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### COMMUNICATION

#### ICHTHYOFAUNAL DIVERSITY IN THE UPPER-CATCHMENT OF KABINI RIVER IN WAYANAD PART OF WESTERN GHATS, INDIA

Dencin Rons Thampy, M.R. Sethu, M. Bibin Paul & C.P. Shaji

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## Ichthyofaunal diversity in the upper-catchment of Kabini River in Wayanad part of Western Ghats, India

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**Abstract:** We present here a detailed account of the diversity, distribution, threats, and conservation of freshwater fishes in the upper-catchment of the Kabini River in the Wayanad part of the Western Ghats Biodiversity Hotspot. A total of 136 fish species belonging to 13 orders, 29 families, and 69 genera were recorded. Order Cypriniformes dominated with five families, 36 genera, and 84 species, and Cyprinidae was the dominant family represented by 51 species within 21 genera. The true diversity of ichthyofauna in this catchment, is still unclear and requires further exploration and taxonomic studies. At least 44 species recorded during the study are endemic to the Western Ghats, of which 16 are endemic to the Cauvery River System and two species endemic to the Kabini Catchment. A total of 20 non-native fish species were recorded from the study area, of which six species were inter-basin (within India) transplants and 14 species were exotic. Among the native species with confirmed identity, four are Critically Endangered (CR) and nine Endangered (EN) as per the IUCN Red List of Threatened Species. As a part of the study, we also extend the distribution ranges of *Opsarius malabaricus*, *Laubuka trevori*, *Opsarius bendelisis*, *Puntius cauveriensis*, *Oreochthys coorgensis*, *Mesonoemacheilus pambarensis*, *Hypselobarbus curmuca*, and *Pseudosphromenus cupanus* to the Kabini Catchment. The presence of four species, which were earlier considered to be endemic to the west flowing rivers of the Western Ghats, viz, *Laubuka fasciata*, *Hypselobarbus kurali*, *Sahyadria denisonii*, and *Puntius mahecola*, in an east flowing stream is reported and discussed. Deforestation and removal of riparian vegetation, pollution, stream channel modification, sand mining, destructive fishing practices, dams and other impoundments, monsoon fishing, and non-native species are the major threats to freshwater fishes in the region. Strategies for the conservation of aquatic ecosystems in the Kabini Catchment are discussed.

**Keywords:** Biodiversity hotspot, conservation, freshwater fish, species, taxonomy.

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For **Author details & Author contribution** see end of this article.

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## INTRODUCTION

The Western Ghats of India, a global biodiversity hotspot (together with Sri Lanka) is also the principal watershed of peninsular India (Myers et al. 2000). Rivers and streams of the Western Ghats are exceptionally biodiverse with high levels of endemism (Kottelat & Whitten 1996; Dahanukar et al. 2011). Much of these critical ecosystems, however, are threatened by a range of anthropogenic stressors (Dahanukar et al. 2011; Kumar et al. 2019). Around 340 species of freshwater fishes are known from the Western Ghats till date, of which more than 60% are endemic (Dahanukar & Raghavan 2013).

Despite several studies on freshwater fish fauna of southern Western Ghats, most upstream tributaries of major river systems continue to remain underexplored. Kabini is one of the major tributaries of the east flowing Cauvery River, originating from the Wayanad region of the Western Ghats. Studies on freshwater fishes of Wayanad date back to Jerdon (1847, 1849) and Day (1867) who described several species from the region, but the first comprehensive list of freshwater fishes of Wayanad was compiled only in the 1990s (Shaji & Easa 1995). Three species, viz., *Pethia pookodensis* (Mercy & Jacob 2007), *Pethia nigripinnis* (Knight, Rema Devi, Indra & Arunachalam 2012), and *Dario neela* (Britz et al. 2018), were subsequently described from this region. Most upstream tributaries of Kabini, however, continue to be poorly studied and the diversity and distribution of fish species in the river system has not been investigated in a comprehensive manner over the past two decades. In this paper, we provide an overview of the diversity and distribution of fishes in the upper-catchment region of Kabini in Wayanad, identify threats to the river and its fish species, and suggest conservation plans.

## MATERIALS AND METHODS

### Study Area

Kabini, also known as river Kapila is an important tributary of Cauvery which waters almost the entire part of the Wayanad Plateau. Kabini is an east flowing eighth order stream with a total basin area of 7,060.362km<sup>2</sup> spread across the southern Indian states of Kerala, Karnataka, and Tamil Nadu. A major part of its catchment area is in Mysore and Chamarajnagar districts of Karnataka. The river flows for around 250km before joining the main Cauvery River at Thirumakudal in Karnataka; however, in Kerala, Kabini is a seventh order

stream with a catchment area of only about 1,934.5km<sup>2</sup>.

For the present study, the total catchment area of Kabini in Wayanad was further subdivided into six sub-catchments following Wakode et al. (2011). Sub-catchments were selected based on the sixth order tributaries, and the seventh order main stem of Kabini, viz., 1. Panamaram sub-catchment, 2. Mananthavady sub-catchment, 3. Karapuzha sub-catchment, 4. Bavali sub-catchment, 5. Nugu sub-catchment, and 6. Kabini sub-catchment.

Wayanad has a total forest cover area of 907km<sup>2</sup>, divided into three major administrative divisions, viz., Wayanad Wildlife Sanctuary (344.44km<sup>2</sup>), Wayanad North (214.94km<sup>2</sup>), and Wayanad South forest divisions (347.66km<sup>2</sup>). The forest patches in various sub-catchment regions of Kabini are represented by 118.9km<sup>2</sup> in the Panamaram sub-catchment, 167.8km<sup>2</sup> in the Mananthavady sub-catchment, 4.7km<sup>2</sup> in the Karapuzha Sub-catchment, 123.2km<sup>2</sup> in the Bavali sub-catchment, 147.1km<sup>2</sup> in the Nugu sub-catchment, and 138.9km<sup>2</sup> in the Kabini sub-catchment. Nagarhole and Bandipur tiger reserves of Karnataka, and Mudumalai Tiger Reserve of Tamil Nadu are the other important protected areas in the Kabini Basin.

### Mapping

The drainage basin of Kabini River was digitized prior to the study. For the delineation of catchments and sub-catchments ArcGIS pro software and Arc Hydro tool was used. Cartosat V3.0 data was used for the delineation of the drainage basin. Streams were delineated using Arc Spatial analyst extension and hydrology tool. Drainage channels were ordered according to Strahler's (1957) classification.

### Sampling sites and methods

Fish sampling was carried out from March 2014 to March 2020. A total of 89 different stream stretches were selected across various sub-catchments of the Kabini (Image 1), with sampling done at every 500m point of the total stream length (Image 2). GPS coordinates at each sampling location was recorded using standard digital GPS reader (Garmin eTrex 30x).

Fish were collected using monofilament gillnets, cast nets and scoop nets of varying mesh size, with the help of local fishers. Traditional fishing techniques like bund making, bamboo cage traps and sieving by cloth were also used in suitable areas. Only a minimum number of fish were collected for identification and the rest were released back into the stream, immediately after capture. Samples were fixed in 5% formaldehyde after

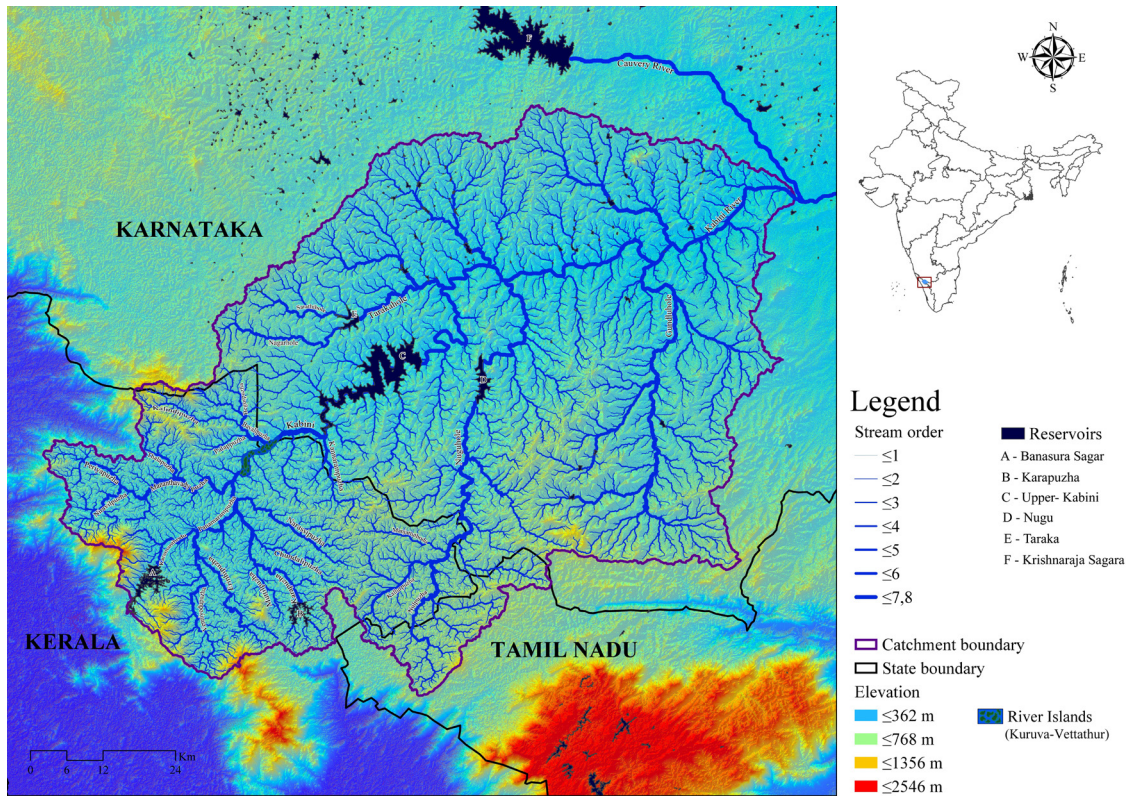


Image 1. The Kabini catchment showing major tributaries and reservoirs.

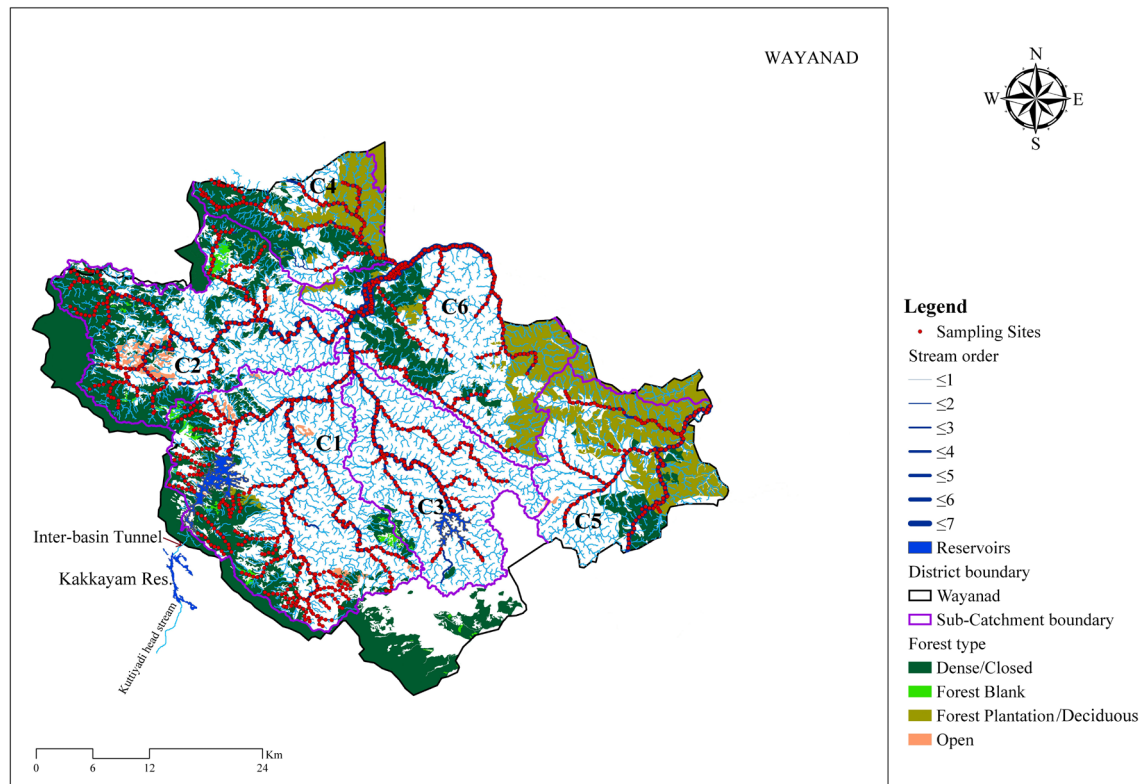


Image 2. Various sub-catchments of Kabini in Wayanad District showing sampling locations and forest cover: C1—Panamaram sub-catchment | C2—Mananthavady sub-catchment | C3—Karapuzha sub-catchment | C4—Bavali sub-catchment | C5—Nugu sub-catchment | C6—Kabini sub-catchment.

anaesthesia with clove oil and later preserved in 70% ethanol. Samples for molecular studies were directly fixed in 80–99 % ethanol. Under the same sampling effort, we categorize records of 10 or less than 10 individual specimens of a species as 'very rare', 10–50 as 'rare', 50–100 as 'moderate', and more than 100 as 'common'. This classification is not based on any standard methodology or literature.

#### Species identification and morphometry:

Measurements were made with point to point using a digital-callipers to the nearest 0.1mm. Fish were identified by comparing the measurements and counts with the type/type series and/or as mentioned in the original description. Fish identification was confirmed using the relevant taxonomic literature for each group. Collected fish specimens are deposited in the museum collection of the Zoological Survey of India Western Ghats Research Centre, Kozhikode (ZSI WGRC) and the Laboratory of Systematics and Germplasm Conservation, Kerala University of Fisheries and Ocean Studies, Kochi (KUFOS). A few species could be identified only up to the generic level, as they showed significant variations in morphology from the currently known species. Some species which closely resembled known species whose specific status could not be confirmed due to a few marked differences in morphology were labelled with cf. (confusion). Specimens which could not be identified up to species level and some species with confusing identity have not been deposited in the museum collection as further studies on them are in progress, while some other species including most of the non-native species could not be preserved due to different logistic reasons (e.g., large size). We follow Nelson et al. (2016); Tan & Armbruster (2018) for family status while overall taxonomy and nomenclature follows Fricke et al. (2020).

## RESULTS AND DISCUSSIONS

### Diversity and distribution

A total of 136 fish species belonging to 13 orders, 29 families and 69 genera were recorded from the study area (Table 1). Cypriniformes was the most dominant order with five families, 36 genera and 84 species, followed by Siluriformes with seven families, 11 genera and 21 species. Cyprinidae was the most dominant family represented by 51 species belonging to 21 genera, followed by Danionidae (19 species within eight genera) and Nemacheilidae (11 species within four genera). Lack of detailed taxonomic and systematic revisions

have rendered the diversity of several groups of fishes in the Western Ghats to be obscure. The specific identity of 45 species collected during the present study could not be confirmed. We refrain from citing some recent publications in predatory journals following the journal policy (see Raghavan et al. 2015). Among the 91 species with confirmed specific identity, 44 are endemic to the Western Ghats, of which 16 are endemic to the Cauvery River System (Image 15a–d, Image 16e,g,i,k and Image 17a–h) and two species are currently known only from the Kabini Catchment (Image 15a, Image 17g). A total of 20 non-native fish species were also recorded from the study area, of which six species were inter-basin transplants within India, and 14 species were exotic to the country. Among the 74 native species with confirmed specific identity, four are Critically Endangered (CR) (Image 15a–d), nine Endangered (EN), three Vulnerable (VU), four Near Threatened (NT), 44 Least Concern (LC), and one species Data Deficient (DD). The conservation status of a further eight species have not yet been assessed.

Panamaram sub-catchment had the highest species richness ( $n=98$ ), followed by Kabini ( $n=97$ ) and Mananthavady ( $n=90$ ) sub-catchments. Number of threatened species was highest in the Bavali sub-catchment ( $n=14$ ), followed by Panamaram sub-catchment ( $n=13$ ) (Figure 1).

Seventeen species (Table 2) which were earlier reported from Kabini could not be collected during the present study. Voucher specimens of these species are not available and based on the latest taxonomic literature, many are assumed to be misidentifications.

Kabini River Basin, identified as a freshwater Key Biodiversity Area (IUCN 2014) is among the regions of Western Ghats with the highest richness and endemism of freshwater faunal groups (Molur et al. 2011). The present study revealed that the river system is exceptionally rich in ichthyofaunal diversity. The total species richness of 136 is higher than many of the studied rivers in Kerala including the Bharathapuzha (117 species) (Bijukumar et al. 2013), and the Chalakkudy (98 species) (Raghavan et al. 2008). It is also important to note that the present study only surveyed the upper-catchment region of Kabini falling within the state boundary of Kerala and a detailed study in the lower reaches of the river and the tributaries in Karnataka may lead to more species being added into the list.

All six sub-catchment regions of Kabini support good numbers of endemic and threatened fish species, and have equal conservation value. Higher order streams running through forests (Images 6, 7 and 8) supported

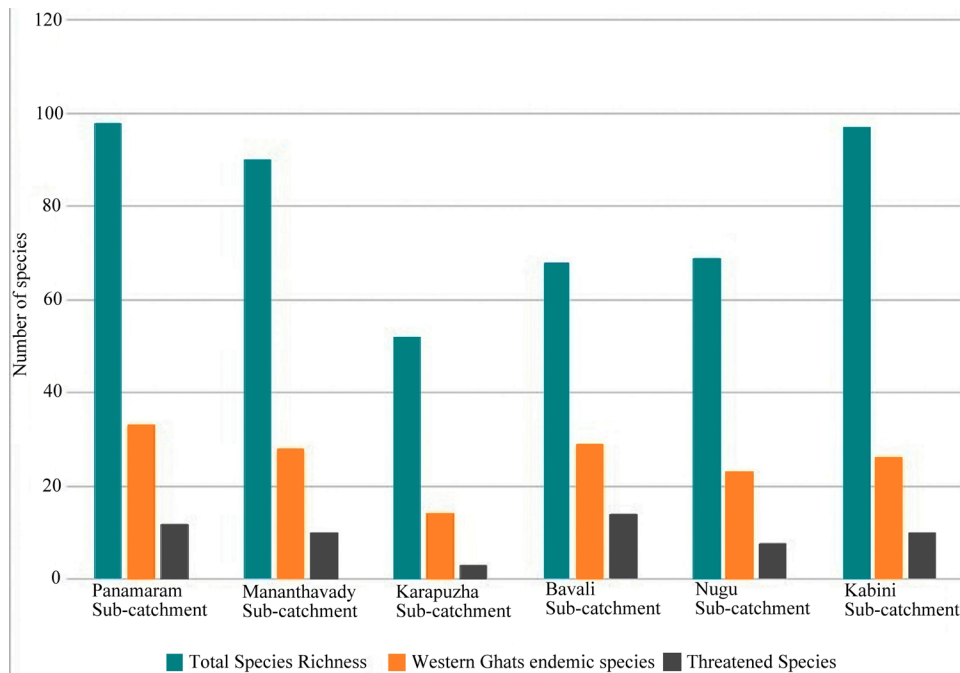


Figure 1. Fish species richness across various sub-catchments of Kabini in Wayanad.

the highest number of species, while several endemic species like *Neolissochilus wynaadensis*, *Pterocryptis wynaadensis*, *Dario neela*, loaches belonging to the family Nemacheilidae and Balitoridae and a few catfishes of the family Sisoridae could be recorded only from the lower order hill streams (Image 3,4 and 5) which are comparatively less disturbed.

Though we studied several streams in the region during the survey span of six years, records of more species are expected and further taxonomic studies are essential for calculating the true diversity of fishes in this region. It was noted that the assemblage and diversity of fishes are greatly dependent on the climatic conditions and vary between seasons, with several species available only during the monsoon.

#### Range extensions and first records

Our study revealed the presence of several species which were previously not recorded from Wayanad, and from the east flowing river systems. *Laubuka fasciata* (Image 16j), *Hypselobarbus kurali* (Image 16d), *Sahyadria denisonii* (Image 16f), and *Puntius mahecola* (Image 16h) are species considered endemic to the west flowing streams of Western Ghats (Abraham 2011a,b; Raghavan & Ali 2011; Ali et al. 2015). All four species mentioned above were recorded from various locations (Table 3) within the Banasura Sagar Reservoir and could not be collected from any other part of the Kabini

catchment. This suggests that the four species could have either been introduced to the reservoir, or might be inter-basin migrants between Kuttiyadi and Kabini rivers, facilitated by a feeder canal which connects the Banasura Sagar Reservoir with the Kakkayam Reservoir built across the west flowing Kuttiyadi River (Image 2). It is currently not understood what the nature and population status of these species inside the reservoir are, as their presence is known only from a few specimens. Juvenile specimens of *H. kurali* and *S. denisonii*, however, were collected during the present study, which confirms that both species are breeding within the reservoir limits. *Sahyadria denisonii* is also one of the most traded ornamental fishes (Raghavan et al. 2018) and therefore the possibilities of introduction of this species into the Kabini Basin by aquarist and breeders needs to be considered. *Laubuka fasciata*, *H. kurali*, and *P. mahecola* are, however, rare native species which are not commonly found in the ornamental fish trade in Kerala, and there are less likely chances of the introduction of these species into the reservoir, further supporting the idea of inter-basin migration. A feeder canal is also suspected to facilitate the movement of fish species endemic to Cauvery River System into the Kuttiyadi Basin (Gopi 2006). There is, however, no conclusive evidence to prove these speculations, and until any further information becomes available, all four species are considered native to the study region.

**Table 1. Details of fish species collected from the Upper Catchment region of Kabini River in Wayanad District from March 2014 to March 2020.**

Order/Family/Species	<sup>a</sup> Red List Status	Native/ Introduced	Presence in Kabini River System	<sup>b</sup> Endemism	Distribution	Voucher code
<b>Cypriniformes: Danionidae</b>						
<i>Opsarius gatensis</i> (Valenciennes, 1844)	LC	Native	Common	WG	C1, C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3009
<i>Opsarius malabaricus</i> Jerdon, 1849	NA	Native	Very Rare	WG	C1	ZSI/WGRC/IR/VER: 3010
<i>Opsarius bendelisis</i> (Hamilton, 1807)	LC	Native	Very Rare		C5, C6	KUFOS.F.2019.2003
<i>Salmostoma acinaces</i> (Valenciennes, 1844)	LC	Native	Common	PI	C1, C2, C3, C4, C5, C6	KUFOS.F.2019.2004
<i>Salmostoma boopis</i> (Day, 1874)	LC	Native	Moderate	WG	C1, C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3011
<i>Salmostoma balookee</i> (Sykes, 1839)	LC	Native	Common	PI	C1, C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3012
<i>Amblypharyngodon cf. mola</i> (Hamilton, 1822)	-	Native	Common		C1, C2, C3, C4, C5, C6	KUFOS.F.2019.2005
<i>Amblypharyngodon melettinus</i> (Valenciennes, 1844)	LC	Native	Rare	PI, SL	C1, C2	ZSI/WGRC/IR/VER: 3013
<i>Laubuka trevori</i> Knight, 2015	NA	Native	Very Rare	WG-CY	C1, C2	KUFOS.F.2019.2006
<i>Laubuka cf. laubuca</i> (Hamilton, 1822)	-	Native	Common		C1, C2, C3, C4, C5, C6	KUFOS.F.2019.2007
<i>Laubuka fasciata</i> (Silas, 1958)	VU	Native	Very Rare	WG-KL	C1	ZSI/WGRC/IR/VER: 3015
<i>Danio rerio</i> (Hamilton, 1822)	LC	Native	Common		C1, C2, C3, C4, C5, C6	KUFOS.F.2019.2008
<i>Devario cf. malabaricus</i> (Jerdon, 1849)	-	Native	Very Rare		C1, C2	KUFOS.F.2019.2009
<i>Devario</i> sp. 1 ***	-	Native	Rare		C1, C2, C4	
<i>Devario neilgherriensis</i> (Day, 1867)	EN	Native	Very Rare	WG-CY	C5	ZSI/WGRC/IR/VER: 3016
<i>Devario</i> sp. 2 ***	-	Native	Common		C1, C2, C3, C4, C5, C6	
<i>Esomus cf. thermoicos</i> (Valenciennes, 1842)	-	Native	Rare		C1, C2, C3, C4, C5	KUFOS.F.2019.2012
<i>Rasbora dandia</i> (Valenciennes, 1844)	LC	Native	Common	PI, SL	C1, C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3017
<i>Rasbora neilgherriensis</i> (Day, 1867) (Thampy et al. 2020)	NA	Native	Very Rare	WG-CY	C5, C6	ZSI/WGRC/IR/VER: 3140
<b>Cyprinidae</b>						
<i>Tor khudree</i> (Sykes, 1839)*	-	Transplanted	Rare		C1, C2, C4, C6	
<i>Tor remadevii</i> Kurup & Radhakrishnan, 2011*	CR	Native	Very Rare	WG-CY	C4, C5, C6	
<i>Neolissochilus wynaadensis</i> (Day, 1873)	CR	Native	Rare	WG-CY	C1, C2, C3, C4	ZSI/WGRC/IR/VER: 3018
<i>Neolissochilus</i> sp. ***	-	Native	Very Rare		C6	
<i>Systemus sarana</i> (Hamilton, 1822)	LC	Native	Rare	PI	C6	ZSI/WGRC/IR/VER: 3019
<i>Barbodes carnaticus</i> (Jerdon, 1849)	LC	Native	Moderate	WG	C1, C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3020
<i>Hypselobarbus dubius</i> (Day, 1867)	EN	Native	Very Rare	WG-CY	C4, C5, C6	ZSI/WGRC/IR/VER: 3021
<i>Hypselobarbus micropogon</i> (Valenciennes, 1842)	EN	Native	Very Rare	WG-CY	C1, C2, C4, C5, C6	ZSI/WGRC/IR/VER: 3022
<i>Hypselobarbus kurali</i> Menon & Rema Devi, 1995	LC	Native	Very Rare	WG	C1	ZSI/WGRC/IR/VER: 3023
<i>Hypselobarbus curmuca</i> (Hamilton, 1807)	EN	Native	Very Rare	WG	C4, C6	KUFOS.F.2019.2015
<i>Hypselobarbus</i> sp. ***	-	Native	Very Rare		C6	
<i>Dawkinsia rubrotincta</i> (Jerdon, 1849)	NA	Native	Rare	WG-CY	C1, C2, C3, C4, C5, C6	KUFOS.F.2019.2016
<i>Dawkinsia filamentosa</i> (Valenciennes, 1844)	LC	Native	Very Rare		C1, C6	ZSI/WGRC/IR/VER: 3024
<i>Sahyadria denisonii</i> (Day, 1865)	EN	Possibly transplanted	Very Rare	WG	C1	ZSI/WGRC/IR/VER: 3025
<i>Puntius cf. chola</i> (Hamilton, 1822)	-	Native	Common		C1, C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3026
<i>Puntius cf. sophore</i> (Hamilton, 1822)	-	Native	Common		C1, C2, C3, C4, C5, C6	KUFOS.F.2019.2017
<i>Puntius cauveriensis</i> (Hora, 1937)	EN	Native	Rare	WG-CY	C2, C4, C6	KUFOS.F.2019.2018





Order/Family/Species	<sup>a</sup> Red List Status	Native/ Introduced	Presence in Kabini River System	<sup>b</sup> Endemism	Distribution	Voucher code
<i>Puntius dorsalis</i> (Jerdon, 1849)*	LC	Native	Rare		C6	
<i>Puntius cf. parrah</i> Day, 1865	-	Native	Common		C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2019
<i>Puntius mahecola</i> (Valenciennes, 1844)	DD	Native	Very Rare	WG-KL	C1	ZSI/WGRC/IR/VER: 3027
<i>Puntius vittatus</i> Day, 1865	LC	Native	Rare		C1, C2, C4, C6	ZSI-WGRC: 3028
<i>Puntius cf. bimaculatus</i> (Bleeker, 1863)	-	Native	Common		C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2020
<i>Puntius cf. melanostigma</i> (Day, 1878)***	-	Native	Rare		C1, C2, C6	
<i>Puntius sp. 1</i> ***	-	Native	Very Rare		C5	
<i>Waikhomia cf. sahyadriensis</i> (Silas, 1953)***	-	Native	Very Rare		C2	
<i>Oreichthys coorgensis</i> (Jayaram, 1982) ***	NA	Native	Very Rare	WG-CY	C6	
<i>Haludaria fasciata</i> (Jerdon, 1849)	LC	Native	Common	WG	C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3029
<i>Pethia pookodensis</i> (Mercy & Jacob, 2007)	CR	Native	Rare	WG-KB	C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2024
<i>Pethia sp.</i> ***	-	Native	Very Rare		C6	
<i>Pethia punctata</i> (Day, 1865)	LC	Native	Rare	WG	C1	ZSI/WGRC/IR/VER: 3030
<i>Pethia conchoni</i> (Hamilton, 1822)	LC	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3031
<i>Pethia nigripinnis</i> (Knight, Rema Devi, Indra & Arunachalam, 2012)	NA	Native	Common	WG	C1, C2, C4	ZSI/WGRC/IR/VER: 3032
<i>Pethia cf. sharmai</i> (Menon & Rema Devi, 1993)***	-	Native	Rare		C6	
<i>Osteochilichthys nashii</i> (Day, 1869)	LC	Native	Rare	WG	C1, C2, C4, C5, C6	ZSI/WGRC/IR/VER: 3033
<i>Kantaka brevadorsalis</i> (Day, 1873)	LC	Native	Rare	WG-CY	C5	ZSI/WGRC/IR/VER: 3034
<i>Cirrhinus mrigala</i> (Hamilton, 1822)*	-	Transplanted	Common		C1,C2, C3, C6	
<i>Gymnostomus ariza</i> (Hamilton, 1807)	NA	Native	Common		C1,C2, C3, C5, C6	ZSI/WGRC/IR/VER: 3035
<i>Bangana cf. dero</i> (Hamilton, 1822)	-	Unknown	Common		C1, C2, C6	KUFOS.F.2019.2027
<i>Labeo kontius</i> (Jerdon, 1849)	LC	Native	Very Rare	WG-CY	C6	ZSI/WGRC/IR/VER: 3036
<i>Labeo cf. potail</i> (Sykes, 1839)***	-	Native	Very Rare		C5	
<i>Labeo cf. nigrescens</i> Day, 1870***	-	Native	Very Rare		C5, C6	
<i>Labeo calbasu</i> (Hamilton, 1822)*	-	Transplanted	Very Rare		C6	
<i>Labeo cf. boga</i> (Hamilton, 1822)	-	Unknown	Rare		C1, C2, C6	KUFOS.F.2019.2028
<i>Labeo cf. porcellus</i> (Heckel, 1844)	-	Unknown	Rare		C2, C6	KUFOS.F.2019.2029
<i>Labeo rohita</i> (Hamilton, 1822)*	-	Transplanted	Common		C1,C2, C3, C5, C6	
<i>Labeo catla</i> (Hamilton, 1822)*	-	Transplanted	Common		C1,C2, C3, C5 C6	
<i>Cyprinus carpio</i> Linnaeus, 1758*	-	Exotic	Common		C1,C2, C3, C4, C5, C6	
<i>Ctenopharyngodon idella</i> (Valenciennes, 1844)*	-	Exotic	Rare		C3, C6	
<i>Garra stenorhynchus</i> (Jerdon, 1849)	LC	Native	Moderate	WG	C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2030
<i>Garra cf. mullya</i> (Sykes, 1839)	-	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3037
<i>Garra maclellandi</i> (Jerdon, 1849)*	LC	Native	Rare	WG-CY	C1, C2, C4, C6	
<b>Balitoridae</b>						
<i>Balitora mysorensis</i> Hora, 1941***	VU	Native	Very Rare	WG	C1, C2, C4	
<i>Bhavana australis</i> (Jerdon, 1849)	LC	Native	Common	WG	C1, C2, C4, C5	ZSI/WGRC/IR/VER: 3038
<b>Nemacheilidae</b>						
<i>Paracanthocobitis cf. mooreh</i> (Sykes, 1839)	-	Native	Common		C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2031
<i>Schistura cf. denisoni</i> (Day, 1867)	-	Native	Rare		C1, C2, C4, C5, C6	KUFOS.F.2019.2032

Order/Family/Species	<sup>a</sup> Red List Status	Native/ Introduced	Presence in Kabini River System	<sup>b</sup> Endemism	Distribution	Voucher code
<i>Schistura cf. nilgiriensis</i> (Menon, 1987)	-	Native	Moderate		C1, C2	KUFOS.F.2019.2033
<i>Schistura semiarmata</i> (Day, 1867)	LC	Native	Common	WG	C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2034
<i>Schistura</i> sp. 1***	-	Native	Rare		C1, C2	
<i>Schistura</i> sp. 2***	-	Native	Rare		C2, C4	
<i>Schistura striata</i> (Day, 1867)	EN	Native	Moderate	WG-CY	C1, C2, C4, C5	KUFOS.F.2019.2037
<i>Mesonoemacheilus pambarensis</i> (Rema Devi & Indra, 1994)	VU	Native	Rare	WG-CY	C1, C4	KUFOS.F.2019.2038
<i>Mesonoemacheilus guentheri</i> (Day, 1867)	LC	Native	Common	WG	C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2039
<i>Mesonoemacheilus</i> sp.***	-	Native	Very Rare		C5, C1	
<i>Nemacheilus monilis</i> Hora, 1921	LC	Native	Rare	WG	C1, C2, C4, C5, C6	KUFOS.F.2019.2041
<b>Cobitidae</b>						
<i>Lepidocephalichthys thermalis</i> (Valenciennes, 1846)	LC	Native	Common	PI, SL	C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3038
<b>Siluriformes: Bagridae</b>						
<i>Mystus seengtee</i> (Sykes, 1839)	LC	Native	Common	PI	C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3040
<i>Mystus malabaricus</i> (Jerdon, 1849)	NT	Native	Rare	WG	C2, C6	KUFOS.F.2019.2042
<i>Mystus montanus</i> (Jerdon, 1849)	LC	Native	Common	WG	C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2043
<i>Mystus cf. armatus</i> (Day, 1865)***	LC	Native	Very Rare		C5	
<i>Mystus cf. vittatus</i> (Bloch, 1794)	-	Native	Common		C1,C2, C3, C5 C6	ZSI/WGRC/IR/VER: 3041
<i>Mystus cf. bleekeri</i> (Day, 1877)***	-	Native	Very Rare		C1	
<i>Hemibagrus punctatus</i> (Jerdon, 1849)	CR	Native	Very Rare	WG-CY	C1,C2, C4, C5, C6	ZSI/WGRC/IR/VER: 3042
<i>Batasio</i> sp.***	-	Native	Very Rare		C2	
<b>Siluridae</b>						
<i>Pterocryptis wynaadensis</i> (Day, 1873)	EN	Native	Rare	WG	C1,C2, C4	ZSI/WGRC/IR/VER: 3043
<i>Ompok bimaculatus</i> (Bloch, 1794)	NT	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3044
<i>Ompok malabaricus</i> (Valenciennes, 1840)	LC	Native	Rare	WG	C5, C6	KUFOS.F.2019.2045
<i>Wallago attu</i> (Bloch & Schneider, 1801)*	NT	Native	Very Rare		C1, C5, C6	
<b>Sisoridae</b>						
<i>Glyptothorax cf. annandalei</i> Hora, 1923	-	Native	Moderate		C1,C2, C4, C5	ZSI/WGRC/IR/VER: 3045
<i>Glyptothorax madraspatanus</i> (Day, 1873)***	EN	Native	Very Rare	WG	C4, C5, C6	
<i>Glyptothorax</i> sp. 1***	-	Native	Very Rare		C1, C2, C4	
<i>Glyptothorax</i> sp. 2***	-	Native	Very Rare		C2, C4	
<b>Clariidae</b>						
<i>Clarias gariepinus</i> (Burchell, 1822)*	-	Exotic	Common		C1,C2, C3, C4, C5, C6	
<i>Clarias cf. dussumieri</i> Valenciennes, 1840	-	Native	Very Rare		C1, C5	KUFOS.F.2019.2048
<b>Heteropneustidae</b>						
<i>Heteropneustes fossilis</i> (Bloch, 1794)	LC	Native	Moderate		C1,C2, C3, C5, C6	ZSI/WGRC/IR/VER: 3046
<b>Pangasiidae</b>						
<i>Pangasius</i> sp.*	-	Exotic	Rare		C1, C6	
<b>Loricariidae</b>						
<i>Pterygoplichthys</i> sp.*	-	Exotic	Rare		C6	
<b>Cyprinodontiformes: Aplocheilidae</b>						
<i>Aplocheilus lineatus</i> (Valenciennes, 1846)	LC	Native	Common	PI	C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3047



Order/Family/Species	<sup>a</sup> Red List Status	Native/ Introduced	Presence in Kabini River System	<sup>b</sup> Endemism	Distribution	Voucher code
<i>Aplocheilus</i> sp.***	-	Native	Common		C1,C2, C4, C6	
<b>Poeciliidae</b>						
<i>Poecilia reticulata</i> Peters, 1859*	-	Exotic	Common		C1, C2, C3, C6	
<i>Xiphophorus maculatus</i> (Günther, 1866)*	-	Exotic	Rare		C6	
<i>Xiphophorus helleri</i> Heckel, 1848*	-	Exotic	Rare		C1	
<b>Synbranchiformes: Mastacembelidae</b>						
<i>Mastacembelus armatus</i> (Lacepède, 1800)	LC	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3048
<b>Ovalentaria (incertae sedis) : Ambassidae</b>						
<i>Parambassis thomassi</i> (Day, 1870)	LC	Native	Rare	WG	C1,C2, C6	ZSI/WGRC/IR/VER: 3049
<i>Parambassis</i> cf. <i>ranga</i> (Hamilton, 1822)	-	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3050
<i>Parambassis</i> sp.***	-	Native	Very Rare		C6	
<i>Chanda nama</i> Hamilton, 1822	LC	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3051
<b>Cichliformes: Cichlidae</b>						
<i>Oreochromis mossambicus</i> (Peters, 1852)*	-	Exotic	Common		C1,C2, C3, C5, C6	
<i>Oreochromis niloticus</i> (Linnaeus, 1758)*	-	Exotic	Common		C1,C2, C3, C4, C5, C6	
<i>Pseudotropheus maculatus</i> (Bloch, 1795)	LC	Native	Common	PI,SL	C1,C2, C6	ZSI/WGRC/IR/VER: 3058
<b>Anabantiformes: Anabantidae</b>						
<i>Anabas cobojius</i> (Hamilton, 1822)*	-	Transplanted	Very Rare		C6	
<b>Pristolepididae</b>						
<i>Pristolepis marginata</i> Jerdon, 1849	-	Native	Rare	WG	C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3052
<i>Pristolepis</i> sp.***	-	Native	Rare		C1, C2, C6	
<b>Channidae</b>						
<i>Channa gachua</i> (Hamilton, 1822)	LC	Native	Common		C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2052
<i>Channa marulius</i> (Hamilton, 1822)	LC	Native	Common		C1,C2, C3, C4, C5, C6	KUFOS.F.2019.2053
<i>Channa striata</i> (Bloch, 1793)	LC	Native	Rare		C1,C2, C6	KUFOS.F.2019.2054
<i>Channa punctata</i> (Bloch, 1793)	LC	Native	Very Rare		C1,C2	KUFOS.F.2019.2055
<b>Badidae</b>						
<i>Dario neela</i> Britz, Anoop & Dahanukar, 2018	NA	Native	Rare	WG- KB	C1, C2	ZSI/WGRC/IR/VER : 2696
<b>Osphronemidae</b>						
<i>Pseudosphronemus cupanus</i> (Cuvier, 1831)	LC	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3054
<i>Osphronemus goramy</i> Lacepède, 1801*	-	Exotic	Very Rare		C3	
<i>Trichopodus trichopterus</i> (Pallas, 1770)	-	Exotic	Very Rare		C6	ZSI/WGRC/IR/VER: 3055
<b>Gobiiformes: Gobiidae</b>						
<i>Glossogobius giuris</i> (Hamilton, 1822)	LC	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3053
<b>Osteoglossiformes: Notopteridae</b>						
<i>Notopterus notopterus</i> (Pallas, 1769)	LC	Native	Common		C1,C2, C3, C4, C5, C6	ZSI/WGRC/IR/VER: 3056
<b>Anguilliformes: Anguillidae</b>						
<i>Anguilla bengalensis</i> (Gray, 1831)*	NT	Native	Very Rare		C6	
<b>Beloniformes: Hemiramphidae</b>						
<i>Hyporhamphus</i> cf. <i>limbatus</i> (Valenciennes, 1847)	-	Native	Common		C1,C2, C6	KUFOS.F.2019.2057

Order/Family/Species	<sup>a</sup> Red List Status	Native/ Introduced	Presence in Kabini River System	<sup>b</sup> Endemism	Distribution	Voucher code
<b>Belonidae</b>						
<i>Xenentodon cancila</i> (Hamilton, 1822)	LC	Native	Rare		C1, C6	ZSI/WGRC/IR/VER: 3057
<b>Characiformes: Serrasalminae</b>						
<i>Piaractus brachipomus</i> (Cuvier, 1818)*	-	Exotic	Rare		C1, C2, C6	
<b>Polypteriformes: Polypteridae</b>						
<i>Polypterus</i> sp.	-	Exotic	Very Rare		C6	KUFOS.F.2019.2058

<sup>a</sup> Endemism: WG—Western Ghats | PI—Peninsular India | SL—Sri Lanka | KL—Kerala | CY—Cauvery River System | KB—Kabini Catchment.

<sup>b</sup> IUCN Red list Categories: CR—Critically Endangered | EN—Endangered | VU—Vulnerable | NT—Near Threatened | DD—Data Deficient | NA—Not Assessed

c—Catchments: C1—Panamaram Sub-catchment | C2—Mananthavady Sub-catchment | C3—Karapuzha Sub-catchment | C4—Bavali Sub-catchment | C5—Nugu Sub-catchment | C6—Kabini Sub-catchment.

\*—specimens not preserved | \*\*\*—specimens not submitted as further studies are in progress.

*Opsarius malabaricus* (Image 16a), described from northern Malabar was considered as a synonym of *Opsarius bakeri* until Knight et al. (2015), cleared the identity of the two species, based on collections from west flowing Payaswini and Valapattanam rivers of Kasargod and Kannur districts. Ten specimens of this species were collected from two locations (Table 3), within the catchment area of Banasura Sagar Reservoir, where they are rarely seen.

*Laubuka trevori* (Image 16e), is a recently described species from the Cauvery Catchment in Coorg District of Karnataka. This species was recorded from four different locations (Table 3) within the Kabini Catchment, extending the range of this species to the Kerala part of the Western Ghats.

In Kerala, *Opsarius bendelisis* (Image 16c) is known only from Chinnar and Pambar rivers of Amaravati Catchment in Idukki District (Easa & Shaji 1996). Our study confirms the range extension of this species to northern Kerala and for the first time from the Kabini Catchment.

*Puntius cauveriensis* (Hora, 1937) (Image 16i) is an endangered barb, endemic to the Cauvery River System in Karnataka, with records from Ithipuzha and Malampuzha in west flowing Bharathapuzha requiring confirmation (Shaji 2011). In our study, we recorded *P. cauveriensis* from seven different locations (Table 3) within the Kabini Catchment extending the range of this species to the Kerala part of Western Ghats.

*Oreochthys coorgensis* (Image 16g) is a poorly known species of small barb known only from the upper reaches of the Cauvery River in Coorg District of Karnataka (Knight & Kumar 2015). We report the range extension of this species to the Kerala part of Western Ghats with specimens collected from a single location (Table 3) within Kabini Catchment.

*Pethia pookodensis* (Image 15a) is a Critically Endangered small-sized barb endemic to Wayanad, with confirmed records only from the Pookode Lake in Wayanad, the type locality (Ali & Raghavan 2015). During our study, the species was recorded from all the sub-catchments of Kabini, confirming their occurrence outside the type locality, and its wide distribution range. A reappraisal of the conservation status of the species is hence required.

*Mesonoemacheilus pambarensis* (Image 16k), currently known only from Chinnar and Pambar rivers of Amaravati Catchment in Kerala, and from the Bhavani River in Tamil Nadu (Anoop et al. 2018) was collected from four different locations (Table 3) in Wayanad, extending the range of this species to northern Kerala.

*Hypselobarbus curmuca* (Image 16b) and *Pseudosphromenus cupanus* (Image 16l), which were not recorded from Wayanad in previous ichthyofaunal studies were recorded in our study. *Hypselobarbus curmuca* was found to be very rare in Kabini with records only from two locations (Table 3), while *Pseudosphromenus cupanus* is widely distributed in the basin with records from all the major tributaries of Kabini.

### Major threats

Deforestation and removal of riparian vegetation (Image 9), pollution (Image 13), stream channel modification, sand mining, destructive fishing practices, dams & other impoundments, monsoon fishing, and non-native species are the major threats to freshwater fishes in the region. Riparian vegetation along Kabini and its major tributaries are severely disturbed, and in many cases totally destroyed. Over the past few decades, the natural vegetation across many of the streams has been cleared for agricultural plantations and construction.



Image 3. Upstream tributary of Periya River in Mananthavady sub-catchment. © Dencin Rons Thampy.

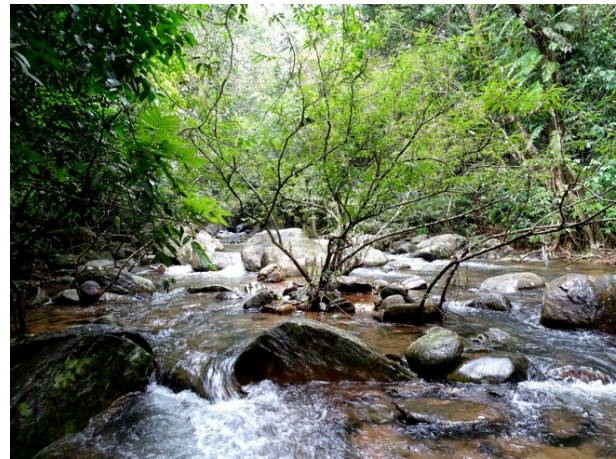


Image 4. Riparian vegetation across Lakkidipuzha, an upstream tributary of Venniyodupuzha in Panamaram sub-catchment. © Dencin Rons Thampy.



Image 5. Shade in stream habitat, riffle-pool ecosystem in Chathankunduthodu, an upstream tributary of Venniyodupuzha in Panamaram sub-catchment. © Dencin Rons Thampy.



Image 6. Nulpuzha tributary of Nugu sub-catchment in Wayanad Wildlife Sanctuary. © Dencin Rons Thampy.



Image 7. Deep pool ecosystem in a distributary of Kabini River in Kuruva-Vettathur River Islands, Kabini sub-catchment. © Dencin Rons Thampy.



Image 8. Shallow run ecosystem with boulder-bedrock substrates, distributary of Kabini at Kuruva-Vettathur River Islands, Kabini sub-catchment. © Dencin Rons Thampy.

**Table 2. Details of fish species reported from Kabini Catchment in the literature, which were not recorded during the present study.**

	Species name	Author	Remarks
1	<i>Sperata aor</i> (Hamilton, 1822)	Arunachalam et al. 2000a, 2000b	Not recorded during the present study
2	<i>Puntius amphibius</i> (Valenciennes, 1842)	Easa & Basha 1995; Shaji & Easa 1995; Easa & Shaji 1997; Shaji & Easa 1998, Arunachalam et al. 2000b & Kurup et al. 2004	Possible misidentification with <i>Puntius mahecola</i> or another <i>Puntius</i> sp., the specific identity of which could not be confirmed
3	<i>Parambassis baculis</i> (Hamilton, 1822)	Arunachalam et al. 2000a	Not recorded during the present study
4	<i>Opsarius bakeri</i> (Day, 1865)	Kurup et al. 2004	Likely to be <i>Opsarius malabaricus</i>
5	<i>Opsarius canarensis</i> (Jerdon, 1849)	Arunachalam & Manimekalan 2000b	Likely to be <i>Opsarius malabaricus</i>
6	<i>Tariqilabeo latius</i> (Hamilton, 1822).	Kurup et al. 2004	Not recorded during the present study
7	<i>Glyptothorax lonah</i> (Sykes, 1839)	Kurup et al. 2004	Possible miss misidentification with <i>Glyptothorax</i> sp. 2, the specific identity of which could not be confirmed
8	<i>Mystus oculatus</i> (Valenciennes, 1840)	Kurup et al. 2004	Not recorded during the present study
9	<i>Indoreonectes evezardi</i> (Day, 1872)	Kurup et al. 2004	Not recorded during the present study
10	<i>Mesonoemacheilus petrubanarescui</i> (Menon, 1984)	Easa & Basha 1995; Shaji & Easa 1995; Kurup et al. 2004	Possible misidentification with another similar looking species of <i>Mesonoemacheilus</i> , the specific identity of which could not be confirmed
11	<i>Tor putitora</i> (Hamilton, 1822)	Kurup et al. 2004	Likely to be <i>Tor remadeviae</i>
12	<i>Dawkinsia arulius</i> (Jerdon, 1849)	Easa & Basha 1995; Shaji & Easa 1995; Arunachalam & Manimekalan 2000a	Likely to be <i>Dawkinsia rubrotincta</i>
13	<i>Esomus danrica</i> (Hamilton, 1822)	Easa & Basha 1995; Shaji & Easa 1995b	Likely to be <i>Esomus</i> cf. <i>thermoicos</i>
14	<i>Pethia ticto</i> (Hamilton, 1822)	Easa & Basha 1995; Shaji & Easa 1995; Arunachalam & Manimekalan 2000b	Possible misidentification with <i>Pethia nigripinnis</i> or another <i>Pethia</i> sp., the specific identity of which could not be confirmed
15	<i>Hypselobarbus thomassi</i> (Day, 1874)	Easa & Shaji 2003	Not recorded during the present study
16	<i>Hypselobarbus periyarensis</i> (Raj, 1941)	Arunachalam et al. 2000b	Possible misidentification, as the species is currently considered endemic to the Periyar River Basin (Ali & Raghavan, 2011)
17	<i>Batasio travancoria</i> Hora & Law, 1941	Arunachalam & Manimekalan 2000b	Mentioned as <i>Batasio</i> sp. in the present study

The Kuruva-Vettathur River Islands (Images 1,7 and 8) is the only region in the Kabini main stem where the riparian vegetation is currently intact. Similarly, the stream stretches running through reserved forests and protected area network are the only reaches with intact or less disturbed riparian buffer. Most of the stream stretches outside forests are severely disturbed, with riparian vegetation completely removed, particularly evident in Panamaram, Karapuzha, and Mananthavady sub-catchments. Loss of forest cover negatively impacts freshwater fish and several other faunal groups, since the nutrient cycle in stream ecosystems are regulated by a healthy riparian buffer (Vannote et al. 1980; Junk et al. 1989; Pusey & Arthington 2003). In addition, several freshwater fish species in the Western Ghats exploit allochthonous food resources and use the flooded riparian forests as spawning grounds (Arunachalam 2000). Canopy cover is also important in regulating stream water temperature which in turn plays an important role in the distribution of fish communities

(Marsh-Matthews & Matthews 2000).

Indiscriminate sand and gravel mining poses irreparable damage to habitats in the Kabini. Even the smallest stream stretches in the region are exploited for sand. Large scale destruction of river beds due to sand mining for commercial purposes are evident in Panamaram River, Mananthavady River, and Kabini main stem (Image 12). Sand mining-related stream bank modifications resulted in mass failure of stream banks in several locations during the floods of 2018 and 2019.

Heavy siltation of streams due to deforestation and sand mining which modify the stream beds directly affects several endemic species as it degrades their breeding substrates (Dahanukar et al. 2011). Hill stream loaches of the families Balitoridae, Cobitidae, and Nemacheilidae, and several species of cyprinids including the Critically Endangered *Neolissochilus wynaadensis* and *Tor remadevii* are particularly vulnerable to siltation.

Indiscriminate fishing, often using destructive practices such as dynamiting and poison fishing is



**Table 3. Details of sampling locations of the species recorded for the first time in Kabini Basin.**

	Species	Details/ GPS co-ordinates of locations
1	<i>Laubuka fasciata</i>	11.597°N, 75.926°E to 11.670°N, 75.958°E
2	<i>Hypselobarbus kurali</i>	11.597°N, 75.926°E to 11.670°N, 75.958°E
3	<i>Sahyadria denisonii</i>	11.597°N, 75.926°E to 11.670°N, 75.958°E
4	<i>Puntius mahecola</i>	11.597°N, 75.926°E to 11.670°N, 75.958°E
5	<i>Opsarius malabaricus</i>	11.636°N, 75.926°E & 11.616°N, 75.929°E
6	<i>Laubuka trevori</i>	11.910°N, 75.984°E; 11.845°N, 75.939°E; 11.827°N, 75.840°E & 11.532°N, 76.025°E
7	<i>Opsarius bendelisis</i>	11.808°N, 76.095°E; 11.846°N, 76.120°E & 11.706°N, 76.396°E
8	<i>Puntius cauveriensis</i>	11.747°N, 76.128°E; 11.777°N, 75.925°E; 11.831°N, 76.093°E; 11.852°N, 76.128°E; 11.862°N, 76.098°E; 11.862°N, 76.204°E & 11.827°N, 76.209°E
9	<i>Oreochthys coorgensis</i>	11.829°N, 75.094°E
10	<i>Mesonoemacheilus pambarensis</i>	11.909°N, 75.985°E; 11.843°N, 76.113°E; 11.837°N, 75.817°E & 11.352°N, 76.025°E
11	<i>Hypselobarbus curmuca</i>	11.833°N, 76.095°E & 11.859°N, 76.101°E
12	<i>Pseudosphromenus cupanus</i>	Widely distributed: All the major tributaries and the main stem of Kabini in Wayanad.



**Image 9. Main stem of the Kabini with severe disturbance to riparian vegetation. © Dencin Rons Thampy.**

observed in almost all the major sub-catchments of Kabini. Monsoon triggers the local migration of several fish species from large rivers into smaller streams, flooded marsh lands (Image 10), paddy fields and riparian forests, which serves as their spawning grounds. This mass movement of fishes is locally called ‘ootha or ootha keattam” (Shaji & Laladhas 2013). Many of



**Image 10. “Vayals” or grassy swamp-lands are sites where many lower order streams originate, and are spawning grounds for several fish species. © Dencin Rons Thampy.**



**Image 11. Local tribal communities engaged in fishing using traditional method of bund making during the drought period, from Chekadi, Kabini sub-catchment. © Dencin Rons Thampy.**



**Image 12. Sand mining in Kolavally, Kabini sub-catchment during the drought period. © Dencin Rons Thampy.**

the migratory routes, mostly at the mouths of smaller seasonal streams are blocked and large numbers of spawning individuals are caught. Fishing during ootha, though banned by the Government of Kerala, is seldom



Image 13. Sewage disposal into river through underground tunnel. Kabini sub-catchment from Palvelicham. © Bibin Paul M.



Image 14. Flood in Kabini River; Photo taken from Chekadi, Kabini sub-catchment. © Dencin Rons Thampy.



Image 15 (a–d). Critically Endangered fish species from the Upper Kabini Catchment: a—*Pethia pookodensis* | b—*Neolissochilus wynaadensis* | c—*Tor remadevii* | d—*Hemibagrus punctatus*. © a,c—Dencin Rons Thampy | b—Abhijith T.V. | d—Rahul G. Kumar.

enforced, and is one of the major factors resulting in the decline and extirpation of several fish species.

Exotic fish species pose serious threats to the fish fauna of Kabini, especially to those having low population sizes and narrow distribution. *Cyprinus carpio*, *Ctenopharyngodon idella*, *Clarias gariepinus*, *Pterygoplichthys* sp., *Oreochromis mossambicus*, *O. niloticus*, *Poecilia reticulata*, and *Xiphophorus helleri* are invasive species as per the IUCN Global Invasive Species Database (2020). *Oreochromis niloticus*, *Clarias gariepinus*, *Poecilia reticulata*, and *Cyprinus carpio* are now well established, and widely distributed in the Kabini Basin. Occurrence of the bichir (*Polypterus* sp.) (Image 18) in the Kabini River system is known only from the collection of seven individuals during the

2018 monsoon. Similarly, species such as *Osphronemus goramy*, *Trichopodus trichopterus*, *Pterygoplichthys* sp., and *Xiphophorus helleri* were also collected only during the post flood period of 2018 and could be attributed to their escape from private aquaculture facilities during the flood. Flood-associated inundation of fish farms and other aquaculture facilities is identified as one of the major factors facilitating the introduction of several exotic species into rivers and other open water sources (Casimiro et al. 2018; Bijukumar et al. 2019).

Climate change is also accelerating the decline of fish diversity in the Kabini catchment. Kabini experienced severe shortage of water during the summers of 2017, 2018, and 2019 (Image 11), and also experienced massive floods during the monsoons of 2018 and





Image 16 (a to l). Fish species recorded for the first time from the Kabini Catchment: a—*Opsarius malabaricus* | b—*Hypselobarbus curmuca* | c—*Opsarius bendelisis* | d—*Hypselobarbus kurali* | e—*Laubuka trevori* | f—*Sahyadria denisonii* | g—*Oreichthys coorgensis* | h—*Puntius mahecola* | i—*Puntius cauveriensis* | j—*Laubuka fasciata* | k—*Mesonoemacheilus pambarensis* | l—*Pseudosphromenus cupanus*. © a—Anandu V | c,g—Rahul G. Kumar | b,d,e,f,h,i,j,k,l—Dencin Rons Thampy.

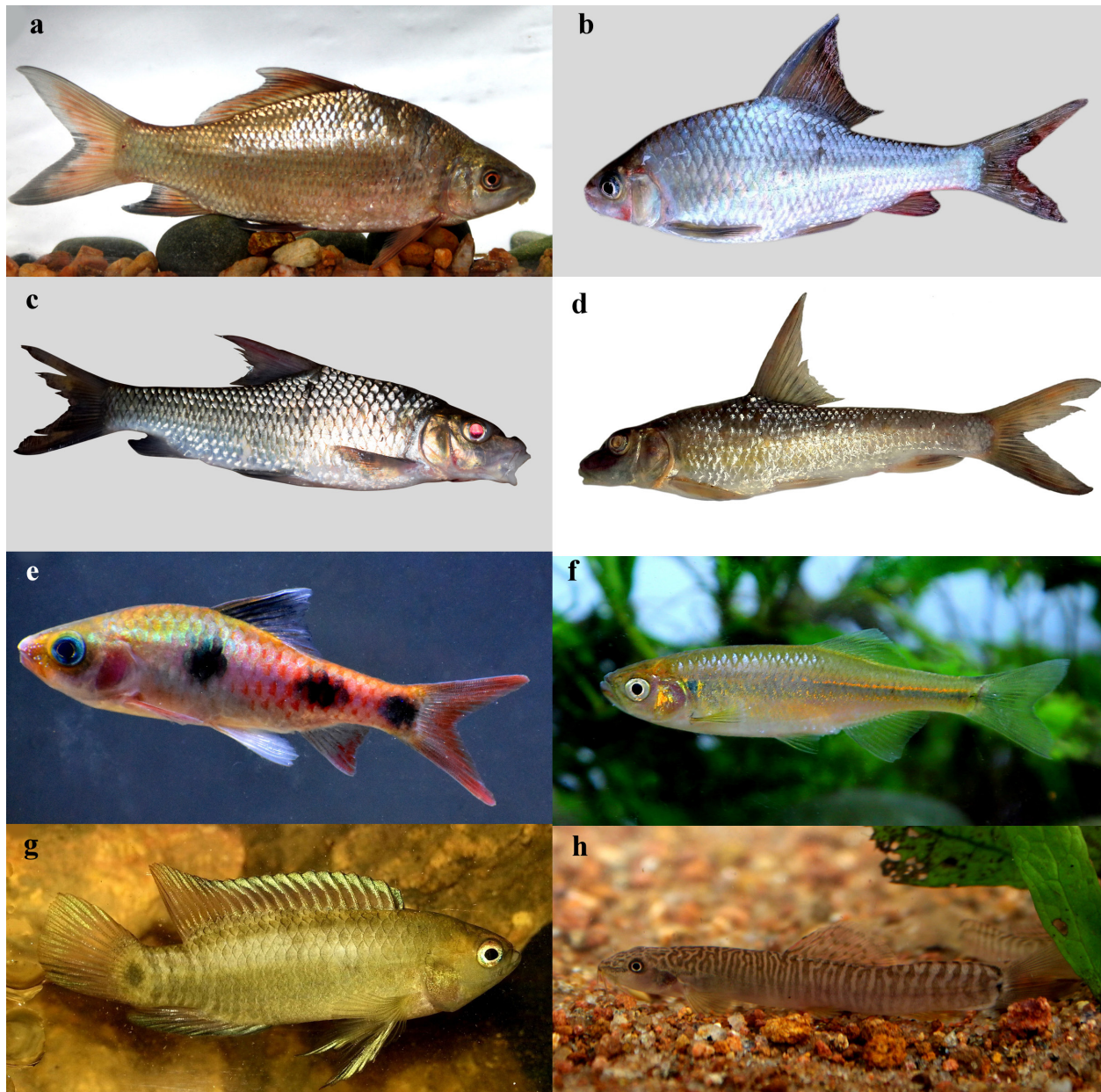


Image 17 (a-h). Endemic fish species of the Cauvery Basin: a—*Labeo kontius* | b—*Kantaka brevidorsalis* | c—*Hypselobarbus micropogon* | d—*Hypselobarbus dubius* | e—*Dawkinsia rubrotincta* | f—*Devario neilgherriensis* | g—*Dario neela* | h—*Schistura striata*. © a,b,f,g,h—Dencin Rons Thampy | c,d—Abhijith T.V. | e—Subin Yacob

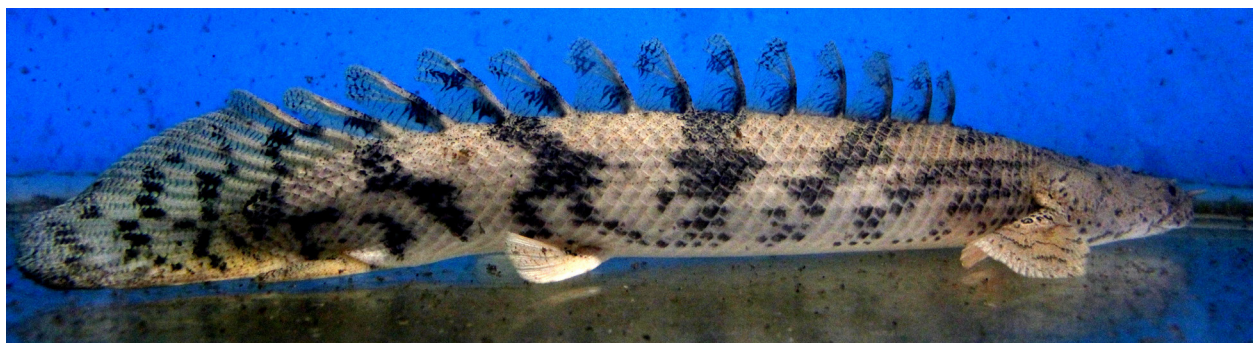


Image 18. *Polypterus* sp. from the Kabini catchment, an example for post-flood escapees. © Dencin Rons Thampy.



2019 (Image 14). Extreme climatic events increase the susceptibility of freshwater fishes to infections and disease outbreaks (Lopez et al. 2010), which was evident during the summer and post flood months of 2018 and 2019, when bacterial disease outbreaks resulted in widespread mortality of fishes at several locations in the Kabini catchment.

### Conservation measures

Streams and rivers across the Kabini Catchment are severely threatened by a range of anthropogenic activities, leading to the fragmentation of available habitats. For the effective conservation of aquatic species in the river basin, a landscape-scale conservation strategy should be implemented, such that the complexity and diversity of the watershed is maintained. Longitudinal and lateral drainage network connections including lower order streams, head-water tributaries, upper-slope areas, wetlands and flood plains in the region should be maintained to provide un-obstructed corridors, to satisfy the life history requirements of several endemic species. River protection should be taken as a priority issue by the District Environmental Impact Assessment Authority (DEIAA) before giving clearances for activities such as mining, waste disposal plants and construction. To stop further ecological degradation of the river, we recommend that clearance should not be given to any large-scale constructional activities along the stream stretches, which includes dams, buildings and roads.

Structural diversity and species integrity of plant communities in wetland and riparian zones within the catchment should be conserved and the continuity of riparian forests can be maintained via restoration of degraded landscapes. Eco-restoration of the river can be initiated by the local self-governments by collaborating with non-governmental organizations, educational institutes and other public bodies like the Vana Samrakshana Samithi of the state forest and wildlife department.

It is also important to maintain the physical integrity of the ecosystems which include stream banks, shorelines and substrates. Regular monitoring of river sand extraction, recording the severity of extraction and periodic environmental auditing could prevent further degradation of river beds. Immediate actions are to be taken by the government to stop illegal sand mining in the region. Large scale conversion of floodplains and marshes for construction and unsustainable farming practices should be prohibited by strict implementation of the available laws. Actions should also be taken to

stop the disposal of sewage water and domestic wastes into the river system.

Destructive fishing practices and indiscriminate harvest of fishes in Kabini, especially during the breeding seasons should be completely prohibited. The official ban on dynamiting and poisoning should be reinforced by the concerned authorities. Seasonal streams and marshes adjacent to the main river channels should be protected to secure the migratory corridors and spawning grounds of several native species.

Immediate actions are also to be taken to control the populations of exotic and invasive species in the river system and the introduction of new non-native species should be prevented. Farming and cultivation of non-native species in the regions adjacent to river channels should not be promoted, and parties associated with such activities have to be made aware of the issue.

Designation of river reaches in reserved forest areas as fish sanctuaries or river sanctuaries with elevated protection level will also help in conserving the habitat and the species. Kuruva-Vettathur River Island region (image 1) in the Kabini main stem is a potential site which can be declared a riverine sanctuary.

Conservation and management of aquatic environments in the Kabini Basin require research involving inter-disciplinary approaches aimed at understanding the various aspects of landscape evolution, biodiversity and socio-economic vulnerability. Awareness campaigns involving researchers, students, farmers, fishing communities and other stakeholders can be arranged at local levels to create a network of people who can be employed for long-term monitoring and restoration of ecosystems.

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**Author contributions:** DRT, conceived the idea; DRT, MBP and MRS conducted field surveys; DRT and CPS did taxonomic studies; DRT developed the manuscript with the inputs from MBP and CPS; MRS developed the maps for the study; CPS was in charge of overall direction and planning.





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