Asian Journal of Conservation Biology, July 2024. Vol. 13 No. 1, pp. 105–117 AJCB: FP0245/85367
ISSN 2278-7666 ©TCRP Foundation 2024 https://doi.org/10.53562/ajcb.85367

Research Article

First record two species of Tor Mahseer in the Indravati River system of Godavari Basin of Eastern Ghats in Odisha, India, and Conservation Strategies

Alok Kumar Naik[1], Anirban Mahata[2] & Sharat Kumar Palita[3*]

[1,2,3]*Department of Biodiversity and Conservation of Natural Resources, Central University of Odisha, Koraput-763004, Odisha, India*

(Received: March 17, 2024; Revised: April 16, 2024; Accepted: May 07, 2024)

ABSTRACT

Despite advanced genetic tools, morphological taxonomy remains crucial for managing fish genetic resources. Mahseer, a prized fish known as the "King of Indian Aquatic Systems," faces taxonomic challenges due to incomplete morphological descriptions. Ambiguities arise in Mahseer taxonomy due to the occurrence of a few holotypes, inconspicuous morphological distinctions in them, and differences in recognizing specific morphological characters. This study collected Mahseer specimens from the Indravati River (a tributary of the Godavari River system) in Odisha and analysed morphometric and meristic characteristics using Least Discriminant Analysis (LDA). The study came out with records of two Tor Mahseer species, *Tor putitora* and *Tor tor*, in the region, with *Tor putitora* being a new record for the entire Godavari Basin in India. Strategies for the conservation of Mahseers and suggestions for conservation awareness among the local population have been discussed. Further, a comprehensive investigation on Mahseer diversity and distribution in rivers of southern Odisha has been recommended.

Key words: *Tor tor*, *Tor putitora*, Koraput, morphometric parameters, Southern Odisha

INTRODUCTION

Indian Mahseer fishes are large-bodied big-scaled carps (Dinesh *et al.* 2010) often called as “King of Indian Aquatic Systems” (Langer, Ogale & Ayyappan, 2001) and included under 20 mega fishes of the world (Stone, 2007). It inhabits fast-flowing cold, clear water with pebbly, stony, and rocky bottoms and intermittent rocky pools (Ng, 2004; Dinesh *et al.* 2008) and is recognised as a sport and table fish all over the world (Nautiyal, 2014; Sarkar *et al.,* 2015). It is a sacred fish and is worshiped in many Hindu Temples (Desai, 2003) in India. In Indian rivers, mahseer fishes of the genus Tor are referred to as "iconic species," serving as "flagship" species for conservation efforts in addition to having additional dietary, cultural, and economic values (Everard & Kataria, 2011). However, in recent times Mahseer fishes natural environments have been declining due to various anthropogenic activities (Sarkar *et al.,* 2015) and are facing the threat of extinction as some of the Mahseer species are categorised as critically endangered (CR), some are endangered while others are threatened (IUCN, 2023). Across the extensive Asian range, Mahseers are endangered due to a variety of human activities; including dam construction, water pollution, overexploitation, and degradation of habitat (Everard *et al.,* 2021).

The world Mahseer species are subdivided into three genera i.e. *Tor*, *Neolissochilus,* and *Naziritor* (Kottelat, 2013; Eschmeyer, Fricke & van der Laan, 2017; Froese & Pauly, 2018), whereas the members of species under the *Tor* genus are recognised as “true Mahseer” (Desai, 2003; Nguyen *et al.,* 2008). Globally 16 valid species of the *Tor* Genus are found in countries like India, China, Myanmar, Nepal, Sri Lanka, Pakistan, Thailand, Bangladesh, Vietnam, Laos, Afghanistan, Bhutan, and Indonesia (Pinder *et al.,* 2019).

Out of 16 species under *Tor* genera, India is home to eight species of Tor Mahseer (Pinder *et al.,* 2019). These species are *Tor barakae* Arun Kumar and Basudha 2003, *Tor khudree* Sykes 1839, *Tor kulkarnii* Menon 1992, *Tor malabaricus* Jerdon 1849, *Tor mosal* Hamilton 1822, *Tor putitora* Hamilton 1822, *Tor remadevii* Kurup and Radhakrishnan 2007 and *Tor tor* Hamilton 1822, distributed over several river systems of India (Pinder *et al.,* 2019). One of India's largest freshwater fishes, *Tor putitora*, the Golden Mahseer is indigenous to rivers in the Himalayas (Everard & Kataria, 2011; Gupta *et al.,* 2014). In India, it occurs in the states of Jammu & Kashmir, Sikkim, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Bihar, and West Bengal (Johal, Tandon, & Sandhu, 1994a; Nautiyal, Rizvi & Dhasmanaa, 2008). Additionally, it has been described from Pakistan, Afghanistan, Bangladesh, Bhutan, and Nepal. Overall, its longitudinal distribution covers the Indus, Ganges, and Brahmaputra river systems and stretches from Hindu Kush-Kabul-Kohistan in the North West Himalaya to Sadiya (Brahmaputra) in the North-East Himalaya. (Talwar & Jhingran, 1991; Pervaiz *et al.,* 2012).

In India, Tor mahseer, *Tor tor* (Hamilton 1822) is recognised to be one of the principal game and food

[*]*Corresponding Author’s E-mail: skpalita@gmail.com*

fish. It lives in plains with rocky bottoms and rivers in the 'Tor region' (600–1200 m) (Singh & Kumar, 2000). The Narmada River sustains a notable fish population of this species, which has also been observed in the Ganges (including the regions below the Himalayas), Brahmaputra, Godavari, and Krishna river systems (Desai, 2003; Jayaram, 2005; Lal *et al.,* 2013).

Tor Mahseer in Godavari River system

The River Godavari, popularly called "Ganga of South" is the second-largest river in India which rises from Western Ghats near Triambakeshwar, Maharashtra. It contributes major diversity of *Tor* species in the Western Ghats having three different species of Tor Mahseer including *Tor kulkarni*, distributed in Dharana River at Deolali (Menon, 1992), *Tor khudree* and *Tor tor* from Adan River of Maharashtra state (Heda, 2009). Recently Lal *et al.* (2012) recorded *Tor tor* from Penganga and Satnala, tributaries of the River Godavari of Southern India (Figure 1). The state of Odisha has about 5.7% area under the catchment of Godavari River Basin with Kolab River and Indravati River as two most important tributaries of the Godavari River Basin in Southern Odisha (MWRI, 2014).

Tor Mahseer in Odisha

Odisha, the eastern coastal state of India with a major part of the northern Eastern Ghats, comprises 13.92% of the freshwater fish fauna of the country (Dutta, Kunda & Karmakar, 1993). The topography of Odisha is suitable for fish fauna (Dutta *et al.* 1993; Pathak *et al.,* 2007) including Mahseer fishes. The state of Odisha has a large catchment area of three important river basins- the Mahanadi River Basin, the Brahmani River Basin, and the Godavari River Basin (Figure 1). Four different species of Tor Mahseer i.e. *Tor khudree, Tor mahanadicus, Tor putitora* and *Tor tor* inhabit the river systems of Odisha. While three Mahseer species including *T. khudree, T. mahanadicus* and *T. tor* are found in the River Mahanadi (Chauhan, 1947; David, 1953; Dutta *et al.* 1993; Johnson *et al.* 2023), Brahmani River has *T. khudree* and *T. tor* (Dutta *et al*., 1993) and both *T. putitora* and *T. tor* were reported from Similipal Biosphere Reserve (Sethy, 2009) (Figure 1). Also, *T. khudree* was reported in the Indravati drainage of Odisha (Dutta *et al.,* 1993). Tor Mahseer of Mahanadi River was originally described by David (1953) as *Tor mosal mahanadicus* from Hirakud stretch of the River Mahanadi. Due to the assessment of the lack of genetic distinctions between *T. m. mahanadicus* and *T. putitora*, Khare *et al.* (2014) later synonymized it with *T. putitora*. However, recently Johnson *et al.* (2023) carried out an integrated morpho-molecular analysis to redescribe *T. m. mahanadicus* to *Tor mahanadicus* as a separate species from the Mahanadi River. With the inclusion of *T. mahanadicus*, the Tor Mahseer species number has

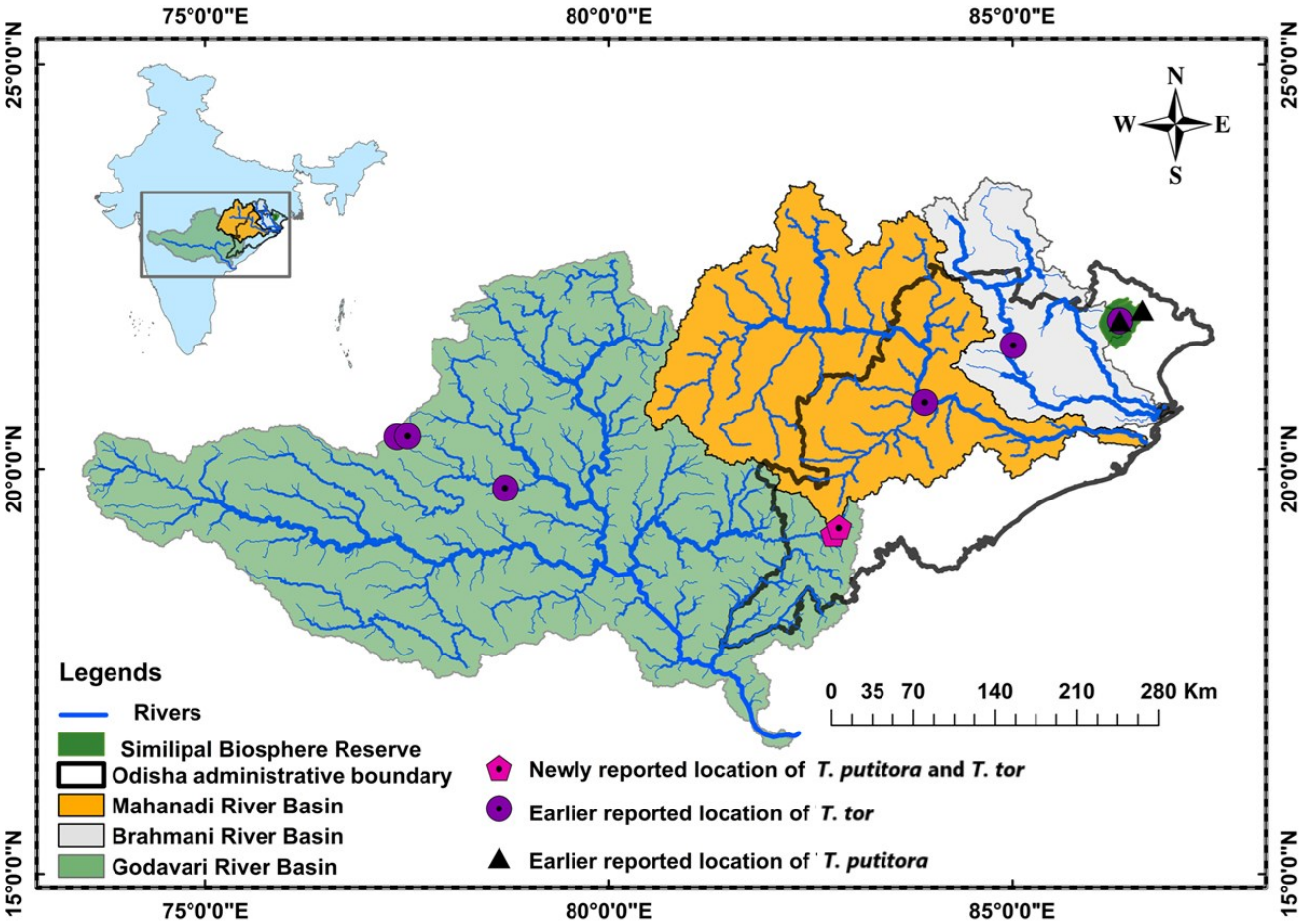

Figure 1. Distribution Map of Tor Mahseer in River Basins of Mahanadi, Brahmani of Odisha and Godavari River Basin, India.

increased to 17 species globally and nine in Indian freshwaters.

Notwithstanding the availability of biochemical and molecular genetic techniques, in managing fish genetic resources, morphological taxonomy and phenotypic descriptions of species are crucial. Because of morphological variations, the mahseer taxonomy and systematics remain uncertain (Bagra *et al.,* 2009). Several problems are faced in the traditional taxonomy of mahseer because of the absence of morphometric details in the original description. The ambiguities in mahseer taxonomy are in question for a few reasons i.e. occurrence of very few holotypes, unnoticeable morphological distinctions in them, and differences in recognizing specific morphological characters (Jayaram, 1999). To overcome this, more studies on the diversity and assemblage of Mahseer species including their morphometrics in the natural habitats can help clear ambiguities for this unique biodiverse group of fishes. Given this, our study deals with records of two Tor Mahseer species *Tor putitora* and *Tor tor*, from Indravati River system in the Godavari Basin of southern Odisha, India.

MATERIALS AND METHODS

Study Area

The River Indravati of Odisha is an important interstate river and a tributary of River Godavari. It arises from a small rivulet of village Mardiguda of Thuamul Rampur Block of Kalahandi district situated at an elevation of 914 m asl in the Dandakaranya Range on the western slopes of the Eastern Ghats. The River Indravati (Figure 2), after traveling 164 km through the Odisha districts of Kalahandi, Nabarangpur, and Koraput, forms 9.5 km of the interstate border between Odisha and Chhattisgarh and then enters the Bastar district of Chhattisgarh. It flows around 233 km in the state of Chhattisgarh and then turns south and forms an interstate border of 129 km between Chhattisgarh and Maharashtra until joining the Godavari River at the intersection of the borders of Chhattisgarh, Maharashtra, and Telangana states. It flows for a length 535 km with a drainage area of 41,665 sq. km. (Vansutre, Deshmukh & Hari, 2014; Choudhury, 2017).

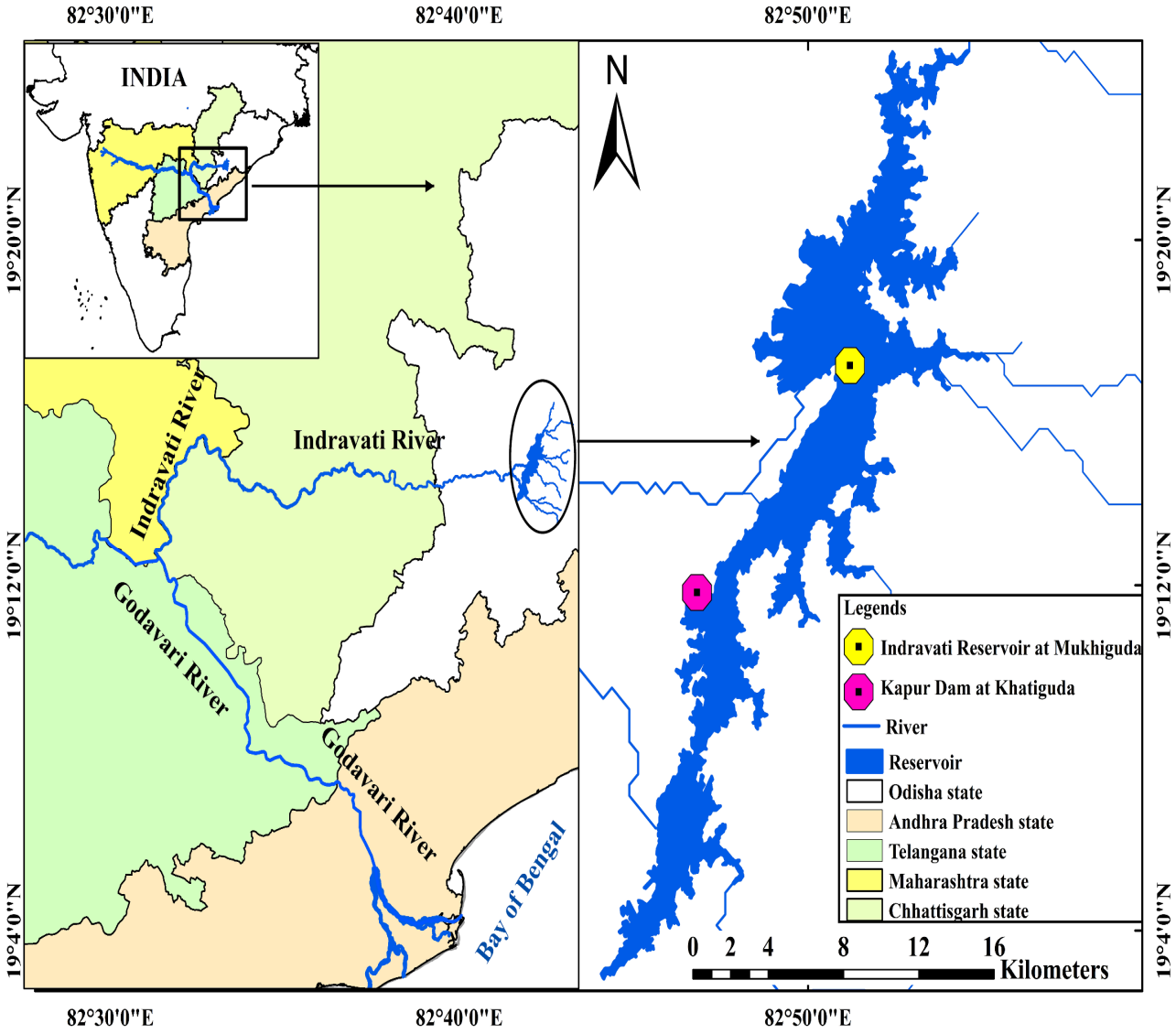

Figure 2. Map of Indravati River Drainage basin, India

Mahseer Specimens were collected from Indravati Dam Reservoir at Mukhiguda, Kalahandi (82º51′12.27″E and 19º17′05.66″N), and Kapur Dam (82º46′49″E and 19º11′50″N) at Khatiguda, Nabarangpur, Odisha (Figure 2).

Samples Collection and Analysis

The Mahseer fishes were sampled using gill nets supported by local fishermen during July 2019 to July 2023. Specimens were preserved in 10% formaldehyde. The geographical coordinates of sampling sites were taken by GPS (GPSMAP 64s, Garmin, United States). The habitat parameters were as per Arunachalam (2000). pH and water temperature were recorded at the sampling sites by pH meter (eco Tester pH 2) and water thermometer. Water samples were carried to the laboratory for analysis of Electrical Conductivity (EC), Dissolved Oxygen (DO), and Total Dissolved Solid (TDS), The MultipleParameter PCS Tester TM 35 was used to measure TDS and EC and DO were analysed by Winkler's method (APHA, 2005). The standard taxonomic keys of Sen & Jayaram (1982), Talwar & Jhingran (1991), Menon (1992), Jayaram (2010) and Langer *et al.* (2013) were used for species identification. The specimens of the two species were deposited at the Zoological Survey of India (ZSI), Kolkata, and final identification was ascertained by the experts of ZSI, Kolkata.

Twenty-two morphometric parameters, which were studied (Table 1) include: TL-Total Length; SL-Standard Length; HL-Head Length; SNL- Snout Length; POL- Post Orbital Length; FL-Fork length; PDL- Pre Dorsal Length; PODL- Post Dorsal Length; DFL- Dorsal Fin Length; PFL-Pectoral Fin Length; PVFL- Pelvic Fin Length; AFL- Anal Fin Length; PPL-Pre-Pelvic Length, LCPD- Length of Caudal Peduncle; DFBL -Dorsal Fin Base Length; AFBL- Anal Fin Base Length ; LHCPD -Least Height of Caudal Peduncle, BD-Body Depth; ED-Eye Diameter; HW- Head Width, HD- Head Depth, IOW -Inter Orbital Width. Using a digital vernier calliper, measurements were obtained on a continuous scale from the lateral side of the fish. Except for the body depth and head depth, all lengths were measured along the anterior-posterior body axis (Manimegalai *et al.,* 2010).

Since Mahseer fish of different sizes were taken in this work, their morphometric characters and growth may vary, to rectify the differentiations among the morphometric characters, the morphometric data were standardized in the form of the ratio of TL to other body parameters, and Head length (HL) to other body parameters. The descriptive analysis (mean, range, and standard deviation) was applied to all of the morphometric measurements and ratios(Table 1).The standardized parameters were subjected to one-way Multivariate analysis of variance (MANOVA), and the significant variables (Table 3) were extracted for linear discriminant analysis (LDA). Linear Discriminant Analysis (LDA) serves as a supervised learning algorithm employed for classification purposes within the realm of machine learning. It is a technique used to find a linear combination of features that best separates the classes in a dataset. Thus, in the current work, the ratios used in LDA were utilized to discern the differences in morphological traits of the two Mahseer species (*T. putitora* and *T. tor*). LDA was used to obtain eigenvalue, variance percentage, and axis scores (Table 4). Similarly, the standardized data were used to construct the box plot to show the variation between the two Mahseer species through median, range, and quartiles (Fig. 6).

The aforementioned analysis was conducted using Microsoft Excel 2007 and PAST 4.03 **(**Hammer, Harper & Ryan, 2001**)** and Origin(Pro) Ver. 2023.

The eight meristic characters of two species of Mahseers are: Lls-Lateral Line Scale; L.tr- Lateral Line Transverse Scale; PDS- Pre-Dorsal Scale; DFR-Dorsal Fin Rays; PFR- Pectoral Fin Rays; PVFR- Pelvic Fin Rays; AFR-Anal Fin Rays; CFR-Caudal Fin Rays (Table 2)

Since no noteworthy sexual dimorphism with regard to the chosen morphometrics was found, the data analysis was carried out without taking the individual's sex and developmental stage into account.

RESULTS

The two Mahseer species *Tor putitora* (ZSI Registration No. FF8623, 30 cm) and *Tor tor* (ZSI Registration No. FF8624, 33.6 cm) were reported as new records from the Indravati River system of Eastern Ghats in Odisha with the Ref. No. F. ZSI/FPSB/FWFS/2019-20. The specimens have been deposited in the Zoological Survey of India (ZSI), Kolkata, India for future reference (Figure 3).

Distinguishing Characters

***Golden Mahseer Tor putitora* (Figure 4)**

The collected specimens of *Tor putitora* exhibited the following distinguishing characteristics:

i. Fin formula: D. 13 (4/9), P. 16-17, V. 8-9 (1/7-8), A. 7-8 (2-3/5), Lls. 24-27, L. tr. 3½/1/2½
ii. Description: Six exs of *T. putitora*
iii. Dorsal Fin Ray (D): All six specimens with 13 (4/9) dorsal fin rays.
iv. Pectoral Fin Rays (P): Four specimens with 16, and two with 17 pectoral fin rays.
v. Ventral/ Pelvic Fin Rays (V): Five specimens with 9 (1/8) and one with 8(1/7) Ventral/ Pelvic fin rays.
vi. Anal Fin Rays (A):Four specimens had 8 (3/5), and two with 7 (2/5) Anal fin rays.
vii. Body streamlined, oblong, and somewhat compressed.
viii. Its depth is 5.0 to 5.5 in Total length.
ix. Head broadly pointed its length greater than the depth of the body and 4.6 to 5 times in Total length.
x. 24-27 scales along the lateral line.
xi. Description: Two specimens with 25 scales, and another two with 27, while one with 24 and the other one with 26 scales in the Lateral line.
xii. Lateral line Transverse scale: 3½/1/2½
xiii. Body colouration: The species has reddish sap-green back, light orange flanks that turn silvery white on the belly, watery buff-yellow eyes, Irish light green scales with dark blue pupils, and bright orange scale centres. The distal tip of the caudal fin has a reddish-orange patch, and the fin's posterior border is reddish-green. The pectoral, pelvic, and anal fins are yellowish.

***Mahseer Tor tor* (Figure 5)**

The collected specimens of *Tor tor* exhibited the following distinguishing characteristics:

i. Fin formula: D. 13 (4/9), P. 15-18, V. 9-10 (1-2/8), A. 7-8, Lls. 22-27, L. tr. 3½/1/2-2½.
ii. Description: - 13 exs of *T. tor*

iii. Dorsal Fin Rays (D): All specimens have 13 (4/9) dorsal fin rays.
iv. Pectoral Fin Rays (P): Five specimens with 17, another five with 16, two with 15, and one with 18 Pectoral fin rays.
v. Ventral/ Pelvic Fin Rays (V): Eight specimens with 9 (1/8), and the rest five with 10 (2/8) ventral/ pelvic fin rays.
vi. Anal Fin Rays (A): Eleven specimens had 8 (3/5 and 2/6) and two with 7 (2/5 and 1/6) anal fin rays.
vii. The body is deep and relatively hefty. Its depth is 4.4 to 4.9 in Total length.
viii. Rather tiny head. Its length 4.8 to 5.3 times in Total length.
ix. 22-27 scales along the lateral line.
x. Description: Six specimens with 25, three with 24, two with 22, one with 26, and another one with 27 lateral line scales.
xi. Lateral line Transverse scale: 3½/1/2-2½.
xii. Body colouration: The dorsal side is greyish green in life, the flanks are pinkish with greenish gold above and light olive green below; the belly is silvery; the head is light orange above the gill openings, pale yellow below the eyes, and light sky-blue on the operculum: the reddish buff dorsal fin, deep orange pelvic, pectoral, and anal fins.

The Total length (TL) varied from 30.0-51.8cm and 32.0 -53.63 cm among the 6 specimens of *T. putitora* and 13 specimens of *T. tor* respectively (Table 1).

Box plot of standardized data has shown the variations between the Mahseer fish species *T. putitora* (Tp) and *T. tor* (Tt) through median, range, and quartiles of the proportions of TL and HL with other body parameters (Figure 6).

One-way MANOVA showed that the parameters including TL/HL, TL/BD, TL/PDL, TL/DFL and HL/HD were found to vary significantly among the two species at $p<0.05$ (Table 3). When these five parameters were subjected to the linear discriminant analysis, it showed 100% variations among the two species with Eigenvalue 12.67. The Axis 1 score of *T. putitora* (4.95) was found to be different from the *T. tor* (-2.28), indicating a great variation between the two species (Table 4 and Figure 7). Confusion matrix of LDA showed that all the specimens were 100% correctly classified (Table 5).

Table 1. Morphometric parameters (Mean, Standard deviation and Range) and Stanadarised morphometric parameters of *Tor putitora* (N=6) and *Tor tor* (N=13) from Indravati River System, Odisha, India.

Sl. No	Parameters	*T. putitotra*				*Tor tor*			
		Mean± SD	Range	Mean Ratio with TL	Range of Ratio with TL	Mean±SD	Range	Mean Ratio with TL	Range of Ratio with TL
1	TL	41.73±8.80	30.0-51.8	-	-	39.35±7.02	32.0-53.63	-	-
2	SL	33.34±7.98	22.88-42.4	1.26±0.04	1.22-1.31	31.59±5.99	25.0-43.52	1.25±0.04	1.22-1.37
3	FL	36.24±8.25	25.15-45.4	1.16±0.03	1.13-1.19	33.99±6.36	27.2-46.53	1.16±0.04	1.13-1.27
4	HL	8.72±2.07	6.0-11.2	4.81±0.17	4.62-5.0	7.80±1.35	6.2-10.4	5.04±0.15	4.85-5.30
5	BD	8.00±1.92	5.4-10.32	5.25±0.22	5.01-5.55	8.36±1.38	6.7-10.9	4.70±0.17	4.43-4.93
6	PDL	16.36±3.33	12.0-20.43	2.55±0.04	2.5-2.6	14.99±2.85	11.9-20.71	2.63±0.09	2.44-2.85
7	PoDL	17.09±3.68	12.14-22.54	2.45±0.26	2.21-2.94	17.19±3.06	13.68-24.51	2.29±0.18	2.03-2.71
8	PPL	16.82±3.75	12-21.61	2.49±0.06	2.38-2.55	15.43±2.97	12.59-22.01	2.56±0.12	2.41-2.83
9	DFL	7.3±1.22	5.4-8.67	5.69±0.29	5.3-6.09	7.32±1.12	6.0-9.9	5.36±0.31	4.88-5.89
10	DFBL	4.56±0.98	3.2-5.91	9.17±0.42	8.71-9.66	4.31±0.99	2.0-6.1	9.44±2.23	8.30-16.80
11	PFL	6.26±1.24	4.6-7.56	6.66±0.29	6.34-7.0	6.13±1.20	4.8-8.7	6.44±0.31	5.96-7.00
12	PVFL	5.28±1.08	4.0-6.38	7.91±0.52	7.44-8.75	5.19±0.90	4.0-6.9	7.58±0.34	7.04-8.00
13	AFL	6.41±1.54	4.0-7.97	6.58±0.48	6.09-7.5	6.09±1.31	4.4-8.7	6.52±0.49	5.86-7.30
14	AFBL	2.22±0.54	1.6-2.91	18.90±1.46	17.5-20.9	2.09±0.35	1.65-3.0	18.79±1.75	16.80-23.26
15	LCPD	6.12±1.25	4.6-7.71	6.81±0.19	6.52-7.01	5.94±1.19	4.2-8.3	6.67±0.48	6.06-7.62
16	LHCPD	3.72±0.67	3.0-4.59	11.17±0.89	9.37-11.73	3.73±0.56	2.99-4.9	10.54±0.75	8.84-11.42

17	ED	1.81±0.27	1.4-2.1	4.75±0.43	4.28-5.33	1.67±0.24	1.4-2.2	4.64±0.22	4.25-5.05
18	POL	4.59±1.40	2.6-6.18	1.94±0.20	1.81-2.3	4.10±1.01	2.6-5.9	1.94±0.19	1.76-2.38
19	HW	4.89±1.37	3.23-6.89	1.80±0.09	1.62-1.85	4.58±1.06	3.41-6.4	1.73±0.12	1.52-1.94
20	HD	5.28±1.43	3.45-6.91	1.67±0.09	1.56-1.74	5.00±0.99	3.86-7.2	1.57±0.07	1.44-1.71
21	SNL	2.77±0.65	1.8-3.58	3.15±0.18	2.91-3.34	2.52±0.53	1.8-3.8	3.12±0.20	2.74-3.44
22	IOW	2.83±0.70	2.0-3.73	3.08±0.08	3-3.18	2.63±0.55	2.0-3.9	2.99±0.18	2.67-3.30

TL-Total Length; SL-Standard Length; HL-Head Length; SNL- Snout length; POL- Post orbital length; FL-Fork length; PDL- Pre Dorsal Length; PODL- Post Dorsal Length; DFL- Dorsal Fin Length; PFL-Pectoral Fin Length; PVFL-Pelvic fin length; AFL- Anal fin length; PPL- Pre-Pelvic length, LCPD-Length of Caudal Peduncle; DFBL -Dorsal fin base length; AFBL- Anal fin base length ; LHCPD -Least height of caudal peduncle, BD-Body Depth; ED-Eye Diameter; HW- Head width, HD- Head depth, IOW -Inter orbital width

Table 2. Meristic counts of *Tor putitora* (N=6) and *Tor tor* (N=13) from Indravati River System, Odisha, India.

Sl. No	Meristic Counts	*Tor putitora*	*Tor tor*
1	Lateral line Scale (Lls)	24-27	22-27
2	Lateral line Transverse Scale (L.tr.)	3½/1/2½	3½/1/2-2½
3	Pre-Dorsal Scale (PDS)	9	8-10
4	Dorsal Fin Ray (DFR)	iv9	iv9
5	Pectoral Fin Ray (PFR)	16-17	15-18
6	Pelvic Fin Ray (PVFR)	i 7-8	ii 7/ i-ii 8
7	Anal Fin Ray (AFR)	ii-iii5	iii 5 - ii 6
8	Caudal Fin Ray (CFR)	23-25	23-25

Figure 3. Two species of Tor Mahseer recorded from Indravati River, Odisha deposited in Zoological Survey of India (ZSI)., Kolkata. A- *Tor putitora*, B-*Tor tor*

Habitat characteristics

The microhabitat of both the Indravati Dam Reservoir at Mukhiguda and Kapur Dam at Khatigudaare deep pools. While substrates such as bedrock, boulders, cobbles, sediments, and silts predominate in the Indravati Dam Reservoir, substrates like sediments, boulders, gravels, and cobbles predominate in the Kapur Dam. The values of physicochemical parameters varied among both the sites except pH having the same value of 7.85, but other parameters such as water temperature, TDS, EC, and DO were 29.35℃, 38.15 ppm, 62.15 µs/cm, and 5.36 mg/l respectively in Indravati Dam Reservoir, while in case of Kapur dam, it was 31.1℃, 26.6 ppm, 51 µs/cm and 4.87 mg/l respectively (Table 6).

Other fish species in the habitat

The *Labeo rohita*, *Labeo calbasu*, *Gibelioncatla*, *Ctenopharyngodon idella*, and *Cirrhinus mrigala* were other fish species identified as cohabiting species in the study locations.

Table 3. One way -Multiple analysis of variance (MANOVA) of standardized morphometric parameters *Tor putitora* (N=6) and *Tor tor* (N=13) from Indravati River System, Odisha, India.

Parameters	P Value
TL/SL	0.60
TL/FL	0.83
TL/HL*	0.01
TL/BD*	1.28E-05
TL/PDL*	0.04
TL/PoDL	0.13
TL/PPL	0.20
TL/DFL*	0.04
TL/DFBL	0.78
TL/PFL	0.16
TL/PVFL	0.12
TL/AFL	0.83
TL/AFBL	0.89
TL/LCPD	0.50
TL/LHCPD	0.13
HL/ED	0.48
HL/POL	0.96
HL/HW	0.19
HL/HD*	0.01
HL/SNL	0.76
HL/IOW	0.25

Table 4. Summary of Linear Discriminant Analysis (LDA) of *Tor putitora* (N=6) and *Tor tor* (N=13) from Indravati River System, Odisha, India.

Proportions	Axis 1
Eigen value	12.67
Percentage of Variance (%)	53.08
Scores	
Species	Axis 1
Tor putitora	4.95
Tor tor	-2.28

Table 5. Confusion matrix of LDA of *Torputitora* (N=6) and *Tor tor* (N=13) from Indravati River System, Odisha, India.

	T. putitora	Tor tor	Total
T. putitora	6	0	6
Tor tor	0	13	13
Total	6	13	19

Figure 4. *Tor putitora*. (a) Photograph of the fish from the lateral side, (b) Head with barbels -view from lateral side and (c) Head with barbels from ventral side

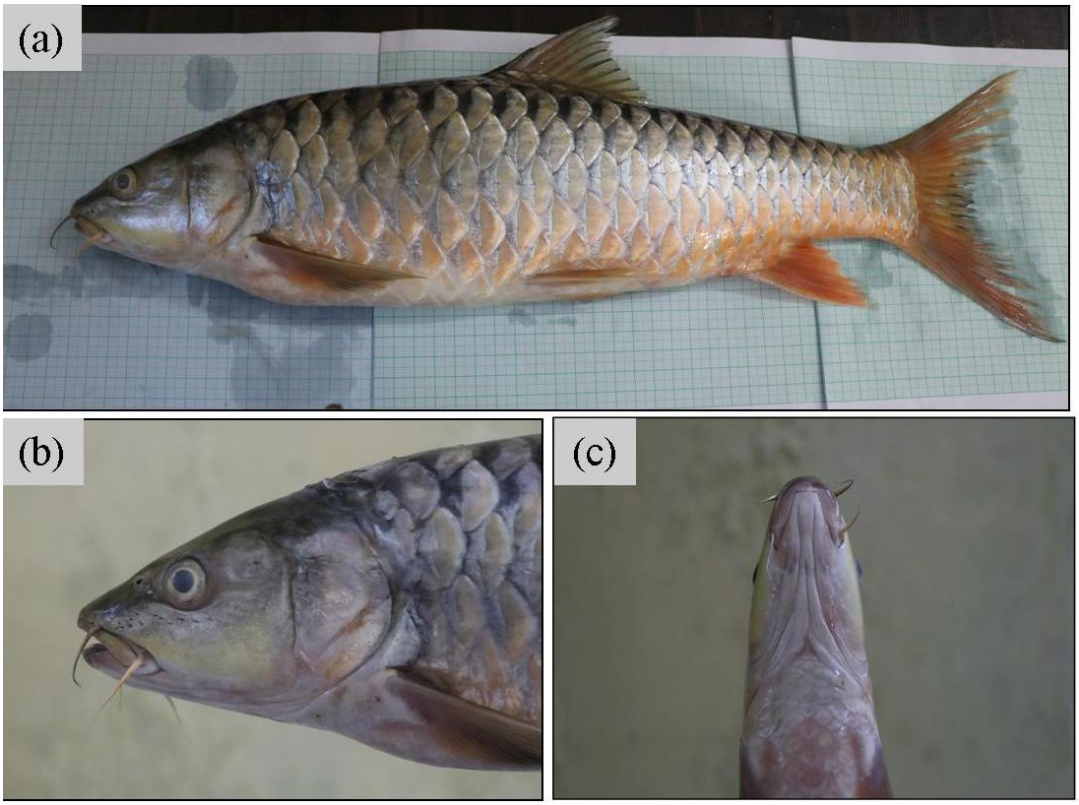

Figure 5. *Tor tor*. (a) Photograph of the fish from the lateral side, (b) Head with barbels -view from lateral side and (c) Head with barbels from ventral side

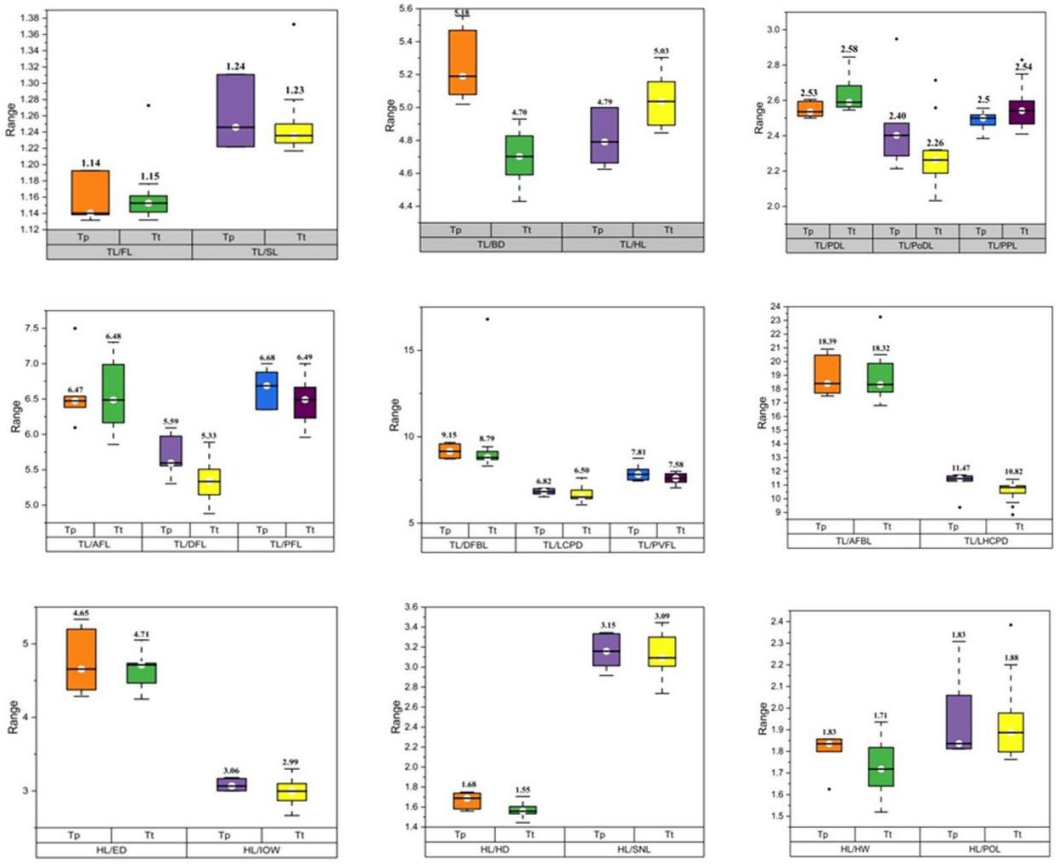

Figure 6. Box plot representing the Standardized Data of *T. putitora* (Tp) and *T. tor* (Tt) with the Median value on the top of the maximum limit.

DISCUSSION

The current research identified two species of Tor Mahseers, *Tor putitora* and *Tor tor*, based on morphometric analysis and the application of Linear Discriminant Analysis (LDA) utilizing standardized parameters. Morphometric measurements have been utilized to a great extent for describing the variation between *T. putitota* and *T. tor* species of Mahseer fish (Day, 1878; Hora & Mukerji, 1936). In the present observations, the ratios of TL with SL, HL, BD and the ratios of HL with ED, HD of *T. putitora* coincide with the description of Bhatt & Pandit (2015) about the relationship of morphometric characters including standard length (SL), head length (HL) and maximum body depth (MBD) with total length (TL), eye diameter (ED) and head depth (HD) with head length (HL) of *T. putitora*, which were established by Dasgupta (1982, 1991a), Johal *et al.* (1994b), Bhatt, Nautiyal & Singh (1998) and Sharma, Mohan & Kouser, (2015). All the meristic characteristics of *T. putitora* from the Indravati River were similar to the findings of Yousaf *et al.* (2021); Sharma *et al.* (2015) and Langer, Tripathi & Khajuria (2013). The meristic counts of *T. tor* from the Indravati River are within the range established by Day (1878, 1889); Hora (1941); Misra (1959); Shrivastava (1980); Sen & Jayaram (1982); Dasgupta (1990); Talwar & Jhingran (1991); Desai (2003) and Ujjania *et al.* (2012) except those of Pelvic fin ray (PVFR) and Caudal fin ray (CFR) were found to be ii 7/ i-ii 8 and 23-25 respectively.

The *Tor putitora* and *Tor tor* were reported as new records from the Indravati River system of Eastern Ghats in Odisha. In the riverine system of Odisha, *Tor tor* has previously been documented from Similipal Biosphere Reserve (Sethy, 2009), Mahanadi River system (Chauhan, 1947; David, 1953; Dutta *et al.,* 1993) as well as in Brahmani River systems (Dutta *et al.,* 1993; Sethy, 2009). The record of *Tor tor* is also a new record for the Godavari basin in South Odisha.

The species *Tor putitora* is originally distributed across the rivers Indus, Ganges and Brahmaputra flowing through the Himalayan foothills (Talwar & Jhingran, 1991) and northeastern states of India like Meghalaya (Dasgupta, 1991a, b, 1993), Manipur (Rahman, 1989). Before the 1960s the Himalayan Mahseer (*Tor putitora*) was reported in the northern Gangetic plains (Nautiyal *et al.,* 2008) and later from the Narmada River in central (Desai, 1972; Bakawale & Kanhere, 2013). In Odisha, The Mahanadi River drains the largest parts of Odisha including its western, central, and eastern parts. The earlier report of *T. putitora* from the Mahanadi system (Khare *et al.,* 2014) is presently no longer valid, as the species is now recognised as a separate species *Tor mahanadicus* (Johnson *et al.* 2023). However, the major rivers of southern Odisha form part of the Godavari Basin of India. The record of *Tor putitora* from the Indravati River is not only a new record for the Godavari basin of southern Odisha, but it is also a new record for the Godavari River system because there is no previous record of this species in the entire Godavari River system of India.

The type locality of *Tor tor* is the Mahananda River (flowing through northeast Bengal, India), discovered by Hamilton (1822). This Mahseer species is now widely occurring throughout the Himalayan ranges from Jammu in the west to the Brahmaputra valley in the east (Sehgal, 1971) and distributed towards the rivers of the Indian peninsula (Pinder *et al.* 2019), with the , Narmada River in Madhya Pradesh being assumed to be the southernmost range of native distribution. But Lal *et al.* (2012) discovered *T. tor* from the Penganga and Satnala River of the Godavari Basin and Bhima River of the Krishna basin and also they have collected specimens with various life stages including adults and juveniles, that indicate the establishment of a self-recruiting population in that region. *T. tor* was also recorded by Heda (2009) from the Adan River (a tributary of Godavari) in Maharashtra. The distribution of *T. tor* in the Indravati River of southern Odisha indicates there is a possibility of range extension of this species from the Himalayan region to the entire tropical Peninsular India and because of the eurythermal behaviour, the species can inhabit both cold and warm water (Lal *et al.,* 2012).

Presently, freshwater ecosystems globally are encountering considerable challenges, posing threats to both biodiversity and the equilibrium of ecosystem (Nautiyal *et al.* 1998; Menon, Singh & Kumar, 2000; Langer *et al*., 2001). In India, the Mahseer population has been dwindling across the nation (Mahanta *et al*., 1998; Bhatt *et al*., 1998; Nautiyal *et al*., 1998; Nautiyal *et al.*, 2008; Kumar, 2000; Menon *et al.*, 2000; Ogale, 2002 a,b,c; Malik & Negi, 2007; Dinesh & Nandeesha, 2007; Kalita, Bhagapati & Sarma, 2007; Oliver, Sangma & Basavaraja, 2007; Vinod, Mahapatra & Mandal, 2007; Chalkoo, Ajmair & Qureshi, 2007), primarily due to the construction of dams, uncontrolled fishing, degradation of freshwater habitats, and various other human-induced activities (Langer *et al.*, 2001; Sharma *et al*., 2015; Everard *et al.*, 2021). The habitats of Mahseer in the foothills of the Himalayas, as well as in the regions of Vindhya-Satpura and Western Ghats, are particularly vulnerable to these threats (Sarkar *et al*., 2015).

The population of *T. putitora* is currently facing severe threats across various regions of India, including the Himalayan area. The construction of dams and projects along rivers has disrupted the breeding and migration patterns of this species. Over the past years, its population has plummeted by approximately 50% across its entire distribution range, and if these challenges persist, further decline is anticipated (Pinder *et al.,* 2019). Recognized as Endangered (EN), urgent conservation efforts are imperative to prevent its extinction in diverse habitats (Jha *et al.* 2018). Additionally, *Tor tor*, initially categorized as Near Threatened (NT) due to rapid population decline (Rayamajhi, Jha & Sharma, 2010), has recently been reclassified as Data Deficient (DD) (Rayamajhi *et al*., 2018).

The river systems in Odisha are currently undergoing significant alterations in their natural and hydrological characteristics, largely due to various human activities such as untreated sewage, waste disposal, and discharge of polluted water from various sources (Bag, 2022). Reservoirs in Odisha, such as the Indravati, play a pivotal role in sustaining biodiversity in aquaculture and in providing livelihood opportunities for numerous communities that depend on them.

Many conservation strategies are being developed to address the crisis (Nautiyal *et al.* 1998; Menon *et al.*, 2000; Langer *et al*., 2001). Various bodies, including state governments in India, are making efforts to conserve Mahseers and their natural habitats. Eight Indian states, including Odisha, have designated a 'State Fish Tag' for one Mahseer species or another. The Golden Mahseer (*T. putitora*) has been recognized with the 'State Fish Tag' by the states of Arunachal Pradesh,

Himachal Pradesh, Jammu & Kashmir, and Uttarakhand; the Chocolate Mahseer (*N. hexagonolepis*) by Nagaland and Sikkim, and the Mahanadi Mahseer (*T. mahanadicus*) by Odisha (ICAR-NBFGR, 2006). While these steps are crucial for the conservation of these iconic fish species, raising education and awareness among local communities is equally important. Moreover, the sustainable conservation of Mahseers and the protection of their aquatic ecosystems can only be achieved if conservation efforts also ensure the livelihood sustainability of the communities dependent on fishery resources (Everarda & Kataria, 2011).

CONCLUSION

The record of two Mahseer species *T. putitora* and *T. tor* from Indravati Reservoir, a tributary of Godavari is the first record from southern Odisha. Regarding their possible range extension, first, it requires to be ascertained whether these two species are from the natural population or an artificially propagated stock. For this, a phylogeographic study is recommended, which might show genetic structure in various populations of these two widely distributed species, helping to support or refute the hypothesis that these are in fact range extensions and not introductions. Further, there are Rivers in southern Odisha where the presence of the Mahseer population requires thorough investigation. A thorough study of Mahseers in other tributaries of the Godavari River system and other rivers of southern Odisha, India can truly give a broader picture of Mahseer distribution in the state, based upon which a holistic conservation management strategy can be built up.

ACKNOWLEDGEMENTS

We are grateful to the University Grants Commission, New Delhi for awarding the UGC Non-NET Fellowship to the first author (CUO/ACA/NNF-PHD/135). The authors are thankful to the Director, Zoological Survey of India, Kolkata, India for permission for the deposition of the holotype of *Tor* species and Dr. L. Kosygin Singh, Scientist-E, Fish Division, Zoological Survey of India, 27 J.L. Nehru Road, Kolkata-700016, India for identification of specimens.

REFERENCES

APHA 2005. Standard methods for the examination of water and wastewater, 21st Edn. Washington D.C.

Arunachalam, M. 2000. Stream fish habitat inventory methodology. pp. 200-203. In Endemic Fish Diversity of Western Ghats. (eds Ponniah, A.G. and Gopala Krishnan, A.). NBFGR – NATP Publication – 1, 347 p. National Bureau of Fish Genetic Resources, Lucknow, U.P., India.

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.

Bakawale, S. and Kanhere, R.R. 2013. Study on the fish species diversity of the river Narmada in Western Zone. Res. J. Anim. Vet. Fishery. Sci 1:18–20.

Bhatt, J.P. and Pandit, M.K. 2015. Endangered Golden mahseer *Tor putitora* Hamilton: a review of natural history. Rev. Fish. Biol. Fish. 26(1): 25 -38. http://doi.org/10.1007/s11160-015-9409-7.

Bhatt, J.P., Nautiyal, P. and Singh, H.R. 1998. A comparative study of the morphometric characters of the Himalayan Mahseer *Tor putitora* (Ham.) between Ganga and Gobindsagar reservoir. Indian J. Fish 45: 85-87.

Chalkoo, S.R., Ajmair, T.A.Q. and Qureshi, T.A. 2007. Status of Coldwater fisheries of Kashmir. Fish. Chimes 26(10): 152-54.

Chauhan, B.S. 1947. Fish and Fisheries of the Patna State, Orissa. Rec. Indian Mus. 5: 267–82.

Choudhury, P. 2017. State of India's Rivers for India Rivers Week, 2016- ODISHA. INTACH. 150 pages. Available from: https://indiariversblog.files.wordpress.com/2017/05/state-of-river-report-odisha.pdf (accessed 6 August 2023).

Dasgupta, M. 1982. An investigation on some aspects of biology of mahseer from the North-Eastern India. Ph.D. thesis, North-Eastern Hill University, Shillong, India.

Dasgupta, M. 1990. Biometry of the Mahseer *Tor tor* (Hamilton). Rec ZoolSurv India 87(3): 201-214.

Dasgupta, M. 1991a. Biometry of the Mahseer, *Tor putitora* (Hamilton) collected from Garo Hills, Meghalaya. Indian J. Fish 38: 129-131.

Dasgupta, M. 1991b. Food and feeding habits of the Mahseer, *Tor putitora* (Hamilton). Indian J Fish 38: 212–217.

Dasgupta, M. 1993. A study on food and feeding habits of the Mahseer *Tor putitora* (Hamilton). Proc 80th Indian Sci Cong 3: 22–23.

David, A. 1953. Notes on bionomics and some early stages of Mahanadi Mahseer. J. Asiat. Soc 9: 197-209.

Day, F. 1878. The Fishes of India: being a natural history of fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon. London, 1878, 788.

Desai, V.R. 1972. Notes on the early larval stages of *Tor putitora* (Hamilton). 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. No. 158. Rome, FAO, 2003, 36p.

Dinesh, K. and Nandeesha, M.C. 2007. Status of mahseers 'the king of freshwater systems' in India: a review. pp. 3–35. In Mahseer: The biology, culture and conservation. (eds Siraj, S.S., Christianus, A., Kiat, N.C. and Desilva, S.S.). Occasional publication No. 14. 236 p. Proceedings of the International Symposium on the Mahseer, Malaysian Fisheries Society, Kuala Lumpur, Malaysia,

Dinesh, K., Kappen, D.C., Nair, C.M., Induchoodan, N.C. and Abraham, J. 2008. Final Report of the project entitled ―Studies on feasibility of ranching in Chalakudy River for empowering tribal communities of Vazhachal Forest Division, Western Ghats, submitted to the Department of Science and Technology, New Delhi. 108 p.

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 (4) (Suppl. 1): 26–38.

Dutta, A.K., Kunda, D.K. and Karmakar, A.K. 1993. Freshwater fishes. In State Fauna Series 1. *Fauna of Orissa*. Director, Zoological Survey of India. Part 4, 1–37.

Eschmeyer, W.N., Fricke, R. and van der Laan, R. 2017. Catalog of Fishes, electronic version (3 January 2017). CA (California Academy of Sciences), San Francisco.

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.

Everard, M., Pinder, A.C., Claussen, J.E. and Orr, S. 2021. Assessing the societal benefits of mahseer (Tor spp.) fishes to strengthen the basis for their conservation. Aquat. Conserv.: Mar. Freshw. Ecosyst, 1–8. https://doi.org/10.1002/aqc.3683.

Froese, R. and Pauly, D. 2018. Fish Base. World Wide Web electronic publication. Available from: www.fishbase.org, version (02/2019).

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*. doi:10.1111/area.12124

Hamilton, F. (1822) An account of the fishes found in the river Ganges and its branches. Edinburgh (1981) Bishan Singh Mahendra Pal Singh. Dehradun, India.

Hammer, Ø., Harper, D.A.T., and Ryan, P.D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica,* 4(1), 9pp.

Heda, N.K. 2009. Fish diversity studies of two rivers of the north-eastern Godavari basin, India. J. Threat. Taxa 1(10): 514-518.

IUCN 2023. The IUCN Red List of Threatened Species. Version 2023-1. Avilable from: https://www.iucnredlist.org (accessed on 11 November 2023).

Jayaram, K.C. 1999. The freshwater fishes of the Indian region. Narendra Publishing House. Delhi.

Jayaram, K.C. 2005. The Deccan mahseer fishes: their eco-status and threat percepts. Rec. Zool. Surv. India, Occ. Paper no. 238.

Jayaram, K.C. 2010. The Freshwater Fishes of the Indian Region. Narendra Publishing House. Delhi, 616 p.

Jerdon, T.C. 1849. On the fresh-water fishes of southern India. Madras J. Lit. & Sci, 15: 302–346.

Jha, B.R., Rayamajhi, A., Dahanukar, N., Harrison, A. and Pinder, A.C. 2018. *Tor putitora*. The IUCN Red List of Threatened Species (2018-2), e.T126319882A1263222 (accessed 24 September 2023).

Johal, M.S., Tandon, K.K. and Sandhu, G.S. 1994a. Morphometry of *Tor putitora*. pp B68–B75. In Mahseer the game fish. (eds Nautiyal, P.). Jagdamba Publication, Dehradun, India.,

Johal, M.S., Tandon, K.K., and Sandhu, G.S. 1994b. Mahseer in lacustrine water, Gobindsagar Reservoir. In Mahseer the Game Fish. (eds Nautiyal, P.). Rachna. Srinagar (Garhwal), India.

Johnson, J.A., Nanda, P. and Pant, B., Mane, S.S. and Kolipakam, V. 2023. Redescription of an endemic mahseer, *Tor mahanadicus* (David, 1953) from Mahanadi River basin, India based on integrated morphological and molecular techniques. PLoS ONE 18(9), e0291436. http://doi.org/10.1371/journal.pone.0291436.

Kalita, K., Bhagapati, S.K. and Sarma, D.K. 2007. Status of threatened fishes in Assam. Fish. Chimes 26(10): 142- 144.

Khare, P., Mohindra, V., Barman, A.S., Singh, R.K. and Lal, K.K. 2014. Molecular evidence to reconcile taxonomic instability in mahseer species (Pisces: Cyprinidae) of India. Org. Diver. Evol 14: 307–326.

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.

Kumar, K. 2000. Conservation and development of golden mahseer (*Tor putitora* Ham.) in Himachal waters. Fish. Chimes 20(9): 26-27.

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 Mahseer: The biology, culture and conservation. (eds Siraj, S.S., Christianus, A., Kiat, N.C. and Desilva, S.S.), Proceedings of the International Symposium on the Mahseer. Occassional publication No. 14. 236 p. Malaysian Fisheries Society, Kuala Lumpur. Malaysia.

Lal, K.K., Singh, R.K., Pandey, A., Gupta, B.K., Mohindra, V. and Punia, P. 2013. Distribution Records of Tor Mahseer *Tor tor* (Hamilton 1822) from southern India. *J Appl Ichthyol,* 29, 1–5.

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. 2012. Distributional records of Tor mahseer, *Tor tor* (Hamilton, 1822) from Southern India. J. Appl. Ichthyol 29(5): 1-5.

Langer, R.K., Ogale, S.N. and Ayyappan, S. 2001. Mahseer in Indian Subcontinent- A Bibliography. Central Institute of Fishery Education, Mumbai, 109 p.

Langer, S., Tripathi, N.K. and Khajuria, B. 2013. Morphometric and Meristic Study of Golden Mahseer (*Tor putitora*) from Jhajjar Stream (J and K), India. Res. J. Anim. Vet. Fishery Sci. 1(7): 1-4.

Mahanta, P.C., Kapoor, D., Pandey, A.K., Srivastava, S.M., Dayal, R., Patiyal, R.S., Joshi, K.D. Singh, A.K. and Paul, S.K. 1998. In Conservation and rehabilitation of Mahaseer in India. Fish Genetics and Biodiversity Conservation. pp. 93-105. (eds A.G. Ponniah, P. Das, and S.R. Verma). Nature Conservators. Muzaffarnagar.

Malik, D.S. and Negi, K.S. 2007. Mahseer Fish - Bionomics and Population: Barrage Impact on Fish Biology. Daya Publishing House. New Delhi.

Manimegalai, M., Karthikeyeni, S., Vasanth, S., Ganesh, A., Siva, S., Vijayakumar, T. and Subramanian, P. 2010. Morphometric Analysis – A tool to identify the Difference in a Fish species *E. maculatus*. Int. J. Environ. Sci 1(4): 52-56.

Menon, A.G.K. 1992. Taxonomy of Mahseer fishes of the genus Tor Gray with description of a new species from the Deccan. J. Bombay Nat. Hist. Soc, 89 (2): 210–28.

Menon, A.G.K., Singh, H.R. and Kumar, N. 2000. Present ecostatus of coldwater fish and fisheries. p.1-36. In Coldwater Fish and Fisheries. (Eds. Singh, H.R. and Lakra, W.S.). Narendra Publishing House. Delhi.

MWRI 2014. Godavari Basin. Version 2.0. Generation of Database and Wen Enabled Water Resources Information System (India-WRIS) in the Country. The report jointly prepared by Central Water Commission (CWC) and India Space Research Organisation (ISRO). Ministry of Water Resources, Govt. of India (MWRI). 178 Pages. Available from: www.india-wris.nrsc.gov.in (accessed on 6 August 2023).

Nautiyal, P. 2014. Review of the art and science of Indian Mahseer (Game fish) from nineteenth to twentieth century: road to extinction or conservation? Proc. Natl. Acad. Sci. India Sect B Biol. Sc, 84: 215–236.

Nautiyal, P., Bhatt, J.P., Rawat, V.S., Kishore, B., Nautiyal, R. and Singh, H.R. 1998. Himalayan Mahseer: Magnitude of commercial fishery in Garhwal Hills. pp. 107–114. In Fish Genetics and Biodiversity Conservation. (Eds Ponniah, A.G., Das, P. and Verma, S.R.), Natcon Publication-5, Nature Conservators, Muzaffarnagar. India.

Nautiyal, P., Rizvi, A.F. and Dhasmanaa, 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. Sc 8: 125-132.

Nguyen, T.T.T., Nanakorn, 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.

Ogale, S.N. 2002a. Mahseer breeding and conservation and possibilities of commercial culture. In The Indian experience. Cold water fisheries in the Trans-Himalayan Countries. (Eds T. Petr, D.B. Swar). FAO Tech. Pap. No.431. FAO. Rome, 376.

Ogale, S.N. (2002c). Mahseer ranching. In Riverine and Reservoir Fisheries of India. pp. 225-229. (Eds M.R. Boopendranath, B. Meenakumari, J. Joseph, T.V. Sankar, P. Pravin, and L. Edwin). Society of Fisheries Technologists India, Cochin.

Ogale, S.N. 2002b. Broodstock production of endangered golden mahseer in Tarai region of Uttaranchal. pp. 264-268. In Highland Fisheries and Aquatic Resource Management. (Eds K.K. Vass and H.S. Raina) National Research Centre on Coldwater Fisheries (ICAR), Bhimtal. India.

Oliver, K., Sangma, N. and Basavaraja, N. 2007. Deccan mahseer (*Tor khudree*) of Karnataka- on location of its wild brooders and fry and breakthrough in the hatchery production of its seed. Fish. Chimes 26(10): 32-36.

Pathak, V., Shdvastava, N.P., Chakraborty, P.K. and Das, A.K. 2007. Ecological status and production dynamics of river Mahanadi: Bulletin No. 149. Central Inland Fisheries Research Institute, Barrackpore, Kolkata 100120, India, pp. 1–40.

Pervaiz, K., Iqbal, Z., Mirza, M.R., Javed, M.N. and Naeem, M. 2012. Meristic and Morphometric Studies on Indus Mahseer *Tor macrolepis* (Teleostei: Cyprinidae) from District Attock, Pakistan. Int. J. Agric. Biol 14 : 169-175.

Pinder, A.C., Britton, J.R., Harrison, A.J., Nautiyal, P., Bower, S.D., Cooke, S.J., Lockett, S., Everard, M., Katwate, U., Ranjeet, K., Walton, S., Danylchuk, A.J., Dahanukar, N. and Raghavan, R. 2019. Mahseer (Tor spp.) fishes of the world: status, challenges and opportunities for conservation. Rev. Fish. Biol. Fish 29: 417– 452.

Rahman, A.K.A. 1989. Freshwater Fish of Bangladesh. Zoological Society of Bangladesh, Department of Zoology, University of Dhaka, Dhaka. p 364.

Rayamajhi, A., Jha, B.R. and Sharma, C.M. 2010. *Tor tor*. The IUCN Red List of Threatened Species 2010: e.T166534A6231157. Available from: http://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T166534A6231157.en. (accessed 17 July 2023).

Rayamajhi, A., Jha, B.R., Sharma, C.M., Pinder, A., Harrison, A., Katwate, U. and Dahanukar, N. 2018. *Tor tor*. The IUCN Red List of Threatened Species 2018: e.T166534A126321898.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T166534A126321898.en. (accessed 17 July 2023).

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. J. Ecophysiol. Occup. Health 15(1 & 2): 45–52.

Sehgal, K.L. 1971. Fisheries survey of Himachal Pradesh and some adjacent areas with special reference to trout, Mahseer, and allied species. J. Bombay Nat. Hist. Soc 70(3): 458-74.

Sen, T.K. and Jayaram, K.C. 1982. Mahseer Fishes of India: a review. Rec. Zool. Surv. India, 39:1–34.

Sethy, P.G.S. 2009. Faunal Resources in Similipal Biosphere Reserve, Mayurbhanj, Orissa, A Part of Eastern Ghats. EPTRI-ENVIS, Newsletter, 15 (4).

Sharma, J., Parashar, A., Bagare, P., Dayal, R., Pandey, A.K. and Sarkar, U.K. 2015. Tor Mahseer in Indian Water With Special Reference to Conservation Strategies for Tor tor in Madhya Pradesh (India). J. Appl. Biosci 41(2).

Sharma, K.K., Mohan, V.C. and Kouser, U. 2015. Comparative accounts of meristic count and morphometric measurements of Golden Mahseer (*Tor putitora*) among Chenani hydroelectric dam, Jhajjar stream and Dansar stream, (J&K) India. Indian J. Appl. Res 5: 772–774.

Singh, H.R. and Kumar, N. 2000. Some aspects of ecology of hill streams; stream morphology, zonation, characteristics, and adaptive features of ichthyofauna in Garhwal Himalaya. pp. 1–18. In Modern Trends in Fish Biology Research. (Eds Datta Munshi, J. S.). Narendra Publishing House, New Delhi, India.

Stone, R. 2007. The last of the leviathans. *Science* 316: 1684-1688.

Sykes, W.H. 1839. On the fishes of the Deccan. Proc. Zool. Soc. Lond 6:157–165.

Talwar, P.K. and Jhingran, A.G. 1991. Inland Fisheries of India and Adjacent Countries. Vol. I and II. Oxford and IBH Publication Co. Calcutta. vol. I & II. p. 1–1158.

Ujjania, Girish Kumar, N.C., Langar, R.K. and Krishna, G. 2012. Biometric Studies of Mahseer (*Tor tor* Ham. 1822) from Bari Talab (Udaipur), India. Int. J. Innov. Bio-Sci 2 (3): 138-141.

Vansutre, S., Deshmukh, S.D. and Hari, K.R. 2014. Past, Present, and Future of Indravati River Capture: A Geomorphological Investigation. IOSR J. Appl. Geol. Geophy 2 (5): 1-5.

Vinod, K., Mahapatra, B.K. & Mandal, B.K. 2007. Umiam reservoir fisheries of Meghalaya (Eastern Himalayas) - strategies for yield optimization. Fish. Chimes 26(10): 8-15.

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 6;83:e243975. http://doi: 10.1590/1519-6984.243975.