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Status and Scope of Conventional Morphometry and its Integration with Bar Coding in Jammu and Kashmir (J&K) Fisheries.

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Abstract

Correct identification is at the core of taxonomy. Although morphometric characterization is the most straightforward and cost-effective method, it has a number of limitations. By overcoming this limitation, bar coding of mitochondrial cytochrome c oxidase gene (COI) helps in accurate and cost-effective identification of fish species. This communication discusses limitations of conventional morphometry and how its integration with bar coding can help to solve the taxonomic ambiguity of morphologically similar species. Along with that information, different water bodies from J&K region have been analysed with special reference to fish diversity which revealed that the diversity is more in Jammu region as compared to Kashmir, due to favourable climatic conditions and larger number of lotic water bodies and also the fact that the integrated approach has been successfully adopted in Kashmir valley, contributing to accurate identification of fish fauna. There is a lot of room for research in this area as bar coding of fishes has just become popular in the Jammu region, despite its immaturity. This will aid in a better knowledge of the region's fish ecology, the preservation of the gene pool, and the rise of economically significant species.

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Introduction

The ichthyofauna found in riverine ecosystems provides essential supplies. Therefore, an important strategy for future sustainable use and conservation management of both the species and aquatic ecosystems is knowing the Ichthyofaunal population structure.[1]

Because it serves as the basis for all other life sciences, taxonomic clarity is a vital prerequisite. As sampling and identification are the initial stages, therefore it is the duty of a researcher to precisely identify a species for the purpose of conservation and sustainable use. In recent times, biodiversity research is under priority and new fish identification

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techniques have been developed, however, their practical application during fish identification is still in its infancy. The most popular, straightforward, economical, and historical approach of identifying fish habitats is morphometric characterization.[2,3,4]

Morphometric Characterization

All life forms express their phenotypic characters as a result of their genetic constituents and various environmental influences. Morphometrics is basically a more or less interwoven set of statistical procedures used to analyze variability in size and shape measurements of organs and organisms. Morphometric characterization is an old traditional practice being used in fisheries science since 1980's, therefore there is huge array of literature available to enhance pertinent knowledge regarding this.[5]

In order to identify a species of fish, morphological characteristics such as body shape, scale size and count, colour pattern, number and relative location of fins, type and number of fin rays, and numerous relative measures of body parts are analysed.[6] The statistical analysis of various morphometric characters has helped in recognition of various fish samples.[7]

The morphometric characterization involves the analysis of both measureable and countable characters i.e. meristic characters.[8] Even though the meristic characters provide some evidence for stock separation, morphometric characters provide the best statistical separation.[9] Analysis of morphometric characters help not only in correct identification of fishes but also in analysis of migration pattern, stock discrimination, reproductive isolation and commercially important species.[10]

Although external morphological characteristics are usually used to identify fish species, there are many distinct fish species and their many developmental phases that make it challenging to do so.[11]

Fish Habitat and its Ecology Plays A Major Role in Influencing its Morphometric Characterization.

A. Resource Specialization and Ecological Conditions of Habitat

Fish exhibit the phenomenon of morphological adaptation depending on the resources and ecological conditions of their habitat, the availability of food, the temperature etc. As a result, it is possible for the same fish raised under different ecological conditions to develop different phenotypic characteristics.[12,13,14,15,16,17] hence there is a risk of misidentification if visual assessment is employed to identify fishes.[18] Convergent and divergent adaptations also affect the correct identification.[19]

B. Morphologically Identical Species

In certain cases using morphometry for species identification yields errornous results because of close resemblance between the morphometric characters,[20] sometimes lack of quality in original description can also lead to errornous results.[21]

C. Early Life Stage

Morphological identification of eggs and larval fishes is more difficult, as their morphometric characters are not fully developed.[22,23] Morphometric characters are also subject to ontogenic transformation leading to error as they change during the process of development.[24]

D. Sex of the Fish

Although it has been seen that the sex does not significantly influence the morphometric or meristic characters[25] but error in morphological identification also depends on the sex of the fish eg. female sharks are more prone to misidentification as compared to male sharks, also the error rate is inversely propotional to body length.[26]

E. Mislabelled Fishes

Fishes identified by conventional methods being sold in market couldbe mislabeled, either intentionally to fetch higher prices or unintentionaly due to close resemblance between species, incorrect identification of edible fishes can lead to fluctuations in market prices, also some times the mislabeled fishes being sold in the market could be poisonous.[27,28,29] Therefore correct identification of fishes is essential to prevent their mislabeling.[30] Also traditional methodology helps inidentifying the live or dead fish in good form, but not applicabe for identification of processed or mixed samples.[31]

F. More Intraspecific Variations than Interspecific Variations

Even with whole fish specimens, morphometric characterization is occasionally not a good enough

option because they can display either more intraspecific variations or minor interspecific variations. For example, it can be challenging to distinguish between the various Barbus species that live in the Iberian Peninsula based solely on external morphology.[32]

G. lack of Classical Taxonomists and Pertinent Literature

Taxonomists provide crucial knowledge about ecosystem thereby providing the key information in life sciences. It has been estimated that about 6000-10000 taxonomists are working worldwide with only a few of them are from developing countries that inhabit most of the Earth's biodiversity.[33,34] This limited taxonomic community's distribution of competence is similarly uneven; more than 80% of taxonomists are either close to or older than 50 years of age, many among which are not having much computer knowledge.[35] Therefore not able to send or retrieve literature electronically, hence there is a gap in expertise, among ecologically and phylogenetically important taxon,[36] which has lead to taxonomic impediment.[37,38]

In India, not only do we lack an updated checklist of fishes, but also the identification keys which have not been updated after the work of Talwar and Jhingran (1991),[39] KC Jayaram(2010)[40] and Sarma and Mankodi (2017).[41] Also the original descriptions are referred to forever, irrespective of the quality of the paper. Making descriptive taxonomic literature available online is still a major task to promote quality in taxonomy, the unavailability of which impacts the taxonomic process, and often leads to erroneous results and phylogenetic assumptions.[36]

Academics are currently researching and utilising cutting-edge identifying techniques as a result of these difficulties. The application of DNA technologies for fish identification as a potent substitute tool has overcome the limitations of morphology-based identification approaches and the lack of local fish taxonomists.[19]

Dna Barcoding

Paul Hebert (2003) created the idea of DNA barcoding as a molecular identification tool, and it is now a frequently used approach for species identification even by non-specialists. Cytochrome oxidase subunit 1(COI), a mitochondrial DNA gene utilised as a universal bio-identifying system for an animal, is typically used as a short, standardised nucleotide sequence of DNA for the identification of fish in the process of DNA barcoding[42] Near the 5'-end of the mitochondrial gene cytochrome c oxidase subunit 1(COI) is a 648 base pair segment known as the animal barcode region.

The idea behind this method is that even within the same species, some components of an organism's DNA would vary individually. Finding these components at the species level was the very first task for the scientists who created this method. Geographic isolation causes some populations to stop sharing genetic material, and over time, separate gene pools evolve. These sub-populations maintain morphological similarity but diverge genetically, making them unable to mate and create offspring. These species are known as cryptic species. Because of this speciation, the morphological study of these populations can become questionable as we can't be exactly sure. Such situations can be easily dealt with the molecular characterization method of DNA barcoding.[43,44] Thus,it has now become a widely accepted and essential method for proper identification of species on a molecular level.

WHY COI?

This method is employed because mitochondrial DNA has unique properties, such as maternal inheritance, a high copy number per cell, a lack of recombination, a lack of introns, and a greater nucleotide substitution rate, which cause variations between species to rapidly accumulate. Due to COI's low mutation rate compared to other mitochondrial genes in animals, which facilitates its recovery using polymerase chain reaction, it was also chosen as the barcode marker.[45] A comparative analysis of three mitochondrial genes i.e16S rRNA, cytochrome b, and cytochrome oxidase subunit I (COI) revealed that cyt b and COI are appropriate for clear identification of fishes whereas the 16S rRNA fails to discriminate closely related fish species.[46]

Bar Coding of Fishes Globally and in India

DNA barcoding finds immense application and success in fisheries and furthers the results of conventional morphometry. It is now well established and practiced all across the world. The costs involved in performing the experiment

were very expensive in the past but are declining with advancements in technology.[47]

It is commonly believed that taxonomy and barcoding compete with one another for financing, but in reality, entities other than those supporting taxonomic work fund barcoding programmes. Therefore, bar coding would not in any way compete with traditional taxonomy, and the money spent on bar coding is also used to collect and preserve specimens, which are crucial for taxonomy. Therefore, the DNA barcoding programme has the potential to significantly increase fresh financing for museums, herbaria, and individual taxonomy labs rather than reducing support for taxonomy.[48]

Many workers have successfully tested the methodology of barcoding in not only identifying the species but also in the discovery of new species, monitoring of fisheries quotas, correct identification of fisheries products in market, keeping a check on trade of endangered species and identification of cryptic species.[49,50,51,52,53] Molecular characterization also assists in confirming the absence or presence of a species in given area.[54]

In India, many researchers examined Ichthyofaunal diversity using DNA barcoding as a molecular appliance both for marine as well as freshwater fishes. One of the earliest work done on bar coding of fishes in India was by Lakra *et al.*(2011)[55] for validating the application of bar coding.

Meanwhile many other researchers working on barcoding have confirmed its role in correct identification of fishes[56,57,58,59,60] and also that barcoding enhances the global data base for quick identification of fishes, validates the checklist of fish fauna of the area, identifies invasive species and helps in formulation of conservation strategies.[61,62]

Jammu & Kashmir at a Glance

Jammu & Kashmir, the northernmost state in India, is located between 32.17" and 36.58" north latitude and between 73.26" and 80.30" east to west longitude. Due to its uneven topography, the weather in Jammu & Kashmir varies drastically.

Jammu Region

Although the region is sufficiently far west compared to the region's regular 40 to 50 mm (1.6 to 2 inches) of rainfall per month between January and March, the southern regions around Jammu typically have a monsoonal climate. Jammu town can see monthly extremes of rainfall of up to 650 millimetres in August and July, while temperatures in the warmer seasons can exceed 104°F.By early October, conditions are cool and incredibly dry, with little rain and temperatures of about 29 °C (84 °F). By September end, rainfall decreases.

Kashmir Region

The region of Kashmir is renowned for its meadows, lakes, and springs. The earliest records of the area reveal that there was once a sizable lake in the valley, which was encircled by snow-covered mountains. It is thought that Kashmir Valley was once affected by earthquakes that it split apart the mountain wall near Baramulla, letting the water from Satisar Lake pour out and leaving behind karewas, or lacustrine mud, on the mountain edges. For hundreds of millions of years, Kashmir Valley was submerged beneath the Tethya Sea, and the valley's present-day tall sedimentary rock hills were originally submerged in water. The circular but erratic Valley of Kashmir was created in this way. There are many bodies of water in this area, which has a temperate climate.[63]

Water Bodies and Fish Fauna of Kashmir Region

Table 1. Showing list of lentic and lotic water bodies in Kashmir region

WATER BODIES OF KASHMIR[64]		
1Dal lake	15 Sheikhsar	29 Jhelum River
2Anchar.	16 Waskursar	30 Neelum River
3Hokersar	17Manasbal Lake	31 Lidder
4Nambli Narkara.	18Vethnar Lake	32 Rambi
5Wular.	19Ratan sar	33 Sind river
6Ajas Wetlands.	20Gaditar Lake	34 Veshaw

7Hygham.	21Sheshnag Lake
8Tarsar Lake	22Marsar Lake
9Mirgund	23Haigam Jeel
10Vishansar	24 Krishansar
11Satsar	25Nundkol Lake
12Nilnag Lake	26 Gadsar
13Kounsarnar	27 Demansar
14Didufnag Lake	28 Gangbal lake

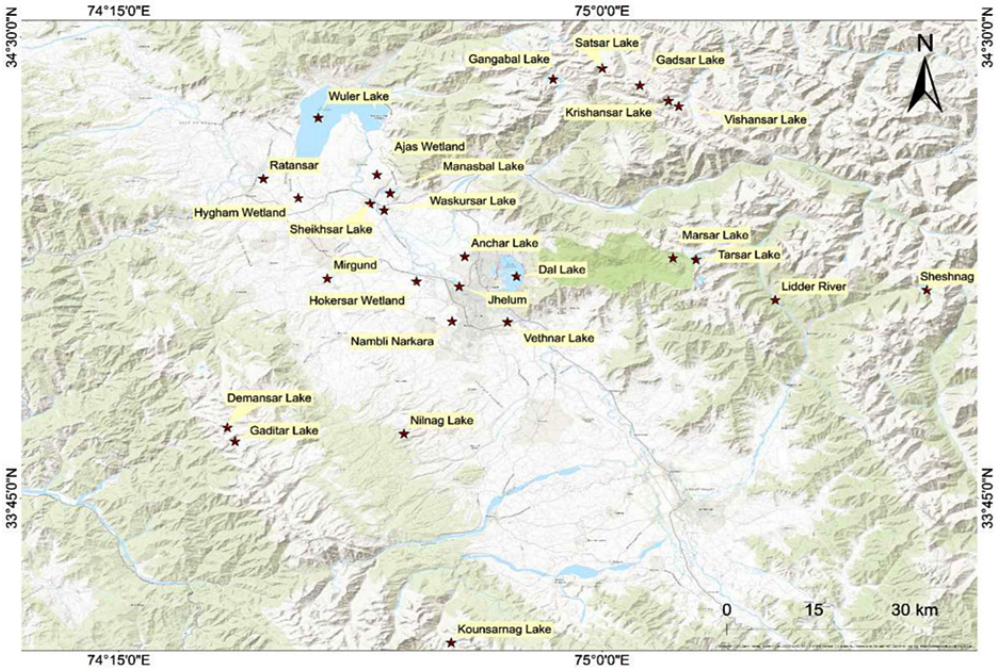

Fig 1: Displaying the GIS-marked Lentic and Lotic water bodies in the Kashmir region.

Fish Fauna of Kashmir Region

The importance of the fish fauna has substantially increased since the endeavour of Haeckel in 1838,[65] when he published "Fischeaus Caschmir" and thereafter various renowned ichthyologists have come up with very ingenious work like Day (1876),[66] Silas (1960),[67] Das and Subla (1964),[68] Das and Nath(1965),[69] Yousuf (1996),[70] Kullander *et al.*(1999),[71] Enderlin and Yousuf (1999),[72] Balkhi (2007).[73]

Following table is based on compilation of most recent data obtained from details provided by numerous workers regarding the region's fish fauna as determined by conventional morphometry.

Table 2: Status of fish fauna in Kashmir region.

WATERBODY/REFERENCE	Lotic	Lentic	FISHES FAUNA REPORTED
1 River Jhelum			ORDER:CYPRINIFORMES
a. khan and ali (2013)[74]	+		FAMILY:CYPRINIDAE
			1 Schizothorax curvifrons
			2 Schizothorax esocinus

			3 Schizothorax plagiostomus *4 Schizothorax labiatus* *5 Schizothorax niger* *6 Cyprinus carpio*
b. Jan *et al.*(2015)[75]	+		ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1 Schizothorax plagiostomus* *2 Schizothorax curvifrons* *3 Schizothorax esocinus* *4 Schizothorax labiatus* *5 Cyprinus carpio* ORDER:SALMONIFORMES FAMILY:SALMONIDAE *6 Salmo trutta fario* *7 Salmo gairdneri*
c. Ahmed *et al.*(2017)[76]	+		RIVER:JHELUM ORDER :CYPRINIFORMES FAMILY :CYPRINIDAE *1 Schizothorax Esocinus* *2.Schizothorax Plagiostomus* *3 Schizothorax Labiatus* *4 Schizothorax Curvifrons* *5.Schizothorax Niger* *6 Cyrinus Carpio Communis* *7.Cyprinus Carpio Specularis* FAMILY:NEMACHEILIDAE *8 Crossochelius Diplochilus* *9 Triplophysia Kashmirensis* *10.Triplophysa Marmorata*
2. Anchar Lake- Bashir *et al.* (2016)[77]		+	ORDER :SALMONIFORMES FAMILY:SALMONIDAE *1 Salmo trutta fario* ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE 2 S. plagiostomus 3 Schizothorax ecocinus 4 S.labiatus 5 S. niger 6 S. richardsoni 7 S. curvifrons 8 Crossocheilus diaplochilus 9 Bangana diplostoma 10 Cypinus carpio communis 11 Cyprinus carpio specularis 12 Puntius conchonius 13 Carassius carassius FAMILY:NEMACHEILIDAE 14 Tritlophysa kashmirensis ORDER:CYPRINIDONTIFORMES FAMILY:POECILIIDAE *15 Gambusia affinis*
3.Wular Wetland- a.Brraich and malik (2016)[78]		+	ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE

		1Schizothorax labiatus *2 Schizothorax esocinus* *3 Cyprinuscarpio var. communis* *4 Schizothorax micropogon* *5 Cyprinuscarpio var. specularis* *6 Ctenopharyngodon idella* *7 Schizothorax richardsonii* *8 Schizothorax niger* *9 Carassius carassius* *10 Schizothorax curvifrons* *11 Crossocheilus latius* FAMILY:NEMACHEILIDAE *12Triplophysa marmorata*
b Wular Lake- Rumysa *et al.*(2016)[79]	+	ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1Cyprinus carpio specularis* *2 Cyprinus carpio communis* *3 Carassius carassius* *4 Schizothorax niger* *5 Schizothorax esocinus* *6 Schizothorax curvifrons* *7 Schizothorax labiatus* *8 Schizothorax plagiostomus* *9 Crossochelius diplochilus* *10 Puntius conchonius* FAMILY: COBITIDAE *11 Botia birdi* FAMILY:NEMACHEILIDAE *12 Triplophysa kashmirensis* *13 Triplophysa marmorata* ORDER:CYPRINODONTIFORMES FAMILY:POECILIIDAE *14Gambusia affinis* ORDER:SILURIFORMES FAMILY:SISORIDAE *15 Glyptothorax kashmirensis* *16 Glyptothorax pectinoptrus*
c-Qadri *et al.*(2018)[80]	+	ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1 Cyprinus carpio var. communis* *2Cyprinus carpio var. specularis* *3Carassius carassius* *4Schizothorax niger* *5Schizothorax esocinus* *6Schizothorax curvifrons* *7Crossocheilus diplocheilus* *8Puntius conchonius* FAMILY:NEMACHEILIDAE *9Triplophysa spp*
4.Dal lake a-Ahmed *et al.*(2017)[76]	+	ORDER :CYPRINIFORMES FAMILY :CYPRINIDAE

			1Cyrinus Carpio Communis *2.Cyprinus Carpio Specularis* *3 SchizothoraxCurvifrons* *4. Schizothorax Niger* *5. CrossocheilusDiplochilus* 6. CarassiusCarassius ORDER:CYPRINODONTIFORMES FAMILY:POECILIIDAE *7. PuntiusConchonius* *8. GambusiaHolbrooki* FAMILY:BOTIDAE *9. BotiaBirdi*
5.Hokersar Wetland- Mushtaq *et al.* (2019)[81]		+	ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1Cyprinus Carpio. Communis* *2 Cyprinus Carpio Specularis* *3 Schizothorax Niger*
6.River Viashaw- a-Hamid and Singh(2019)[82]	+		ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE *1 Schizothorax plagiostomas* *2 Schizothorax curvifrons* *3 Schizothorax esocinus* *4 Schizothorax richardsonii* *5 Triplophysa kashmirensis* *6.Crossocheilus diplochilus*
b-Rashid and singh (2020)[83]	+		ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1 Schizothorax plagiostomus* *2 Schizothorax labiatus* *3 Schizothorax esocinus* *4 Schizothorax curvifrons* *5 Cyprinus carpio communis* FAMILY:NEMACHEILIDAE *6 Triplophysa kashmirensis* *7 Triplophysa marmorata* ORDER: SILURIFORMES FAMILY: SISORIDAE *8 Glyptosternon reticulatum*

Table 3: Summary of fish species found in Kashmir region (based on compilation of data of table 2)

ORDER	FAMILY
1.CYPRINIFORMES	CYPRINIDAE *1. Bangana diplostoma* *2. Cyprinus carpio* *3. Crossochelius Diplochilus* *4. Crossocheilus latius* *5. CarassiusCarassius*

	6. Ctenopharyngodon idella
	7. Puntius conchonius
	8. Schizothorax curvifrons
	9. Schizothorax esocinus
	10. Schizothorax plagiostomus
	11. Schizothorax micropogon
	12. Schizothorax labiatus
	13. Schizothorax niger
	14. Schizothorax richardsonii
	15. Triplophysa kashmirensis
	COBITIDAE
	1. Botia birdi
	NEMACHEILIDAE
	1. BotiaBirdi
	2. Crossochelius Diplochilus
	3. Crossocheilus latius
	4. GambusiaHolbrooki
	5. PuntiusConchonius
	6. Triplophysa kashmirensis
	7. Triplophysa marmorata
2.CYPRINIDONTIFORMES	POECILIIDAE
	1. Gambusia affinis
3.SALMONIFORMES	SALMONIDAE
	1. Salmo trutta fario
	2. Salmo gairdneri
	NEMACHEILIDAE
	1. Triplophysa kashmirensis
	2. Triplophysa marmorata
4. SILURIFORMES	SISORIDAE
	1. Glyptothorax kashmirensis
	2. Glyptothorax pectinoptrus
	3. Glyptosternon reticulatum

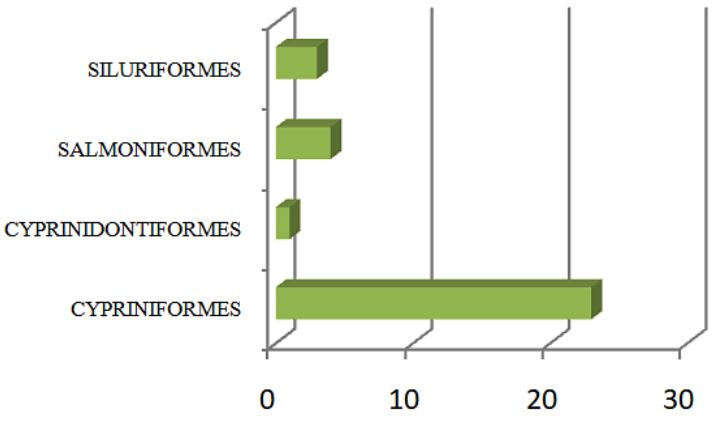

Fig. 2:Percentage contribution of different orders to fish diversity of Kashmir region (according to table 3's data)

Analysis of the data in table 2 demonstrates that only a small portion of the total number of water bodies existent (given in table 1) have been extensively studied, leaving the majority of water bodies undiscovered.

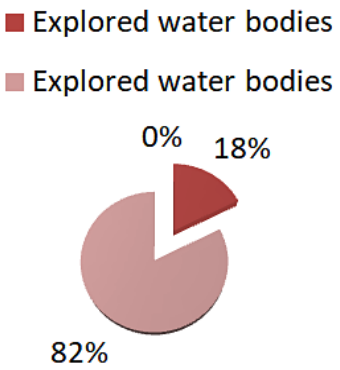

Fig. 3: Percentage of explored and unexplored water bodies of Kashmir region (based on information from tables 1 and 2).

Current Status of Barcoding Integrated with Conventional Morphometry in the Valley.

Analysis of the data (table 2) reveals that different researchers have identified different species in the same body of water, and also that there is not a significant temporal gap between those reports, therefore taxonomic ambiguity must have been a major factor in the inconsistent results reported, as many of the species native to the region are challenging to identify using conventional morphometry. Like Identification of species of genus *Schizothorax* and *Tryplophysa* through conventional methodology can some times lead to errornous results.

The morphology of the genus *Schizothorax* is strikingly similar, making it challenging to distinguish between species based on morphological characteristics. Lately collaboration of barcoding with conventional morphometry has been adopted and tested. After performing morphometric characterization to see if barcoding can aid in accurate species identification in fishes, researchers DNA-barcoded *schizothorax* species from the Neelum and Jhelum rivers in Azad Kashmir. The results showed that barcoding is accurate, dependable, and has enormous potential for species identification.[84] In addition to that a similar study on five different species of *Schizothorax* validated the role of cytochrome oxidase I in species delineation in conjunction with morphometric information and also that the Sequence-based phylogenetic analysis reveals different species groups[85] (Bashir *et al.*, 2015).

This integrated approach was also used to characterise two significant fish species from the Kashmir valley, *Triplophysa marmorata* and *T. kashmirensis*. Due to the inadequate original descriptions and the dearth of positive reviews, it is difficult to distinguish between these two species. A morphometric and molecular analysis was carried out with this in mind. Investigation concluded that these two taxonomic Triplophysa taxa should be accepted as valid based on morphological and mt DNA COI sequence analyses. These findings can help ichthyologists better understand the ichthyofauna of the Kashmir valley and may aid them in developing methods for protecting and managing these lesser-studied native tiny species within their area of distribution[21]

Water Bodies and Fish Fauna of Jammu Region

Jammu region with subtropical climate is blessed with a number of lentic and lotic water water bodies offering ample water resources for development of fisheries

WATER BODIES OF JAMMU[64]

1.Gharana Wetland	11.Chenab River
2.Pargwal Wetland	12.Tawi River
3.Sangral Wetland	13.Ravi River
4.Nanga Wetland	14.Poonch River
5.Kukrian Wetland	
6.Cheshara	
7.Mansar Lake	
8.Surinsar Lake	
9.Thein	
10.Bahu	

Fish Fauna of Jammu Region

Icthyofauna of the Jammu region was intensively investigated for the first time by Das and Nath (1965,1966)[86] eventually many workers have reported fish fauna from the region like Das and Nath (1971),[87] Malhotra *et al.* (1975)[88] Joshi *et al.* (1978),[89]Tilak (1971)[90] Dutta and Malhotra(1984),[91] Jyoti *et al.* (2006)[92] and Balkhi (2007).[73]

Following table is based on a collection of recent information on fish diversity provided by multiple workers for various lentic and lotic water bodies in the Jammu region, as determined by conventional morphometry.

Table 5: Status of fish fauna reported from the Jammu region

WATERBODY/ REFERENCE	LOTIC	LENTIC	FISHES FOUND
1. River Chenab:			ORDER:CYPRINIFORMES
a.Baba *et al.* (2014)[93]	+		FAMILY:CYPRINIDAE *1. Schizothorax plagiostomus* *2. S. labiatus 3. Tor putitora* *4. T.tor 5.Tor khudree* *6. Crossocheilus latius* *7. Garra gotyla* *8. G.lamta 9.Barilius vagra* *10. B.bendelisis 11. Labeo rohita* *12 .Labeo bata 13 .Puntius conchonius* *14. P. sophore 15. P. ticto* *16. Schizothorax richardsoni* *17.Cyprinus carpio 18. Cirrhinus reba* FAMILY:NEMACHEILIDAE *19. Nemacheilus botia* FAMILY:COBITIDAE *20.Botia dayi* ORDER:SYNBRANCHIFORMES FAMILY:MASTACEMBELIDAE *21 Mastacembalus armatus* *22 Macrognathus pancalus* ORDER:SILURIFORMES FAMILY:SISORIDAE *23. Glyptothorax botium* *24. G. pectinopterum* *25. Glyptosternum maculatum* *26 Bagarius bagarius* FAMILY:SILURIDAE *27 Wallago attu* FAMILY:BAGRIDAE *28. Mystus seenghala* *39. M. bleekeri* *30 Mystus cavasius* ORDER:BELONIFORMES FAMILY:BELONIDAE *31 Xenentodon cancila*
b.River Chenab Kishtwar district. Bhutyal and Langer(2015)[94]	+		ORDER:SALMONIFORMES FAMILY:SALMONIDAE. *1 Oncorhynchus mykiss* ORDER:SILURIFORMES FAMILY : SISORIDAE

			2 Glyptosternum reticulatum ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE *3 Schizothorax sp.* *4 Cyprinus carpio* *5.Schizothorax richardsonii*
2.River Tawi Gandotra et. al (2017)[95]	+		ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE *1 Garra gotyla 2 Schizothorax richardsonii* *3 Labeo boga 4 Tor putitora* *5 Barilius vagra 6 Puntius ticto* *7 Puntius conchonius 8 Aspidoparia morar* *9 Crossocheilus latius 10 Barilius bendelisis* *11 Schizothorax richardsonii 12 Labeo bata* *13 Puntius sophore* ORDER :BELONIFORMES FAMILY:NEMACHEILIDAE *14 Schistura montanus 15 Nemacheilus botia* ORDER:MASTACEMBELIFORMES FAMILY:MASTACEMBELIDAE *16 Mastacembelus pancalus* *17 Mastacembelus armatus* ORDER:PERCIFORMES CHANNIDAE *18 Channa punctatus 19 Channa striatus* ORDER: SILURIFORMES SISORIDAE *20 Bagarius yarrelli* BAGRIDAE *21 Mystus seenghala*
3.River Basantar Sharma and Dutta (2012)[96]		+	ORDER : OSTEOGLOSSIFORMES FAMILY : NOTOPTERIDAE *1Notopterus notopterus* ORDER : CYPRINIFORMES FAMILY:CYPRINIDAE *2 Catla catla 3. Cirrihinus mrigala* *4. Cirrihinus reba 5. Labeo gonius* *6. Labeo rohita 7. Labeo calbasu* *8. Puntius ticto 9. Puntius sophore* *10. Puntius sarana 11. Puntius chola* *12. Tor tor 13.Aspidoparia morar* *14. Barilius vagra 15. Danio devario* *16. Rasbora rasbora* *17. Crossocheilus latius diplochilus* *18. Garra gotyla* FAMILY:COBITIDAE *19. Botia dayi* ORDER:SILURIFORMES FAMILY:BAGRIDAE *20. Mystus bleekeri 21. Mystus vittatus* *22. Aorichthys seenghala 23. Rita rita*

			FAMILY:SILURIDAE *24. Ompak bimaculatus 25. Wallago attu* FAMILY:SCHILBEIDAE *26.Clupisoma garua* FAMILY:SISORIDAE *27. Bagarius bagarius 28. Gagata cenia* *29. Glyptothorax stoliczkae* ORDER : PERCIFORMES FAMILY : NANDIDAE *30. Badis badis* FAMILY:CHANNIDAE *31. Channa punctatus 32. Channa marulius* *33. Channa orientalis* ORDER : SYNBRACHIFORMES FAMILY: MASTACEMBELIDAE *34. Mastacembelus armatus* *35. Macrognathus pancalus*
4.Ornamental Fishes of Jammu Region a.Vohra *et al.* (2013)[97]	+	+	ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1 Danio devario 2 Danio rerio* *3 Chela bacaila 4 Esomus danricus* *5 Rasbora rasbora 6 Puntius spp* *7 Barilius vagra 8 Osterobrama cotia* *9 Aspidoparia morar* FAMILY: BOTIIDAE *10 Botia dayi* FAMILY:NEMACHEILIDAE *11 Noemachilus botia* FAMILY:COBITIDAE *12 Lepidocephalichthys guntea* ORDER:SILURIFORMES FAMILY:BAGRIDAE *13 Mystus bleekri* FAMILY:HETEROPNEUSTIDAE *14 Heteropneustes fossilis* ORDER:SYNBRANCHIFORMES FAMILY: MASTACEMBELIDAE *15 Macrognathus aculeate* *16 Mastacembellus sps.* *17 Mastacembellus armatus* *18 Mastacembellus pancalus* ORDER:ANABANTIFORMES FAMILY:OSPHRONEMIDAE *19 Trichogaster fasciatus* ORDER :BELONIFORMES FAMILY:BELONIDAE *20 Xenentodon cancilla* *21 Aspidoparia morar*
b.Arif *et al.* (2019)[98]	+	+	ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE *1Salmostoma bacaila*

			2 Salmostoma panjabensis *3 Aspidoparia morar 4 Barilius vagra* *5 Barilius bendelisis* *6 Rasbora rasbora 7 Esomus danricus* *8 Danio devario 9 Chela cahius* *10 C.laubuca 11Tor tor 12 T. putitora* *13 Puntius sophore 14 P. chola* *15 P. ticto 16 P. conchonius* *17 P.sarana 18 Crossocheilus latius* FAMILY:NEMACHEILIDAE *19 Nemacheilus botia* ORDER:SILURIFORMES FAMILY :BAGRIDAE *20 Mystus seenghala 21 Mystus bleekeri* FAMILY:HETEROPNEUSTIDAE *22 Heteropneustes fossilis* ORDER:BELONIFORMES FAMILY:BELONIDAE *23 Xenentodon cancilia* ORDER:SYNBRACHIFORMES FAMILY:MASTACEMBELIDAE *24 Mastacembelus armatus* *25 Macrognathus pancalus* ORDER:ANABANTIFORMES FAMILY :CHANNIDAE *26 Channa punctatus 27 C. striatus* *28 C.maruilius* FAMILY:OSPHRONEMIDAE *29 Trichogaster fasciatus* ORDER:PERCIFORMES FAMILY:BADIDAE *30 Badis badis*
5.Erstwhile Udhampur District Dutta (2015)[99]	+	+	ORDER : CYPRINIFORMES FAMILY : CYPRINIDAE *1 Hypothalmichthys molitrix* *2 Salmostoma bacaila 3 Aspidoparia morar* *4 Barilius vagra vagra 5 B. bendelisis* *6 B. shacra 7 B. modestus 8 B. radiolatus* *9. Esomus danricus 10 Danio devario* *11Brachydanio. rerio 12 Rasbora. rasbora* *13 Amblypharyngodon. mola* *14 Ctenopharyngodon idellus* *15 Cyprinus carpio communis* *16 C. carpio specularis 17 Tor. tor* *18. T. putitora 19 . Catla catla* *20 Osteobrama. cotio cotio* *21 Puntius.sarana sarana* *22 Puntius. conchonius 23 P. terio* *24 P. ticto 25 P. chola 26 P. sophore* *27 Cirrhinus mrigala 28 C reba* *29 Labeo bata 30. Labeo calbasu*

31. L. dero 32. L. dyocheilus dyocheilus
33. L. pangusia 34. L. rohita
35. Schizothrax. richardsonii
36. Schizothorichthys. progastus
37. S. esocinus 38. S. curvifrons
39. Crossoscheilus. latius diplocheilus
40. Garra. gotyla gotyla 41. Garra. lamta
42. Nemacheilus. corica
43. Acanthocobitis.botia
44. Schistura. punjabensis
45. S.montanus 46. Triplophysa. yasinensis
47. Botia. almorhae 48. B. birdi
49. B. lohachata 50. B. dario
51. Lepidocephalus. guntea
ORDER : SILURIFORMES
FAMILY : BAGRIDAE
52. Mystus. bleekeri 53. M. cavasius
54. M. vittatus 55. Aorichthys. seenghala
FAMILY :SILURIDAE
56. Ompok. bimaculatus 57. O. pabda
58. Wallago. attu
FAMILY : SCHILBEIDAE
59. Eutropiichthys. vacha
FAMILY : AMBLYCIPITIDAE
60. Amblyceps.mangois
FAMILY :SISORIDAE
61. Bagarius. bagarius
62.Glytosternon. reticulatum
63. Glyptothorax. pectinopterus
64. G. indicus 65. G. telchitta telchitta
66. G. cavia 67. G. Kashmirensis
68. G. punjabensis
FAMILY:HETEROPNEUSTIDAE
69. Heteropneustes. fossilis
ORDER :BELONIFORMES
FAMILY:BELONIDAE.
70. Xenentodon. cancila
ORDER : SYNBRANCHIFORMES
FAMILY: MASTACEMBELIDAE
71. Macroganthus. pancalus
72. Mastacembelus. armatus
ORDER : PERCIFORMES
FAMILY: BELONTIDAE
73. Colisa fasciatus
FAMILY :CHANNIDAE
74. Channa. Orientalis
75. C. punctatus
ORDER :SALMONIFORMES
FAMILY : SALMONIDAE
76. Salmo trutta fario

6.River Ujh, an important tributary of the river Ravi. Rathore and Dutta (2015)[100]	+	ORDER : CYPRINIFORMES FAMILY: CYPRINIDAE *1. Salmostoma bacaila* *2. Salmostoma panjabiensis* *3. Aspidoparia morar 4. Barilius vagra vagra* *5. B. bendelisis 6. Rasbora rasbora* *7. Esomus danricus 8. Danio devario* *9. Tor tor 10. T. putitora 11. Puntius sophore* *12. P. chola 13. P. ticto 14 P. conchonius* *15. Cirrhinus mrigala 16. C. reba* *17. Labeo dero 18. L. dyocheilus* *19. L. pangusia 20. Catla catla* *21. Crossocheilus latius diplocheilus* *22. Garra lamta 23. G. gotyla* FAMILY: BALITORIDAE *24. Acanthocobitis botia* FAMILY:COBITIDAE *25. Botia almohare* *26. Botia birdi* *27. Lepidocephalichthys guntea* ORDER : SILURIFORMES FAMILY : BAGRIDAE *28. Aorichthys seenghala* *29 Mystus bleekeri* *30 Mystus Vittatus* FAMILY : SILURIDAE *31 Ompok bimaculatus* *32 Wallago attu* FAMILY:AMBLYCIPITIDAE *33. Amblyceps mangois* FAMILY:SISORIDAE *34. Bagarius bagarius* *35. Glyptothorax pectinopterus* *36. G. stoliczkae 37. G. telechitta telechitta* ORDER:BELONIFORMES FAMILY:BELONIDAE *38. Xenentodon cancilia* ORDER:SYNBRANCHIFORMES FAMILY:MASTACEMBELIDAE *39.Mastacembelus armatus* *40.Macrognathus pancalus* ORDER:PERCIFORMES FAMILY:CHANNOIDAE *41. Channa punctatus 42. C. orientalis*
7.Chadwal Stream Khajuria *et al.*(2015)[101]	+	ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE *1 Labeo boga 2 Puntius ticto* *3 Labeo dero 4 Labeo calbasu* *5 Labeo rohita 6 Danio devario* *7 Crossocheilus latius 8 Puntius sophore* *9 Puntius sarana 10 Chela bacaila*

		11 Barilius bendelesis 11 Barilius vagra *12 Garra gotyla gotyla 18 Tor putitora* FAMILY:NEMACHEILIDAE *19 Nemacheilus botia* ORDER :BELONIFORMES FAMILY:BELONIDAE *20 Xenentodon cancila* ORDER:ANABANTIFORMES FAMILY:CHANNIDAE *21Channa punctatus*
8.Sunderbani(stream) Gandotra and Sharma (2015)[102]	+	ORDER:CYPRINIFORMES FAMILY: CYPRINIDAE *1 Schizothorax richardsonii 2 Tor putitora* *3 Garra gotyla 4 Labeo boga 5 Labeo bata* *6 Labeo dero 7 Crossocheilus latius* *8 Puntius conchonius 9 Puntius sophore* *10 Puntius ticto 11 Barilius bendelisis* *12 Barilius vagra* ORDER: SILURIFORMES FAMILY :SISORDAE *13 Glyptothorax pectinopterus*
9. Lotic waterbodies of r.s.pura Tehsil Kour *et al.* (2015)[103]	+	ORDER: CYPRINIFORMES FAMILY:CYPRINIDAE *1. Amblypharyngodon mola* *2. Barilius bendelisis 3. Garra gotyla gotyla* *4. Osteobrama cotio 5. Puntius sophore* *6. Puntius ticto7. Puntius conchonius* *8. Salmostoma bacaila 9. Aspidoparia morar* *10. Danio devario 11. Chela laubucca* *12. Barilius vagra 13. Esomus danricus* *14. Labeo boga* FAMILY:COBITIDAE *15 Lepidocephalichthys guntea* *16 Noemacheilus botia* ORDER:SILURIFORMES FAMILY:BAGRIDAE *17. Mystus bleekeri* *18. Mystus seenghala 19. Mystus vittatus* FAMILY:SILURIDAE *20. Wallago attu* FAMILY:SCHILBEIDAE *21. Pseudoeutropius athernioides* ORDER:PERCIFORMES FAMILY:AMBASSIDAE *22. Ambassis nama* ORDER :BELONIFORMES FAMILY:BELONIDAE *23. Xenentodon cancila* ORDER :OPHIOCEPHALIFORMES FAMILY:OPHIOCEPHALIDAE *24. Channa punctatus*

10.Wajoo nullah (an important tributary of the river) Dutta (2016)[104]	+	ORDER:MASTACEMBELIFORMES FAMILY:MASTACEMBELIDAE *25. Mastacembelus pancalus* ORDER: OSTEOGLOSSIFORMES FAMILY:NOTOPTERIDAE *1 Notopterus notopterus* *2 Chitala chitala* ORDER: CLUPEFORMES FAMILY: CLUPEIDAE *3.Gudusia chapra* ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE *4 Securicula gora 5 Salmostoma bacaila* *6. S.punjabensis 7. Aspidoparia morar* *8. Barilius bendelisis 9. B.vagra vagra* *10. B.modestus 11. Danio.devario* *12. Esomus danricus 13. Rasbora rasbora* *14. Amblypharyngodonmola* *15. Chela laubuca 16. Chela cachius* *17. Cyprinus carpio communis* *18. Tor tor 19. Tor putitora 20. Puntiusticto* *21. P.sophore 22. P.saranasarana* *23. P.conchonius 24. Labeo.bata* *25. Labeo.dero 26. L.dyocheilus dyocheilus* *27. L.gonius 28. L.calbasu* *29. L.pangusia 30. L.boggut* *31. Cirrhinus.mrigala 32. C.reba* *33. Osteobrama cotio cotio* *34. Crossocheilus.latitus diplocheilus* *35. Garra gotyla gotyla 36. G.lamta* FAMILY: BALITORIDAE *37. Acanthocobitis botia* FAMILY: COBITIDAE *38. Botia almorhae 39. B. lohachata* *40. Lepidocephalus guntea* ORDER: SILURIFORMES FAMILY: BAGRIDAE *41. Rita rita 42. M.vittatus* *43. M.bleekeri 44. M.cavasius* *45. Aorichthys seenghala* FAMILY: SILURIDAE *46.Ompok pabda* *47. Wallago attu* FAMILY: SCHILBIDAE *48. Pseudeutropius atherinoides* FAMILY:AMBLYCPTIDAE 49 Amblyceps mangois FAMILY:SISORIDAE *50. Bagarius bagarius 51. Gagata cenia* FAMILY:HETEROPNEUSTES *52 Heteropneustes fossilis*

			ORDER : BELONIFORMES FAMILY: BELONIDAE *53. Xenontodon cancila* ORDER :SYNBRANCHIFORMES FAMILY :MASTAMCEMBELIDAE *63. Macroganthus pancalus* *64. Mastacembelus armatus*
11.Tehsil mendhar (district- poonch) Hussain and Dutta (2016)[105]	+	+	ORDER : CYPRINIFORMES FAMILY : CYPRINIDAE *1 Cyprinus carpio communis* *2 Hypophthalmichthys molitrix* *3 Ctenopharyngodon idellus* *4 Schizothorax richardsonii 5 L. dero* *6 L. dyocheilus dyocheilus 7 L. bata* *8 Gara gotyla 9 G. lamta* *10 Crossocheilus latius diplocheilus* *11 Barilius vagra 12 Tor putitora* *13 Puntius conchonius* FAMILY :BALITORIDAE *14 Schistura prashadi 15. S. punjabensis* *16. S. montanus* FAMILY :COBITIDAE *17 Botia birdi* ORDER : SILURIFORMES FAMILY : SISORIDAE *18 Glyptothorax punjabensis* FAMILY : SILURIDAE *19 Ompok pabda* ORDER : SYNBRANCHIFORMES FAMILY : MASTACEMBELIDAE *20 Mastacembelus armatus* ORDER :PERCIFORMES FAMILY:CHANNIDAE *21 Channa orientalis*
12.Selum nullah and Aik nullah Khajuria *et al.*(2016)[106]	+		ORDER :CYPRINIFORMES FAMILY:CYPRINIDAE *1 Puntius conchonius 2 Puntius sophore* *3 Garra gotyla gotlya 4 Labeo boga* *5 Labeo dero 6 Labeo calbasu* *7 Cirrhinus reba 8 Crossocheilus latius* *9 Barilius vagra 10 Danio devario* FAMILY:COBITIDAE *11 Rasbora rasbora 12 Botia dayi* *13 Lepidochephalus thermalis* *14 Lepidochephalus guntea* ORDER:SILURIFORMES FAMILY:SILURIDAE *15 Heteropnuestes fossilis* FAMILY:BAGRIDAE *16 Mystus bleekeri* FAMILY:SISORIDAE

			17 Gagata gagata ORDER:SYNBRANCHIFORMES FAMILY:MASTACEMBALIDAE *18 Mastacembalus armatus* ORDER :OPHIOCEPHALIFORMES FAMILY:OPHIOCEPHALIDAE *19 Channa punctatus* ORDER:BELONIFORMES FAMILY:BELONIDAE *20 Xenentodon cancila*
13. Ichthyofauna of Rajouri district. Nisa *et al.* (2020)[107]	+	+	ORDER:CYPRINIFORMES. FAMILY:DANIONIDAE *Barilius vagra* FAMILY:NEMACHEILIDAE. *2 Triplophysa sp*. FAMILY :CYPRINIDAE *3 Cirrhinus mrigala 4 Cyprinus carpio* *5 Garra gotyla 6 Garra lamta* *7 Labeo bata 8 Labeo boga 9 Bangana dero* *10 Labeo rohita 11Puntius sophore* *12 Pethia ticto 13 Shizothorax richardsoni* *14 Tor putitora 15 Tor tor* ORDER:SILURIFORMES. FAMILY:SISORIDAE *16 Glyptothorax pectinopterus*
14River Ravi Dutta(2021)[108]	+		ORDER: OSTEOGLOSSIFORMES FAMILY: NOTOPTERIDAE *1. Notopterus notopterus 2. Chilata chitala* ORDER: CLUPEIFORMES FAMILY: CLUPEIDAE *3. Gudusia chapra* ORDER: CYPRINIFORMES FAMILY:CYPRINIDAE *4. Salmophasia bacaila 5. Salmophasia phulo* *6. Salmophasia Punjabensis 7. Securicula gora* *8. Asidoparia morar 9. Barilius vagra vagra* *10. B. barila 11. B. modestus 1* *2. B. radiolatus Gunther 13. B. bendelisis* *14. Raiamas bola 15. Chela cachius* *16. Chela laubuca 17. Esomus danricus* *18. Danio. devario 19. Rasbora daniconius* *20. Amblypharyngodon. mola* *21. Cyprinus. carpio communis* *22. Cyprinus. carpio specularis* *23. Tor. tor 24. Tor. putitora* *25. Osteobrama. cotio cotio* *26. Puntius. sarana sarana* *27. P. conchonius 28. P. terio 29. P. ticto* *30. P. chola 31. P. sophore* *32. Cirrhinus mirgala* *33. Cirrhinus reba 34. Catla catla*

35. Labeo bata 36. L. boga
37. L. calbasu 38. L. dero 39. L. dyocheilus
40. L. gonius 41. L. pangusia 42. L. rohita
43. L. lippus 44. Schizothorax. richardsonii
45. Crossocheilus. latius diplocheilus
46. C. latius punjabensis
47. Garra. gotyla gotyla 48. G. lamta
FAMILY: BALITORIDAE
49. Nemacheilus corica 50. Acanthocobitis botia
51. Schistura prashadi 52. S. montanus
53. S. punjabensis
FAMILY: COBITIDIAE
54. Botia almorhae 55. Botia birdi
56. Botia lohachata
57. Lepidocephalus. guntea
ORDER: SILURIFORMES
FAMILY: BAGRIDAE
58. Rita rita 59. Mystus bleekeri
60. M. cavasius 61. M. vittatus
62. M. tengara 63. Aorichthys seenghala
64. A. aor
FAMILY: SILURIDAE
65. Ompok pabda 66. Wallago attu
FAMILY: SCHILBIDAE
67. Ailia punctata 68. Neotropius atherinoides
69. Clupisomagarua 70. Clupisomanazri
71. Eutropiichthysmurius 72. E. vacha
FAMILY: AMBLYCIPITIDAE
73. Amblyceps mangois
FAMILY:SISORIDAE
74. Bagarius. bagarius 75. Gagata. cenia
76. Glyptosternum reticulatum
77. Glyptothorax cavia
78. G. conirostreconirostre
79. G. pectinopterus
80. G. stoliczkae
81. G. telchitta
FAMILY: CLARIIDAE
82. Heteropneustes fossilis
83. Clarius batrachus
ORDER: SALMONIFORMES
FAMILY: SALMONIDAE
84.Salmo trutta fario
FAMILY: BELONIDAE
85. Xenentodon. cancila
ORDER: SYNBRANCHIFORMES
FAMILY: MASTACEMBELIDAE
86. Macroganthus aral 87 M. pancalus
88. Mastacembelus armatus
ORDER: PERCIFORMES
FAMILY: CHANDIDAE

			89. Chanda nama 90. Parambassisbaculis *91. P. ranga* FAMILY: NANDIDAE *92. Nandus nandus* FAMILY: GOBIIDAE *93. Glossogobius giuris* FAMILY :CHANNIDAE *94. Channa marulius 95. C. orientalis* *96. C. punctatus 97. C. striatus*
15.Fish Fauna of River Sewa Gupta and Dutta (2021)[109]	+		ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1 Barilius vagra 2 Barilius bendelisis* *3 Crossocheilus latius diplocheilus* *4 Tor putitora 5 Cirrhinus reba* *6 Schizothorax richardsonii* ORDER:SILURIFORMES FAMILY:SISORIDAE *7 Glyptothorax stoliczkae* ORDER:SALMONIFORMES FAMILY:SALMONIDAE *8 Salmo trutta fario*
16.Mansar-Surinser Lake (Information Sheet on Ramsar sites)		+	ORDER:CHANNIFORMES FAMILY:OPHIOCEPHALIDAE *1.Channa gachua 2.Channa punctatus* ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *3.Cyprinus carpio 4.Danio rerio* *5.Labeo rohita 6.Puntius chonchonius* *7.Rasbora rasbora* FAMILY:BELONTIIDAE *8.Trichogaster fasciatus* FAMILY:MASTACEMBELIDAE *9.Mastacembelus armatus*
17.Gharana wetland (Information Sheet on Ramsar sites)		+	ORDER:CYPRINIFORMES FAMILY:CYPRINIDAE *1.Puntius sophore 2.Puntius ticto* *3.Rasbora rasbora* FAMILY:CHANNIDAE *4Channa marulius 5Channa orientalis* *6Channa punctatus 7Channa striatus* FAMILY:BELONTIIDAE *8Trichogaster fasciatus* FAMILY:CLARIIDAE *9Heteropneustes fossilis*

According to an analysis of the data in table 5, only a small percentage of the total number of water bodies that are known to exist (as shown in table 4) have undergone comprehensive research, leaving the bulk of water bodies unexplored.

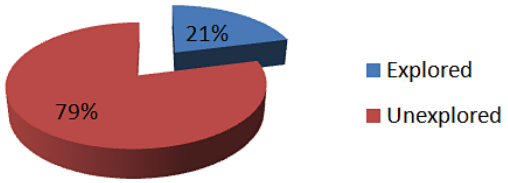

Fig. 4: Showing percentage of explored and unexplored water bodies of Jammu region.

Status of Bar Coding in Jammu Region

The present study, which is based on an examination of past findings, found that several lentic and lotic water bodies in the area has documented about 160 species. However, due to a lack of molecular characterization work, the employment of contemporary methodologies is still in its infancy.

Arif and Gandotra (2017)[110] carried out DNA barcoding of ornamental fishes in various water bodies in the Jammu region for the first time, verifying its usage for precise species identification. Analysis of the economic value of the fish fauna of the region reveals that the majority are food fishes, with ornamental fishes accounting for the second-highest percentage, and the remainder have both food and ornamental fishes as economic status. Since food and forage fish make up the majority of the fish in the area, molecular characterization of the major section of fish diversity remains untouched, placing the data available regarding the current status of fish fauna under uncertainty.

As shown by the data in table 5, the Jammu region is blessed with a rich diversity of fish species, many of which are generally difficult to identify morphometrically. However, bar coding is still in its infancy in this area. Major factors contributing to this research gap include outdated knowledge of current techniques, lack of funding, greater expertise in conventional methodologies, and most importantly, the fact that basic research is being neglected in favour of applied research as taxonomy has taken a backseat over time. Because most of the species lack accurate taxonomic resolution, analyses of the historical record of fish distribution, making temporal comparisons, and tracking the proper phylogeny have all been impeded.

Discussion

Due to the difference in topography, larger number of lotic water bodies, and more favourable climatic conditions, the fish diversity in the Jammu region is greater than that in the Kashmir region. Cypriniformes is the most prevalent order in both Jammu and Kashmir due to their great level of adaptability and capacity to occupy any area. Along with the endemic species of the genus *Schizothorax*, many of the fishes listed above (tables 4 and 5) are exotic species, such as carps, which are not native to the area and were introduced by the state fisheries department.

Anthropogenic Stress, Declining Fish Diversity and Need for Conservational Measures

Fish, which have a heterothermic body temperature, are easily impacted by changes in the physicochemical characteristics of the body of water they reside in.[111,112] The aquatic ecosystem is being negatively impacted by climate change and anthropogenic factors such as pollution, overfishing, hydropower projects, etc. These factors also cause coral bleaching, the loss of coastal wetland, changes in the distribution and timing of freshwater flow, and a decline in fish diversity.[113]

The largest freshwater lake in Asia, Wular Lake, is home to several fish species. However, eutrophication caused by human activity, which alters the water's physicochemical properties and impairs ecological conditions, has caused the extinction of numerous *schizothorax* species that are adapted to clean water.[79,80] Fish population of *Schizothorax plagiostomus* and *Schizothorax esocinus* in Dal lake has also been affected because of the constantly degrading water quality of the water body.[114]

The River Jhelum, a significant tributary of the Indus River System that drains through the entire state of Kashmir, is a celebrated river economically and a significant source of water for expanding human population and irrigation. However, the water body's shifting biological conditions have also encouraged the effective colonisation of foreign fish species with exceptional adaptability. The Viashaw River, a left tributary of the Indus River System, is also being affected by illicit mining and overfishing, which is reducing the diversity of fish.[83,114]

Water pollution has affected the fish fauna of Jammu region as well, a comparative analysis of fish fauna of different water bodies have revealed a decline in fish diversity,[96] especially those of threatened species.[115] Therefore for conservation of the river system allochthonous sources of pollution like sewage, dumping of garbage, mining and agricultural activities needs to be monitored. Different conservation measures like using a species as flagship species,creating awareness and starting different projects towards conservation needs to be adopted,[116] also small hydropower projects should be prioritised over large reservoir-based hydropower projects since they are more environmentally friendly and have fewer negative effects on flora and wildlife.[117]

Research Gap and Future Prespective

Only a small number of the area's waterbodies have been thoroughly examined; the remainder of the wetlands and many lentic water bodies have mostly remained uncharted due to accessibility concerns (remote location), financial limitations, and the locals' intense religious convictions. Fish production in the area can increase significantly when the existing resources (waterbodies and fish fauna) are used wisely in order to meet the demands of UT's growing population. As the majority of the water bodies in the Jammu and Kashmir region are unexplored, concealing a substantial portion of the fish flora and its gene pool, an integrative strategy can assist close the study gap.

Therefore a collaboration on the molecular aspect of fisheries in J and k especially in Jammu region with conventional taxonomy will immensely help in better understanding of the fish ecology of the region and will also aid in properly identifying and conserving the gene pool thereby boosting the growth of the economically important fishes belonging to this region.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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