# Status of freshwater fishes in the Sahyadri-Konkan Corridor: diversity, distribution and conservation assessments in Raigad.

September 2015

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**Project report**

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Systematic fish taxonomy of fishes of Raigad District and implementing regional conservation plans.

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5) International Union for Conservation of Nature (IUCN)

Developing strategic conservation plans for fishes in northern Western Ghats through IUCN Red List assessment of fishes.

6) Maharashtra Forest Department

Project involvement through participation in workshop and logistic support.

7) Katkari community members and villagers in Raigad District.

Active involvement in project and conservation activities, to establish a local platform for implementing freshwater conservation plans in Raigad District.

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**Content:**

## 1. Introduction:

Western Ghats, one of the 34 global biodiversity hotspots (Mittermeier et al. 2005) harbours exceptional diversity and endemism of freshwater fishes (Dahanukar et al. 2004, Molur et al. 2011). Recent assessment of the state of freshwater biodiversity in the Western Ghats (Molur et al. 2011) revealed that 50% of the endemic fish fauna is threatened due to various anthropogenic threats. Major hindrances in implementing strong conservation policies for freshwater fishes in this region is the fact that many aspects of their taxonomy, distribution, ecology and population are still unknown or poorly known. The region also harbours many cryptic species and species complexes that require detailed taxonomic evaluation (Dahanukar et al. 2011), as well as several undescribed species as evidenced by a flurry of new species description papers in the recent past (Bhoite et al. 2012, Britz et al. 2012, Katwate et al. 2014a, Katwate et al. 2014b, Dahanukar et al. 2015, Knight et al. 2015). The freshwater ichthyofauna of the Western Ghats is therefore influenced by both the Wallacean and Linnean shortfalls (Bini et al. 2006).

Rivers of northern Western Ghats are relatively less explored compared to those in the southern region. The project has systematically assess the status of freshwater fishes in the west flowing rivers of Konkan corridor, in Raigad district of Maharashtra, as well as in other parts of northern Western Ghats which helped to fill the knowledge gap and improve our understanding of the ichthyofauna of northern Western Ghats.

Lack of information on taxonomy, diversity, distribution and ecology of freshwater fish species, is a major hindrance in developing and implementing conservation policies for freshwater fishes in the Western Ghats. The two year project has specifically helped by filling gaps in the limited knowledge of these aspects in a poorly studied landscape. The project has generated vast scientific information on extant diversity and distribution of fishes in six major west flowing rivers of Raigad District. The rapid assessment surveys conducted as part of this project across the northern and central Western Ghats has resulted in description of three new freshwater fish species to science and description of several poorly known fish species. The community involvement of tribal groups like Katkari has benefited the conservation practices through community awareness and long term capacity building in study area. The project also benefited the local participant's livelihood through honorariums and help in poverty reduction through education and conservation awareness.

## 2. Study area:

The study was carried out in the Raigad District region of northern Western Ghats in the state of Maharashtra. Six isolated and non interconnected west flowing rivers namely Patalganga, Bhogawati, Amba, Kundalika, Mandad and Savitri that drain the Raigad District (17°51'–19°80'N & 72°51'–73°40'E) have been systematically surveyed in the current study (Table 1). Among these west flowing rivers, Amba, Kundalika and Savitri are major river systems in study area, which are part of the Sahyadri-Konkan Corridor of the CEPF Ecosystem Profile.

In this study protected areas like Bhimashankar Wildlife Sanctuary, Phansad Wildlife Sanctuary and some parts of Sahyadri Konkan Corridor has been surveyed for potential new species. Further down in northern Western Ghats areas like Amboli, Sindhudurga and parts of Goa were also accessed for unknown and less known fish species.

Figure 1: Map of the study area: Raigad District in northern Western Ghats.

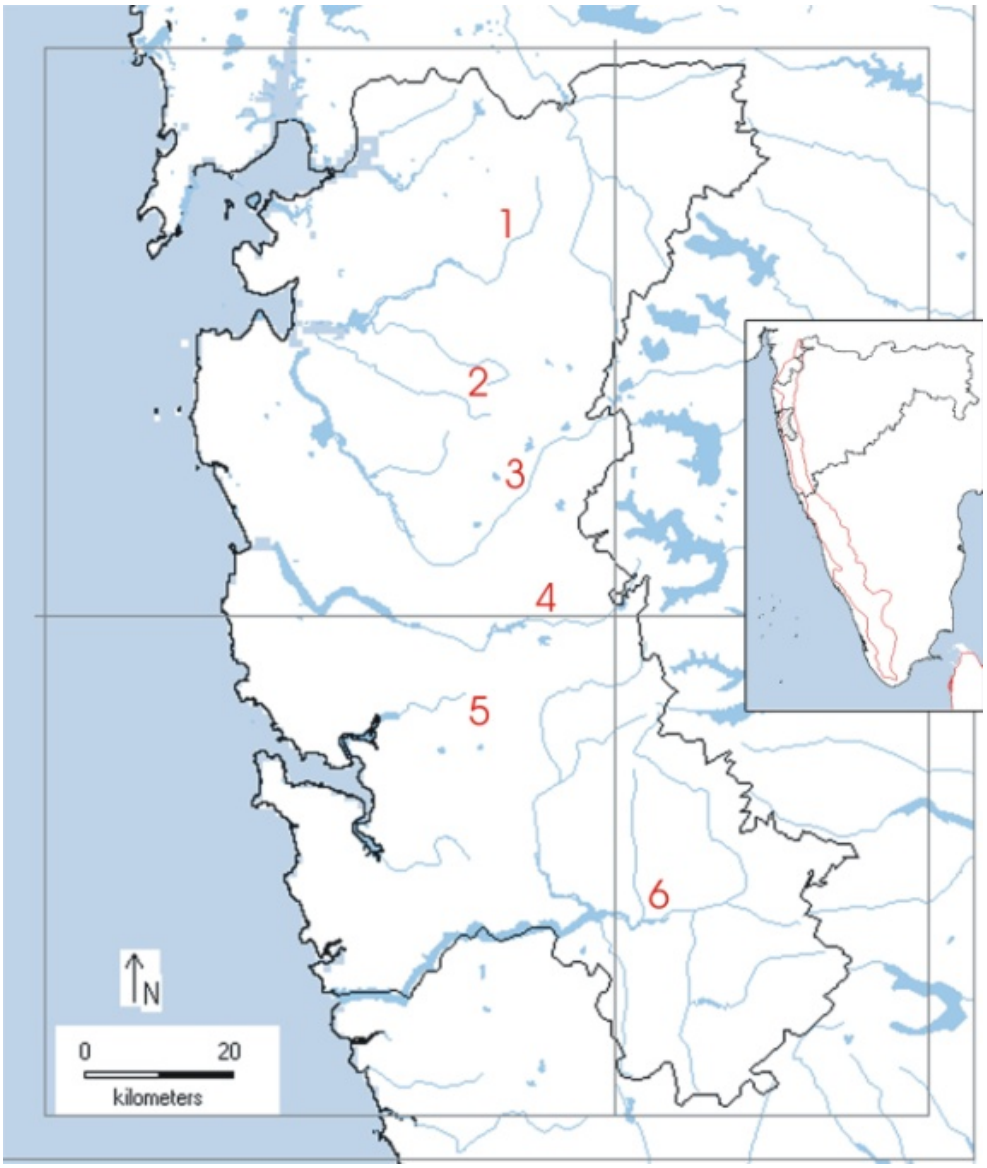


Table 1. List of river systems studied from the project area.

| Sr. No. | Name of the River | Lat-long of starting point of survey | Lat-long of end point of survey |
|---|---|---|---|
| 1 | Patalganga | 18.46° to 73.21°E | 18.51°N to 73.09°E |
| 2 | Bhogawati | 18.42° to 73.15°E | 18.45°N to 73.05°E |
| 3 | Amba | 18.71° to 73.38°E | 18.69°N to 73.01°E |
| 4 | Kundalika | 18.53° to 73.40°E | 18.46°N to 73.08°E |
| 5 | Mandad | 18.22° to 73.06°E | 18.19°N to 73.07°E |
| 6 | Savitri | 18.06° to 73.59°E | 17.98°N to 73.09°E |

**3. Project objectives:**

1. To fill the gaps in knowledge on diversity and distribution of freshwater fishes in the Sahyadri-Konkan corridor in the northern Western Ghats.

2. To map the distribution of threatened fish species, their critical habitats and prioritising important freshwater areas for conservation.

3. To involve the indigenous community in field surveys, education and conservation.

4. To estimate the impact of anthropogenic stressors on the fish fauna of the region.

**4. Methodologies:**

1. Fishing surveys were carried out across the study area in two year project period.

2. Watershed area of the each river was map and sample sites were selected across the watershed areas of respective river.

3. Fishing surveys were carried out in day and night across all sampling points.

4. Fishing practices was carried out by using standard fish catching techniques like cast net, hook and line, hand net and by using local traps with the help of local fishing communities.

5. Daily fishing efforts of local fishermen across study areas were considered as valid fishing attempt to avoid excessive fishing pressure in study region.

6. All freshwater fish habitats were carefully studied for cryptic fish species.

7. After identification and photography fishes were released back in natural environment.

8. Specimens were collected only in case of unidentified specimens.

9. After identification and publication of proper species description, all voucher specimens were deposited in reliable natural history museums like BNHS, WILD and ZSI.

10. Fish count was taken after each fishing attempt, and species abundance data was used to estimate diversity indices. To maintain consistency in abundance data, only cyprinid fishes were counted to estimate diversity indices.

11. Anthropogenic threats found at fishing sites were carefully documented throughout the study.

**5. Results:**

i) Species diversity and distribution –

We studied the freshwater fish diversity of six major rivers of Raigad District viz. Patalganga, Bhogawati, Amba, Kundalika, Mandad and Savitri, in northern Western Ghats part of Maharashtra. We found total 60 freshwater fish species, including 51indigenous freshwater fishes belongs to 20 families and 37 genera and nine introduced fish species (Table 2). Maximum number of indigenous freshwater fish diversity was recorded from Savitri (49 species) and Kundalika River (46 species). Total 33 indigenous freshwater fish species were recorded from Amba River and followed by Mandad (29 species) and Patalganga River (27 species). Bhogawati River showed very low number of species richness with estimated count of total 24 indigenous freshwater fish species. Among the 51 indigenous fish species, 39 species are exclusive freshwater inhabitants whereas 12 species are found to be secondary freshwater water fishes which inhibit estuarine as well as riverine habitats. Cyprinids were found to be the most diverse and dominant fish group across all the rivers, represented by total 20 species, followed by Cat fishes of the family Bagridae with four species and later by Snakehead fishes of the family Channidae and silurid catfishes of the family Siluridae, with three species in each family. Fishes of the family Cyprinidae found to be more diverse with total of 20 species belongs to 13 different genera.

Out of 51 native fish species recorded across the study area, 20 fish species are endemic to the Western Ghats biodiversity hotspot region. Maximum number of endemic species was found in Kundalika and Savitri River (17 species in each river), followed by Amba River with 11 endemic species and Patalganga and Mandad River (seven species per river). Bhogawati River has very low number of endemic fish species count (5 species). Species like *Pethia lutea*, *Parapsilorhynchus discophorus* and *P. tentaculatus* are known to occur only in small isolated streams of northern Western Ghats. Among the 51 freshwater fish species recorded across the study area, seven fish species has been listed in IUCN Red List of threatened species as Endangered (EN) or Vulnerable (VU) and found to be threatened with the greater risk of extinction. We found total four Endangered (EN) and three Vulnerable (VU) freshwater fish species in the study. Along with the three Near Threatened (NT) fish species, 37 species found to be listed as Least Concern (LC) in IUCN Red List of threatened species. The project has also provided distribution information on three Data Deficient (DD) species viz. *Puntius amphibius*, *Puntius mahecola* and *Anabas testudineus*.

The Endangered (EN) species like *Hypselobarbus mussullah* was recorded from mid-downstream areas of Kundalika and Savitri River. Taxonomic identity of *H. mussullah* was in uncertainty since long time, as there was no reliable description available after the original one. The recent taxonomic identity and description provided by Knight et al. 2014, has helped to assess the correct taxonomic position of *Hypselobarbus* sp. from the study region. Knight et al. 2014 provided the description of *H. mussullah* from Bhira Dam, Kolad which is located in the upstream watershed area of Kundalika River. The new distribution records and population data generated through this project can help to conduct correct

conservation assessment for *H. mussullah*, since the current IUCN Red List assessment and conservation status of this species is based on old and outdated taxonomic data. We also found another endemic and Endangered (EN) species *Hypselobarbus curmuca* from the study area, the species was earlier reported from this region by Singh &Yazdani (1993) and Arunachalam (2002). It is interesting to note that in our previous study (Katwate et al. 2012), we did not find any records of *H. curmuca*, which is probably due to the less sampling efforts in downstream areas. However our current voucher collection from Kundalika and Savitri River has confirmed the occurrence of species reported by Singh & Yazdani (1993) and Arunachalam (2002).

We also assess the conservation status of the newly described Citron Barb *Pethia lutea* from the study region. Proposed IUCN Red list status, criteria used and details of assessment provided in the original description of the species (Katwate et al. 2014).*Pethia lutea* is assessed as Endangered (EN) because of its restricted distribution to the west flowing rivers of northern Western Ghats, fragmented populations and ongoing threats to its habitats. Currently, the species is known from eight isolated locations from six river systems with an extent of occurrence (EOO) 6,000km2 and with estimated area of occupancy (AOO) is not more than 200km2.Occurrence of another Endangered (EN) and endemic species *Tor cf. khudree* is reported for the first time in Savitri River basin of Raigad District. Occurrence of *Tor khudree* in the west flowing rivers of northern Western Ghats was earlier reported from Khandala, streams of Patalganga River (18.8020 N & 73.3179 E) by (Arunachalam, 2002), whereas in earlier(Katwate et al. 2012)and present study we did not find any records of *Tor khudree* in Patalganga River. Occurrence of *Tor cf. khudree* in Savitri River basin clearly indicates that the west flowing rivers of Maharashtra too have a potential to harbour monster fishes. Yet we have not confirmed the taxonomic position of *Tor cf. khudree* collected from Savitri as our specimens differs from Tor khudree in general appearance and body proportions so we retain the species identity in this study as *Tor cf. khudree*.

Along with the species count, we also have conducted the quantitative assessment of freshwater fishes across the study area (Table 3, Table 4). Fishes of the family Cyprinidae were considered in fish count to maintain consistency in data because most of the other fish species found in study are subject to the opportunistic records. Fish count was taken at all sampling sites within the selected watershed area of the River except S10 & S11 as both of the sites are man-made reservoirs where gill net, cast net and drag net fishing is not allowed (Table 3). Details of species count and alpha diversity measures were provided in Table 5.Maximum numbers of cyprinid fish species are recorded from Savitri River (18 species) and Kundalika Rivers (15 species), followed by Amba (12 species), Mandad (10 species), Patalganga (9 species) and Bhogawati (8 species).Similarly, maximum cyprinid fish abundance was found in Savitri River (16-111/ study site) and Kundalika River (17-32/ study site).In the Savitri River basin, maximum number cyprinid fish species were found at site S1 (14 species), S2 (13 species), and S3 (14 species). Moderate number of cyprinids were found at site S5 (10 species), S6 (11 species) and S7 (11 species). Identical pattern were found

while estimating Shannon H' diversity index values. Sites S1, S2, S3 and S6 found to be highly diverse, having maximum H' index values (S1=2.25, S2=2.12, S3=2.16, S6=2.01) which is followed by site S4 (H'=1.82) and S5 (H'=1.81). Surprisingly site S7 attributes maximum Shannon (H'=2.22) index value which is more likely because of greater evenness in species count (E=0.84).In the Kundalika River watershed area, maximum number of cyprinid fish species was found at site S3 (12) and S4 (13). Similar pattern was found in estimating Shannon H' diversity index values. Fishes at sites S3 and S4 found to be highly diverse and more evenly distributed, having maximum H' index values (S3=2.38, S4=2.5) and Evenness (E) value (S3=0.90, S4=0.94). Diversity estimate values for other rivers were provided in Table 5.

ii) Taxonomic inventories –

1) *Pethia lutea (*Katwate, Katwate, Raghavan, Paingankar & Dahanukar 2014)

Proposed IUCN Redlist status – Endangered (EN) B2ab(iii)

Citron Barb

We describe this small cyprinid fish species new to science from the west flowing rivers of the northern Western Ghats. The project has help to systematically describe the new fish species through use integrated taxonomic approach and study the population distribution in rivers of Raigad and Ratnagiri Districts of Maharashtra. The study also helped to assess conservation status for this fish species. The species has been categorized as Endangered (EN) because of its fragmented population, low area of occupancy and multiple anthropogenic threats to the surviving population. IUCN Redlist assessment conducted for this species has helped to priorities this species for implementing future conservation actions. Description of *Pethia lutea* from the west flowing rivers of northern Western Ghats has underline the argument that this region is still a knowledge gap in understanding fish diversity of Western Ghats biodiversity hotspot and has more potential to describe unknown fish species (Dahanukar et al. 2011). For further details, see Katwate et al. 2014a.

2) *Pethia longicauda (*Katwate, Paingankar, Raghavan & Dahanukar 2014)

Long-tailed Pethia

This is another new fish species of the genus *Pethia*, we describe from the Hiranyakeshi River, tributary of Krishna River in the northern Western Ghats. We found the distribution of this species in headwaters of Hiranyakeshi River. The species description is output of the rapid assessment surveys conducted in Amboli region of the northern Western Ghats through multi institutional collaboration. The diversity of genus *Pethia* in India is poorly studied and underestimated for two reasons. Firstly, several parts of the Western Ghats are

still unexplored (Dahanukar et al. 2011); and secondly, several nominal species apparently comprise of species complexes. *Pethia ticto* (Hamilton, 1822) has long been treated as a widely distributed species the Indian subcontinent (Hora et al. 1939; Jayaram 1991). However, recent taxonomic work has suggested that *P. ticto* is a species complex comprising several distinct species (Linthoingambi & Vishwanath 2007; Mercy & Jacob 2007; Knight et al. 2012; Katwate et al. 2014). The description of *Pethia lutea* and *Pethia longicauda* from the northern Western Ghats suggest that the genus *Pethia* is under-studied in rivers of northern Western Ghats and has more potential to describe many unidentified or misidentified fish species. For the further details, see Katwate et al. 2014b.

3) *Badis britzi* (Dahanukar, Kumkar, Katwate & Raghavan 2015)

Britz's chameleon fish

We describe this new Percomorph fish species from the Nagodi tributary of the west flowing Sharavati River, near the town of Nittur, in Karnataka. The description of *Badis britzi* forms the first endemic species of the genus described from the rivers of Western Ghats. The project has helped the researchers to conduct some preliminary fish surveys in the central Western Ghats. Description of *Badis britzi* from the west flowing rivers of central Western Ghats further highlights the arguments that the state of knowledge of the ichthyofauna of this region is poor. For the further details, see Dahanukar et al. 2015.

4) *Pethia ticto* (Hamilton, 1822)

Hamilton's Ticto Barb

While describing the fishes of Ganges, Hamilton described a small cyprinid fish species, *Cyprinus ticto* (now allocated to *Pethia*) from south-eastern parts of Bengal. Many researchers earlier considered *P. ticto* as widely distributed species throughout the peninsular India. Subsequent taxonomic studies have shown that widely considered *P. ticto* is in fact comprises a 'complex' of several distinct species. The unavailability of type material and insufficient diagnostic characters in the original description resulted in ambiguities in the identity of this species. In this paper, we clarify the identity of *P. ticto* through an integrative-taxonomic approach and almost after 200 years. For the further details, see Katwate et al. 2015.

5) *Pethia punctata* (Day, 1865) – identity and a senior synonym of *Pethia muvattupuzhaensis*

Day's Barb or Dotted Saw fin Barb

Day, 1865 describe a species of small barb *Pethia punctata* as *Puntius punctatus* from Cochin, on the Malabar coast of India. While earlier authors considered *P. punctata* as a synonym or a subspecies of *P. ticto*, others more recently have treated *P. punctata* as a valid species. However, the recognition of *P. punctata* as a valid species was not until now been accompanied by a detailed description and diagnosis so as to facilitate definitive identification. Beevi & Ramachandran (2005) described *Puntius muvattupuzhaensis* (now

*Pethia muvattupuzhaensis*) as a small, elongate barb from the Muvattupuzha River, Ernakulam District, Kerala, India. Examination of the type material of *P. muvattupuzhaensis* revealed several discrepancies with the original description, while the species showed remarkable similarity to *Pethia punctata*. Here we provide morphometric, meristic, genetic and osteological evidence to characterize *P. punctata* based on topotypic material. Further, based on the examination of the type material and genetic analysis of fresh topotypic specimens we show that *P. muvattupuzhaensis* is a junior synonym of *P. punctata*. For the further details, see Katwate et al. 2014c.

6) *Pethia setnai* (Chhapgar & Sane, 1992)

Indigo Barb

Vulnerable (VU) B2ab(iii)

The project has helped to discover a new population of threatened fish like *Pethia setnai* from Terekhol River, in Sindhudurga District of Maharashtra. The study helps to understand distribution range and genetic divergence among *Pethia setnai* across the Western Ghats. New information generated on the taxonomy, distribution and anthropogenic stresses may help to implement conservation measures. For the further details, see Katwate et al. 2013.

7) *Tor cf. khudree* (Sykes, 1839)

Deccan Mahseer

Endangered (E) A2acde

Population of *Tor cf. khudree* was recorded only from the upper catchment areas like Walan Kond and Shivathar Ghal in Savitri River basin. We didn't find any other records of *Tor cf. khudree* from rest of the areas, secondary information collected from tribal areas also suggest that *Tor cf. khudree* were only found in unpolluted river channels near Walan and Shivathar Ghal. Surprisingly a protected population of *Tor cf. khudree* through community sanctuary at Walan Kond were recorded during study period. More information on the Walan Kond community sanctuary and its role in *Tor cf. khudree* (Deccan Mahseer) conservation was published in scientific articles, see Katwate & Apte, 2014; Katwate et al. 2014d.

iii) Conservation outcomes –

1) Baseline information generated on the diversity and distribution of freshwater fishes in rivers of the Konkan region within the Sahyadri-Konkan Corridor.

2) Description of new species to the science and information on less known or unknown freshwater fish species.

3) Improved knowledge and understanding of the distribution pattern of several threatened freshwater fish species in Western Ghats.

4) Among the 51 native freshwater fish species reported from the study area and other fish species studied throughout the northern Western Ghats, we prioritize seven threatened and endemic freshwater fish species for implementing long term conservation plans. The species includes *Pethia lutea*, *Pethia setnai*, *Hypselobarbus mussullah*, *Parapsilorhynchus discophorus*, *Tor cf. khudree*, *Monopterus indicus* and *Horabagrus brachysoma*.

5) The baseline information generated on taxonomy and distribution of freshwater fishes has helped to evaluate IUCN Red List status for species like *Pethia lutea* and *Pethia setnai*.

6) Traditional knowledge of local fishing communities regarding endangered (EN) freshwater fish species like *Tor cf. khudree* and *Hypselobarbus mussullah* was used to infer the distribution and population status of these threatened fish species present across the study area. Local knowledge regarding breeding season of these threatened fish species was used to suggest conservation measures.

7) Network establishment and strengthening community involvement through workshops and institutional collaborations with IISER, CRG-Kerala, IUCN- ZOO-WILD and ATREE. Project has facilitated and encourages the local community like Katkari to involve in project activities through participation in fishing practices and workshop.

8) Improved conservation awareness and fish knowledge in local community. Local network establishment for implementation of future fish conservation plans by forming local fish monitoring groups of tribal fishermen near Saje Adiwasi Wadi (18.480$^{o}$N & 73.313$^{o}$E, 112m) and Birwadi (18.097$^{o}$N & 73.505$^{o}$E, 25 m) in Kundalika and Savitri River basin.

iv) Anthropogenic threats –

Freshwater fishes of the Raigad District are under major threat of habitat destruction resulted from several anthropogenic activities viz. construction of Dams, sand mining, sewage pollution, uncontrolled release of industrial effluents, riparian deforestation, siltation, invasive fish species etc. Being an industrialised sector and geographically close to the Mumbai metropolitan region, the Raigad District is going through rapid industrialization and urbanization. With the current outburst in urbanization across the region, demands for the natural resources are potentially high. To fulfil the rising demand of water and energy many small and hydroelectric dams have been constructed across all the rivers and several are under construction. Construction of Dams poses greatest threat to the fishes through long lasting geographical isolation of populations, obstacles in migratory pathways of up & downstream moving fishes and habitat destruction due to flooding and draught. Annual fish kill due to release of toxic industrial waste is also a major problem in the several areas near Mahad in Savitri River. Illegal sand mining activities were observed to larger extent in Kundalika and Savitri River watershed areas. Use of invasive fishing methods like poisoning

and blasting were observed in lower reaches of Savitri River. Spread of introduced invasive fish species is also a major concern and threat to the fishes of this region. In this study we found total nine introduced fish species across the study area. Introduced fishes species poses direct threat to native fish populations through resource completion and niche overlap.

## 6. Freshwater fish conservation mitigation measures and recommendations

1. More systematic fish study is essential in east and west flowing rivers of northern Western Ghats as fish fauna of this region is subject to poor knowledge of species diversity and data gaps.

2. More focused and targeted taxonomic study on different groups of fishes is essential as the region has high potential to uncover several undescribed fish species.

3. Long term monitoring and implementation of stronghold policies are required for conservation of threatened fish species.

4. Spread of invasive fish species needs to be regularly monitored and prevent through eradication programs by involving local fishermen.

5. Policies and recovery plans for the conservation of depleting native fish species are essential.

6. Legal push up to mandate prior environmental impact assessments for large as well as small dams is required.

7. Construction of fish channels/ ladders across the dam area is necessary to sustain migratory movements of fish in breeding and non-breeding period.

8. Pollution through illegal release of industrial and urban sewage should be controlled to avoid negative impact on livelihood and economy of local villagers and fishermen.

9. Outreach programs are needed to raise bars of fish conservation movement among civil society.

10. Establishment of local framework and networking of scientific and fishing communities is needed to implement long term freshwater fish conservation policies.

**7. Project summary:**

Baseline data is generated on diversity and distribution of freshwater fishes in rivers of Raigad District. The project has directly contributed to the implementation of CEPF Investment Priority 2.1 because it has facilitated the conservation of globally threatened species like *Pethia lutea*, *Pethia setnai*, *Hypselobarbus mussullah*, *Parapsilorhynchus discophorus*, *Tor cf. khudree*, *Monopterus indicus* and *Horabagrus brachysoma* etc. Project has generated ecological and distributional data regarding these lesser known organisms, which has helped in IUCN Redlist assessment, to infer conservation status of these species. The project also help to describe unknown freshwater fish species from the Western Ghats like description of three new freshwater fish species viz. *Pethia lutea*, *Pethia longicauda* and *Badis britzi*. The grant further help in reviewing the taxonomic identity of fishes like *Pethia setnai*, *Pethia punctata*, *Pethia ticto* and *Horabagrus brachysoma*. The description of new freshwater fish species and reports of threatened fish species from the CEPF priority sites like Sahyadri-Konkan Corridor underlines the argument that fish diversity of this region is poorly studied. The project results further highlights the need of more systematic studies in east and west flowing rivers of northern Western Ghats.

**8. References –**


1. Ali, A., U. Katwate, S. Philip, K. Dhaneesh, A. Bijukumar, R. Raghavan & Dahanukar, N. (2014) *Horabagrus melanosoma*: a junior synonym of Horabagrus brachysoma (Teleostei: Horabagridae). *Zootaxa*, 3881(4):373–384. http://dx.doi.org/10.11646/zootaxa.3881.4.5
2. Arunachalam, M., A. sankaranarayanan, A. Manimekalan, R. soranam & J.A. Johnson (2002). Fish fauna of some streams and rivers in the Western Ghats of Maharashtra. *Journal of Bombay Natural History Society* 99(2): 337- 341.
3. Bhoite, S., Jadhav, S. & Dahanukar, N. (2012) *Balitora laticauda*, a new species of stone loach (Teleostei: Cypriniformes: Balitoridae) from Krishna River, northern Western Ghats, India. *Journal of Threatened Taxa* 4(11): 3038–3049.
4. Bini, L. M., J. A. F. Diniz-Filho, T. F. L. V. B. Rangel, R. P. Bastos, and M. P. Pinto, "Challenging Wallacean and Linnean shortfalls: knowledge gradients and conservation planning in a biodiversity hotspot," *Diversity and Distributions*, vol. 12, no. 5, pp. 475–482, 2006.
5. Britz, R., A. Ali and S. Philip, "*Dario urops*, a new species of badid fish from the Western Ghats, southern India (Teleostei: Percomorpha: Badidae)", *Zootaxa* vol. 3348, pp. 63–68, 2012.
6. Dahanukar, N., Kumar, P., Katwate, U. & Raghavan, R. (2015) *Badis britzi*, a new percomorph fish (Teleostei: Badidae) from the Western Ghats of India. *Zootaxa*, 3941(3):429–436. http://dx.doi.org/10.11646/zootaxa.3941.3.9
7. Dahanukar, N., R. Raghavan, A. Ali, R. Abraham, and C. P. Shaji, "The status and distribution of freshwater fishes of the Western Ghats", Chapter 3, pp. 21-48. In: S. Molur, K.G. Smith, B.A. Daniel and W.R.T. Darwall (Eds), The status and distribution of freshwater biodiversity in the Western Ghats, India, Cambridge, UK and Gland, Switzerland: IUCN, and Coimbatore, India: Zoo Outreach Organisation, 2011.
8. Katwate U. (2014) A compact amphibian field guide for Kerala, Book review: Common Amphibians of Kerala (Frogs and Toads) - P. S. Sivaprasad 6(5): 5795–5796Pp. http://dx.doi.org/10.11609/JoTT.o4039.5795-6
9. Katwate U. and Apte D. (2014). Where have all the mahseers gone? Hornbill, March-April 2014, 43-46pp. http://www.zoosprint.org/ZoosPrintNewsLetter/MIN_January_2014.pdf

10. Katwate, C., R. Pawar, V. Shinde, D. Apte & U. Katwate (2014). How long will social beliefs protect the pride of River Savitri? MIN Newsletter of the IUCN-SSC/WI Freshwater Fish Specialist Group South Asia & the Freshwater Fish Conservation Network of South Asia 2: 21-24pp; http://www.zoosprint.org/ZoosPrintNewsLetter/MIN_January_2014.pdf
11. Katwate, U., Baby, F., Raghavan, R. & Dahanukar, N. (2014) The identity of Pethia punctata, a senior synonym of P. muvattupuzhaensis (Teleostei: Cyprinidae). *Zootaxa*, 3884(3):201–221. http://dx.doi.org/10.11646/zootaxa.3884.3.1
12. Katwate, U., C. Katwate, R. Raghavan, M.S. Paingankar & N. Dahanukar (2014). *Pethia lutea*, a new species of barb (Teleostei: Cyprinidae) and new records of *P. punctata* from northern Western Ghats of India. *Journal of Threatened Taxa* 6(6), 5797–5818; http://dx.doi.org/10.11609/JoTT.o3929.5797-818
13. Katwate, U., Katwate, C. & Dahanukar, N. (2016) Freshwater fishes of Raigad District, northern Western Ghats of India. ___, manuscript in process…
14. Katwate, U., M.S. Paingankar, S. Jadhav & N. Dahanukar (2013). Phylogenetic position and osteology of Pethia setnai (Chhapgar & Sane, 1992), an endemic barb (Teleostei: Cyprinidae) of the Western Ghats, India, with notes on its distribution and threats. Journal of Threatened Taxa 5(17): 5214–5227; http://dx.doi.org/10.11609/JoTT.o3857.5214-27
15. Katwate, U., Paingankar, M.S., Raghavan, R. & Dahanukar, N. (2014) *Pethia longicauda*, a new species of barb (Teleostei: Cyprinidae) from the northern Western Ghats, India. *Zootaxa*, 3846(2): 235–248. http://dx.doi.org/10.11646/zootaxa.3846.2.4
16. Katwate, U., Raut, R., Khot, M., Paingankar, M. & Dahanukar**, N.** (2012b) Molecular identification and ecology of a newly discovered population of sun catfish *Horabagrus brachysoma* from northern Western Ghats of India. *ISRN Zoology* 2012(419320):1-9. (doi:10.5402/2012/419320).
17. Knight, J. D. M. , A. Rai, R. K. P. D'Souza and B. Vijaykrishnan 2015 *Barilius ardens* (Teleostei: Cyprinidae), a new species from the Western Ghats, India, with redescription of *B. malabaricus* and *B. canarensis*. Zootaxa 3926 (no. 3): 396-412. http://dx.doi.org/10.11646/zootaxa.3926.3.5
18. Molur, S., K.G. Smith, B.A. Daniel and W.R.T. Darwall (Eds), The status and distribution of freshwater biodiversity in the Western Ghats, India, Cambridge, UK

and Gland, Switzerland: IUCN, and Coimbatore, India: Zoo Outreach Organisation, 2011.

19. Paingankar, M.S., U. Katwate & N. Dahanukar (2014). A creepy fish of the northern Western Ghats: endemic and threatened swamp eel Monopterus. MIN Newsletter of the IUCN-SSC/WI Freshwater Fish Specialist Group South Asia & the Freshwater Fish Conservation Network of South Asia 2: 11-14pp; http://www.zoosprint.org/ZoosPrintNewsLetter/MIN_January_2014.pdf
20. Raghavan, R., Dahanukar, N., Knight, M., Bijukumar, A., Katwate, U., Krishnakumar, K., Ali, A. & Philip S. (2014) Predatory journals and Indian ichthyology. *Current science*, 107(5):740-742. http://www.currentscience.ac.in/Volumes/107/05/0740.pdf

## 9. Freshwater fish species diversity and distribution in study area.

i) Table 2: Checklist of freshwater fish species diversity recorded across the study area.

| Species | Remarks* | Selected watershed area/ River | | | | | | IUCN Redlist Category |
|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | |
| **ANGUILLIFORMES** | | | | | | | | |
| **Anguillidae** | | | | | | | | |
| *Anguilla bengalensis* (Gray, 1831) | s | - | - | + | + | - | + | LC |
| **BELONIFORMES** | | | | | | | | |
| **Hemiramphidae** | | | | | | | | |
| *Hyporhamphus limbatus* (Valenciennes, 1847) | s | - | - | + | + | + | + | LC |
| *Hyporhamphus cf. xanthopterus* (Valenciennes, 1847) | s, e | - | - | - | - | - | + | VU [D2] |
| **Belonidae** | | | | | | | | |
| *Xenentodon cancila* (Hamilton, 1822) | | + | + | + | + | + | + | LC |
| **CYPRINIFORMES** | | | | | | | | |
| **Cobitidae** | | | | | | | | |
| *Lepidocephalichthys thermalis* (Valenciennes, 1846) | | + | + | + | + | + | + | LC |
| **Cyprinidae** | | | | | | | | |
| *Dawkinsia filamentosus* (Valenciennes, 1844) | e | - | - | + | + | + | + | LC |
| *Devario aequipinnatus* (McClelland, 1839) | | + | + | + | + | + | + | LC |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Esomus danrica* (Hamilton, 1822) | s | - | - | - | + | - | + | LC |
| *Garra gotyla stenorhynchus* (Jerdon, 1849) | e | + | + | + | + | + | + | LC |
| *Garra mullya* (Sykes, 1839) | | + | + | + | + | + | + | LC |
| *Hypselobarbus mussullah* (Sykes 1839) | e | - | - | - | + | - | + | EN [B2ab(iii,v)] |
| *Hypselobarbus curmuca* (Hamilton, 1807) | e | - | - | + | + | - | + | EN [A2acd] |
| *Labeo calbasu* (Hamilton, 1822) | | - | - | - | - | - | + | LC |
| *Labeo dussumieri* (Valenciennes, 1842) | e | - | - | + | + | - | + | LC |
| *Parapsilorhynchus discophorus* Hora, 1921 | e | - | - | - | - | - | + | VU [B1ab(iii)] |
| *Parapsilorhynchus tentaculatus* (Annandale, 1919) | | + | - | - | + | - | + | LC |
| *Pethia lutea* Katwate, Katwate, Raghavan, Paingankar & Dahanukar, 2014 | e | - | - | + | + | - | + | EN [B2ab(iii)] |
| *Pethia punctata* (Day, 1865) | e | - | - | - | + | - | - | LC |
| *Puntius amphibius* (Valenciennes, 1842) | e | + | + | + | + | + | + | DD |
| *Puntius mahecola* (Valenciennes, 1844) | e | - | - | + | + | + | + | DD |
| *Puntius sophore*(Hamilton, 1822) | | + | + | + | + | + | + | LC |
| *Rasbora daniconius* (Hamilton, 1822) | | + | + | + | + | + | + | LC |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Salmophasia boopis* (Day, 1874) | e | + | + | + | + | + | + | LC |
| *Systomus sarana subnasutus* (Valenciennes, 1842) | e | + | + | + | + | + | + | NE |
| *Tor* cf. *khudree* (Sykes, 1839) | | - | - | - | - | - | + | EN [A2acde] |
| **Nemacheilidae** | | | | | | | | |
| *Indoreonectes evezardi* (Day, 1872) | e | + | - | - | + | - | + | LC |
| *Schistura denisoni* (Day, 1867) | | + | + | + | + | + | + | LC |
| **CYPRINODONTIFORMES** | | | | | | | | |
| **Aplocheilidae** | | | | | | | | |
| *Aplocheilus lineatus* (Valenciennes, 1846) | | + | + | + | + | + | + | LC |
| **OSTEOGLOSSIFORMES** | | | | | | | | |
| **Notopteridae** | | | | | | | | |
| *Notopterus notopterus* (Pallas, 1769) | | - | - | - | + | - | + | LC |
| **PERCIFORMES** | | | | | | | | |
| **Anabantidae** | | | | | | | | |
| *Anabas testudineus* (Bloch, 1792) | s | - | - | + | + | + | + | DD |
| **Channidae** | | | | | | | | |
| *Channa punctata* (Bloch, 1793) | | + | + | + | + | + | + | LC |
| *Channa striata* (Bloch, 1793) | | + | + | + | + | + | + | LC |
| *Channa cf. gachua* (Hamilton, 1822) | | - | - | - | + | + | + | LC |
| **Cichlidae** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Pseudetroplus maculatus* (Bloch, 1795) | s | + | + | + | + | + | + | LC |
| *Etroplus suratensis* (Bloch, 1790) | s | - | + | + | + | + | + | LC |
| **Eleotridae** | | | | | | | | |
| *Eleotris fusca* (Forster, 1801) | s | + | + | + | + | + | + | LC |
| **Gobiidae** | | | | | | | | |
| *Awaous grammepomus* (Bleeker, 1849) | s | + | + | + | + | + | + | LC |
| *Glossogobius giuris* (Hamilton, 1822) | s | + | + | + | + | + | + | LC |
| **Osphronemidae** | | | | | | | | |
| *Pseudosphromenus cupanus (Cuvier, 1831)* | e | - | - | - | + | - | - | LC |
| **SILURIFORMES** | | | | | | | | |
| **Bagridae** | | | | | | | | |
| *Mystus gulio* (Hamilton, 1822) | | + | + | + | + | + | + | LC |
| *Mystus malabaricus* (Jerdon, 1849) | e | + | + | + | + | + | + | NT |
| *Mystus seengtee* (Sykes, 1839) | e | - | - | + | + | - | + | LC |
| *Mystus vittatus* (Bloch, 1794) | | - | - | - | - | - | + | LC |
| **Heteropneustidae** | | | | | | | | |
| *Heteropneustes fossilis* (Bloch, 1794) | | + | - | - | + | - | + | LC |
| **Siluridae** | | | | | | | | |
| *Ompok bimaculatus* (Bloch, 1794) | | + | + | + | + | + | + | NT |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Ompok malabaricus* (Valenciennes, 1840) | e | - | - | - | + | - | + | LC |
| *Wallago attu* (Bloch & Schneider, 1801) | | + | + | + | + | + | + | NT |
| **SYNBRANCHIFORMES** | | | | | | | | |
| **Mastacembelidae** | | | | | | | | |
| *Mastacembelus armatus* (Lacepède, 1800) | | + | + | + | + | + | + | LC |
| **Synbranchidae** | | | | | | | | |
| *Monopterus indicus* (Silas & Dawson, 1961) | e | + | - | - | + | - | + | VU [B2ab(iii)] |
| *Ophisternon bengalense* McClelland, 1844 | s | - | - | - | + | - | + | LC |
| **SYNGNATHIFORMES** | | | | | | | | |
| **Syngnathidae** | | | | | | | | |
| *Microphis cuncalus* (Hamilton, 1822) | s | - | - | - | + | - | + | LC |

* s = can live in brackish and marine habitats as well, e = endemic to Western Ghats assessment region. IUCN Red list threat status, LC - Least Concern; DD - Data Deficient; NT - Near Threatened; VU - Vulnerable; EN – Endangered; NA - Not Available.

Watershed areas/ River abbreviations: A, Patalganga River; B, Bhogawati River; C, Amba River; D, Kundalika River; E, Mandad River; F, Savitri River.

ii) Table 3: Sampling sites studied across different river basins.

| **Name of the Watershed/ River** | **Sampling sites** | **Area/ nearby location** | **Geographical position – Altitude (m ASL)** | **Habitat** | **Anthropogenic activities observed** |
|---|---|---|---|---|---|
| Patalganga | S1 | Gagangiri Nagar, Khopoli | 18.782°N &73.355°E | Primary and secondary stream, pools, fall and cascades | Sewage discharge, pollution due to temple waste, garbage disposal, plastic waste through tourism, invasive fish species |
| | S2 | Sri ram Nagar, Khopoli | 18.798°N&73.336°E | Run, cascade, deep pools | City sewage discharge, urban waste disposal, invasive fish species |
| | S3 | Warad, near Mumbai-Pune express highway | 18.859°N &73.233°E | Main river channel, cascade and pools | - |
| | S4 | Vayal, near Chambharli Village | 18.870°N &73.202°E | Main river channel | Discharge of potentially toxic industrial waste |
| Bhogawati | S1 | Aghai, Hetavane Dam upstream | 18.706°N&73.240°E | Cascade, run, pools and primary streams | - |
| | S2 | Hetavane Village | 18.722°N &73.153°E | Main river channel, cascades, deep pools | Small scale sand mining, urban waste |

| | | | | | |
|---|---|---|---|---|---|
| | S3 | Dhawate, Pen | 18.722°N &73.153°E | Main river channel | City sewage, invasive fish species, garbage disposal |
| Amba | S1 | Dhondase, Ghera Sudhagad | 18.547°N &73.305°E | Falls, cascades and temporary river channels | - |
| | S2 | Wakanwadi | 18.536°N&73.287°E | Deep pools, cascade, run | - |
| | S3 | Zap, Pali | 18.523°N &73.229°E | Main river channel | Small scale sand mining |
| | S4 | Jangali Maharaj Temple, Rabgaon | 18.517°N &73.181°E | Cascades, run, main river channel | Invasive fish species |
| Kundalika | S1 | Downstream of Bhira Dam, Bhira, Patnus | 18.452°N &73.373°E | Run, cascade, pools, secondary water channel | - |
| | S2 | Kundalika River, downstream of Bhira | 18.452°N &73.373°E | Run, cascade, large pools | Small scale sand mining |
| | S3 | Balhe, near Yeral | 18.451°N &73.283°E | Cascade, deep pools and main river channel | - |
| | S4 | Kolad | 18.410°N &73.210°E | Cascades, pools, main river channel, shallow runs and | - |

| | | | | | |
|---|---|---|---|---|---|
| | | | | rapids | |
| | S5 | Tala , Roha | 18.440°N & 73.131°E | Main river channel, rapids, run | Industrial effluent discharge, sand mining, city solid waste disposal in river channel, introduced fish species |
| Mandad | S1 | Karivane | 18.390°N &73.173°E | Perennial streams, falls, pools | - |
| | S2 | Wali | 18.363°N &73.127°E | Perennial streams | - |
| | S3 | Hardi | 18.342°N &73.126°E | Main river channel and semi estuarine zone | Swage water disposal, solid waste |
| Savitri | S1 | Mahad | 18.088°N & 73.445°E, 9 mASL | river channel | Industrial effluent discharge, sand mining, city solid waste disposal in river channel, introduced fish species |
| | S2 | Mahad MIDC route | 18.091°N & 73.465°E, 10 mASL | river channel | Industrial effluent discharge, city solid waste, frequent fish kill by uncontrolled effluent release |
| | S3 | Birwadi | 18.093°N & 73.492°E, 15 mASL | river channel | Industrial effluent discharge, city solid waste |

| | | | | | |
|---|---|---|---|---|---|
| | S4 | Birwadi road | 18.115°N & 73.540°E, 27 mASL | pool, riffle, run | - |
| | S5 | Walangaon/ Mangharun | 18.215°N & 73.491°E, 72 mASL | pool, riffle, canyon, run, cascade | Sand mining |
| | S6 | Walan Kond | 18.225°N & 73.489°E, 91 mASL | canyon, pool, fall | - |
| | S7 | Shivathar Ghal | 18.161°N & 73.622°E, 119 mASL | run, cascade, riffles, falls | Tourism, urban solid waste |
| | S8 | Poladpur | 17.994°N & 73.468°E, 32 mASL | pool, river channel | Industrial effluent discharge, sand mining, city solid waste, quarrying |
| | S9 | Ghagar Kond | 17.974°N & 73.521°E, 10 mASL | pool, canyon, fall | - |
| | S10 | Birwadi Dam | 18.097°N & 73.505°E, 25 mASL | man-made reservoir | Introduced alien fish species |
| | S11 | Savitri Dam | 17.980°N & 73.487°E, 62 mASL | man-made reservoir | Introduced alien fish species |
| | S12 | Veer | 18.108°N & 73.330°E, 5 mASL | River channel | Industrial effluent discharge, sand mining, city solid waste, quarrying |
| | S13 | Mangaon | 18.236°N & 73.290°E, 14 mASL | Riffle, pools, run and river channel | Industrial effluent discharge, city solid waste discharge |

iii) Table 4: Distribution of the freshwater fishes across the sampling sites in study area.

| **Species** | **Selected watershed area/ River** | | | | | |
|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** |
| **ANGUILLIFORMES** | | | | | | |
| **Anguillidae** | | | | | | |
| *Anguilla bengalensis* (Gray, 1831) | - | - | S2, S3 | S2, S3, S4 | - | S1, S2, S3, S6, S9 |
| **BELONIFORMES** | | | | | | |
| **Hemiramphidae** | | | | | | |
| *Hyporhamphus limbatus* (Valenciennes, 1847) | - | - | S3 | S4, S5 | S2, S3 | S1 |
| *Hyporhamphus* cf. *xanthopterus* (Valenciennes, 1847) | - | - | - | - | - | S2, S3 |
| **Belonidae** | | | | | | |
| *Xenentodon cancila* (Hamilton, 1822) | S4 | S3 | S3, S4 | S3-S5 | S3 | S1, S2, S3, S8 |
| **CYPRINIFORMES** | | | | | | |
| **Cobitidae** | | | | | | |
| *Lepidocephalichthys thermalis* (Valenciennes, 1846) | S1-S4 | S1-S3 | S1-S4 | S1-S5 | S1-S3 | S1-S8 |
| **Cyprinidae** | | | | | | |
| *Dawkinsia filamentosus* (Valenciennes, 1844) | - | - | S2, S3 | S3, S4, S5 | S2, S3 | S1, S2, S3 |
| *Devario aequipinnatus* (McClelland, 1839) | S1-S4 | S1-S3 | S1-S4 | S1-S5 | S1-S3 | S1-S8 |
| *Esomus danrica* (Hamilton, 1822) | - | - | - | S4 | - | S1, S2 |
| *Garra gotyla stenorhynchus* (Jerdon, 1849) | S1-S4 | S1-S3 | S1-S4 | S1-S5 | S1-S3 | S1-S8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Garra mullya* (Sykes, 1839) | S1-S4 | S1-S3 | S1-S4 | S1-S5 | S1-S3 | S1-S8 |
| *Hypselobarbus mussullah* (Sykes 1839) | - | - | - | S2, S3 | - | S1, S2, S3 |
| *Hypselobarbus curmuca* (Hamilton, 1807) | - | - | S3 | S4 | - | S1, S2, S3 |
| *Labeo calbasu* (Hamilton, 1822) | - | - | - | - | - | S1, S6 |
| *Labeo dussumieri* (Valenciennes, 1842) | - | - | S3 | S4 | - | S1, S2, S3, S13 |
| *Parapsilorhynchus discophorus* Hora, 1921 | - | - | - | - | - | S7 |
| *Parapsilorhynchus tentaculatus* (Annandale, 1919) | S1 | - | - | S1 | - | S7 |
| *Pethia lutea* Katwate, Katwate, Raghavan, Paingankar & Dahanukar, 2014 | - | - | S2 | S2, S3, S4 | - | S3, S4, S5, S6, S7, S8, S13 |
| *Pethia punctata* (Day, 1865) | - | - | - | S5 | - | - |
| *Puntius amphibius* (Valenciennes, 1842) | S2 | S1, S2 | S3 | S3, S4, S5 | S1 | S1, S2, S3, S4, S5, S6 |
| *Puntius mahecola* (Valenciennes, 1844) | - | - | S3 | S3, S4, S5 | S1 | S1, S2, S3, S4, S5, S6, S7, S8 |
| *Puntius sophore* (Hamilton, 1822) | S3, S4 | S2, S3 | S2, S3, S4 | S3, S4, S5 | S3 | S1-S9 |
| *Rasbora daniconius* (Hamilton, 1822) | S1-S4 | S1-S3 | S1-S4 | S1-S5 | S1-S3 | S1-S9 |
| *Salmophasia boopis* (Day, 1874) | S1 ,S2 | S2 | S1, S2 | S3, S4 | S2 | S3, S4, S7, S8, S9 |
| *Systomus sarana subnasutus* (Valenciennes, 1842) | S4 | S3 | S3, S4 | S3, S4, S5 | S2 | S1-S9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Tor cf. khudree*(Sykes, 1839) | - | - | - | - | - | S5, S6, S7 |
| **Nemacheilidae** | | | | | | |
| *Indoreonectes evezardi* (Day, 1872) | S1 | - | - | S1 | - | S4, S5, S6, S7, S8, S9, S13 |
| *Schistura denisoni* (Day, 1867) | S1 | S1, S2 | S1, S2, S3 | S1, S2, S4 | S1 | S4, S5, S6, S8, S13 |
| **CYPRINODONTIFORMES** | | | | | | |
| **Aplocheilidae** | | | | | | |
| *Aplocheilus lineatus* (Valenciennes, 1846) | S1-S4 | S1-S3 | S1-S4 | S1-S5 | S1-S3 | S1-S8 |
| **OSTEOGLOSSIFORMES** | | | | | | |
| **Notopteridae** | | | | | | |
| *Notopterus notopterus* (Pallas, 1769) | - | - | - | + | - | S1, S12 |
| **PERCIFORMES** | | | | | | |
| **Anabantidae** | | | | | | |
| *Anabas testudineus* (Bloch, 1792) | - | - | S4 | S5 | S3 | S1 |
| **Channidae** | | | | | | |
| *Channa punctata* (Bloch, 1793) | S3 | S1 | S2, S3 | S4 | S3 | S1, S8 |
| *Channa striata* (Bloch, 1793) | S3 | S2 | S3 | S5 | S3 | S1 |
| *Channa cf. gachua*(Hamilton, 1822) | - | - | - | S1 | S1 | S5 |
| **Cichlidae** | | | | | | |
| *Pseudetroplus maculatus* (Bloch, 1795) | S4 | S3 | S4 | S4, S5 | S2, S3 | S1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Etroplus suratensis* (Bloch, 1790) | - | S3 | S4 | S4, S5 | S3 | S1, S2, S3 |
| **Eleotridae** | | | | | | |
| *Eleotris fusca* (Forster, 1801) | S4 | S3 | S4 | S5 | S3 | S1 |
| **Gobiidae** | | | | | | |
| *Awaous grammepomus* (Bleeker, 1849) | S4 | S3 | S4 | S5 | S3 | S1, S2, S3 |
| *Glossogobius giuris* (Hamilton, 1822) | S4 | S3 | S4 | S3, S5 | S3 | S1, S2, S3, S12 |
| **Osphronemidae** | | | | | | |
| *Pseudosphromenus cupanus (Cuvier, 1831)* | - | - | - | S5 | - | - |
| **SILURIFORMES** | | | | | | |
| **Bagridae** | | | | | | |
| *Mystus gulio* (Hamilton, 1822) | S4 | S3 | S4 | S3, S5 | S3 | S1 |
| *Mystus malabaricus* (Jerdon, 1849) | S3, S4 | S2, S3 | S2, S3, S4 | S4, S5 | S3 | S1, S2, S3, S4, S6, S7, S12, S13 |
| *Mystus seengtee* (Sykes, 1839) | - | - | S4 | S4, S5 | - | S1, S2 |
| *Mystus vittatus* (Bloch, 1794) | - | - | - | - | - | S1 |
| **Heteropneustidae** | | | | | | |
| *Heteropneustes fossilis* (Bloch, 1794) | S4 | - | - | S5 | - | S1 |
| **Siluridae** | | | | | | |
| *Ompok bimaculatus* (Bloch, 1794) | S4 | S3 | S4 | S5 | S3 | S1, S2 |
| *Ompok malabaricus* (Valenciennes, 1840) | - | - | - | + | - | S1, S2, S13 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Wallago attu* (Bloch & Schneider, 1801) | S4 | S3 | S4 | S5 | S3 | S1, S10, S11 |
| **SYNBRANCHIFORMES** | | | | | | |
| **Mastacembelidae** | | | | | | |
| *Mastacembelus armatus* (Lacepède, 1800) | S4 | S3 | S4 | S5 | S3 | S1, S2, S3, S4, S6, S13 |
| **Synbranchidae** | | | | | | |
| *Monopterus indicus* (Silas & Dawson, 1961) | S3 | - | - | S4 | - | S7 |
| *Ophisternon bengalense* McClelland, 1844 | - | - | - | S4 | - | S1 |
| **SYNGNATHIFORMES** | | | | | | |
| **Syngnathidae** | | | | | | |
| *Microphis cuncalus* (Hamilton, 1822) | - | - | - | S4 | - | S1, S2 |

Watershed areas/ River abbreviations (A-F): as per Table 2.

Sampling sites abbreviations (S1-S13): as per Table 3.

iv) Table 5: List of introduced or alien fish species recorded across different river basins.

| **Introduced/ Alien fish species** | **Distribution of introduced fish species across the rivers of Raigad District** | | | | | |
|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** |
| *Catla catla* (Hamilton, 1822) | S3 | S3 | S3 | S4 | - | S10, S11, S13 |
| *Cyprinus carpio* Linnaeus, 1758 | S3, S4 | - | S3 | S4, S5 | - | S10, S11, S13 |
| *Labeo rohita* (Hamilton, 1822) | S4 | - | S3 | S4 | - | S10, S11 |
| *Oreochromis mossambicus* (Peters, 1852) | S3, S4 | S3 | S3 | - | S3 | S10, S11, S13 |
| *Oreochromis niloticus* (Linnaeus, 1758) | S3, S4 | S3 | S2, S3 | S4, S5 | - | S10, S11, S13 |
| *Hypophthalmichthys molitrix* (Valenciennes, 1844) | - | - | - | - | - | S10, S11 |
| *Clarias gariepinus* (Burchell, 1822) | S2 | S3 | S4 | S4, S5 | S3 | S10, S11, S13 |
| *Gambusia affinis* (Baird & Girard, 1853) | S1-S4 | S3 | S2, S3, S4 | S3, S4, S5 | S3 | S10, S11, S13 |
| *Piaractus brachypomus* (Cuvier, 1818) | S3 | - | - | - | - | - |

Watershed areas/ River abbreviations (A-F): as per Table 2.

Sampling sites abbreviations (S1-S13): as per Table 3.

v) Table 6: A brief account on diversity of freshwater fish species recorded across the rivers of Raigad District.

| River | Species richness | Number of endemic species found | Number of threatened species found | Number of introduced fish species recorded |
|---|---|---|---|---|
| Patalganga | 27 | 7 | 1 | 8 |
| Bhogawati | 24 | 5 | - | 5 |
| Amba | 33 | 11 | 2 | 7 |
| Kundalika | 46 | 17 | 4 | 6 |
| Mandad | 29 | 7 | - | 3 |
| Savitri | 49 | 17 | 7 | 8 |

vi) Table 7: Variation in alpha diversity indices, cyprinid fish density and species richness recorded across rivers of Raigad District.

| **Name of the River** | **Sampling sites*** | **Total abundance of cyprinid fish species/ 5 fishing attempts** | **Number of cyprinid fish species found/ site** | **Shannon H' index** | **Evenness index** |
|---|---|---|---|---|---|
| Patalganga | S1 | 21 | 6 | 1.522 | 0.7633 |
| | S2 | 24 | 6 | 1.49 | 0.7397 |
| | S3 | 13 | 4 | 1.157 | 0.7951 |
| | S4 | 10 | 4 | 1.28 | 0.899 |
| Bhogawati | S1 | 8 | 4 | 1.255 | 0.8774 |
| | S2 | 26 | 7 | 1.477 | 0.6256 |
| | S3 | 5 | 4 | 1.332 | 0.9473 |
| Amba | S1 | 21 | 5 | 0.751 | 0.4238 |
| | S2 | 23 | 8 | 1.957 | 0.8844 |
| | S3 | 29 | 10 | 2.031 | 0.762 |
| | S4 | 22 | 5 | 1.454 | 0.8556 |
| Kundalika | S1 | 21 | 5 | 1.417 | 0.8251 |
| | S2 | 21 | 6 | 1.336 | 0.6337 |
| | S3 | 26 | 12 | 2.378 | 0.8984 |
| | S4 | 32 | 13 | 2.507 | 0.9436 |
| | S5 | 17 | 6 | 1.56 | 0.7934 |
| Mandad | S1 | 9 | 7 | 1.889 | 0.9448 |
| | S2 | 9 | 6 | 1.581 | 0.81 |
| | S3 | 12 | 3 | 0.8877 | 0.8098 |
| Savitri | S1 | 111 | 14 | 2.253 | 0.6797 |
| | S2 | 93 | 13 | 2.122 | 0.6423 |

| | | | | | |
|---|---|---|---|---|---|
| | S3 | 84 | 14 | 2.164 | 0.622 |
| | S4 | 38 | 8 | 1.829 | 0.7784 |
| | S5 | 60 | 10 | 1.817 | 0.6155 |
| | S6 | 41 | 11 | 2.015 | 0.6816 |
| | S7 | 69 | 11 | 2.225 | 0.8409 |
| | S8 | 61 | 8 | 1.664 | 0.6598 |
| | S9 | 16 | 3 | 0.8314 | 0.7655 |
| | S13 | 30 | 3 | 0.3887 | 0.4917 |

* Sampling sites (S1-S13) are as abbreviated as Table 3.

## 10. Watershed and species distribution maps –

Figure 2: Savitri River basin in northern Western Ghats.

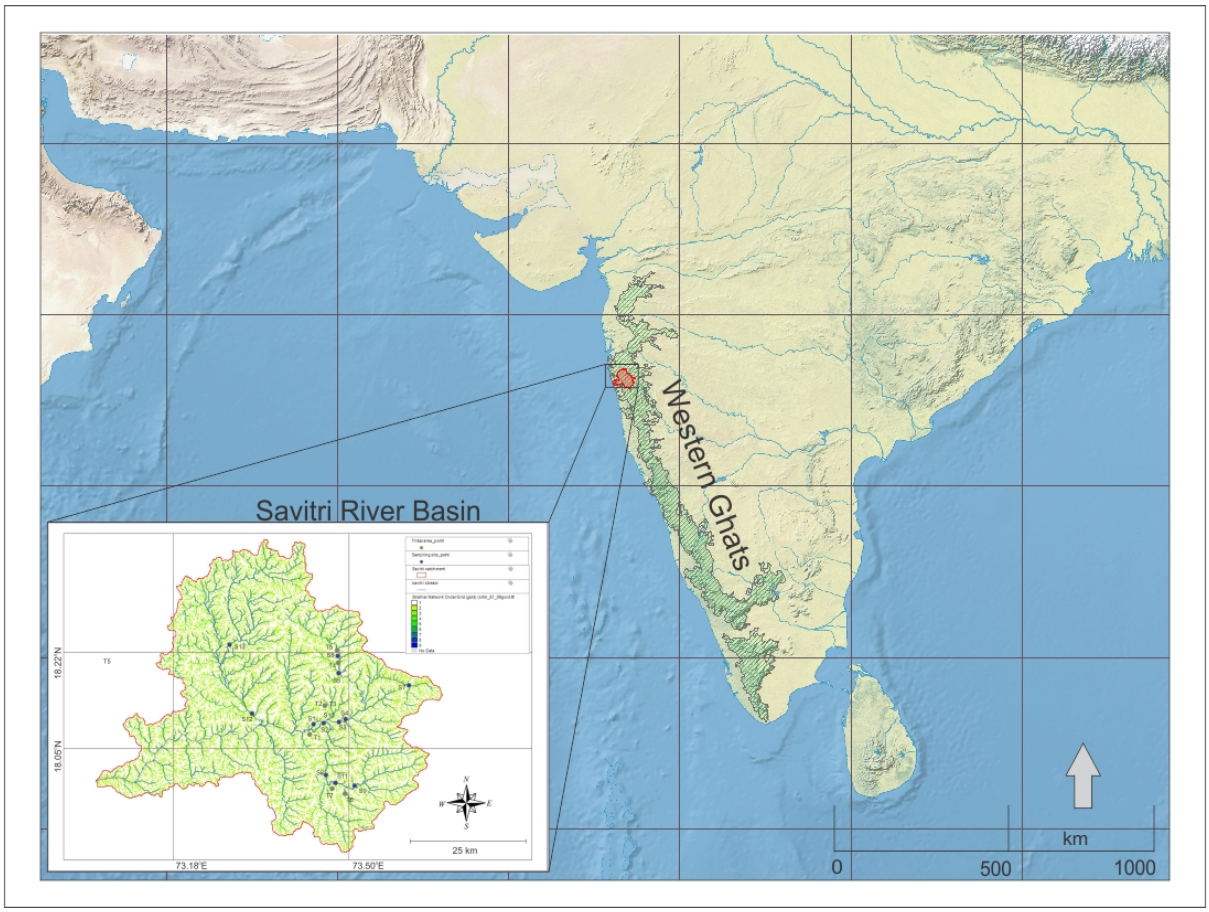


Figure 3: Sampling localities across the Savitri River basin.

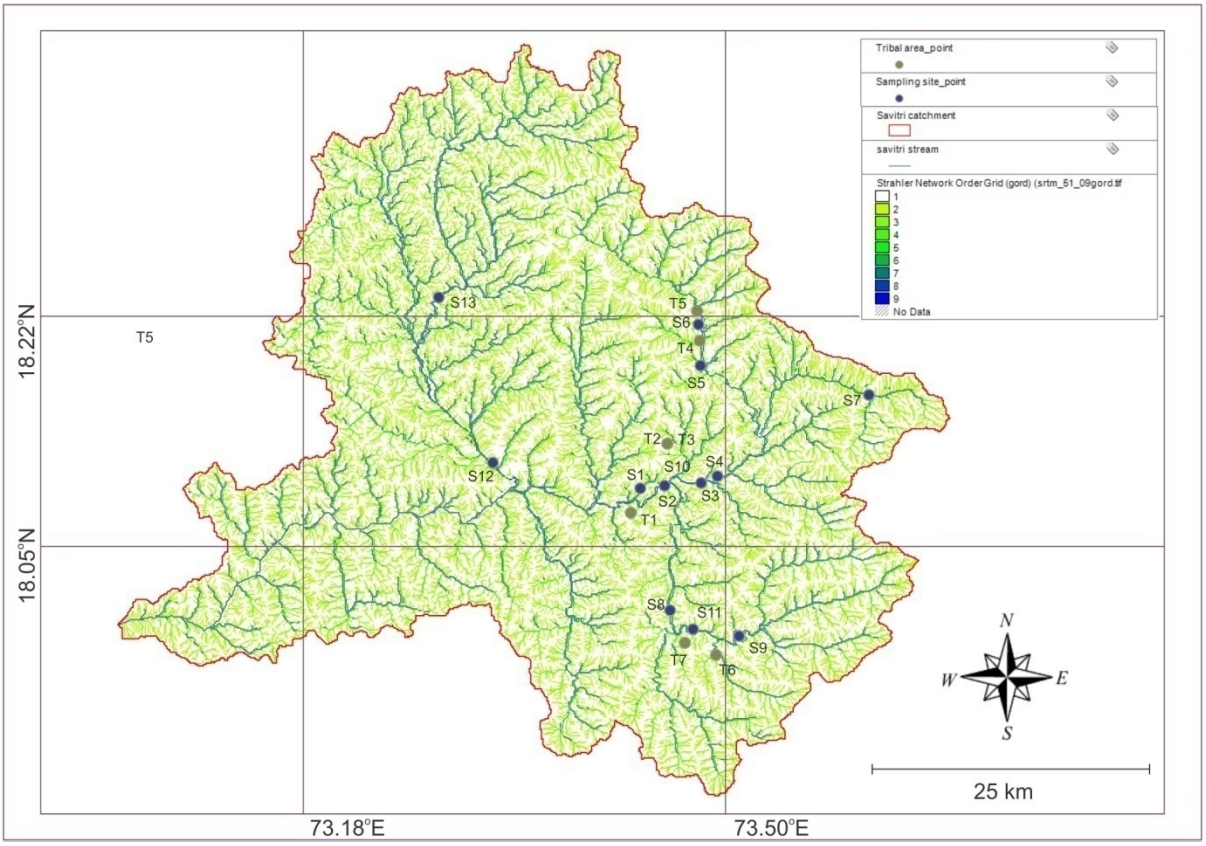


Figure 4: Distribution of rare and threatened freshwater fish species across the Savitri River basin.

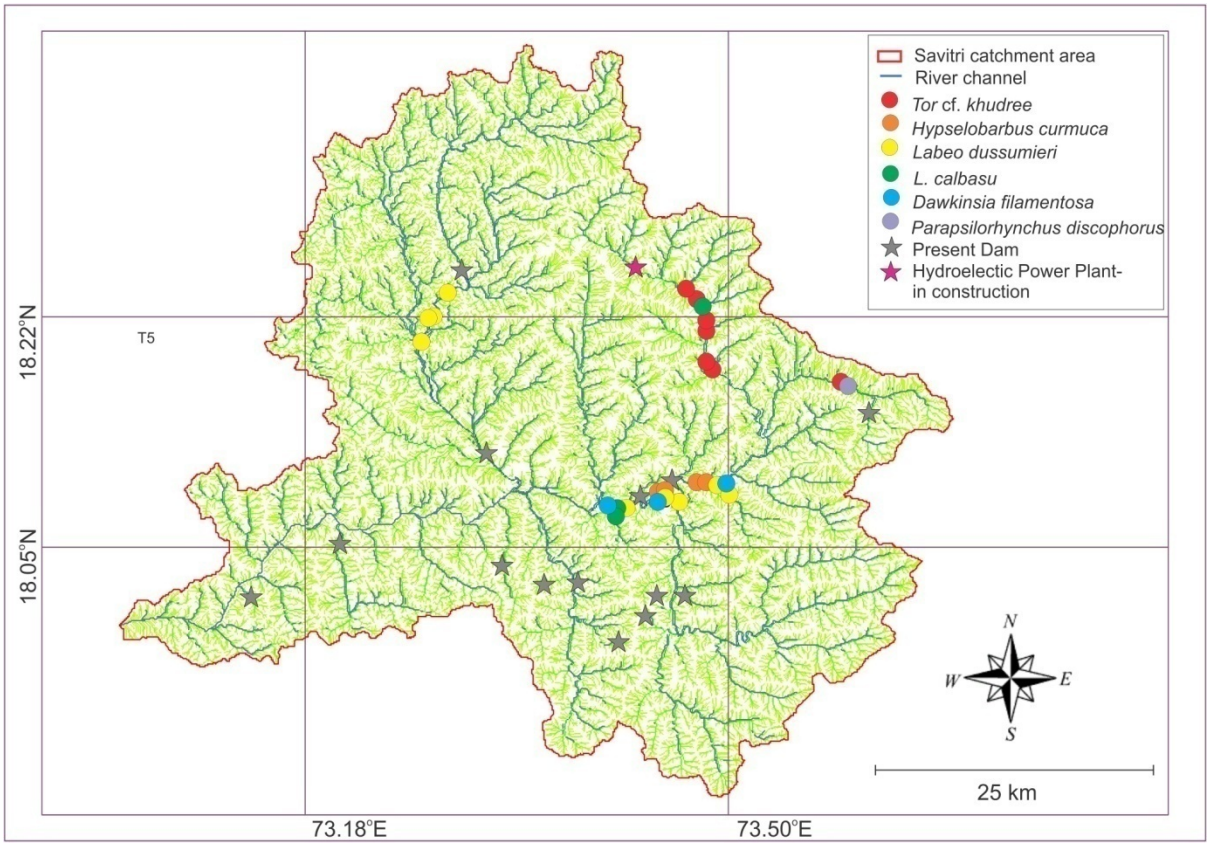


Figure 5: Distribution of newly described *Pethia lutea* in northern Western Ghats, reproduced from Katwate et al. 2014a.

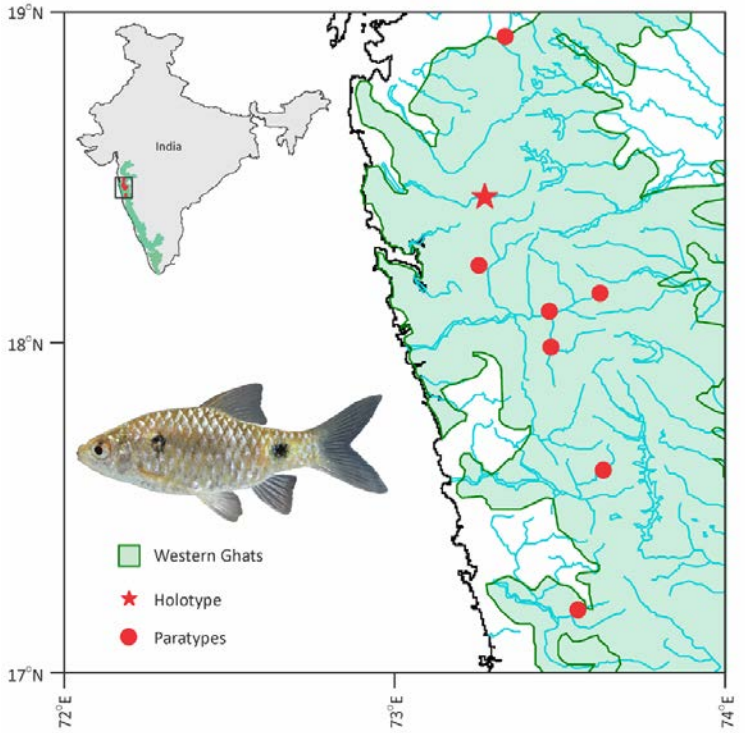
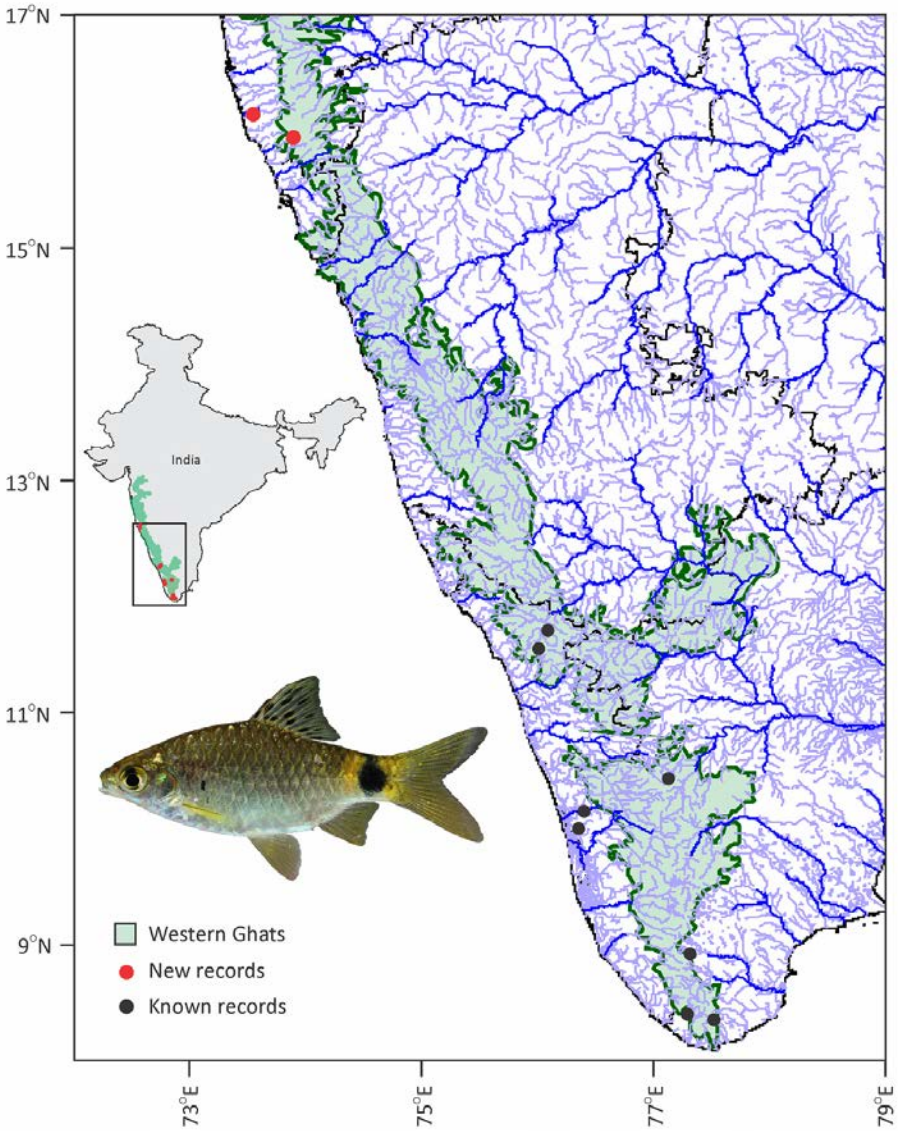


Figure 6: Distribution of *Pethia punctata* with new locality records across the Western Ghats, reproduced from Katwate et al. 2014a.



## 11. Images of freshwater fish species recorded from study area.

Image 1: Citron Barb *Pethia lutea*, new cyprinid fish species described in present study. Male specimen collected from Jagbudi River basin, Khed, Ratnagiri District in northern Western Ghats (reproduced from Katwate et al. 2014a, specimen released back in natural habitat).

Image 2: Deccan Mahseer *Tor* cf. *khudree* at Walan Kond in Savitri River basin. Population of some big Mahseer fishes is conserved through temple and community protected area.

Image 3: Long-tailed Pethia, *Pethia longicauda* – second new cyprinid fish species described in the project study from east flowing Hiranyakeshi River near Ajara, Kolhapur District (reproduced from Katwate et al. 2014b).

Image 4: Britz's chameleon fish *Badis britzi*, a new percomorph fish species described in study period.

Image 5: Record of Day's Barb or Dotted Saw fin Barb, *Pethia punctata* in west flowing rivers of Maharashtra extends its native range of occurrence further north in Western Ghats. Male specimen recorded in life from Bandiwade, Gad River (reproduced from Katwate et al. 2014a).

Image 6: *Hypselobarbus mussullah* collected from fishermen fish catch at Birwadi, Mahad in Savitri River basin.

Image 7: *Labeo dussumieri* a locally priced and endemic carp fish species collected during fish survey at Birwadi, Mahad in Savitri River basin.

Image 8: Mahecola Barb *Puntius mahecola*, an endemic species recorded in present study.

Image 9: Spike-tail paradise fish, *Pseudosphromenus cupanus* recorded from shallow poodles of Kundalika River at Roha.

Image 10: Hill stream loach *Schistura denisoni* recorded from Patalganga River at Khopoli.

Image 11: Maratha hill stream Loach *Indoreonectes evezardi* collected from high altitude streams of Kundalika River in Tamhini Ghat.

Image 12: Birth place of Kundalika River, Plus Valley in Tamhini Ghat.

Image 13: Researchers conducting fish surveys in less explored habitats like Robber's Cave, Mahabaleshwar.

Image 14: Fishing members of Katkari community with a ready to vend fish catch at Mahad.

Image 15: Freshwater biodiversity is a prime source of livelihood for Katkari tribal community.

Image 16: Katkari fishermen participated in fishing surveys in Savitri River basin at Mahad.

Image 17: Researchers carrying out fishing practices in Terekhol River, Sindhudurga District.

Image 18: Typical high altitude mountain landscape in northern Western Ghats.