa, Y. and Abdul Rahim, K. A. 2013. Genetic structure and preliminary findings of cryptic diversity of the Malaysian Mahseer (*Tor tambroides* Valenciennes: Cyprinidae) inferred from mitochondrial DNA and microsatellite analyses. *BioMed Research International*. Article ID 170980. <https://doi.org/10.1155/2013/170980>.
- Eschmeyer, W. N., Ferraries, Jr. C. J., Hoang, M. D. and Long, D. J. 2004. *The catalogue of fishes: Species of fishes* (online). <http://www.calacademy.org/research/ichthyology/catalog/intro.html>.
- Eschmeyer, W. N., Fricke, R. and van der Laan, R. 2017. *Catalogue of fishes: Genera, species*. <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>.
- Eschmeyer, W. N. and Fong, J. D. 2014. *Species by Family/Subfamily*. <http://research.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp>.
- Eschmeyer, W. N., Ferraris, C. J., Hoang, M. D. and Long, D. J. 2013. *The catalogue of fishes, Species of fishes* (online), California Academy of Sciences.
- Everard, M. and Kataria, G. 2011. Recreational angling markets to advance the conservation of a reach of the Western Ramganga River, India. *Aquat Conserv: Mar. Freshw. Ecosyst.*, 21: 101-108. DOI:10.1002/aqc.1159.
- Fricke, R., Eschmeyer, W. N. and Van der Laan, R. 2022. *Eschmeyer's Catalog of fishes: Genera, Species, References*. <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>.
- Fricke, R., Eschmeyer, W. N. and Laan, R. V. D. 2021. *Eschmeyer's Catalog of fishes*. <https://www.calacademy.org/scientists/projects/eschmeyers-catalog-of-fishes>
- Froese, R. and Pauly, D. 2013. *FishBase*. <http://www.fishbase.org>.
- Froese, R. and Pauly, D. 2015. *FishBase*. World Wide Web electronic publication. <http://www.fishbase.org>.
- Ghosh, S. K. and Zamadar, Y. A. 2003. Length-weight relationship, length frequency and condition of chocolate mahseer, *Neolissocheilus hexagonolepis* (Mc Clelland) from Umiam Reservoir, Meghalaya, India. *Indofish*, 5(3&4): 1-7.
- Gray, J. E. 1833-1834. *The illustrations of Indian Zoology, chiefly selected from the collection General Hardwick*. 1:pl. XCIII fig. 1, 2:pl XCVI fig. 1.
- Gupta, N., Sivakumar, K., Mathur, V. B. and Chadwick, M. A. 2014. The 'tiger of Indian rivers': Stakeholders' perspectives on the golden mahseer as a flagship fish species. *Area*, 46(4): 389-397.
- Gupta, N., Bower, S. D., Raghavan, R., Danylchuk, A. J. and Cooke, S. J. 2015a. Status of recreational fisheries in India: Development, issues and opportunities. *Rev. Fish. Sci. Aquac.*, 23(3): 291-301. DOI:10.1080/23308249.2015.1052366.

- Gupta, N., Raghavan, R., Sivakumar, K., Mathur, V. and Pinder, A. C. 2015b. Assessing recreational fisheries in an emerging economy: Knowledge, perceptions and attitudes of catch-and-release anglers in India. *Fish. Res.*, 165: 79-84. DOI:10.1016/j.fishres.2015.01.004.
- Gupta, N., Nautiyal, P., Borgohain, A., Sivakumar, K., Mathur, V. and Chadwick, M. 2016. Catch-and release angling as a management tool for freshwater fish conservation in India. *Oryx*, 50(2): 250-256. doi:10.1017/S0030605314000787.
- Hamilton, B. 1822. *An account of fishes of River Ganges and its branches*. Archibald constable and Co., Edinburgh, UK. DOI: <https://doi.org/10.5962/bhl.title.6897>.
- He, F., Zarfl, C., Bremerich, V., Henshaw, A. and Darwall, W. 2017. *Disappearing giants: A review of threats to freshwater megafauna*. *WIREs Water*, 4(3): e1208.
- Herre, A. W. C. T. 1940. New species of fishes from the Malay Peninsula and Borneo. *Bull. Raffles Mus.*, 16: 5-26, Pls. 1-20.
- Hoang, H. D., Pham, H. M., Durand, J.-D., Tran, N. G. and Phan, P. D. 2015. Mahseers genera *Tor* and *Neolissochilus* (Teleostei: Cyprinidae) from southern Vietnam. *Zootaxa*, 4006(3): 551-568. doi: 10.11646/zootaxa.4006.3.8.
- Hora, S. L. 1921. On some new or rare species of fish from the eastern Himalayas. *Rec. Indian Mus. (Calcutta)* v. 22 (pt 5, no. 33): 731-744, Pl. 29.
- Hora, S. L. 1939. The game fishes of India III: The mahseer or the large scaled barbels of India. 1. The putitora mahseer *Barbus (Tor putitora)* Hamilton. *J. Bombay Nat. Hist. Soc.*, 41: 272-285.
- Hora, S. L. 1940. The game fishes of India XI. The mahseers or the large-scaled barbels of India IV. The Boker of the Assamese and Katli of the Nepalese, *Barbus (Lissocheilus) hexagonolepis* (McClelland). *J. Bombay. Nat. Hist. Soc.*, 42: 78-88.
- Hora, S. L. 1942. The game fishes of India xv. The mahseers or large-scaled barbels of India 8. On the specific identity of Syke's species of *Barbus* from the Deccan. *J. Bombay Nat. Hist. Soc.*, 42:163-169.
- Hora, S. L. 1943. The game fishes of India XVII. The mahseers or the large-scaled barbels of India 10. On the specific identity of Jerdon's species of mahseer from Southern India. *J. Bombay Nat. Hist. Soc.*, 44: 164-168.
- Hora, S. L. 1951. A sanskrit work on angling of the early twelfth century, *Nature*, 167.
- Hora, S. L. 1953. Knowledge of ancient Hindus concerning fish and fisheries of India, 4. Fish in Sutras and Smriti literature, *J. Asiat. Soc. Lett.*, 110: 63-77.
- Hossain, M. K., Ishak, S. D., Iehata, S., Noordiyana, M. N., Kader, M. A. and Abol-Munafi, A. B. 2022. Growth performance, fatty acid profile, gut and muscle histo-morphology of Malaysian mahseer, *Tor tambroides* post-larvae fed short-term host associated probiotics. *Aquaculture and Fisheries*. <https://doi.org/10.1016/j.aaf.2022.03.013>
- Indra, T. J. 1993. Report on the ichthyofauna of Kanyakumari District, Tamil Nadu. *Rec. Zool. Surv. India*, 92: 177-192. DOI: 10.26515/rzsi/v116/i1-4/1993/160895.
- Inger, R. F. 1962. The freshwater fishes of North Borneo. *Fieldiana Zoll.*, 45: 1-268.
- Ingram, B., Sungan, S., Gooley, G., Sim, S. Y., Tinggi, D. and De Silva, S. S. 2005. Induced spawning, larval development and rearing of two indigenous Malaysian mahseer, *Tor tambroides* and *T. douronensis*. *Aquac. Res.*, 36: 1001-1014. DOI: 10.1111/j.1365-2109.2005.01309.x.
- Islam, M. S. and Tanaka, M. 2004. Optimisation of dietary protein requirement for pond-reared mahseer *Tor putitora* Hamilton (Cypriniformes: Cyprinidae). *Aquac. Res.*, 35(13): 1270-1276. DOI:10.1111/j.1365-2109.2004.01149.x.
- IUCN 2014. *The IUCN Red List of Threatened Species. Version 2014.3*. <https://www.iucnredlist.org/>
- IUCN 2019. *The IUCN Red List of Threatened Species. Version 2019-3*. <https://www.iucnredlist.org/>
- Jayaram, K. C. 1981. *The freshwater fishes of India, Pakistan, Bangladesh, Burma and Sri Lanka-A handbook*. Zoological Survey of India. i-xxii + 1-475, Pls. 1-13.
- Jayaram, K. C. 1999. *The freshwater fishes of the Indian region*, Narendra Publishing House, New Delhi, India, 551 pp.
- Jayaram, K. C. 2005. The Deccan mahseer fishes: Their ecostatus and threat percepts. *Rec. Zool. Surv. India*, 238: 1-102.
- Jayaram, K. C. 2010. *The freshwater fishes of the indian region*. Narendra Publishing House, New Delhi, India.
- Jerdon, T. C. 1849. On the freshwater fishes of southern India, *Madras J. Lit. Sci.*, 15: 302-346
- Jhingran, V. G. 1975. *Fish and fisheries of India*. Hindustan Publishing Corporation (India), New Delhi, India, 954 pp.
- Johal, M. S., Tandon, K. K. and Sandhu, G. S. 2000. Maturity, fecundity and sex ratio of an endangered coldwater fish, Golden mahseer, *Tor putitora* (Ham.) from Gobindsagar (HP), India. *Coldwater aquaculture and fisheries*, p. 265-278.
- Joshi, K. D. 1999. Piscine diversity in Kumaon rivers (Central Himalaya). *J. Inland Fish. Soc. India*, 31(2): 20-24.
- Joshi, K. D. 2007. Preliminary observations on rearing of the hill stream fish, *Naziritor chelynooides* (Mc Clelland) under pond environment. *Indian J. Fish.*, 54(4): 423-425.
- Joshi, K. D., Das, S. C. S., Pathak, R. K., Khan, A., Sarkar, U. K. and Roy, K. 2018. Pattern of reproductive biology of the endangered golden mahseer *Tor putitora* (Hamilton 1822) with special reference to regional climate change implications on breeding phenology from lesser Himalayan region, India. *J. Appl. Anim. Res.*, 46(1): 1289-1295. DOI: 10.1080/09712119.2018.1497493.

- Jumani, S., Hull, V., Dandekar, P. and Mahesh, N. 2022. Community-based fish sanctuaries: Untapped potential for freshwater fish conservation. *Oryx*, 1-10.
- Kabir, M. S. U., Sarder, M. R. I., Rahman, M. M., Mollah, M. F. A. and Ryhan, N. B. 2022. Development of a sperm cryopreservation protocol for critically endangered mohashol, *Tor tor* (Hamilton). *Biopreserv. Biobank.*, 20(4): 357-366. doi: 10.1089/bio.2021.0055.
- Karamchandani, S. J. 1972. *Mahseer; a sport fish of India. Silver Jubilee Souvenir*; ICAR-Central Inland Fisheries Research Institute, Barrackpore, India, p. 132-137.
- Keshavanath, P., Gangadhara, B., Basavaraja, N. and Nandeesha, M. C. 2006. Induced breeding of pond raised mahseer, *Tor khudree* using carp pituitary and ovaprim. *Asian Fish. Sci.*, 19: 411-422.
- Khaironizam, M. Z. and Ismail, M. Z. 2013. Spawning period and fecundity of *Neolissochilus soroides* (Duncker, 1904) (Pisces, Teleostei, Cyprinidae) from a small Malaysian stream. *Turk. J. Zool.*, 37(1): 65-72. DOI:10.3906/zoo-1201-10.
- Kharat, S. S., Dahanukar, N., Raut, R. and Mahabaleshwarkar, M. 2003. Long term changes in freshwater fish species composition in north Western Ghats, Pune District. *Curr. Sci.*, 84: 816-820.
- Khare, P., Vindhya, M., Barman, A. S., Singh, R. K. and Lal, K. K. 2014. Molecular evidence to reconcile taxonomic instability in mahseer species (Pisces: Cyprinidae) of India. *Organis. Divers. Evol.*, 14: 307-326. DOI 10.1007/s13127-014-0172-8.
- Khuda-Bukhsh, A. R. 1980. A high number of chromosomes in the hill stream cyprinid, *Tor putitora* (Pisces). *Experientia*, 36: 173-174. Doi: 10.1007/BF01953714.
- Khuda-Bukhsh, A. R. 1982. Karyomorphology of two species of *Tor* (Pisces, Cyprinidae) with a high number of chromosomes. *Experientia*, 38: 82-83. DOI:10.1007/BF01944540.
- Khuda-Bukhsh, Chanda, T. and Barat, A. 1986. Karyomorphology and evolution in some India hillstream fishes with particular reference to polyploidy in some species. In: Uyeno, T., Arai, R., Taniuchi, T. and Matsuura, K. (Eds.), *Indo-Pacific fish biology: Proceedings of the Second International Conference on Indo Pacific Fishes*. Ichthyological Society of Japan, Tokyo, p. 886-898.
- Kiper, T. 2013. Role of ecotourism in sustainable development. In: Murat Ozyavuz (Eds.), *Advances in landscape architecture*, IntechOpen, London, UK, 940 pp. DOI: 10.5772/55749.
- Kohli, M. P. S., Ayyappan, S., Ogale S. N., Langer, R. K., Chandra, P., Dube, K., Reddy, A. K., Patel, M. B. and Saharan, N. 2002. Observations on the performance of *Tor khudree* in floating cages in open waters. *Appl. Fish. Aquac.*, 2: 51-57.
- Kottelat, M. 2013. The fishes of the inland waters of Southeast Asia: A catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. *Raffles Bull. Zool.*, 27: 1-663.
- Kottelat, M. 2016. The fishes of the Nam Theun and Xe Bangfai drainages, Laos. *Hydroe'cologie Applique'e*, 19: 271-320.
- Kottelat, M., Baird, I. G., Kullander, S. O., Ng, H. H., Parenti, L. R., Rainboth, W. J. and Vidthayanon, C. 2012. The status and distribution of freshwater fishes of Indo-Burma. In: Allen, D. J. Smith, K. G. and Darwall, W. R. T. (Compilers). IUCN, Cambridge, UK and Gland, Switzerland, p. 36-65.
- Kottelat, M., Pinder, A. and Harrison, A. 2018. *Tor tambroides* The IUCN Red List of Threatened Species 2018. <https://www.iucn.org>.
- Kottelat, M., Whitten, A. J., Kartikasari, N. and Wirjoatmodjo, S. 1993. *Freshwater fishes of western Indonesia and Sulawesi*. Periplus Editions, Hong Kong, 221 pp.
- Kottelat, M. 2013. The fishes of the inland waters of Southeast Asia: A catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. *Raffles Bull. Zool.*, (Suppl. 27): 1-663.
- Kulkarni, C. V. 1971. Spawning habits, eggs and early development of Deccan mahseer, *Tor khudree* (Sykes). *J. Bombay Nat. His. Soc.*, 67: 510-521.
- Kulkarni, C. V. 1980. Eggs and early development of *Tor mahseer*. *J. Bombay Nat. His. Soc.*, 77: 70-75.
- Kumar, R., Goel C., Sahoo, P. K., Singh, A. K. and Barat, A. 2015. Complete mitochondrial genome organisation of *Tor tor* (Hamilton, 1822). *Mitochondrial DNA*, 27(4): 2541-2542. DOI: 10.3109/19401736.2015.1038795.
- Kunlapapuk, S. and Kulabtong, S. 2011. Breeding, nursing and biology of Thai mahseer (*Tor tamboides*) in Malaysia: An overview. *J. Agric. Sci. Technol.*, 1: 1214-1216.
- Kurup, B. M. and Radhakrishnan, K. V. 2007. *Tor remadevii*, a new species of mahseer from Kerala (South India), and distribution and abundance of *Tor* spp. in the river systems of Kerala. In: Siraj, S. S., Christianus, A., Kiat, N. C. and De Silva, S. S. (Eds.), *Mahseer; the biology, culture and conservation. Proceedings of the international symposium on the Mahseer*, 29-30 March 2006, Malaysian Fisheries Society, Kuala Lumpur, Malaysia.
- Kurup, B. M. and Radhakrishnan, K.V. 2010. *Tor remadevii*, a new species of *Tor* (gray) from Chinnar Wildlife Sanctuary, Pambar River, Kerala, Southern India. *J. Bombay Nat. Hist. Soc.*, 107(3): 227.
- Kushwaha, B., Srivastava, S. K., Nagpure, N. S., Ogale, S. N. and Ponniah, A. G. 2001. Cytogenetic studies in two species of mahseer, *Tor khudree* and *Tor mussullah* (Cyprinidae, Pisces) from India. *Chromosome Science*, 5: 47-50.
- Lacy, G. H. and Cretin, E. 1905. *The anglers handbook for India*, 4th edn. W. Newman & Co., Calcutta, India.

- Lakra, W. S. and Rishi, K. K. 1991. Chromosomes of Indian fishes: An annotated list. *Indian J. Anim. Sci.*, 61: 342-349.
- Lakra, W. S. 1996. Cytogenetic studies on endangered fish species, 1. Karyotypes of three species of mahseers, *Tor putitora*, *T. tor* and *T. khudree* (Cyprinidae: Pisces). *Cytobios*, 85: 205-218.
- Lakra, W. S., Bhonde, R. R., Sivakumar, N. and Ayyappan, S. 2006. A new fibroblast like cell line from the fry of golden mahseer *Tor putitora* (Ham). *Aquaculture*, 253(1-4): 238-243.
- Lakra, W. S., Sarkar, U. K., Gopalakrishnan, A. and Kathirvel Pandian, A. 2010. *Threatened freshwater fishes of India*. National Bureau of Fish Genetic Resources, Lucknow, India.
- Lal, K. K., Singh, R. K., Pandey, A., Gupta, B. K., Mohindra, V., Punia, P., Dhawan, S., Verma, J., Tyagi, L. K., Khare, P. and Jena, J. K. 2013. Distributional records of *Tor mahseer Tor tor* (Hamilton, 1822) from Southern India. *J. Appl. Ichthyol.*, 29: 1086-1090. <https://doi.org/10.1111/jai.12017>.
- Lalramliana, S., Lalronunga, S. K. and Singh, M. 2019. DNA barcoding revealed a new species of *Neolissochilus* Rainboth, 1985 from the Kaladan River of Mizoram, North-east India. *Mitochondrial DNA Part A*, 30(1): 52-59. <https://doi.org/10.1080/24701394.2018.1450398>.
- Langdale, S. W. K. 1944. A note on the breeding habits of Katli; *Barbus (Lissocheilus) hexagonolepis* (McClelland). *J. Bombay Nat. Hist. Soc.*, 17: 107-110.
- Laskar, B. A., Kumar, V., Kundu, S., Tyagi, K. and Chandra, K. 2018. Taxonomic quest: Validating two mahseer fishes (Actinopterygii: Cyprinidae) through molecular and morphological data from biodiversity hotspots in India. *Hydrobiologia*, 815: 113-124.
- Laskar, B. A., Bhattacharjee, M. J., Dhar, B., Mahadani, P., Kundu, S. and Ghosh, S. K. 2013. The species dilemma of North-east Indian mahseer (Actinopterygii: Cyprinidae): DNA barcoding in clarifying the riddle. *PLoS One*, 8(1): e53704.
- Laskar, B. A., Das, D. N. and Tyagi, B. C. 2009. Growth performance of the *Neolissochilus hexagonolepis* (McClelland) in pond system in Arunachal Pradesh. *Indian J. Fish.*, 56: 55-59.
- Lau, M. M. L., Lim, L. W. K., Chung, H. H. and Gan, H. M. 2022. The first draft genome assembly and data analysis of the Malaysian mahseer (*Tor tambroides*). *Aquac. Fish.* (In Press). <https://doi.org/10.1016/j.aaf.2022.05.002>.
- Lothian, A. J. 2021. *Behaviour of fishes around engineered structures and in modified rivers*, Doctoral thesis, Durham University, Durham, UK. <http://etheses.dur.ac.uk/13872>.
- MacDonald, A. S. J. 1948. Circumventing the mahseer and other sporting fish in India and Burma. *J. Bombay Nat. Hist. Soc.*, (Bombay) Published 1992, Natraj Publishers, Dehradun.
- Mahapatra, B. K. and Vinod, K. 2011. Reproductive biology and artificial propagation of chocolate mahseer *Neolissocheilus hexagonolepis* (McClelland) in Meghalaya, India. *Indian J. Fish.*, 58(2): 35-40.
- Mahapatra, B. K., Vinod, K. and Mandal, B. K. 2004. Studies on chocolate mahseer, *Neolissocheilus hexagonolepis* (McClelland) fishery and the cause of its decline in Umiam reservoir, Meghalaya. *J. Natcon.*, 16(1): 199-205.
- Majhi, S. K. and Das, S. K. 2013. Thermal tolerance, oxygen consumption and stress response in *Danio dangila* and *Brachydanio rerio* (Hamilton, 1822) acclimated to four temperatures. *Turk. J. Fish. Aquat. Sci.*, 13(2). DOI:10.4194/1303-2712-v13-2-19.
- Mani, I., Kumar, R., Singh, M., Kushwaha, B., Nagpure, N. S., Srivastava, P. K. and Lakra, W. S. 2009. Karyotypic diversity and evolution of seven mahseer species (Cyprinidae) from India. *J. Fish. Biol.*, 75: 1079-1091. doi: 10.1111/j.1095-8649.2009.02379.x.
- Manimekalan, A. 1998. The fishes of Mudumalai Wildlife Sanctuary, Tamil Nadu, South India. *J. Bombay Nat. Hist. Soc.*, 95(3): 431-443.
- Marwein, B. 2000. Fish biodiversity of north-east India. In: Ponniah, A. G. and Sarkar, U. K. (Eds.), *Life history traits of Neolissocheilus hexagonolepis (McClelland)*, NATP Publication No. 2. ICAR-National Bureau Fish Genetic Resources, Lucknow, India, p. 131-133.
- Maskur 2002. *Indonesian Aquaculture Germplasm Conservation Program*, 1(3): 139-143 (In Indonesian).
- McClelland, J. 1839. Indian Cyprinidae. *Asiatic Researches* v. 19 (pt 2): 217-471, Pls.37-61.
- McClelland, J. 1845. Description of four species of fishes from the rivers at the foot of the Boutan Mountains. *Calcutta J. Nat. Hist.*, v. 5 (18): 274-282.
- Menon, A. G. K. 1954. Fish geography of the Himalayas. *Proc. Nat. Sci. India*, 20: 467-493.
- Menon, A. G. K. 1992. Taxonomy of the Mahseer fishes of genus *Tor* Gray with description of new species from Deccan. *J. Bombay Nat. Hist. Soc.*, 89: 210-228.
- Menon, A. G. K. 1999. Checklist of freshwater fishes of India. *Rec. Zool. Surv. India*, 175: 56-57.
- Menon, A. G. K. 1974. *A checklist of fishes of Himalayan and Indo-Gangetic Plains. Special Publication No. 1*, Inland Fisheries Society of India, Barrackpore, India.
- Menon, A. G. K. 1989. Conservation of Ichthyofauna of India. In: Jhingran, A. G. and Sugunan, V. V. (Eds.), 1989. *Conservation and management of inland capture fisheries resources of India*. Inland Fisheries Society of India, Barrackpore, India.
- Menon, A. G. K. 1999. Check List: Freshwater fishes of India. *Record of the Zoological Survey of India. Occasional Paper No. 175*, 366 pp.
- Menon, A. G. K. 2004. *Threatened fishes of India and their conservation*. Zoological Survey of India, 170 pp.

- Mirza, M. R. and Javed, M. N. 1985. A note on Mahseer of Pakistan with the description of *Naziritor*, a new subgenus (Pisces: Cyprinidae). *Pak. J. Zool.*, 17: 225-227.
- Mohindra, V., Pravin, K., Kuldeep, K. L., Peyush, P., Rajiv, K. S., Barman, A. S. and Lakra, W. S. 2007. Genetic identification of five mahseer species from Indian peninsula using RAPD analysis. *Acta. Zool. Sin.*, 5: 725-732.
- Mohsin, A. K. M. and Azmi, A. M. 1983. *Freshwater fishes of Peninsular Malaysia*, University Pertanian Malaysia, Serdang, Malaysia, 284 pp.
- Monkolprasit, S., Sontirat, S., Vimollohakarn, S. and Songsirikul, T. 1997. *Checklist of fishes in Thailand*. Office of Environmental Policy and Planning, Bangkok, Thailand.
- Nath, P. and Dey, S. C. 2002. A profile of watersheds of river Kameng in Arunachal Pradesh - A case study for conservation measures. In: *Life history traits of freshwater fish population for its utilisation in conservation, AC-26, NATP Publication No. 4*. National Bureau of Fish Genetic Resources, Lucknow, India.
- Nautiyal, P., Rizvi, A. F. and Dhasmana, P. 2008. Life history traits and decadal trends in the growth parameters of Golden mahseer *Tor putitora* (Hamilton 1822) from the Himalayan stretch of the Ganga River system. *Turk. J. Fish. Aquat. Sci.*, 8: 125-132.
- Nautiyal, P. 1984. Natural history of the Garhwal Himalayan mahseer *Tor putitora*. II. Breeding biology. *Proc. Indian Acad. Sci. (Anim. Sci.)*, 93: 97-106.
- Nautiyal, P. 1985. Length-weight relationship and relative condition factor of the Garhwal Himalayan mahseer with reference to its fishery. *Indian J. Anim. Sci.* 55: 65-70.
- Nautiyal, P. 1996. Conservation of mahseer in India: Research, a priority. *Fish. Chimes*, 15: 27.
- Nautiyal, P. 2000. Spawning ecology and threats to mahseer. In: Singh, H. R. and Lakra, W. S. (Eds.), *Coldwater aquaculture and fisheries*. Narendra Publishing House, New Delhi, India, p 291-306.
- Nautiyal, P. 2006. Rising awareness and efforts to conserve the Indian mahseers. *Curr. Sci.*, 91: 1604.
- Nautiyal, P. 2014. Review of the art and science of Indian mahseer (game fish) from nineteenth to twentieth century: Road to extinction or conservation. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 84(2): 215-236.
- Nevill, C. A. 1915. The breeding habitats of the mahseer (*Barbus tor*). *J. Bombay Nat. Hist. Soc.*, 24: 838.
- Ng, C. K. 2004. *King of the rivers: Mahseer in Malaysia and the region*. Inter Sea Fishery (M) SDN BHD, Kuala Lumpur, Malaysia, 170 pp.
- Nguyen, T. T., Na-Nakorn, U., Sukmanomon, S. and ZiMing, C. 2008. A study on phylogeny and biogeography of mahseer species (Pisces: Cyprinidae) using sequences of three mitochondrial DNA gene regions. *Mol. Phylogenet. Evol.*, 48: 1223-1231. doi: 10.1016/j.ympev.2008.01.006.
- Nguyen, T. T. T., Brett, I., Sungan, S., Gooley, G., Sim, S. Y., Tinggi, D. and De Silva, S. S. 2006. Mitochondrial DNA diversity of brood stock of two indigenous mahseer species, *Tor tambroides* and *Tor douronensis* (Cyprinidae) cultured in Sarawak, Malaysia. *Aquaculture*, 253: 259-269.
- Ogale, S. N. 2002. Mahseer breeding and conservation and possibilities of commercial culture. The Indian experience. In: *Cold water fisheries in the trans-Himalayan countries. FAO Fisheries Technical Paper No. 431*. Food and Agriculture Organisation of the United Nations, Rome, Italy, p. 193-212.
- Oo, W. 2002. *Inland fisheries of the Union of Myanmar; FAO Fisheries Technical Paper*. Food and Agriculture Organisation of the United Nations, Rome, Italy.
- Oshima, M. 1919. Contributions to the study of the freshwater fishes of the island of Formosa. *Annals of the Carnegie Museum*, 12 (2-4): 169-328, Pls. 48-53.
- Pant, B., Pandey, N. N. and Ram, R. N. 2018. Bioetric characteristics based assessment of habitat suitability for the growth of a cold water cyprinid golden Mahseer (*Tor putitora*). *The Pharma Innovation Journal*, 7: 45-51.
- Pathani, S. S. and Das, S. M. 1979. On induced spawning of mahseer *Tor putitora* (Hamilton) by mammalian and fish pituitary hormones injection. *Sci. Cult.*, 45: 209-210.
- Pathani, S. S. 1978. A note on secondary sexual characters in Kumaun mahseers *Tor tor* and *Tor putitora*. *Indian J. Anim. Sci.*, 48:773-775.
- Pavan-Kumar, A., Raman, S., Koringa, P. G., Patel, N., Shah, T., Singh, R. K. and Chaudhari, A. 2016. Complete mitochondrial genome of threatened mahseer *Tor tor* (Hamilton 1822) and its phylogenetic relationship within Cyprinidae family. *J. Genet.*, 95(4): 853-863. doi: 10.1007/s12041-016-0706-2.
- Pellegrin, J. and P. Chevey. 1936. New or rare fish from Tonkin and Annam. *Bull. Zool. Soc. France*, 61: 219-232 (In French).
- Pinder, A. and Harrison, A. 2018. *Tor dongnaiensis*. *The IUCN red list of threatened species 2018*: e.T126318880A12 6323439.
- Pinder, A. C. and Raghavan, R. 2013. Conserving the endangered Mahseers (*Tor* spp.) of India: The positive role of recreational fisheries. *Curr. Sci.*, 104: 1472-1475.
- Pinder, A. C., Katwate, U., Dahanukar, N. and Harrison, A. 2018. *Tor remadevii*. *The IUCN Red List of Threatened Species 2018*. E.T56096394A56717605.
- Pinder, A. C., Raghavan, R. and Britton, J. R. 2015. Efficacy of angler catch data as a population and conservation monitoring tool for the flagship Mahseer fishes (*Tor* spp.) of Southern India. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 25(6): 829-838. <https://doi.org/10.1002/aqc.2543>
- Pinder, A. C., Raghavan, R. and Britton, J. R. 2020. From scientific obscurity to conservation priority: Research on angler catch rates is the catalyst for saving the hump-backed mahseer *Tor remadevii* from extinction.

- Aquatic Conservation: Marine and Freshwater Ecosystems*, 30(9): 1809-1815. <https://doi.org/10.1002/aqc.3335>.
- Pinder, A.C., Britton, J. R., Harrison, A. J., Nautiyal, P., Bower, S. D., Cooke, S. J., Lockett, S., Everard, M., Katwate, U. and Ranjeet, K. 2019. Mahseer (*Tor* spp.) fishes of the world: Status, challenges and opportunities for conservation. *Rev. Fish Biol. Fish.*, 29: 417-452.
- Pisolkar, M. D. and Karamchandani, S. J. 1981. Fishery biology of *Tor tor* (Hamilton) from Govindgarh Lake (Madhya Pradesh). *J. Inland Fish. Soc. India*, 13: 15-24.
- Qin, T., Chen, Z. Y., Xu, L. L., Zaw, P., Kyaw, Y. M. M., Maung, K.W. and Chen, X. Y. 2017. Five newly recorded Cyprinid fish (Teleostei: Cypriniformes) in Myanmar. *Zool. Res.*, 38: 300.
- Rahman, A. A. 1989. *Freshwater fishes of Bangladesh*. Zoological Society of Bangladesh. Department of Zoology, University of Dhaka, Dhaka, 364 pp.
- Rahman, M. R., Rahman, M. S., Khan, M. G. Q. and Mostary, S. 2007. Suitability of Mahseer *Tor putitora* (Hamilton) in polyculture with Indian major carps. *Progr. Agric.*, 18: 175-182.
- Rainboth, W. J. 1985. *Neolissochilus*, a new genus of South Asian Cyprinid Fish. *Beaufortia*, 35(3): 25-35.
- Rainboth, W. J. 1996. *FAO species identification field guide for fishery purposes. Fishes of the Cambodian Mekong*. Food and Agriculture Organisation of the United Nations, Rome, Italy, 265 pp.
- Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A. and Johnson, P. T. J. 2019. Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biol. Rev.*, 94(3): 849-873. <https://doi.org/10.1111/brv.12480>.
- Reid, G. M., Contreras MacBeath, T. and Csatadi, K. 2013. Global challenges in freshwater-fish conservation related to public aquariums and the aquarium industry. *International Zoo Yearbook*, 47(1):6-45. <https://doi.org/10.1111/izy.12020>.
- Richter, B. D., Braun, D. P., Mendelson, M. A. and Master, L. L. 1997. Threats to imperilled freshwater fauna: Threats to freshwater fauna at risk. *Conservation Biology*, 11(5): 1081-1093 (In Spanish).
- Roberts, T. R. 1989. The freshwater fishes of western Borneo (Kalimantan Barat, Indonesia). *Memoirs California Academy of Science*, 14: 1-210.
- Roberts, T. R. 1999. Fishes of genus *Tor* in the Nam Theun watershed (Mekong Basin) of Laos, with description of a new species. *Raffles Bull. Zool.*, 47: 225-236.
- Sahoo, P. K., Goel, C., Kumar, R., Dhama, N., Ali, S., Sarma, D. and Barat, A. 2015. The complete mitochondrial genome of threatened chocolate mahseer (*Neolissochilus hexagonolepis*) and its phylogeny. *Gene*, 570(2): 299-303. doi: 10.1016/j.gene.2015.07.024.
- Sarkar, U. K., Mahapatra, B. K., Saxena, S. R. and Singh, A. K. 2015. Mahseer in India: An overview on research status and future priorities. *Journal of Ecophysiology and Occupational Health*, 15(1-2): 45-52.
- Sarma, D. 2009. Captive breeding and grow out of the golden mahseer. *Info Fish Int.*, 2: 26-29.
- Sarma, D., Akhtar, M., Sharma, P. and Singh, A. 2018. Resources, breeding, eco-tourism, conservation, policies and issues of Indian mahseer: A review. *Coldwater Fisheries Society of India*, 1(1): 4-21.
- Sarma, D., Das, R., Akhtar, M. S., Ciji, A., Sharma, N. K. and Singh, A. K. 2016. Morpho-histological and ultra-architectural changes during early development of endangered golden mahseer *Tor putitora*. *J. Fish Biol.*, 89(4): 2038-2054. <https://doi.org/10.1111/jfb.13109>.
- Sarma, D., Haldar, R. S., Das, P. and Mahanta, P. C. 2010. Management in seed production of golden mahseer, *Tor putitora* in hatchery conditions. *Aquac. Asia*, 15(4): 11-14.
- Sarma, D., Mohan, M., Haldar, R. S., Das, P. and Mahanta, P. C. 2009. Captive breeding and grow out of golden mahseer (*Tor putitora*). *Infotish International*, 2: 18-22.
- Sarma, D., Singh, A. K. and Akhtar, M. S. 2016. *Mahseer in India: Resources, breeding, eco-tourism, conservation, policies and issues*. ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, India, 168 pp.
- Sati, J., Sah, S., Pandey, H., Ali, S., Sahoo, P. K., Pande, V. and Barat, A. 2013. Phylogenetic relationship and molecular identification of five Indian Mahseer species using COI sequence. *J. Environ. Biol.*, 34(5): 933.
- Sawhney, S. 2014. Effect of partial substitution of expensive ingredient *i.e.*, fish meal on the growth of (*Tor putitora*) fed practical diets, *Journal of International Academic Research for Multidisciplinary*, 2: 7.
- Sehgal, K. L., Shukla, J. P. and Shah, K. L. 1971. Observations on fisheries of Kangra Valley and adjacent areas with special reference to mahseer and other indigenous fishes. *J. Inland Fish. Soc. India*, 3: 63-71.
- Sehgal, K. L. 1972. *Coldwater fisheries and their development in India for sport and profit. Silver Jubilee Souvenir*, ICAR-Central Inland Fisheries Research, Barrackpore, India, p 125-131.
- Sehgal, K. L. 1987. *Sport fisheries in India*. Indian Council of Agriculture Research, New Delhi, India, 126 pp.
- Shahi, N., Mallik, S. K. and Sarma, D. 2014. Golden mahseer, *Tor putitora*-A possible candidate species for hill aquaculture. *Aquac. Asia*, 14: 22-28.
- Shahi, N., Mallik, S. K., Pande, J., Das, P. and Singh, A. K. 2015. Spermatogenesis and related plasma androgen and progesterin level in wild male golden mahseer, *Tor putitora* (Hamilton, 1822), during the spawning season. *Fish Physiol. Biochem.*, 41(4): 909-920. doi: 10.1007/s10695-015-0057-6.
- Shahi, N., Pandey, J., Mallik, S. K., Sarma, D. and Das, P. 2015. Gonadal development stages of wild male golden mahseer, *Tor putitora* from Nainital region of Uttarakhand, India. *Journal of Ecophysiology and*

- Occupational Health*, 14(3-4): 133-138. DOI: <https://doi.org/10.18311/jeoh/2014/1656>.
- Sharma, A., Sarma, D., Joshi, R., Das, P., Akhtar, M. S., Pande, V. and Sharma, P. 2022. Gonad indices, morphology and muscle fatty acid compositions of male and female golden mahseer (*Tor putitora*) sampled from lake Bhimtal (Himalaya) at different seasons of the year. *Aquaculture and Fisheries*. DOI:10.1016/j.aaf.2022.08.002.
- Sharma, J. and Parashar, A. 2013. Fertilisation regime in culture pond - An attempt for rehabilitation and conservation of endangered fish mahseer (*Tor tor*). *Indian J. App. Pure Biol.*, 28: 39-44.
- Sharma, L., Ali, S., Siva, C., Kumar, R., Barat, A., Sahoo, P. K. and Pande, V. 2019. Genetic diversity and population structure of the threatened chocolate mahseer *Neolissochilus hexagonolepis* (McClelland 1839) based on SSR markers: Implications for conservation management in Northeast India. *Molecular Biology Reports*, 46(5): 5237-5249. doi: 10.1007/s11033-019-04981-7.
- Shrestha, T. K. 1986. Spawning ecology and behavior of the mahseer *Tor putitora* in the Himalayan waters of Nepal. In: Maclean, J. L., Dizon, L. B. and Hosillos, L. V. (Eds.), *Proceedings of the first Asian Fisheries Forum*, 26-31 May 1986, Manila, Philippines, p 689-692.
- Silas, E. G., Gopalakrishnan, A., John, L. and Shaji, C. P. 2005. Genetic identity of *Tor malabaricus* (Jerdon) (Teleostei: Cyprinidae) as revealed by RAPD markers. *Indian J. Fish.*, 52: 125-140.
- Singh, H. R. and Lakra, W. S. *Coldwater aquaculture and fisheries*. Narendra Publishing House, Delhi, India, p 265-278.
- Singh, M., Kumar, R., Nagpure, N. S., Kushwaha, B., Gond, I. and Lakra, W. S. 2009. Chromosomal localization of 18S and 5S rDNA using FISH in the genus *Tor* (Pisces, Cyprinidae). *Genetica*, 137(3): 245-252. doi: 10.1007/s10709-009-9367-x.
- Sinha, M. 1994. Threatened cold water species of North-eastern region of India. In: *Threatened fishes of India*, Dehadrai, P. V., Das, P. and Verma, S. R. (Eds.), Natcon Publication, p. 172-176.
- Siraj, S. S., Christianus, A., Chee Kiat, N. and De Silva, S. S. 2007. Mahseer: The biology, culture and conservation, *Proceedings of the International Symposium on the Mahseer*, 29-30 March 2006, Kuala Lumpur, Malaysia, Malaysian Fisheries Society, Serdang, Malaysia, 235 pp.
- Smith, H. M. 1945. The fresh-water fishes of Siam or Thailand. *Bulletin of the United States National Museum No. 188*, i-xi + 1-622, Pls. 1-9. DOI: <https://doi.org/10.5479/si.03629236.188.1>.
- Steven, J. C., Zeb, S. H., Paul, A. B., Michael, J. W. S., Rajeev, R., Austin, J. G., Neil, H. and Andy, J. D. Angling for endangered fish: Conservation problem or conservation action? *Fish Fish.*, 17 (1): 249-265. <https://doi.org/10.1111/faf.12076>.
- Stone, R. 2007. The last of the leviathans. *Science*, 316: 1684-1688. DOI: 10.1126/science.316.5832.1684.
- Sugunan, V. V. 1995. *Reservoir fisheries of India. Fisheries Technical Paper*. Food and Agriculture Organisation of the United Nations, Rome, Italy, 423 pp.
- Sunder, S. and Joshi, C. B. 1977. Preliminary observations on the spawning of *Tor putitora* in Anji stream Jammu Province. *J. Inland Fish. Soc. India*, 24:153-158.
- Sykes, W. H. 1839. On the fishes of the Deccan. *Proc. Zool. Soc. Lond.*, 6: 157-165.
- Talwar, P. K. and Jhingran, A. G. 1990. *Inland fishes of India and adjacent countries*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.
- Talwar, P. K. and Jhingran, A. G. 1991. *Inland fishes of India and adjacent countries, vol. 1*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.
- Thomas, H. S. 1897. *The rod in India being hints how to obtain sport with remarks on the natural history of fish and their culture*, 3rd edn. W. Thacker and Co., London, UK.
- Thomas, H. S. 1873. *The rod in India*. Naval and Military Press. 308 pp.
- Tripathi, P. H., Pandey, A., Ciji, A., Pande, V., Rajesh, M., Kamalam, B. S. and Akhtar, M. S. 2022. Molecular characterisation of four innate immune genes in *Tor putitora* and their comparative transcriptional abundance during wild-and captive-bred ontogenetic developmental stages. *Fish Shellfish Immunol. Rep.*, 3: p. 100058.version (11/2014).
- Vidhayanon, C. and Kottelat, M. 2003. Three new species of fishes from Tham Phra Wang Daeng and Tham Phra Sai Ngam caves in northern Thailand (Teleostei: Cyprinidae and Balitoridae). *Ichthyological Exploration of Freshwaters v. 14*(no. 2): 159-174.
- Vidhayanon, C. and Pinder, A. C. 2018. *Tor sinensis*. The IUCN Red List of Threatened Species, (2018-2). <https://www.iucnredlist.org>.
- Vishwanath, W. 2014. *Neolissochilus* fishes of Northeast India. In: *Proceedings of the National Workshop on Mahseer in India: Resources, breeding, propagation, conservation, policies and issues*. 22-23 December 2014, Guwahati, India. ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, India.
- Vishwanath, W. 2011. *The status and distribution of freshwater biodiversity in the Eastern Himalaya*. Al-len, D. et al. (Compilers), IUCN, Cambridge, UK and Gland, Switzerland and Zoo Outreach Organisation, Coimbatore, India, 88 pp.
- Wagh, G. K. and Ghate, H. V. 2003. Freshwater fish fauna of the rivers Mula and Mutha, Pune, Maharashtra. *Zoo's Print, J.* 18: 977-981. DOI:10.11609/JoTT.ZPJ.18.1.977-89.
- Walker, W. 1888. *Angling in Kumaun Lakes, with a map of the Kumaon Lake Country*. Thacker Spink and Co., Calcutta, India.
- Walton, S., Gan, H., Raghavan, R., Pinder, A. C. and Ahmad, A. 2017. Disentangling the taxonomy of the mahseers

- (*Tor* spp.) of Malaysia: An integrated approach using morphology, genetics and historical records. *Rev. Fish. Sci. Aquac.*, 25: 171-183. <https://doi.org/10.1080/23308249.2016.1251391>.
- Weber, M. and de Beaufort, L. F. 1916. The fishes of the Indo-Australian Archipelago. III. Ostariophysi: II Cyprinoidea, Apodes, Synbranchi. *E. J. Brill, Leiden*. v. 3: i-xv + 1-455.
- Wei, Z. and Cui, G. H. 1996. A review of *Tor* species from the Lancangjiang River (Upper Mekong River), China (Teleostei: Cyprinidae). *Ichthyol. Explor. Freshw.*, 7: 131-142.
- WWF 2020. *Living planet report 2020: Bending the curve of biodiversity loss*. World Wide Fund for Nature, Gland, Switzerland.
- WWF 2021. *The world's forgotten fishes*. World Wide Fund for Nature, Gland, Switzerland.
- Wu, H. W., Lin, R. D., Chen, Q. X., Chen, X. L. and He, M. Q. 1977. Barbinae. In: Wu, H. W. (Ed.), *The cyprinid fishes of China, vol. 2*. People's Press, Shanghai, China, p. 229-394 (In Chinese).
- Nautiyal, P., Babu, S. and Behera, S. 2013. *Mahseer conservation in India: Status, challenges and the way forward*. WWF India, New Delhi, India, 38 pp.
- Yang, L., Sado, T., Hirt, M. V., Pasco-Vie, E., Arunachalam, M., Li, J., Wang, X., Freyhof, J., Saitoh, K., Simons, A. M. and Miya, M. 2015. Phylogeny and polyploidy: Resolving the classification of cyprinine fishes (Teleostei: Cypriniformes). *Mol. Phylogenet. Evol.*, 85: 97-116. doi: 10.1016/j.ympev.2015.01.014.
- Yazdani, G. M., Devi, K. R., Raghunathan, M. B. and Singh, D. F. 2001. *Fauna of Nilgiri Biosphere Reserve - Pisces. Fauna of Conservation Area Series 11*. Zoological Survey of India, p. 207-224.
- Youn, S. J., Taylor, W. W., Lynch, A. J., Cowx, I. G., Beard, T. D. and Bartley, D. 2014. Inland capture fishery contributions to global food security and threats to their future. *Global Food Security*, 3(3-4): 142-148. <https://doi.org/10.1016/j.gfs.2014.09.005>.
- Yousaf, M., Hasan, Z., Zaidi, F. and Rasheed, S. B. 2021. An overview of the taxonomic instability of endangered Golden and Zhobi mahseer in Pakistan. *Braz. J. Biol.*, 83 :e243975. DOI: 10.1590/1519-6984.243975.
- ZiMing, C. and JunXing, Y. 2014. A new species of the genus *Tor* from Yu China (Teleostei: Cyprinidae). *Environ. Biol. Fishes*, 70: 185-191.