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Diversity, distribution and conservation status of genus *Tor* (Cyprinidae) in Southern Western Ghats, India

Ambili T.R.[1]*, Manimekalan A[2]. and Verma M.S.[3]

[1]PG Department of Zoology, Alphonsa College, Pala, Kottayam, Kerala, India
[2]Biodiversity and Aquatic Ecology Lab, Department of Environmental Sciences, Bharathiar University, Coimbatore, India.
[3]National Bureau of Fish Genetic Resources, Lucknow, India.

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Key Words: Genus *Tor*, Diversity, Distribution, Southern Western Ghats.

Abstract: Genus *Tor* is regarded as one of the most threatened group of freshwater fish in the Western Ghats. The taxonomy and distribution of this genus is extremely confusing due to the different morphological variations they exhibit. There are no reliable estimates of the number of *Tor* species found in Indian rivers. In the present study, the distribution and current status of *T. khudree, T. mussullah* and *T. malabaricus* were investigated from the selected river systems of Southern Western Ghats. The *Tor* species are under tremendous stress in Western Ghats and needs urgent attention to conserve this precious national icon for future generation.

Introduction

The Western Ghats of India is considered as one of the 35 biodiversity hotspots in the world and also recognized by UNESCO as one of the world's eight most important biodiversity hotspots (Myers *et al.*, 2000; Mazoomdaar, 2013). India harbours a rich and diverse fish fauna with nearly 11% of the total fish species of the world. This highly diverse and unique fresh water ecosystem provides an immense importance to the livelihoods and economies (Anon, 1996; NBSAP India, 2009; Molur *et al.*, 2011). The Kerala Part of Western Ghats shows high levels of endemism, but the lack of studies makes vague our understanding about the true patterns in fish diversity (Dahanukar *et al.*, 2011).

Genus *Tor* (Gray, 1834), well known as *mahseer*, is one of the most diversified groups of fresh water fishes of family Cyprinidae distributed across Asia. It is an important game and food fish and inhabits mountainous streams and rivers as well as fast flowing rivers in the plains, often preferring clear, swift flowing waters with stony, pebbly or rocky bottoms (Shrestha, 1997; Lal *et al.*, 2012). The genus is mainly distinguishable by its big head and large scales, anteriorly deep body, fleshy lips continuous at the angles of the mouth with an interrupted fold or groove across the lower jaw, prominent snout, two pairs of big barbels, lateral-line scales ranging from 22 to 28, and length of head equal to or greater or less than the body depth (Jayaram, 2013). Due to the large size, they are considered as one of the 20 mega fishes of the world and also called as the 'tiger of the freshwater' and the world's hardest fighting fish. It forms the major fishery of the tribes in the rivers and tributaries of Peninsular India and provides the protein security (Dinesh *et al.*, 2010; Raghavan *et al.*, 2011; Pinder and Raghavan, 2013).

Due to the taxonomic uncertainties from the morphological variations and habitat adaptation within the genus, there are no reliable estimates of the number of *Tor* species found in Indian waters (Siraj, 2007; Pinder and

*Corresponding author
E-mail: ambilitherese@gmail.com

Raghavan, 2013). There are around ten valid species of *Tor* reported from India like *Tor khudree* (Sykes), *T. kulkarnii* (Menon), *T. malabaricus* (Jerdon), *T. mosal* (Hamilton-Buchanan), *T. mussullah* (Sykes), *T. neilli* (Day), *T. progenies* (Mc Clelland), *T. putitora* (Hamilton-Buchanan), *T. remadevii* (Kurup and Radhakrishnan), *T. tor* (Hamilton-Buchanan) and *T. barake* (Arunkumar and Basudha) (Menon, 1992; Sarkar and Srivastava, 2000). Among this, 6 species are reported from south India viz. *T. khudree, T. mussullah, T. tor*, *T. malabaricus*, *T. putitora* and *T. remadevii* (Kurup and Radhakrishna, 2010).

According to the report submitted to Ministry of Environment by Kasturirangan, 37% of the Western Ghats is Ecologically Sensitive Area (ESA) and the Western Ghats is a biological treasure of endangered species and it needs to be protected and regenerated for its enormous wealth of endemic species and natural beauty (Mazoomdaar, 2013). The southern part of the Western Ghats in Kerala, Tamil Nadu and southern Karnataka have the highest freshwater species richness and levels of endemism, but also contain the highest number of threatened species (IUCN, 2016). The genus *Tor* is regarded as one of the most threatened groups of freshwater fish in the country. The diversity of these largest fresh water cyprinids is depleting alarmly due to introduction of exotic species and various anthropogenic activities like illegal and highly destructive fishing methods in Western Ghats (Raizada, 1981; Lakra *et al.,* 2010). Not much study has been carried out about the current status and distribution of *Tor* species from the peninsular India, except a few reports on the presence of genus *Tor* in Southern Western Ghats. The aim of the present study is to find out the current status and distribution of *Tor* species in southern Western Ghats of India.

Materials and Methods

The details of *Tor* species inhabiting various rivers of southern Western Ghats were gathered during the survey and samplings were carried out during 2009 – 2012. The rivers selected for the present study are Chaliyar, Bhavani, Kabini, Chalakudy, Periyar, Kallada and Cauvery. Sampling sites were selected based on the earlier records and the discussions with local tribals and fishermen. The fishes were collected by cast nets and gill nets in different habitat type. The collected specimens were labelled and preserved in 10% formaldehyde. The species were identified based on the classification of Talwar and Jhingran (1991), Menon (1992) and Jayaram (2013). The literature of the earlier works describing the freshwater fishes of the Western Ghats was reviewed. Data describing the lists of the species were extracted and complied. The distribution and the collection sites of *Tor* species was mapped using ArcGIS (**Fig. 1 & 4**).

Results and Discussion

A total of 150 individuals of three *Tor* species were collected from 17 tributaries of 7 river systems in the southern Western Ghats (**Table-1**). *Barilius bakeri* (Day), *Garra mullya* (Sykes), *Hypselobarbus curmuca, Puntius denisonii* (Day), *P. fasciatus* (Jerdon) etc., are the other fresh water species recorded along with *Tor* species during the present study.

Tor khudree (Sykes, 1839)

Tor khudree was described by Sykes (1839) as *Barbus khudree* from Mulamutha river in Pune, India. It is distributed in the major rivers and reservoirs of central and peninsular India (Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu and Kerala) as well as Sri Lanka (Easa and Shaji, 2003; Nguyen *et al*., 2008).

In Kerala, *T. khudree* occurs in Neyyar, Pamba, Chalakudy, Periyar, Kallar and a good population is found in Periyar Lake and Parambikulam Wildlife Sanctuary (Easa and Basha, 1995; Ajithkumar *et al*., 1999; Easa *et al*., 2000). The presence of this species was also reported from Mudumalai Wildlife Sanctuary

(Manimekalan, 1998), Chittar and Tamiraparani (Johnson and Arunachalam, 2009), Achankoil river (Baby *et al.*, 2011), Aralam Wildlife sanctuary (Shaji *et al.*, 1995), Anamalai Hills (Manimekalan and Suryaprakash, 2009), Valapattanam river (Biju *et al.*, 2000), Periyar river (Radhakrishnan and Kurup, 2010), Puyankutty river (Ajithkumar *et al.*, 2001) and Cauveri (Johnson and Arunachalam, 2009).

In the present study, *Tor khudree* was collected from Chaliyar, Chalakudy, Periyar Lake, Parambikulam Wild Life Sanctuary, Kabini, Shendurney Wild Life Sanctuary Kallada and Hogeneckal of the Cauvery river in Karnataka. Ajithkumar *et al.*, (1999); Dinesh *et al.*, (2010); Raghavan *et al.* (2011) etc. reported this species from Chalakudy river. Easa and Basha (1995) and Easa and Shaji (2003) had also mentioned about *T. khudree* in Chaliyar river. The presence of this species is also reported by Radhakrishnan and Kurup (2010) in Periyar.

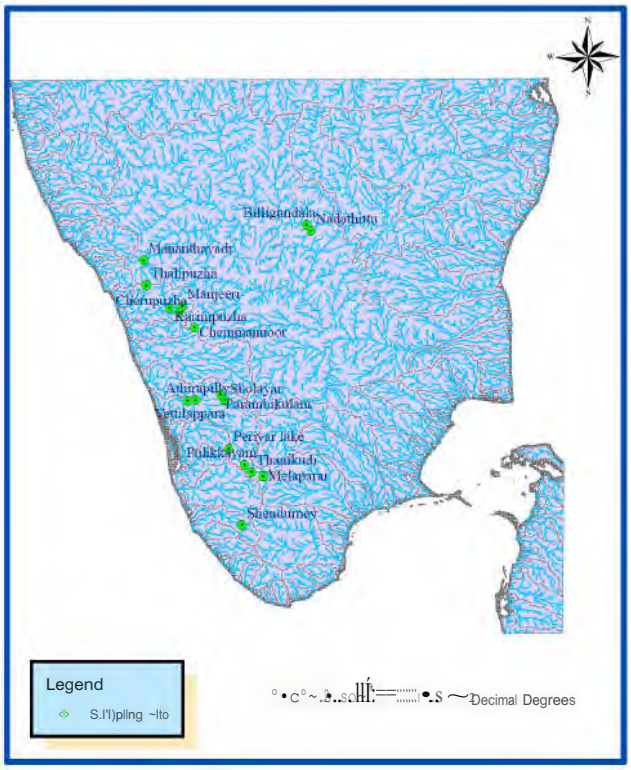

Fig.1. Collection sites in Southern Western Ghats

Tor mussullah (Sykes, 1839)

Sykes (1839) described *T. mussullah* species from the Ghod river, Pune District, Maharashtra for the first time. *T. mussullah,* hump backed Mahseer, is an endemic and endangered species from Western Ghats (IUCN, 2016). Now the generic status of this species is under great debate. Talwar and Jhingran (1991), Annandale (1919) and Jayaram (2010) treated this species as *T, mussullah* while Menon (1992) referred this species under genus *Hypselobarbus* and Rainboth (1989) considered as *Barbus mussullah*. This is a very rare species reported so far from Maharashtra, Karnataka, Tamil Nadu and Kerala (Sykes, 1839, Manimekalan, 1998, Easa and Shaji, 2003; Shahnawaz and Venkateshwarlu, 2009).

Fig. 2. A-D *Tor* species from different river systems

Previously Hora and Law (1941) reported this species from the Kallar and Pampadmpara streams of Kerala but we can't to trace it from there. Chacko (1952) recorded this species from Hogeneckal and stated it as rare occurrence. In the present study *Tor mussullah* was collected only from Karimpuzha, tributary of Chaliyar river.

Tor malabaricus (Jerdon, 1848)

Tor malabaricus (Jerdon, 1848) is also known as Malabar Mahseer. It was described by Jerdon (1848) as *Barbus malabaricus* from the mountain streams of Malabar, India. In 1992, Menon synonymised this species with *T. khudree* and Indra (1993) brings its status to a sub species level. Later, Molur and Walker (1998) retained it as a distinct species. Silas *et al.* (2005) carried out the genetic work using RAPD technique and also confirmed the validity of *T. malabaricus* as a separate species. Menon (1992), Arunachalam (2013) also suspects that all *T. khudree* recorded from Kerala, Karnataka and Tamil Nadu are *T. malabaricus*, except three populations from Chalakudy, Cauvery and Krishna basins.

Fig. 3. E-G *Tor* species from different river systems

Abraham *et al.* (2011) recorded this species from Kallada, Vamanapuram, Karamana and Neyyar rivers. Biju *et al.* (2000) reported *T. malabaricus* from Valapattanam, Chandragiri, Chaliyar, Kabini, Bhavani, Bharathapuzha, Periyar, Achankoil, Pamba, Neyyar, Chalakudy and Karamana rivers. Baby *et al.* (2010) have recorded this species from Chaliyar river. Based on the previous studies (Silas *et al.*, 2005; Abraham *et al.*, 2011) this species has been reported from Kallada river, but didn't show up such a species in the present study. According to Arunachalam *et al.* (2000), habitats of *T. malabaricus* in Tambraparini river are known to be under threat due to the siltation, alteration in flow, resultant drying up of pools in summer, destructive fishing practices and other anthropogenic activities. During the present study *T. malabaricus* was collected from the tributaries of Chalakudy, Periyar and Chaliyar river.

Tor tor (Hamilton, 1822)

The species *T. tor* was originally described by Hamilton (1822) as *Cyprinus tor* from the Mahananda river (north-eastern part of Bengal) which is known from the Indus, Ganga (including sub-Himalayan range), Brahmaputra, Tapti, Narmada and Chambal river systems in India (Shrestha, 1997). The distribution of *T. tor* from the tributaries of the Godavari and Krishna river systems were also recorded (Lal *et al.*, 2012). In India this species occurs from Jammu in the west to the Brahmaputra Valley in the east all along the Himalayan range. Very few records are available on the distribution of *T. tor* from South India except from Anamalai Hills (Manimekalan and Suryaprakash, 2009) and Nelliampathi Hills (Silas, 1951). Biju *et al.* (2000) have reported this species from Chandragiri river. This species was not collected from any streams of Western Ghats in the present study.

Tor putitora (Hamilton, 1822)

Tor putitora was described as Cyprinus *putitora* by Hamilton (1822) from Eastern part of Bengal and it is also known as Himalayan Mahseer or golden Mahseer. It is the most common species found all along the Himalayan Belt from Kashmir to Assam (Malik and Negi, 2007). Manimekalan and Suryaprakash (1997) reported the occurrence of this species from Anamalai hills. According to Manojkumar and Kurup (2004) *T. putitora is* present in Kabini river as an addition to the fish fauna of Peninsular India. But in the present study we were unable to find out this species even from Kabini river.

New *Tor* species are still being discovered from Indian rivers. *Tor barake* is a new species described by Arunkumar and Basudha (2003) from the Barak river, Manipur, India. The validity of the species needs to be confirmed, as further collections from the type locality have recorded other species of *T.* but not *T. barakae*. Hence it is presently placed under 'Data Deficient' because of the lack of further information on the species.

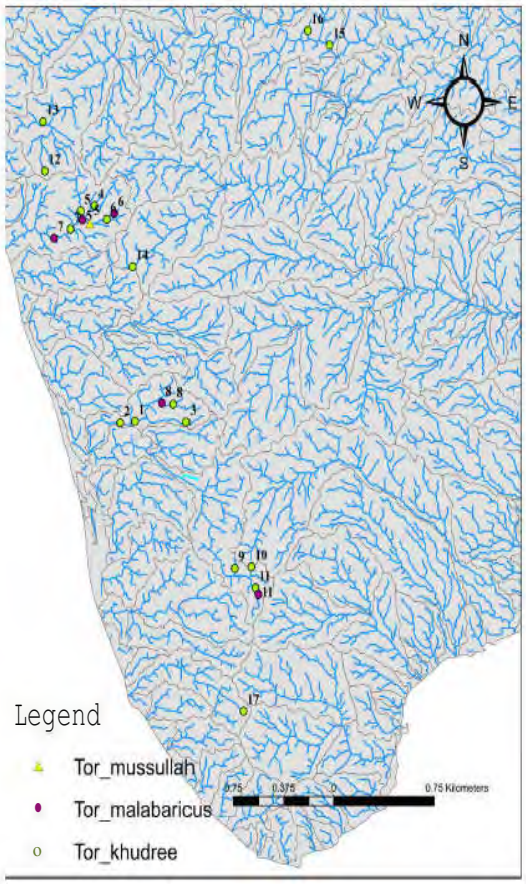

Fig. 4. Map showing the distribution of *Tor*

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Table 1. Distribution of *Tor species* from different location in Southern Western Ghats

River System	Sampling location	GPS Co-ordinates	Species collected	Number of species
Chalakudy	Athirappalli	10º 18′ 06.44′′ 76º 34′ 46.78′′	*T. khudree* *Tor sp. nov.*	10 2
	Vetilappara	10º 17′ 39.97′′ 76º 29′ 28.27′′	*T. khudree*	8
	Sholayar	10º 17′ 54.17′′ 76º 52′ 56.44′′	*T. khudree*	10
	Parambikulam	9º 26′ 24.86′′ 77º 18′ 24.66′′	*T. khudree* *T. malabaricus*	12 5
Chaliyar	Punnapuzha	10º 20′ 45.6′′ 76º 17′ 38.39′′	*T. khudree*	7

	Karimpuzha (Manjeeri)	11° 18′ 26.14″ 76° 26′ 19.02″	*T. khudree* *T. mussullah* *T. malabaricus*	13 4 4
	Manjakallanpuzha	11° 18′ 46.8″ 76° 28′ 8.39″	*T. khudree* *T. malabaricus*	7 2
	Cherupuzha	11° 14′ 19.22″ 76° 24′ 12.22″	*T. khudree* *T. malabaricus*	9 3
Periyar	Periyar Lake	9° 34′ 3.12″ 77° 10′ 4.51″	*T. khudree*	11
	Melaparai	9° 28′ 58.12″ 77° 16′ 47.78″	*T. khudree*	6
	Pulikkayam	9° 28′ 10.8″ 77° 17′ 22.4″	*T. khudree* *T. malabaricus*	7 5
Kabini	Thalipuzha	11° 33′ 09.27″ 76° 02′ 29.70″	*T. khudree*	6
	Mananthavadi Puzha	11° 47′ 59.63″ 76° 01′ 49.74″	*T. khudree*	4
Bhavani	Chemmannoor	11° 04′ 31.54″ 76° 33′ 53.92″	*T. khudree* *Tor sp. nov.*	4 2
Cauveri	Hogeneckal	12° 07′ 02.4″ 77° 46′ 36.7″	*T. khudree* *Tor sp. nov.*	6 4
	Nadathittu	12° 08′ 32.0″ 77° 44′ 49.0″	*T. khudree*	8
Kallada	Shendurney	8° 51′ 14.97″ 77° 3′ 17.19″	*T. khudree*	3
Tapti	Burhanpur	21° 18′ 22.95″ 76° 14′ 18.52″	*T. putitora* *T. tor*	3 3

1. Athirappalli, 2. Vetilappara, 3. Sholayar, 4. Punnapuzha, 5. Manjeeri,

6. Manjakallanpuzha, 7. Cherupuzha, 8. Parambikulam, 9. Periyar Lake,

10. Melaparai, 11. Pulikkayam, 12. Thalipuzha, 13. Mananthavadipuzha,

14. Chemmannoor, 15. Hogeneckal, 16. Nadathittu, 17. Shendurney

Tor remadevii is another new species from the river Pambar in Chinnar Wildlife Sanctuary reported by Kurup and Radhakrishnan (2010). Description of new species denotes that there are many more *Tor* species yet to be described and needs more and more fish survey

During the present study it was observed that *T. khudree* is the dominant species throughout the study in all the sites compared to all the other *Tor* species (**Fig. 5 & 6**). New varieties of

Tor specimens were also identified in river Bhavani flowing through the Attapadi Reserve Forest, tributary of Chalakudy river and river Cauvery at Hogeneckal. *Tor* specimens where seen abundantly in Chaliyar, Chalakudy and Periyar river systems. River Chaliyar is the only river system in which all the three species *T. khudree*, *T. malabaricus* and *T. mussullah* were collected. We could collect *T. malabaricus* from the tributaries of Chaliyar and Periyar river systems. So far no reports are available on the presence of this species from Periyar river. Highest number of *T. malabaricus* was collected from tributaries of Periyar than the Chaliyar. Manjeeri, Cherupuzha, Manjakalanpuzha, Parambikulam and Pulikayam are the sites where *T. malabaricus* and *T. khudree* are seen together. The lowest number of *T. khudree* was collected from Shendurney of Kallada river and the highest number was collected from Manjeeri of Chaliyar. *T. mussullah* was collected only from Manjeeri and Cherupuzha (Easa and Shaji, 2003) and in Manjeeri we could see all the three species of *Tor*.

Table 2. *Tor* species found in India and their IUCN status

Sl. No.	Tor species	IUCN status
1	*T. khudree* (Sykes,1839)	Edangered
2	*T. malabaricus* (Jerdon,1848)	Edangered
3	*T. mussullah*(Sykes,1839)	Critically Edangered
4	*T. tor*(Hamilton,1822)	Near Threatened
5	*T. putitora* (Hamilton,1822)	Edangered
6	*T. remadevii* (Kurup and Radhakrishna, 2010)	Not Evaluated
7	*T. progenies* (Mc Clelland,1839)	Near Threatened
8	*T. kulkarnii* (Menon,1992)	Edangered
9	*T. barake* (Arunkumar and Basudha,2003)	Data insufficient

The external appearance and the colour patterns observed in the specimens of *Tor* species from various geographical locations were differed. The individuals of *T. Khudree, T.mussullah* and *T. malabaricus* collected from different river systems showed varying colour pattern and differential body shape (**Fig. 2 & 3**). Based on the morphological and molecular characterisation of these species conducted by the authors, it is possible to say that the colour variation is not a criterion for the identification of *Tor* species. The colour will change depending on the environmental factors like temperature (Beacham, 1990), quantity of food (Currens *et al.,* 1989) and type of food or feeding mode (Pakkasmaa, 2001; Proulx and Magnan, 2004). The abundance of *Tor* species in many river systems has declined and in some places it was totally depleted. The *Tor* specimen could not be collected from Peppara (tributary of Neyyar river,) Punchola (tributary of Bharathapuzha) and Chittar Dam.

Even the earlier reports (Easa and Shaji, 2003; Biju *et al.*, 2000) and the discussions with the local fishermen informed that there had been a good population of *Tor* species long back. According to the local inhabitants of the tributaries of these river systems, illegal fishing and some infectious disease are the major threats of *Tor* species here. Though many collection trips were made to Punchola of Bharathapuzha, *Tor* species could not be collected. Group of fishermen were fishing and carrying fishes to the market is a regular scenario in most of the tributary of Bharathapuzha. According to the IUCN Red list of threatened species (IUCN, 2016), *T. khudree*, *T. malabaricus*, *T. mussullah* and *T. putitora* are listed under the category of endangered species. Conservation status of *Tor tor* is evaluated as "near threatened" (**Table-2**). During the present study the species abundance of *T. khudree* is high (86.25%) comparing to the other two species (Figure 1.11). This supports the opinion of Biju *et al.* (2000); Dahanukar *et al.* (2004) and Radhakrishnan and Kurup (2010) and the status of this species is vulnerable. It has a good population and has wide distribution in Kerala. The species abundance of *T. mussullah* is very low (2.5%) and its threat status was Critically Endangered which supports the views of Dahanukar *et al.* (2004). Based on the present study *T. malabaricus* can also be considered as a Critically Endangered species in southern Western Ghats which had low species abundance (11.87%).

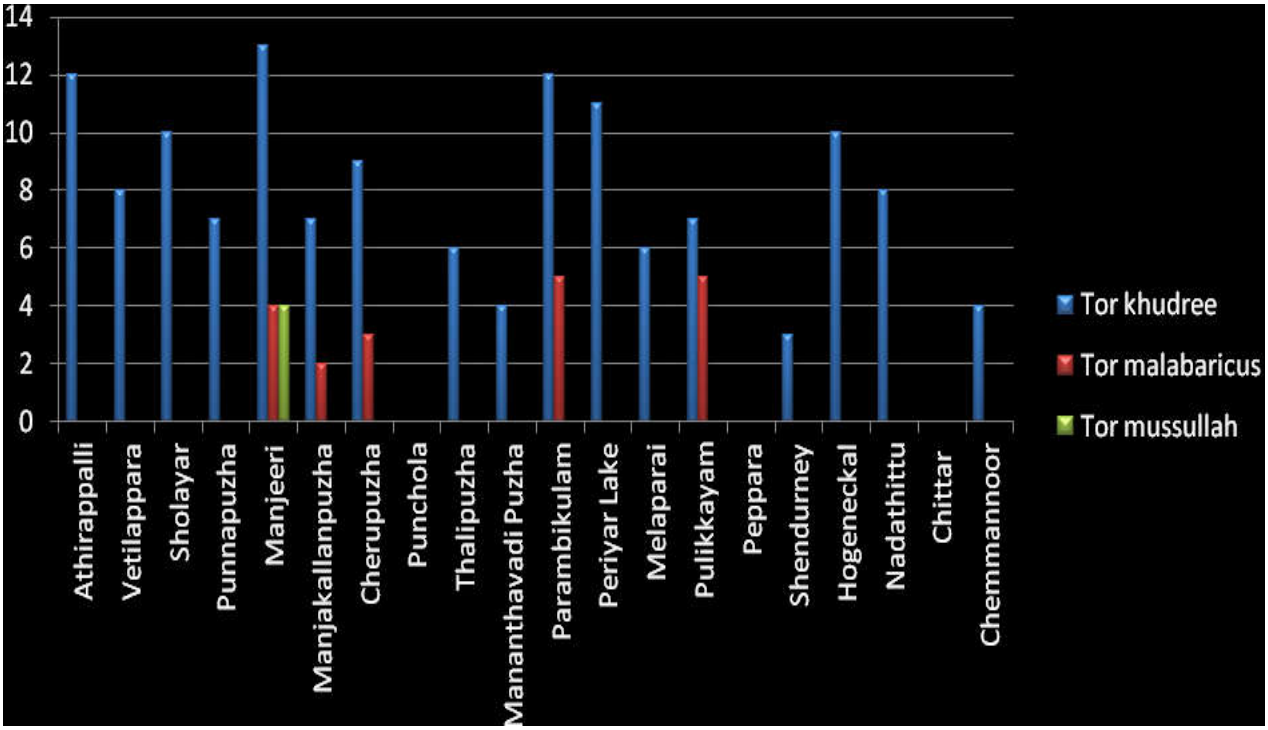

Fig. 5. Distribution of *Tor* species in the sampling sites

Tor species are under severe threat in Western Ghats from overfishing, loss of habitat and decline in quality of habitat resulting in loss of breeding grounds and from other anthropogenic effects due to urbanization, illegal encroachment, over fishing and chemical and physical alterations of their natural habitats (Dinesh *et al.*, 2010). Dynamite

fishing has been documented from the southern Western Ghats since the early 1940's and continues to be one of the most widely used destructive fishing techniques practiced in the region (Raghavan *et al*., 2008). Although dynamite fishing has been banned vide the Travancore Cochin Fisheries Act of 1950 (Government of Kerala, India) there is very little enforcement, and the practice continues to exist even inside protected areas of the region (Abraham *et al*., 2010). Most of the species population is declining due to over exploitation and habitat loss. Introduction of *Tor* species in the rivers of Kerala from the other geographical region making more confusion and it leads taxonomic ambiguities and sometimes people wrongly quoting for supporting this evidence for Satpura Hypothesis (Manojkumar and Kurup, 2004).

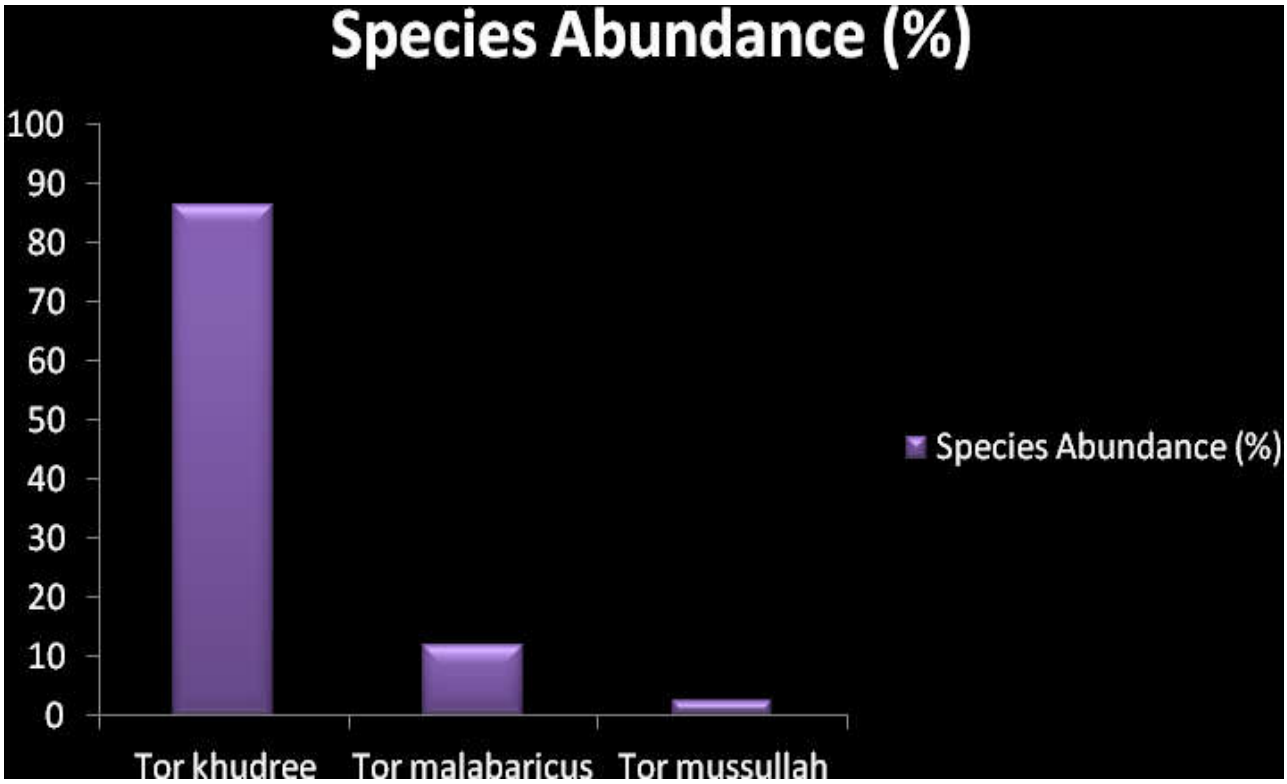

Fig. 6. Species abundance (%) of *Tor* in the present study

Conclusion

Genus *Tor,* the elegant group of sport and food fishes, are in peril in the Western Ghats and most of these species are considered as endangered. There is an urgent need for the detailed study on the distribution and taxonomic status of *Tor* species in the Western Ghats. The freshwater fish are the most threatened group in peninsular India with more than one third (37%) at risk of global extinction. Hence more efforts are needed to find out the un-explored diversity and to protect the existing precious fauna of genus *Tor*. Implications of potent conservation measures are necessary to conserve the fish fauna especially the *Tor* species of southern Western Ghats.

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