Assessing fish diversity and occurrence in the rivers of the Amravati district including Melghat, Maharashtra, India: An ecological approach

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Abstract

Fish assemblages are one of the four biological indicators used to analyze aquatic ecosystems and are a crucial component of ecosystems. The present study was carried out from the major rivers and their tributaries in Amravati district including Melghat landscape in Maharashtra. Fishes were collected with the help of locals and fishermen by following a maximum random methodology. Photographic evidence of fishes and ecological parameters concerning habitat was recorded onsite and the specificity of fishes occurrence was studied. 33 species of fishes belonging to 16 different families were recorded of which cyprinidae is the most abundant and 16 species were newly reported from the study sites. The obtained data revealed that the Wardha river showed more specificity followed by the Tapi river and others. A keen observation of species specificity reveals their preference for the particular rivers due to supporting ecological elements present there. The study shows a statistical significance for both fish documented and ecological parameters studied respectively. In a world where aquatic biodiversity is declining, this study may add to our understanding of the diversity and specificity of freshwater fishes in Maharashtra and provides important insights for conservation and management strategies.

Keywords: Freshwater, Ichthyofauna, Melghat, Purna, Tapi, Wardha.

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Introduction

Fish is one of the most important components of food for human beings because it provides proteins, lipids, vitamins, essential amino acids, fatty acids (ω3 polyunsaturated fatty acids, eicosapentaenoic and docosahexaenoic fatty acids), and minerals for the growth and development of the body as well as maintenance of human health by preventing several nutritional deficiency diseases (Sadguru, 2021).

India is an exceptional hotspot of freshwater fish diversity with a high specificity contributing to the World's biological resources. Understanding species and communities reveals crucial facts necessary for the management of ecosystems and habitats (Mogalekar, et al., 2017). Freshwater fish are not only the most diverse group of vertebrates but also have the greatest proportion of threatened species. Fish assemblages are also an important element in aquatic ecosystems, and are used as one of four biological indicators for aquatic ecosystem assessment (Guo Q. et al., 2018). A total of 34,300 fish species are identified in the world and constitute nearly 50 percent of the total vertebrates. India accounts for around 7.7% of the worldwide fish fauna of which 1,673 fishes are marine fishes and 994 are freshwater fishes (Shelake et. al., 2021).

Freshwater fish species must survive in harsher and more unpredictable environments, and human activities may put them under extreme stress. It is more difficult to plan conservation and development initiatives for water resources when considering biodiversity and its distribution through time and place since natural water has more stable conditions for fish evolution. Therefore, it is crucial to properly investigate and record fish diversity to create a freshwater diversity information system (Sadguru, 2021).

In Maharashtra, Amravati district affords natural potential for developing inland fisheries as major rivers flow through the districts like the Tapi river, Purna river, and Wardha river and their tributaries afford habitat facilities for fish life and growth. However, the resources afforded by these rivers are exploited to a beneficial extent. There is a wide scope for fisheries development in the Amravati district. Important fishery resources have been exploited and the supply of fish has been appreciably increased. Melghat Tiger Reserve is a wonderful assemblage of various ecosystems, a fully protected forest sustaining piscine fauna. There are many hill streams, nallas,

lakes, rivulets, and rivers mostly tributaries of the west–flowing river Tapi like the Khandu river, the Khapra river, the Sipna river, the Gadga river, and the Dolar river.

As per the previous literature studied (Yadav, B. E., 2005; Wagh, G. A. et. al., 2008; Wankhade, V. R., 2015) reported 96 species under 52 genera and 19 families from Melghat Tiger Reserve, 17 species from the Salbardi region near Morshi taluka of Amravati district and 36 species belonging to 11 families from the rivers of the Amravati district respectively. So to investigate the current fish diversity potential and the ecological status of different rivers in Amravati district, an effort was made. Such type of study will help in the updated documentation of fishes in the Amravati district including the Melghat landscape.

Materials and methods

Study Area

Amravati district lies between – (20° 32' and 21° 46' NL) and (76° 37' and 78° 27' EL). It occupies an area of 12,149.7 sq. Km. This district is situated right in the center of the northern border of Maharashtra State. The district is an undulating plain of black soil of a fertile type, its richest tracts being perhaps in the neighborhood of the Wardha and the Purna rivers. It is watered by several streams which rise in the Satpudas in the north. The climate of this district is characterized by a hot summer and general dryness throughout the year except during the southwest monsoon season. The temperature of the district varies between 12.4 ℃ to 44.5 ℃ and the average rainfall is 841.8.

The district is bestowed with three major rivers namely the Tapi river, Purna river, and the Wardha river, and their important tributaries like the Sapan river, Chandrabhaga river, Pedhi river, Sipna river, Gadga river, Khandu river, Khapra river, Dolar river, were surveyed during the study (Table 1). Tapi lies towards the southern part of the Melghat hills, The Purna, the largest of them rises near Bhainsdehi in the Betul district of Madhya Pradesh at a height of just over 760 meters in the Satpudas, The Wardha river rises to the east of Multai in Madhya Pradesh and forms the eastern boundary of the Amravati district and receives several short tributaries on its right flowing within the district.

In the Amravati district, the Melghat terrain is known for its dramatic and diverse landscape. The name Melghat references the chain of hills that dominate the region. These hills, part of the Satpura Range, have an average elevation of around 600 meters, with some peaks reaching up to 1000 meters. The ghats are cut through by numerous rivers like by the Khandu river, the Khapra river, the Sipna river, the Gadga river and the Dolar river which are tributaries of the Tapi river. The climate of Melghat is tropical and the forest is dry and deciduous in which December is the coldest month 13°C and 22°C is the maximum temperature. Annual rainfall amounts to 2250 mm which gradually decreases towards the North where it is recorded to 1000 mm only.

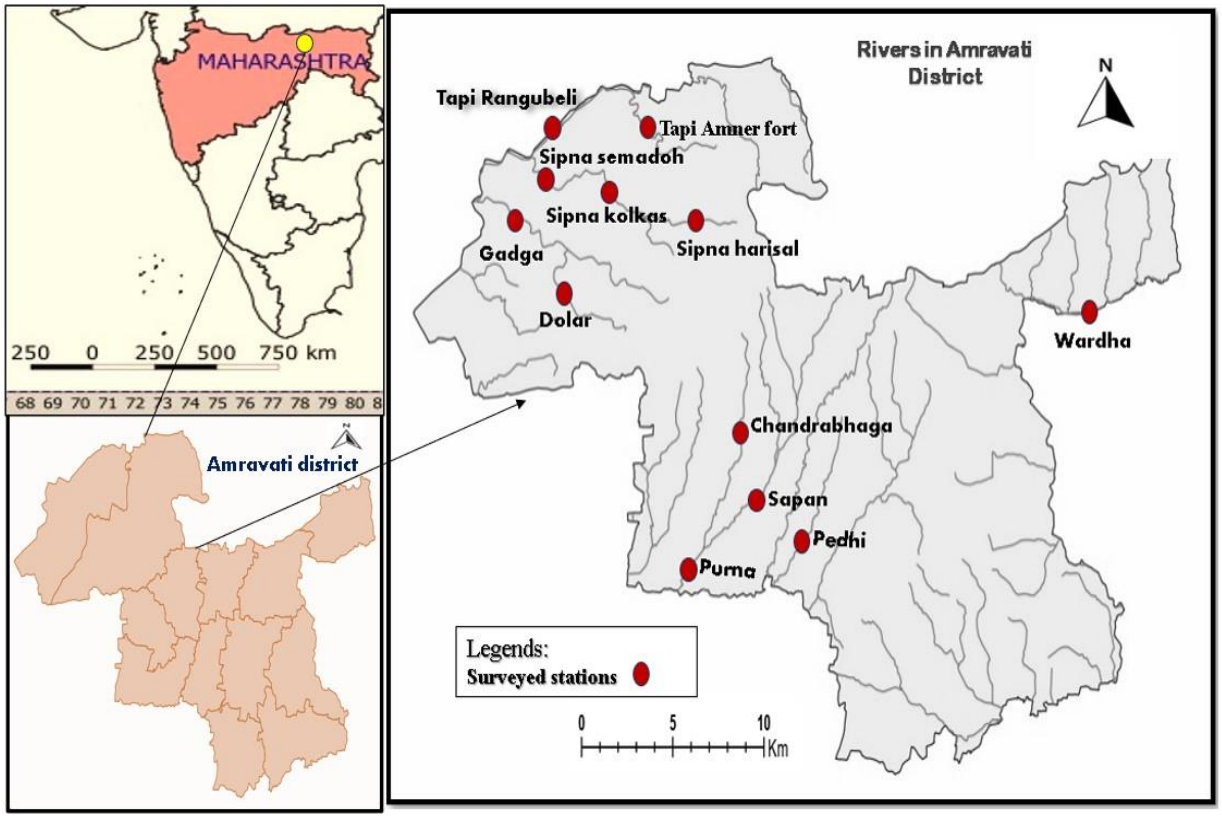

Figure 1: Map showing surveyed station in the rivers of the Amravati district including Melghat

Table 1. Stations surveyed with coordinates

Rivers	Surveyed Stations	GPS coordinates
Tapi	Rangubeli	77.14015°N and 21.71775°E
	Amner fort	76.78457°N and 21.52881°E
Sipna	Semadoh	77.31222°N and 21.497444°E

	Kolkas	77.17418°N and 21.50213°E
	Harisal	77.124218°N and 21.523066°E
Gadga	Amner fort	76.78457°N and 21.52881°E
Dolar	Dhakna	77.05934°N and 21.433778 °E
Wardha	Upparwardha	78.022228°N and 21.30918°E
Purna	Asegaon Purna	77.569182°N and 21.1267°E
Pedhi	Walgaon	77.70328°N and 20.99899°E
Sapan	Sawali	77.485433°N and 21.310439°E
Chandrabhaga	Wadgaon	77.438672°N and 21.279106°E

Methodology

The present study was carried out on fish diversity from the major rivers and their tributaries in the Amravati district including the Melghat landscape in Maharashtra (Figure 1). The study was conducted from December 2022 to October 2023. The rivers were surveyed and the confirmations of stations were done with the record of their GPS coordinates (Table 1).

Fish diversity

Fish samples were gathered monthly from local fishermen, neighboring fish markets, and landing hubs located alongside the water bodies in the chosen sampling stations. The methodology was random sampling methodology. Additionally, the specimens are taken to the laboratory where they are identified using the available standard reference material. There, each species was photographed and the morphological characteristics, were recorded and compared with the readily accessible standard keys for identification. Additionally, if necessary, the assistance of specialists from the Western Regional Centers, Zoological Survey of India, Pune, has been taken for identification.

Patterns of fish occurrence

Data on river habitat preferences were gathered when observations were being made throughout the fish- collecting process. To determine the status of specificity of fishes in a particular environment over others, it was also performed to interact with local fishermen to know about the presence of fish.

Physico- chemical parameters

To assure accuracy and consistency, assessments of physicochemical parameters in the rivers where fishes were recorded were carried out so that the present status of the habitat would came to know. These included measurements of pH levels, water temperature, total dissolved solids (TDS), dissolved oxygen (D.O.) levels, river substratum analysis, and water flow rate by following standard protocols APHA, (1995). To learn about the differences in the habitat's past and present conditions, frequent interactions with the inhabitants were done.

Data analysis

For data analysis, diversity indices like the Simpson diversity test and Shannon's diversity test were applied.

$$D = 1 - (\Sigma(n\_i * (n\_i - 1)) / (N * (N - 1)))$$

Where D is the Simpson Diversity Index, Σ represents the sum of all species, n_i is the number of individuals of the i^{th} species, and N is the total number of individuals in the community.

$$H' = -\Sigma (p\_i * \ln(p\_i))$$

Where H' is the Shannon Diversity Index, Σ represents the sum of all species, p_i is the proportion of individuals of the i^{th} species relative to the total number of individuals in the community, and ln(p_i) is the natural logarithm of p_i.

Results

A total of 33 distinct fish species belonging to 16 distinct families were recorded during the survey comprehensively conducted in the rivers of the Amravati district, encompassing the Melghat area covering its abundance, pattern of occurrence, and IUCN status (Table 2). The Cyprinidae family was discovered to be the most numerous among these species (Figure 2a).

Notably, *Oreochromis mossambicus* was listed as Vulnerable (VU), while *Tor ramadevii* and *Ompok bimaculatus* were considered Near Threatened (NT) (Figure 2 b). The Wardha river was recorded with a maximum number of 17 species of fish in which prominent species like *Oreochromis mossambius, Schistura savona* were recorded for the first time. The Chandrabhaga

and Pedhi rivers with 12 species of fishes. The Tapi river of Rangubeli stations yielded 11 fish species, including a noteworthy record of *Systomus sarana*, which is the first documented record in the Melghat. The Gadga river was found with a record of *Tor khudree* which is specific to it. The Purna River has a record of 10 fishes *Cirrhinus cirrhosus*, *Devario aequipinnatus* making a new record for the district. The Sapan river was found with 6 species of fish (Photoplate 1).

Among the rivers in the study area, five fish species that are specific to the Wardha river were discovered. The Tapi River in the Melghat region was found to be specific to three more fish species. Based on observations, the Purna river shows specificity for two fish species. One type of fish that lives only in the Pedhi river has been identified. Likewise, it was discovered that the Gadga and Chandrabhaga river each have one fish species that is specific to their rivers. By showing the existence of a variety of fish species that are only found in certain rivers in the Amravati region. The findings emphasize the need for local conservation programs and the preservation of these distinctive aquatic habitats (Table 2 and Table 3; Figure 2c).

The study found considerable seasonal differences in the physicochemical parameters of many rivers in the Amravati District, demonstrating the influence of both seasonal changes and the particular rivers on these ecological factors establishing the basis for the specificity results. Data analysis showed significant seasonal and river-specific variations in important variables such as pH, TDS (Total Dissolved Solids), dissolved oxygen (D.O.), and temperature. As the temperature rises in the warmer seasons the pH and D.O. decline and TDS increases considerably (Table 5; Figure 2-d).

Significant variations in fish populations were found across several rivers in the research area, according to the statistical analysis using ANOVA. The conventional ANOVA test resulted in a p- value of ($0.001746 < 0.05$), indicating that at least one group mean differs significantly from the others and indicating the existence of unique variances among the fish populations in various rivers of the Amravati district.

According to Simpson diversity indices, the Wardha River had the highest diversity at 0.9412 while the Gadga River had the lowest diversity at 0.5. The Shannon diversity indices also revealed a similar pattern, with Wardha having the highest at 2.833 and the Gadga river having the lowest diversity at 0.6931 (Table 4). Surprisingly, the rivers in our research region displayed

an equitable distribution of fish species, as shown by an evenness. The investigation specifically applied the non-parametric Kruskal –Wallis test to determine the statistical significance of variations in these ecological measures' medians. The extremely low computed p-value (4.265E–15 < 0.05) from this test confirmed the presence of statistically significant changes.

Table 2. List of fishes with IUCN status and Abundance of study area

SCIENTIFIC NAME	Abundance	Specificity	IUCN
Barbus barbus* **(Linnaeus, 1758)**	**Moderate**	**+**	**LC**
Barilius bendelisis* **(Hamilton, 1822)**	**Moderate**	**+**	**LC**
Cirrhinus cirrhosus* **(Bloch, 1795)**	**Abundant**	**–**	**LC**
Devario aequipinnatus* **(McClelland, 1839)**	**Moderate**	**+**	**LC**
Garra mullya **(Skyes, 1839)**	**Moderate**	**+**	**LC**
Labeo catla **(Hamilton, 1822)**	**Abundant**	**–**	**LC**
Labeo rohita **(Hamilton, 1822)**	**Abundant**	**–**	**LC**
Puntius sophore **(Hamilton, 1822)**	**Moderate**	**–**	**LC**
Rasbora doniconius **(Hamilton, 1822)**	**Moderate**	**–**	**LC**
Systomus sarana* **(Hamilton, 1822)**	**Moderate**	**–**	**LC**
Thynnichthys sandkhol* **(Skyes, 1841)**	**Abundant**	**–**	**LC**
Tor khudree* **(Skyes, 1839)**	**Moderate**	**+**	**LC**
Tor remadevii* **(Mcclelland, 1839)**	**Moderate**	**–**	**NT**
Channa punctatus **(Bloch, 1793)**	**Abundant**	**–**	**LC**
Channa marulius* **(Hamilton, 1822)**	**Abundant**	**+**	**LC**
Channa striata **(Bloch, 1792)**	**Abundant**	**–**	**LC**
Channa gachua* **(Hamilton, 1822)**	**Abundant**	**–**	**LC**
Mystus bleekeri* **(Day, 1877)**	**Moderate**	**–**	**UC**
Mystus cavasius **(Hamilton, 1822)**	**Moderate**	**+**	**LC**
Wallago attu **(Bloch and Schneider, 1801)**	**Abundant**	**–**	**LC**
Ompok bimaculatus* **(Bloch, 1754)**	**Moderate**	**+**	**NT**

***Parambassis ranga* (Hamilton, 1822)**	**Moderate**	**+**	**LC**
***Xenentodon cancila* (Hamilton, 1822)**	**Moderate**	**+**	**LC**
Oreochromis mossambius* **(Peters, 1852)**	**Moderate**	**+**	**VU**
***Clarius batratus* (Linneaus, 1758)**	**Abundant**	**–**	**LC**
Lepidocephalichthys guntea* **(Hamilton, 1822)**	**Moderate**	**+**	**LC**
***Glossogobius giuris* (Hamilton, 1822)**	**Moderate**	**–**	**LC**
***Heteropneustes fossilis* (Bloch, 1797)**	**Moderate**	**+**	**LC**
***Mastacembelus armatus* (Lacepede, 1800)**	**Abundant**	**–**	**LC**
Schistura savona* **(Hamilton, 1822))**	**Moderate**	**–**	**LC**
Notopterus notopterus (Pallas, 1769)	**Moderate**	**–**	**LC**
***Pangasius pangasius* (Hamilton, 1822)**	**Abundant**	**–**	**LC**
Pygocentrus nattereri* **(Kner, 1858)**	**Rare**	**–**	**UC**

Abbreviations: **LC** –Least concern, **NT** –Near Threatened, **VU** –Vulnerable, **UC** –Under creation; the **(+)** sign indicates the presence and the **(–)** sign indicates the absence of endemism. **Asterisk (*)** showing species are newly recorded.

Table 3. Occurrence of fishes in the rivers of the Amravati district including Melghat

FAMILY	SCIENTIFIC NAME	COMMON NAME	LOCAL NAME	TA	GA	WA	PU	SA	CA	PE
Cyprinidae	***Barbus barbus****	**The common barbel**	**Polshi**	+	–	–	–	–	–	–
	Barilius bendelisis*	**Indian hill trout**	**Mallya**	+	–	–	–	–	–	–
	Cirrhinus cirrhosus*	**Mrigal carp**	**Mrigal**	–	–	–	+	–	+	–
	Devario aequipinnatus*	**Giant danio**	**Paloti**	–	–	–	+	–	–	–
	Garra mullya	**Sucker fish**	**Gohli**	+	–	–	–	–	–	–
	Labeo catla	**Catla**	**Catla**	+	–	+	–	+	+	+
	Labeo rohita	**Rohu**	**Rohu**	+	–	+	–	+	+	+
	Puntius sophore	**Pool barb**	**Tepdi**	–	–	+	+	–	–	–
	Rasbora doniconius	**Blackline rasbora**	**Kanera**	–	–	–	+	–	+	–
	Systomus sarana*	**Olive barb**	**Dodhhad**	+	–	–	–	–	+	+
	Thynnichthys sandkhol*	**Sandkhol**	**Sandkhol**	+	–	+	–	+	+	+

	Tor khudree*	**Blue – finned Mahaseer**	**Mahaseer**	–	+	–	–	–	–	–
	Tor remadevii*	**Orange – finned Mahaseer**	**Mahaseer**	+	–	–	–	–	–	+
Channidae	***Channa punctatus***	**Spotted snakehead**	**Kallya**	–	–	+	+	–	+	–
	Channa marulius*	**Bullseye snakehead**	**Maral**	–	–	–	–	–	–	+
	Channa striata	**Stiped snakehead**	**Maral**	–	–	–	–	–	+	+
	Channa gachua*	**Dwarf snakehead**	**Dok**	–	–	–	+	+	+	–
Bagridae	***Mystus bleekeri****	**Day's mystus**	**Katarna**	–	–	–	+	–	–	+
	Mystus cavasius	**Gangetic mystus**	**Katyar**	–	–	+	–	–	–	–
Siluridae	***Wallago attu***	**Wallago attu**	**Pallan**	+	–	+	–	–	–	–
	Ompok bimaculatus*	**Butter catfish**	**Gungay**	–	–	–	+	–	–	–
Ambassidae	***Parambassis ranga***	**Indian glassy fish**	**Zanjhda**	–	–	+	–	–	–	–
Belonidae	***Xenentodon cancila***	**Freshwater garfish**	**Chache**	–	–	+	–	–	–	–
Cichlidae	***Oreochromis mossambius****	**Mazambique tilapia**	**Talpi**	–	–	+	–	–	–	–
Clarridae	***Clarius batratus***	**Walking catfish**	**Catfish**	–	–	–	+	–	–	+
Cobitidae	***Lepidocephalichthys guntea****	**Guntea loach**	**Chembal**	–	–	–	–	–	+	–
Gobiidae	***Glossogobius giuris***	**Tank gobby**	**Ghegra**	+	–	+	–	–	–	–
Heteropneustidae	***Heteropneustes fossilis***	**Fossil cat**	**Shingad**	–	–	+	–	–	–	–
Mastacembelidae	***Mastacembelus armatus***	**Zig–zag eel**	**Vam**	+	–	+	–	+	+	+
Nemacheilidae	***Schistura savona****	**Stone loach**	**Bhat**	–	–	+	–	+	+	+
Notopteridae	***Notopterus notopterus***	**Bronze featherback**	**Bhadas**	–	–	+	–	–	–	+
Pangassidae	***Pangasius pangasius****	**Pangus**	**Pangus**	–	–	+	+	–	–	–
Serrasalmidae	***Pygocentrus nattereri****	**Red–bellied piranha**	**Silver fish**	–	–	+	–	–	–	–

Abbreviations :**TA** –Tapi river, **GA** –Gadga river, **WA** –Wardha river, **PU** –Purna river, **SA** –Sapan river, **CH** – Chandrabhaga river, **PE** –Pedhi river. Asterisk (*) showing species are newly recorded.

Table 4. Diversity indices applied to the documented fish in the study area.

RIVERS	Taxa_S	Individuals	Dominance_D	Simpson_1 - –D	Shannon_H	Evenness_e^H/S
TA	11	11	0.09091	0.9091	2.398	1
GA	2	2	0.5	0.5	0.6931	1
WA	17	17	0.05882	0.9412	2.833	1
PU	10	10	0.1	0.9	2.303	1
SA	6	6	0.1667	0.8333	1.792	1
CH	12	12	0.08333	0.9167	2.485	1
PE	12	12	0.08333	0.9167	2.485	1

Abbreviations: **TA** –Tapi river, **GA** –Gadga river, **WA**–Wardha river, **PU** –Purna river, **SA** –Sapan river, **CH** – Chandrabhaga river, **PE** –Pedhi river.

Table 5. Physico -chemical parameters of rivers in the study area.

Rivers	Seasons	pH	TDS	D.O.(ppm)	TEMP (°C)
TA	**S**	7.4	250	6	33.8
	M	7.2	220	8	29.8
	W	8.4	220	7	19.8
GA	**S**	7.1	240	5	36.7
	M	7.4	200	7	28.2
	W	8.75	250	10	24.4
WA	**S**	7.5	145	7	30.5
	M	8.9	137	8	29.1
	W	9.1	145	9	22.4
PU	**S**	7.4	123	7	34
	M	9.2	190	8	30.2
	W	8.8	210	10	19.7
SA	**S**	6.1	112	6	33
	M	8.92	110	5	29.2
	W	10.7	117	11	27.5
CH	**S**	7.2	190	6	32.2
	M	8.19	201	7	31.2
	W	9.24	200	10	27.5
PE	**S**	7.2	270	7	32.1
	M	8.6	261	8	29.1
	W	8.4	133	9	29.8

Abbreviations – **S** –Summer, **M** –Monsoon, **W** –Winter; **TA** –Tapi river, **GA** –Gadga river, **WA** –Wardha river, **PU** –Purna river, **SA** –Sapan river, **CH** – Chandrabhaga river, **PE** –Pedhi river; **TDS**–Total dissolved solids, **D.O**.–Dissolvedoxygen, **TEMP** –Temperature.

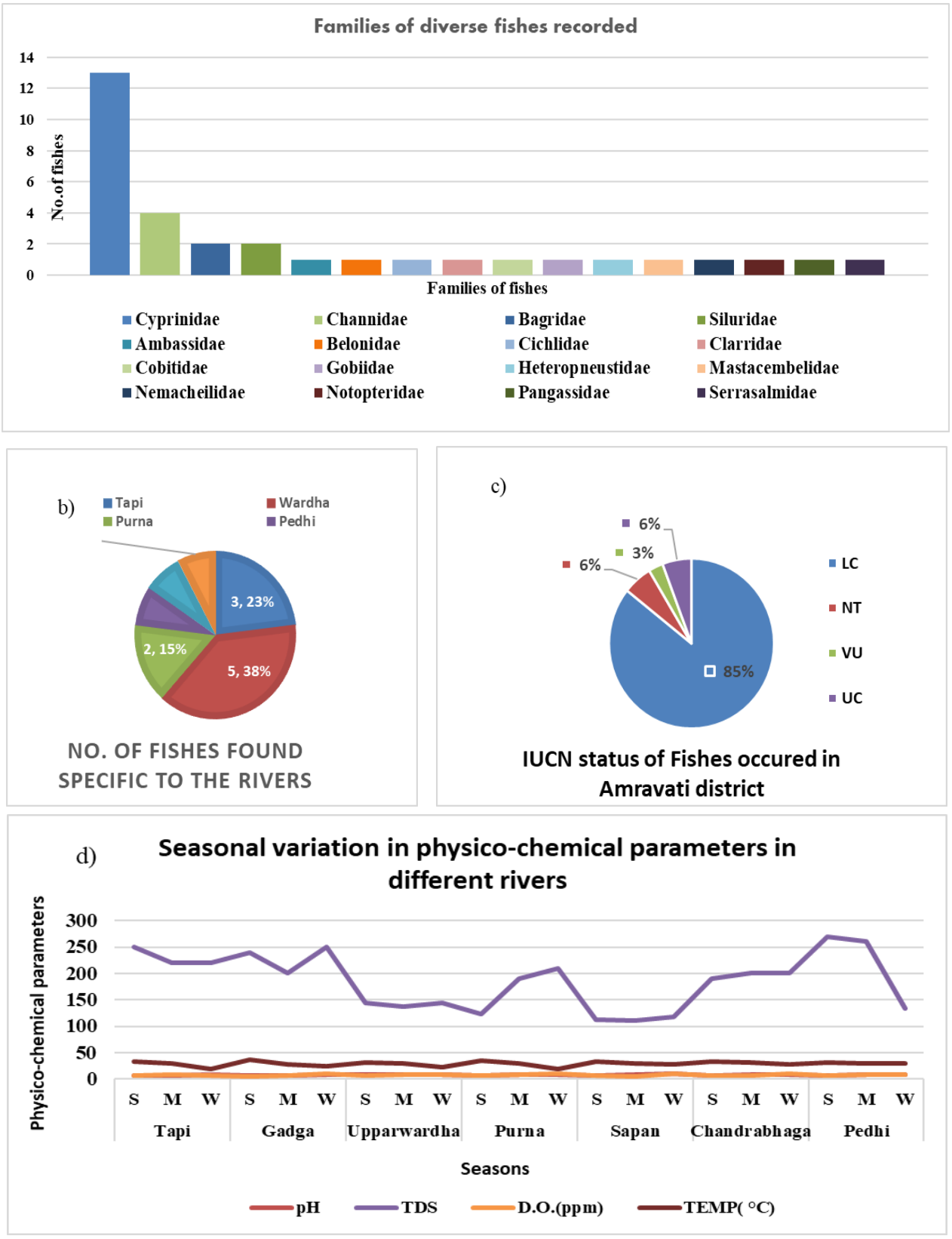

Figure 2. a) Families of diverse fishes recorded b) IUCN status of fishes c) Fishes specific to the rivers of the Amravati district d) Seasonal variation in physicochemical parameters in different rivers

Photoplate 1: Images of significant fishes reported from the study area

a) Pygocentrus nattereri b) Heteropneustes fossilis c) Notopterus notopterus d) Tor remadev
e) Mastacembelus armatus f) Labeo rohita g) Oreochromis mossambius h) Garra mullya
i) Barilius bendelisis j) Systomus sarana k) Tor khudree l) Clarius batracus

Discussion

The present research in the Amravati District has provided important insights into the diversity and distinctiveness of riverine ecosystems in the field of biodiversity studies, with an emphasis on aquatic habitats. This work builds on prior research by (Yadav B.E., 2005; Wankhade V. R., 2015), which within the area by reporting a remarkable 96 species belonging to 52 genera and 19 families within the Melghat landscape and documented 36 species from 11 different groups within the Amravati district respectively. The research done by the Western Regional Centre of the Zoological Survey of India (ZSI) in Pune has significantly contributed to growing awareness of the aquatic life in the area. In this larger setting, this research adds a novel species to the ichthyofauna of the Amravati District: the Olive barb (*Systomas sarana*), locally known as Doddhad by the Melghat tribal people and found in the Tapi river (Photoplate 1).

A total of 16 new species were recorded that were previously not reported in the area, totaling 33 species across 16 families from several rivers within the Amravati district with the strong support of statistical test ANOVA giving significant results. This shows a changing aquatic biodiversity that calls for more investigation. One more significant result has been recorded from the Wardha river in which Red-bellied piranha (*Pygocentrus nattereri)* has the noticeable feature of dentition which is native to the Amazon forest and has been introduced in India and considered an exotic species (Photoplate 1).

This research has centered on the idea of pattern of distribution of fishes, which refers to species that are exclusive to particular river. According to research done, the Wardha river is home to the most specific fish species, followed by the Tapi, Purna, Pedhi, Gadga, and Chandrabhaga rivers. By indicating unique ecological niches and adaptations within these riverine environments, this specificity highlights the individuality of these aquatic ecosystems within the Amravati district.

The study carried out thorough biological habitat studies, paying special attention to the physicochemical properties of the rivers, which were examined seasonally, to support our specificity findings. The study establishes a link between specific fish species' abundance in these rivers and ecological characteristics with the support of the statistical non-parametric Kruskal–Wallis test interfering with significant results. By examining the subtle distinctions between the physicochemical properties such as pH, temperature, dissolved oxygen, total

dissolved solids and other details of the habitat gave essential information that supports the assertion that some fishes are specific to their distinct rivers. This research highlights the dynamic character of riverine ecosystems and the need for continued studies to track and explore the fish diversity in the rivers and protect the distinctive biodiversity of the Amravati district.

Conclusion

The importance of comprehensive and multifaceted approaches to the study of riverine ecosystems is emphasized by our research. A total of 33 distinct fish species belonging to 16 distinct families were recorded with during the survey comprehensively conducted in the rivers of the Amravati district. The specificity and distribution pattern of fishes in support of the seasonal physicochemical parameters unrevealed the potential of the particular rivers. The results of our study like the first time record of *Systomus sarana* from the Melghat terrain highlight the value of ongoing investigation and observation to preserve and safeguard the unique fish biodiversity of the Amravati District with the strong support of statistical analysis tests. The consistent and extensive study will help in the exploration of unreported fish biodiversity of the Amravati district including the Melghat forest.

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