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REVIEW ARTICLE

ICHTHYOFAUNAL DIVERSITY OF JAMMU REGION OF NORTH-WESTERN HIMALAYA AND ITS CONSERVATION STATUS

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ABSTRACT

Jammu and Kashmir has enormous fisheries potential due to its vast area and quantity of freshwater sources. The UT has rivers like Chenab, Tawi, Ravi, and Jhelum, as well as lakes including Dal lake, Wular lake, Manasbal lake, and Surinsar, Manasar lake. The purpose of this study is to summarize some of the key studies done on the Ichthyofaunal diversity of numerous water bodies in the Jammu region, as well as to create an inventory of the region's Ichthyofauna while analyzing the dominant and least prominent species. The examination undertaken revealed the presence of 158 distinct fish species belonging to 10 orders, with Cypriniformes being the most dominating order and Cyprinidae being the most significant contributing family, while Anabantiformes and Clupeiformes were in traces. Furthermore, analysis of conservation status of the fauna revealed that, majority of the species in the region have a conservation status of "Least Concern", while a few species are endangered or vulnerable. Analysis of fish fauna of the region's major lotic water bodies finds that river Ravi has the largest fish diversity; however, a comparative analysis of fish fauna reveals that diversity is diminishing in the region necessitating extensive conservation strategies.

Keywords: Conservation**,** cypriniformes, fish diversity, Jammu rivers

1. INTRODUCTION

Freshwater covers around 1% of the earth's surface and is home to approximately 51% (18,075 species) of the world's total known fish species (Hughes, 2021). The fish is the most abundant and diverse group of vertebrates on earth, which has play a significant role in human society for millions of years. Along the edges of rivers, lakes, and oceans, ancient humans gathered fin fish, shellfish, and other aquatic life, as evidenced by the usage of fish spears (90,000 years ago), nets (40,000 years ago), and fish hooks (35,000 years ago) (Lackey, 2005). The fish fauna occupies the apex or near the apex of food chain and make up a significant portion of the standing biomass; hence, they serve as an indicator of a healthy aquatic ecosystem. They make up more than half of all vertebrate species and are crucial to the functioning of the ecosystem, as well as the well-being and economy of every geographic region (Arthington *et al.*, 2016). Also, inland fisheries are a significant component of a developing, global blue growth economy (Taylor *et al.*, 2016); hence, the health of our planet, our personal health, and our future food security depend on how we handle aquatic ecosystems.

Water quality has major influence on the diversity and distribution of fishes; hence, fishes being hetero-thermal are severely impacted by any disturbance to the various parameters and flow rate of aquatic ecosystem they inhabit. Generally, fish cannot maintain a steady body temperature; when exposed to cold water their metabolism slows down. In contrast, as the surrounding water warms their metabolism accelerates, and they grow more swiftly, and eventually have greater reproductive energy. However, fish require more food and oxygen to sustain this increased metabolic rate. Warmer fish tend to mature more rapidly, but the trade-off is frequently a smaller body size. Around 90% aquatic species grown in warmer water are smaller than their counterparts raised in cooler water. As temperatures rise, many fish may have fewer offspring, and some may even lose the ability to reproduce and become permanently sterile (Krishan, 2016, Beitinger *et al.*, 2000).

After amphibians, freshwater fishes are the most endangered group of vertebrates (Darwall and Freyhof, 2016). It is speculated that globally fishes have a higher rate of extinction than any other group of vertebrates (Dias *et al.,* 2017). Anthropogenic activities are hazard to > 60% freshwater habitat (Vörösmarty *et al.,* 2010). World Wide International notes that the rates of biodiversity loss in freshwater environments are double than those of ocean and forest habitats (Hughes, 2021). The IUCN has proclaimed the extinction of about 80 freshwater fish species, 10 of which have been declared extinct in the wild, and 115 of which are categorized as "Critically Endangered Possibly Extinct" (Hughes, 2021). In terms of freshwater diversity, India ranks 8th among the mega-biodiversity nations of the globe, and occupies 9th position in terms of freshwater biodiversity (Mittermeier,1997) with 2500 species of fish approximately 930 of which are freshwater and 1570 marine (Kar *et al*., 2003). The Jammu and Kashmir (J&K) is situated in the northwest Himalayas in India between latitude 32.28-37.06° and longitude 72.53-80.32°. The hydrological components have a cumulative effect on a number of developmental processes. J&K outstands in terms of its water riches when total runoff, total water body area, and the extent of drainage pattern are considered (Shukla and Ali, 2018). The areas above 3600 m in J&K are usually covered with snow and glaciers. The region's snow- and ice-melt waters maintain three main rivers, the Indus, Jhelum, and Chenab, which provide many resources to 300 million Indus basin inhabitants, upstream and downstream. With about 3650 wetlands and waterbodies, the J&K is known for its wetlands and lakes (Dar and Khuroo, 2020).

The climate in J&K greatly varies due to its uneven terrain. Because of the differences in altitude and geography, the water bodies have developed in diverse ways, and different kinds of fish have been found in them (Balkhi and Bhat, 2022). Jammu region is located at 32.7666°N and 74.8570°E and is the winter capital of J&K. The region is the home to Dogras, whose name is derived from the Sanskrit term "dogirath," which means "two lakes." These two lakes, Mansar and Surinsar, are among the region's most popular tourist destinations (Nasim and Keng, 2012). The major portion of territory has steep terrain, from which rivers, streams, and their tributaries flow into plains and valleys. Due to the favourable climatic conditions, a greater number of lotic water bodies exist in Jammu and they have greater diversity of fish species than Kashmir (Bhatt *et al*., 2020; Dar and Khuroo, 2020; Balkhi and Bhat, 2022). The fisheries sector in J&K is progressing well, with 21.35 thousand t fish produced in 2020-21. The number of fishing license holders in J&K is now projected to exceed 1,500. The region has around 0.7 lakh ha land under reservoir area, which includes 1248 lakes (Hussain *et al.,* 2016) and the length of rivers and streams is 28,000 km (Government of Jammu and Kashmir, 2017). Fish output in J&K has expanded significantly over the years, although it has declined in Kashmir province (Islam, 2020). The present review analyses the available data on ichthyofaunal diversity of Jammu region, gathered through numerous studies/expeditions done by various researchers on lentic and lotic water bodies in the region.

2. WATER BODIES OF JAMMU REGION

Both lentic and lotic water bodies are essential com ponents of the environment. Gharana, Pargwal, Sangral, Nanga, Kukrian, Cheshara, Mansar, Surinsar, Thein and Bahu are the main wetlands and lakes in Jammu region. The rivers of Jammu & Kashmir include Chenab, Tawi, Ravi, and Poonch (Lone, 2020) and Fig. 1 shows the aerial view of waterbodies of Jammu region.

Major lotic water bodies

River Chenab: Chenab river, also known as Chandrabagha (owing to the confluence of two streams, Chandra and Bagha) or Chand Aab or Moon river, begins at Baralacha La Pass in the Lahaul and Spiti district of Himachal Pradesh, lies between 29°20′57″N and 71°1′41″E. Its overall length is 962 km. In Jammu region the river travels through the districts of Kishtwar, Doda, Ramban, Udhampur, Jammu,

Fig. 1: The map showing various lentic and lotic water bodies of Jammu region

and Rajouri; from Akhnoor it enters into the Pakistani province of Sialkot. Under the Indus Water Treaty, Pakistan has been granted the Chenab River's water (Chenab-INDIA WRIS WIKI). Although many Indian canals receive water from this particular river, it is also extensively used for irrigation and hydropower production throughout most of Pakistan, thus both India and Pakistan depend heavily on the river for many reasons (Muhammad *et al.*, 2019; Bhat *et al.*, 2021).

River Tawi: The origin of river Tawi (Surya Putri) is a glacial tank known as Kailash Kund, which is located at the summit of Mahakailash Choti, which is around 3,965 m high located in Bhaderwah, Doda district of J&K and flows into the river Chenab in Sialkot, Pakistan. The catchment is bounded by the latitude range 32°35′–33°5′ north and the longitude range 74°34′–75°40′ east. Approximately, 95% river basin is located in J&K, and 5% in Pakistan. On its descent from the southern face of the choti, the river takes the form of a little stream. Upon entering Jammu region via a lengthy, winding, steep journey, the river runs through the plains and combines with the river Chenab near Pakistan's borders (Verma *et al.*, 2012). With overall length of 141 km, the Tawi river is revered as a holy river. The river's water quality degrades when it enters the Jammu district plains due to the dense human settlements along its banks throughout the district (Kour *et al.*, 2022).

River Ravi: River Ravi, one of the Indus system's rivers, is the smallest of the five Punjab rivers that rise from glacier fields at 4267.2 m and was formerly known as Irawati. It begins on the northern slope of Rohtang Pass in Himachal Pradesh (district Chamba) and runs between 32°10'00.01"N and 75°17'59.99"E for a total distance of 720 km, of which 360 km are in India. River Ujh is its most significant tributary (*https://en.wikipedia.org/wiki/Ravi_River*). The Ravi irrigates about one million acres of agricultural land in India. Intense pollution from both India and Pakistan endangers irrigation and groundwater, as well as terrestrial and aquatic life (Yasar *et al.*, 2010).

Major lentic water bodies

Mansar lake: The Mansar lake is situated about 60 km east of the city Jammu at an elevation of 650 m above mean sea level (masl). It is located between 32°41′28″ and 32°42′09″ N latitude and 75°08′16″ and 75°08′52″ E longitude. With an area of 0.53 km^2 and a circumference of around 3020 m, it is the largest and deepest freshwater lake in the Jammu region (Das *et al*., 2006). The lake is located in a subtropical climate zone with average annual precipitation of approx. 1500 mm and temperatures ranging from as low as 3°C to as high as 42°C (Kumar *et al*., 2006). The north-eastern sides of the lake are surrounded by human settlements and agricultural areas, while the southern sides are surrounded by forest and hills (Dwivedi, 2012). In comparison to its beauty, Mansar lake is noteworthy for religious purposes and values and is an exciting tourist attraction.

***Surinsar lake*:** Surinsar wetland has a perimeter of around 2.8 km and an elevation of 605 m masl, lies between 32° 46' 16.16" N latitudes and 75° 02' 28" E longitudes. The lake is located in the lower Shiwalik region, about 35 km away from Jammu and 16 km from Mansar lake. Surrounded by hills and deep trees, the lake is an exceptionally beautiful location. It is a warm monomictic lake with a reputation for beauty and a bird refuge. Current uses of marsh water include irrigation of agricultural lands surrounding the lake, domestic uses, and the influx of tourists. In addition, nearby catchment region, drainage basin, agricultural fields, forest area, and wildlife refuge contribute a substantial amount of pollution and dissolved elements to the wetland (Slathia and Dutta, 2013).The lake is currently under intense biotic strain, with deforestation in its catchment area and overall neglect

resulting in modifications to its physical, chemical, and biological properties The decomposition of vegetation has contributed to the formation and expansion of the dry land mass, degrading the overall health of the wetland (Sharma and Kumar, 2022).

***Gharana wetland*:** Gharana wetland is located roughly 400 m masl, lies between 32°32'27"N and 74°41'25"E, 30 km west of Jammu city. The wetland is located in R.S. Pura tehsil in district Jammu and is home to numerous plant species. A village named Gharana is located along the lake's catchment area; its residents are primarily engaged in agriculture, fishing, and forestry. Being a home to thousands of the migratory birds especially during winter, Gharana wetland was declared as a "Conservation Reserve" by J&K Wildlife Protection Act, 1978. It has also been recognized internationally as an important bird area by BirdLife International (UK) and Bombay Natural History Society and is a home to a variety of invertebrates, small fishes along with some of the aquatic plants. Recently it has been found to be the most threatened wetland of the region (Ashger *et al*., 2021).

3. FISH FAUNA OF JAMMU REGION

Ichthyofaunal diversity of the Jammu region was intensively studied for the first time by Das and Nath (1965). Eventually many workers reported fish fauna from the area (Das and Nath, 1971; Malhotra *et al*., 1975; Joshi *et al*., 1978; Dutta and Malhotra, 1984; Jyoti *et al*., 2006; Balkhi, 2007). Table 1 gives the compiled information about the fish fauna in the lentic and lotic water bodies in the region (Tilak,1971; Sharma and Dutta, 2012; Vohra *et al.*, 2013; Baba *et al.*, 2014; Bhutyal and langer, 2015; Dutta, 2015**;** Rathore and Dutta, 2015; Khajuria *et al*., 2015; Gandotra and Sharma, 2015; Dutta, 2016; Kour *et al.*, 2015; Dutta, 2016; Hussain and Dutta, 2016**;** Khajuria *et al.*, 2016; Sharma *et al.*, 2016; Gandotra *et al.*, 2017; Arif *et al.*, 2019; Nisa *et al.*, 2021; Dutta, 2021; Gupta and Dutta, 2021).

Table 1: Fish fauna inhabiting the lentic and lotic water bodies of Jammu and their IUCN status

Order	Family/Species	IUCN status
Anabantiformes	**Osphronemidae**	
	- Trichogaster fasciatus (Bloch & Sch.)	LC
Cypriniformes	**Cyprinidae**	
	1. Amblypharyngodon mola (Ham.)	LC
	2. A. gadighari (Ham.)	LC
	3. Acanthocobitis botia (Peters)	LC
	4. Aspidoparia morar (Ham.)	LC
	5. Botia birdi (Chaudhari)	NE
	6. B. lohachata (Chaudhari)	NE
	7. B. dario (Ham.)	LC
	8. Brachydanio rerio (Ham.)	DD
	9. Bangana dero (Ham.)	LC
	10. Barilius bendelisis (Ham.)	LC
	11. B. vagra (Ham.)	LC
	12. B. radiolatus (Gunther)	DD
	13. B. barila (Ham-Buch.)	LC
	14. B. shacra (Ham.)	DD
	15. B. modestus (Bleeker)	NE
	16. Chela cachius (Ham.)	LC
	17. C. bacaila (Ham.)	DD
	18. C. laubucca (Ham.)	NT
	19. Ctenopharyngodon idellus (Val.)	NE
	20. Cyprinus carpio communis (Linn.)	VU
	21. Cirrihinus reba (Ham.)	LC
	22. Catla catla (Ham.)	LC
	23. Crossocheilus diplochilus (Haeckel)	LC
	24. Cirrhinus mrigala (Ham.)	LC
	25. Cyprinus carpio specularis (Lacepede	VC
	26. Danio rerio (Ham.)	LC
	27. D. devario (Ham.)	LC
	28. Esomus danrica (Ham.)	LC
	29. Garra gotyla gotyla (Gray)	LC
	30. G. lamta (Ham.)	LC
	31. Hypothalmichthys molitrix (Val.)	NT

In all water bodies Cypriniformes (59%) is the dominating order while Anabantiformes and Clupeformes are poorly represented. Cyprinidae is the most important contributing family due to their high adaptive plasticity and capacity to occupy all potential environments. Reason being, their biology is quite variable; they dwell in both cold and warm waters and can endure low oxygen levels. Despite their ability to survive in difficult climes, Cyprinids are threatened and many

32. Labeo dero (Ham.)	LC
33. L. dyocheilus (McClelland)	LC
34. L. bata (Ham.)	LC
35. L. calbasu (Ham.)	LC
36. L. boga (Bloch)	LC
37. L. gonius (Ham.)	LC
38. L. rohita (Ham.)	LC
39. L. boggut (Sykes)	LC
40. L. pangusia (Ham.)	NT
41. L. lippus (Fowler)	DD
42. Lepidocephalus guntea (Ham.)	LC
43. Securicula gora (Gunther)	LC
44. Oxygaster bacaila (Ham.)	LC
45. Osteobrama cotio (Ham.)	LC
46. Puntius ticto (Ham.)	LC
47. Pethia ticto (Ham.)	LC
48. Puntius conchonius (Ham.)	LC
49. P. sarana sarana (Ham-Buch)	LC
50. P. sophore (Ham.)	LC
51. P. terio (Ham.)	LC
52. P. chola (Ham.)	LC
53. P. sarana (Ham.)	LC
54. Raiamas bola (Ham.)	LC
55. Rasbora rasbora (Ham.)	EN
56. R. danioconius (Ham.)	LC
57. Salmophasia bacaila (Ham.)	LC
58. S. phulo (Ham.)	LC
59. S. punjabenis (Day)	LC
60. Schizothrax richardsonii (Gray)	NE
61. S. plagiostomus (Heckel)	NE
62. S. progastus (McClelland)	VU
63. S. esocinus (Heckel)	LC
64. S. curvifrons (Heckel)	NE
65. S. labiatus (McClelland)	LC
66. Salmostoma bacaila (Ham.)	NE
67. S. punjabensis (Day)	LC
68. Schistura punjabensis (Hora)	LC
69. S. montanus (McClelland)	DD
70. Securicula gora (Gunther)	DD
71. Nemacheilus corica (Ham.)	LC
72. Tor tor (Ham.)	LC
73. T. putitora (Ham.)	DD
74. T. mosal (Ham.)	EN
75. T. khudree (Sykes)	VU
76. Triplophysa yasinensis (Alcock)	LC
Nemacheilidae	
1. Nemacheilus botia (Ham.)	LC
2. N. corica (Ham.)	LC
3. Schistura montanus (McClelland)	NE
Botiidae	
1. Botia dayi (Hora)	NE
2. Botia almorhae (Gray)	LC

of species are moving towards IUCN's category of endangered.

Exotic fish species: Exotic carp species were introduced in 1996 to lake Mansar and lake Surinsar after numerous indigenous freshwater fishes died due to an unknown disease as a result of pouring sewerage water into the lakes. Being omnivorous, Carp have wiped out jellyfish and impacted the aquatic vegetation of the region. In addition, *Cyprinus carpio* and *Ctenopharyngodon idella* have been introduced by the state fishery department in the water sources of the R.S. Pura district (Sharma et al., 2016). Furthermore, *Catla catla, Laheo rohita, Ctenopharyngodon idellus, Hypothalmichthys molitrix, Cyprinus carpio communis, Cyprinus carpio specularis* have been stocked by the fishery department in various lentic and lotic water bodies of district Udhampur (Dutta, 2015).

The relative contribution of various orders, families, and genera to the fish diversity of the three most significant lotic water bodies in Jammu region is depicted in Fig. 2-15, which illustrate the rich diversity of orders and families inhabiting the water bodies, as well as the dominance of the Cyprinidae family. The number of families constituting other orders is either equal or greater than that of Cypriniformes order (Fig 3, 7 & 11), but still Cypriniformes makes greatest contribution to the biodiversity due to the higher number of species flourishing within the Cyprinidae family (Fig. 6, 10 & 14).

The comparative analysis of fish fauna of the water bodies (Fig. 15) revealed that river Ravi has highest fish diversity (97), followed by Chenab (31) and Tawi (21). Further, the Table 2 shows that the

	Balitoridae	
	1. Acanthocobitis botia (Peters)	LC
	2. Schistura prashadi (Hora)	VU
	3. S. punjabensis (Hora)	NE
	4. S. montanus (McClelland)	NE
	Cobitidae	
	1. Botia birdi (Chaudhari)	NE
	2. B. almorhae (Gray)	LC
	3. B. dayi (Hora)	NE
	4. B. lohachata (Chaudhari)	LC
	5. Lepidocephalus guntea (Ham.)	LC
	6. Noemacheilus botia (Ham.)	LC
	7. N. corica (Ham.)	LC
	8. N. prashari (Hora)	NE
	9. Lepidochephalus thermalis (Val.)	LC
Beloniformes	**Belonidae**	
	1. Aspidoparia morar (Ham.)	LC
	2. Osterobrama cotia (Ham.)	LC
	3. Xenentodon cancilla (Ham.)	LC
Clupeformes	**Clupeidae**	
	- Gudusia chapra (Ham.)	LC
Mastacembeli-formes	**Mastacembelidae**	
	1. Mastacembelus pancalus (Ham.)	LC
	2. M. armatus (Lacepede)	LC
Osteoglossiformes	**Notopteridae**	
	1. Notopterus notopterus (Pallas)	LC
	2. Chitala chitala (Ham.)	NT
Perciformes	**Nandidae**	
	- Nandus nandus (Ham.)	LC
	Gobiidae	
	- Glossogobius giuris (Ham.)	LC
	Belontidae	
	- Colisa fasciatus (Bloch & Schn.)	LC
	Channidae	
	1. Channa punctatus (Bloch)	LC
	2. C. marulius (Ham.)	LC
	3. C. orientalis (Bl.& Schn.)	VU
	4. C. striatus (Bloch)	LC
	Badidae	
	- Badis badis (Ham.)	LC
	Ambassidae	
	1. Ambassis nama (Ham.)	LC
	2. Chanda nama (Ham.)	LC
	Chandidae	
	1. Parambassis ranga (Ham.)	LC
	2. P. baculis (Ham.)	LC
Siluriformes	**Amblycipitidae**	
	- Amblyceps mangois (Ham.)	NT
	Bagridae	
	1. Aorichthys seenghala (Sykes)	LC
	2. A. aor (Ham.)	LC
	3. Mystus seenghala ((Sykes)	LC
	4. M. bleekeri (Day)	LC
	5. M. vittatus (Bloch)	LC
	6. Rita rita (Ham.)	LC

primary water bodies not only inhabit food fishes but also serve as a home to ornamental fish species.

The department has also stocked exotic carp in the ponds of Tehsil Mendhar, namely *Cyprinus carpio communis*, *Hypopthal-michthyes molitrix*, and *Ctenopharyngodon idellus*, among which *Cyprinus carpio communis*, after entering Mendhar stream, has significantly impacted native fish species (Hussain and Dutta, 2016).

Comparative analysis of the fish fauna of the three major lotic water bodies of the region reveal that River Ravi has highest fish diversity (97) followed by Chenab (31) and Tawi (21). Furthermore, it can be noted from Table 2 that the primary water bodies inhabit not only food fishes but are also a home to number of ornamental species. Unfortunately, the area's fish population is falling for numerous causes. Wildlife crime (overfishing, illegal fishing, habitat destruction), climate change, flow of pollutants, invasive species, fragmented rivers, dams, hydro-electric projects, and excessive dredging of fish and sand are among the most severe environmental threats (Singh and Akhtar, 2015; Krishan, 2016; Bhat *et al.*, 2020).

A comparative study of fish fauna of river Tawi revealed decline in species richness; the river's dwindling ichthyodiversity appears an outcome of human intervention (Tilak,1967; Gandotra, 2017). Only a few tolerant species thrive in polluted portion of the body of water, whilst the population of endangered species continues to decline (Andotra, 2014). During lockdown, the role of human activities in the deterioration of water quality became evident, as the pollutant load of river Tawi decreased, the river's water quality improved (Kour *et al.*, 2022).

	7. Mystus cavasius (Ham.)	LC
	8. M. tengara (Ham.)	LC
	Siluridae	
	1. Ompak bimaculatus (Bloch)	NT
	2. O. pabda (Ham.)	NT
	3. Wallago attu (Schneider)	VU
	Sisoridae	
	1. Bagarius bagarius (Ham.)	NT
	2. B. yarrelli (Sykes)	VU
	3. Glyptothorax pectinopterus (McClelland)	LC
	4. Gagata cenia (Ham.)	LC
	5. Glyptothorax botium (Ham.)	LC
	6. G. stoliczkae (Steindachner)	LC
	7. Glytosternon reticulatum (Regan)	LC
	8. Glyptosternum maculatum (Regan)	LC
	9. Glyptothorax indicus (Talwar)	DD
	10. G. telchitta telchitta (Ham.)	LC
	11. G. cavia (Ham.)	LC
	12. G. Kashmirensis (Hora)	CR
	13. G. punjabensis (Mirza & Kashmiri)	EN
	14. Glyptothorax cavia (Ham.)	LC
	15. G. conirostre conirostre (Stein.)	EN
	Schilbeidae	
	1. Clupisoma garua (Ham.)	LC
	2. Eutropiichthys Vacha (Ham.)	LC
	3. Pseudoeutropius atherinoides (Bloch	LC
	4. Ailia punctata (Day)	DD
	5. Clupisoma nazri (Mirza & Iqbal)	LC
	6. Eutropiichthys murius (Ham.)	LC
	7. Neotropius atherinoides (Bloch)	LC
	Heteropneustidae	
	- Heteropneustes fossilis (Bloch)	LC
	Clariidae	
	- Clarius batrachus (Linn.)	LC
Synbrachiformes	**Mastacembelidae**	
	1. Mastacembelus armatus (Lacepede)	LC
	2. Macrognathus aculeate (Bloch)	LC
	3. M. pancalus (Ham.)	LC
	4. Macroganthus aral (Bloch & Sch.)	LC
Salmoniformes	**Salmonidae**	
	1. Oncorhynchus mykiss (Walbaum)	NE
	2. Salmo trutta fario (Linn.)	LC

CR: Critically endangered, EN: Endangered, VU: Vulnerable, NT: Near threatened, LC: Least concern, DD: Data deficient, NE: Not evaluated (from IUCN Red list 2021-2003)

Similarly, in river Chenab, the majority of fish habitats are regularly subjected to sand and shingle mining, construction of crushers at the river's bank, and leaching of detergents into the water, all of which degrade the ecology of riverine system (Baba *et al.*, 2014). The water quality and aquatic life in river Ravi are also under threat of intense pollution that has come from both India and Pakistan (Yasar *et al.*, 2010). A comparative analysis of the fish fauna of river Basantar, an important tributary of river Ravi, revealed a decline in diversity as a result of environmental factors and anthropogenic pressure (Sharma and Dutta, 2012). Consequently, it is evident that human interference and climate change has negatively impacted the fish fauna of the region, and urgent conservation strategies are required.

Phylogenetic tree or classical clustering of fish fauna was developed on the basis of physico-chemical parameters (pH, water temperature, and depth). For this, PAST software (Hammer *et al.*, 2001) was used to develop dendrograms for rivers Tawi, Chenaab and Ravi (Fig. 16) using abiotic parameters like pH, water temperature and depth range of fishes inhabiting these water bodies. The phylogenetic tree clustered the families that inhabit similar abiotic conditions, and showed that families are more likely to coexist under a given set of abiotic conditions.

4. CONSERVATION STATUS OF FISH FAUNA OF JAMMU REGION

The IUCN status of the majority of region's fishes is “Least Concern” (Table 1). In addition, the region's water bodies are home to a few endangered and vulnerable species as well.

Endangered Golden Mahseer: India has 216 vulnerable species, including the Sub-Himalayan cold-water fish Mahseer, one of the largest freshwater fish in the Indian subcontinent. The population of golden Mahseer (*Tor putitora*), is diminishing due to multiple stressors including overfishing and dam construction (Bhatt and Pandit, 2016). Several workers have studied its biology and tried to estimate its status in Jammu region (Joshi *et al.*, 1978; Arjamand *et al.*, 2013; Langer *et al.*, 2013; Khajuria and

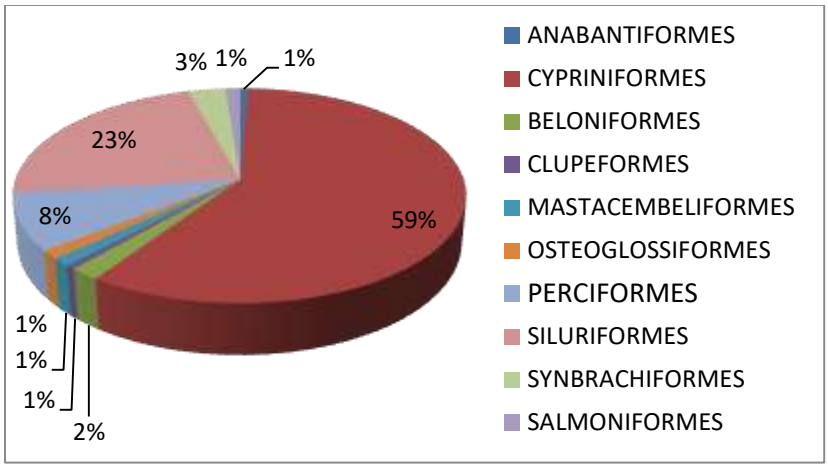


Fig. 2: Relative contribution of various Orders to fish diversity in Jammu

Langer, 2016). Reasi is recognized for its significance as a breeding place for *Tor* species. A comparison of the streams Baba Dansar and Jhajjar (Reasi) indicated a higher density of golden mahseer in Dansar than in Jhajjar (Khajuria and Langer, 2014), highlighting the significance of water variables in determining fish density.

Table 2: Fish fauna of major lotic water bodies of the Jammu region

S. No.	Name of the species	Economic importance (Food/ Ornamental fish)	River Chenab (Baba *et al.* 2014)	River Ravi (Dutta, 2021)	River Tawi (Vivek *et al.*, 2017)
1	*Acanthocobitis botia*	Ornamental	-	+	-
2	*Ailia punctate*	Food	-	+	-
3	*Amblyceps mangois*	Ornamental	-	+	-
4	*Amblypharyngodon mola*	Ornamental	-	+	-
5	*Aspidoparia morar*	Ornamental/Food	-	+	+
6	*Bagarius bagarius*	Food	+	+	-
7	*B. yarrellii*	Food	-	-	+
8	*Barilius barila*	Ornamental	-	+	-
9	*B. bendelisis*	Ornamental/Food	+	+	+
10	*B. modestus*	Ornamental	-	+	-
11	*B. radiolatus*	Ornamental	-	+	-
12	*B. vagra vagra*	Ornamental/Food	+	+	+
13	*Botia almorhae*	Ornamental	-	+	-
14	*B. birdi*	Ornamental	-	+	-
15	*B. dayi*	Ornamental	+	-	-
16	*B. lohachata*	Ornamental	-	+	-
17	*Catla catla*	Food	-	+	-
18	*Chanda nama*	Ornamental	-	+	-
19	*Channa marulius*	Food	-	+	-
20	*C. punctate*	Food	-	+	+
21	*C. orientalis*	Food	-	+	-
22	*C. striatus*	Food	-	+	+
23	*Chela cachius*	Ornamental	-	+	-
24	*C. laubuca*	Ornamental	-	+	-
25	*Chitala chitala*	Food	-	+	-
26	*Cirrhinus mrigala*	Food	-	+	-
27	*C. reba*	Food	+	+	--
28	*Clarias batrachus*	Food	-	+	-
29	*Clupisoma garua*	Ornamental/Food	-	+	-
30	*C. naziri*	Ornamental/Food	-	+	-
31	*Crossocheilus latius*	Ornamental	+	+	+
32	*C. diplocheilus*	Ornamental	-	+	-
33	*Cyprinus carpio communis*	Ornamental/Food	+	+	-
34	*C. carpio specularis*	Ornamental/Food	-	+	-
35	*Danio devario*	Ornamental	-	+	-

36	*Esomus danricus*	Ornamental	-	+	-
37	*Eutropiichthys murius*	Food	-	+	-
38	*E. vacha*	Food	-	+	--
39	*Gagata cenia*	Food	-	+	-
40	*Garra gotyla*	Ornamental	+	+	+
41	*G. lamta*	Ornamental	+	+	-
42	*Glossogobius giuris*	Ornamental/Food	-	+	-
43	*Gudusia chapra*	Food	-	+	-
44	*Glyptosternum reticulatum*	Ornamental	-	+	-
45	*Glyptothorax botium*	Ornamental	+	-	-
46	*G. cavia*	Ornamental	-	+	-
47	*G. conirostre*	Ornamental	-	+	-
48	*G. maculatum*	Ornamental	+	-	-
49	*G. pectinopterus*	Ornamental	+	+	-
50	*G. stoliczkae*	Ornamental	-	+	-
51	*G. telchitta*	Ornamental	-	+	-
52	*Heteropneustes fossilis*	Food	-	+	-
53	*Labeo bata*	Food	+	+	+
54	*L. boga*	Food	-	+	+
55	*L. calbasu*	Food	-	+	-
56	*L. dero*	Food	-	+	+
57	*L. dyocheilus*	Food	-	+	-
58	*L. gonius*	Food	-	+	-
59	*L. lippus*	Food	-	+	-
60	*L. pangusia*	Food	-	+	-
61	*L. rohita*	Food	+	+	-
62	*Lepidocephalus guntea*	Ornamental	-	+	-
63	*Macrognathus aral*	Food	-	+	-
64	*M. pancalus*	Ornamental/Food	+	+	+
65	*M. armatus*	Ornamental/Food	+	+	+
66	*Mystus aor*	Food	-	+	-
67	*M. bleekeri*	Food	+	+	-
68	*M. cavasius*	Food	+	+	-
69	*M. seenghala*	Food	+	+	+
70	*M. tengra*	Food	-	+	-
71	*M. vittatus*	Food	-	+	-
72	*Nandus nandus*	Ornamental	-	+	-
73	*Nemacheilus botia*	Ornamental	+	-	+
74	*N. corica*	Ornamental	-	+	-
75	*N. atherinoides*	Ornamental	-	+	-
76	*Notopterus notopterus*	Ornamental/Food	-	+	-
77	*Ompok pabda*	Food	-	+	-
78	*Osteobrama cotio*	Ornamental	-	+	-
79	*Parambassis baculis*	Ornamental/Food	-	+	-
80	*P. ranga*	Ornamental/Food	-	+	-
81	*Puntius chola*	Ornamental/Food	-	+	-
82	*P. conchonius*	Ornamental/Food	+	+	-
83	*P. sarana*	Ornamental/Food	-	+	-
84	*P. sophore*	Ornamental/Food	+	+	+
85	*P. terio*	Ornamental/Food	-	+	-
86	*P. ticto*	Ornamental/Food	+	+	+
87	*Raiamas bola*	Ornamental	-	+	-
88	*Rasbora daniconius*	Ornamental	-	+	-
89	*Rita rita*	Food	-	+	-
90	*Salmophasia bacaila*	Food	-	+	-
91	*S. phulo*	Food	-	+	-

92	*S. punjabensis*	Food	-	+	-
93	*Salmo trutta fario*	Food	-	+	-
94	*Schistura montanus*	Ornamental	-	+	+
95	*S. prashadi*	Ornamental	-	+	-
96	*S. punjabensis*	Ornamental	-	+	-
97	*Schizothorax labiatus*	Food	+	-	-
98	*S. plagiostomus*	Food	+	-	+
99	*S. richardsonii*	Food	+	+	+
100	*Securicula gora*	Ornamental/Food	-	+	-
101	*Tor khudree*	Food	+	-	-
102	*T. putitora*	Food	+	+	+
103	*T. tor*	Food	+	+	-
104	*Wallago attu*	Food	+	+	-
105	*Xenontodon cancila*	Food	+	+	-
Total			**31**	**97**	**21**

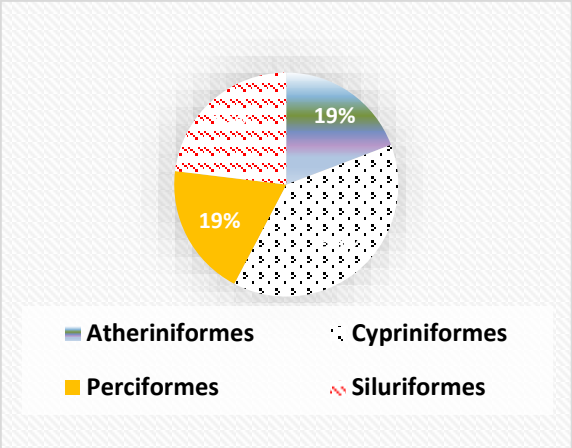


Fig.3: Relative contribution of Orders to fish diversity in river Chenab

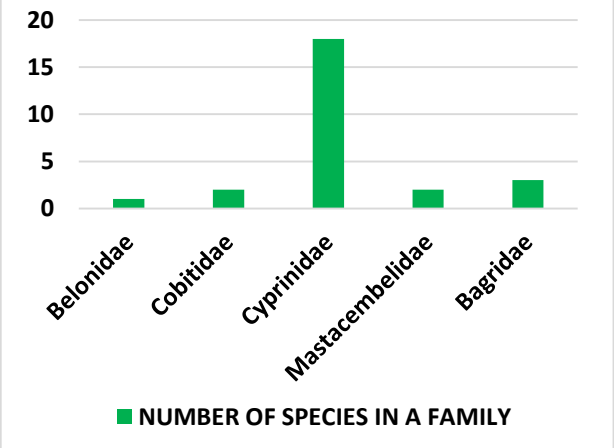
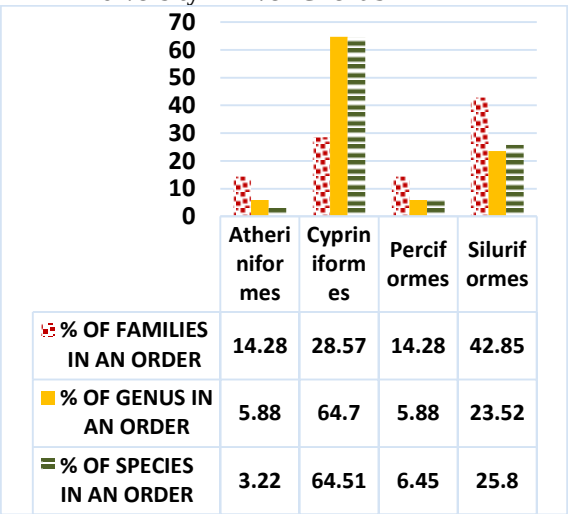


Fig.4: Number of species contributing to various families in river Chenab



	Atherinifor mes	Cyprin iform es	Percif ormes	Silurif ormes
% OF FAMILIES IN AN ORDER	14.28	28.57	14.28	42.85
% OF GENUS IN AN ORDER	5.88	64.7	5.88	23.52
% OF SPECIES IN AN ORDER	3.22	64.51	6.45	25.8

Fig. 5: Relative contribution of families, genus and species of various Orders in Chenab

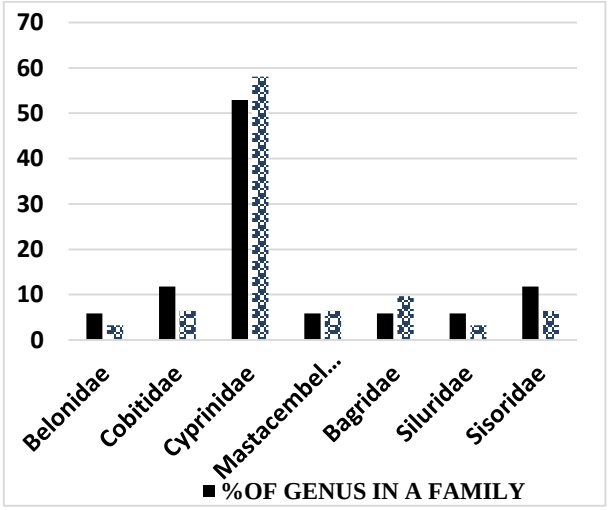


Fig. 6: Relative contribution of genus and species of various families in Chenab

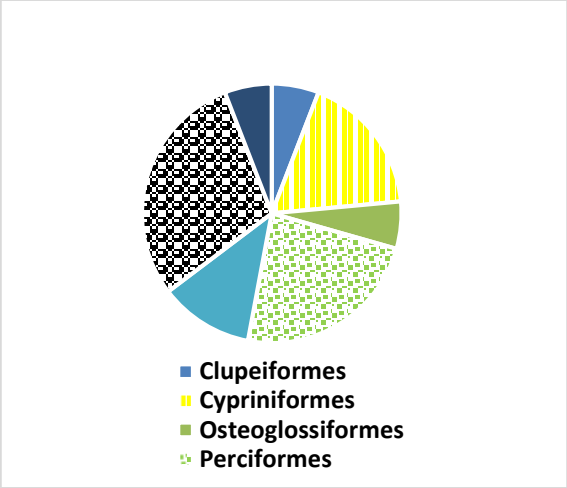


Fig. 7: Relative contribution of Orders to fish diversity in river Ravi

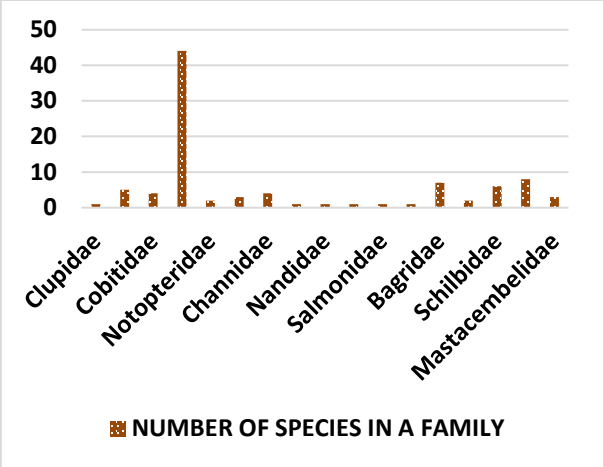
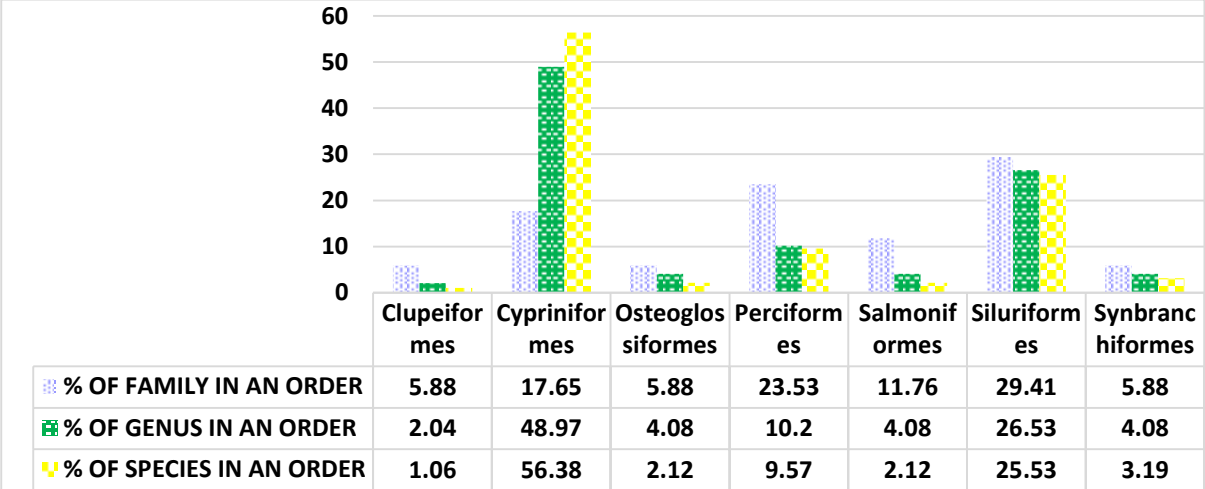


Fig. 8: Number of species from various families in river Ravi



	Clupeiformes	Cypriniformes	Osteoglossiformes	Perciformes	Salmoniformes	Siluriformes	Synbranchiformes
% OF FAMILY IN AN ORDER	5.88	17.65	5.88	23.53	11.76	29.41	5.88
% OF GENUS IN AN ORDER	2.04	48.97	4.08	10.2	4.08	26.53	4.08
% OF SPECIES IN AN ORDER	1.06	56.38	2.12	9.57	2.12	25.53	3.19

Fig. 9: Relative contribution of families, genus and species of various orders in river Ravi

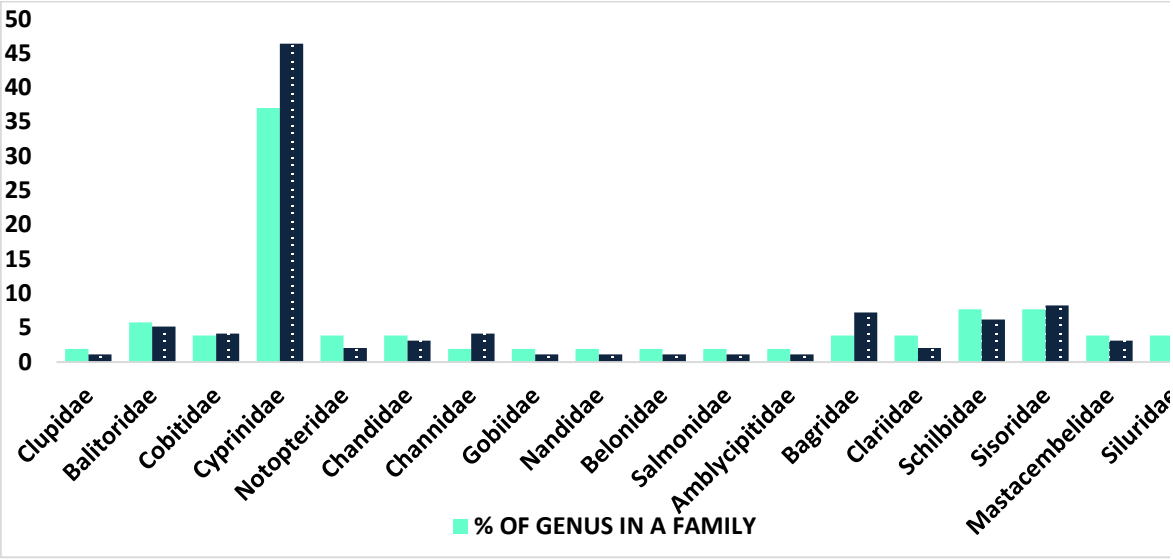


Fig. 10: Relative contribution of genus and species of various families in river Ravi

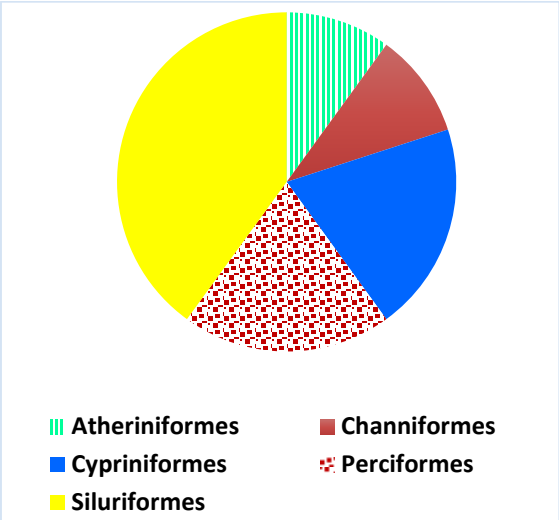


Fig. 11: Relative contribution of orders to fish diversity in river Tawi

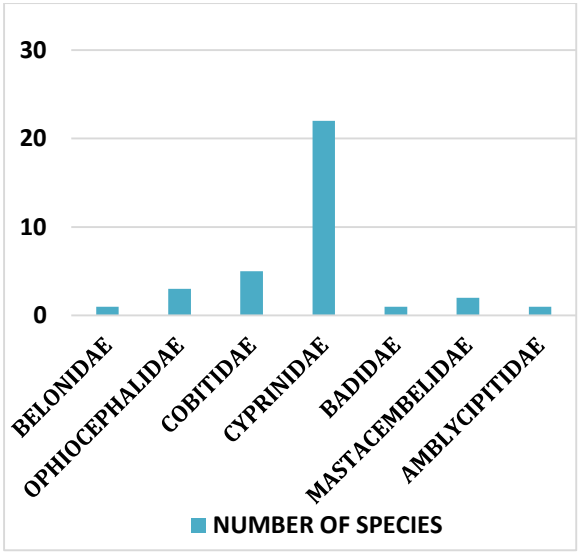
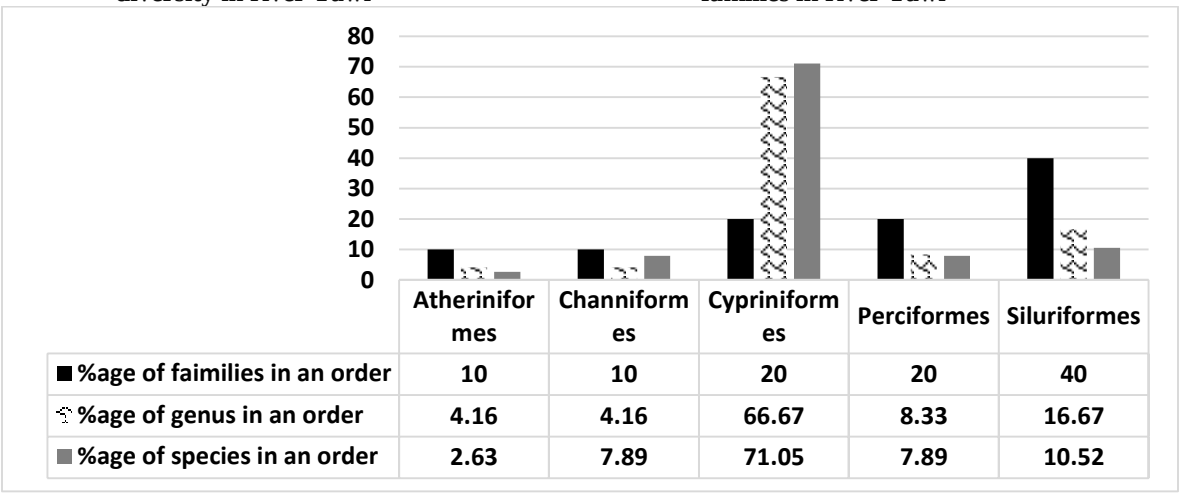


Fig. 12: Number of species contributing to various families in river Tawi



	Atherinifor mes	Channiform es	Cypriniform es	Perciformes	Siluriformes
%age of faimilies in an order	10	10	20	20	40
%age of genus in an order	4.16	4.16	66.67	8.33	16.67
%age of species in an order	2.63	7.89	71.05	7.89	10.52

Fig. 13: Relative contribution of families, genus and species of various Orders in river Tawi

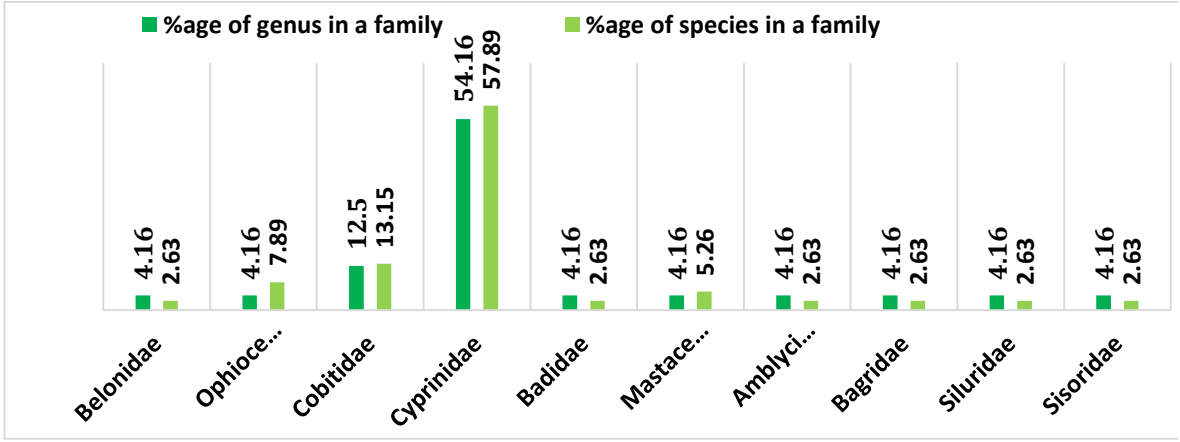


Fig. 14: Percent of genus and species from various families in river Tawi

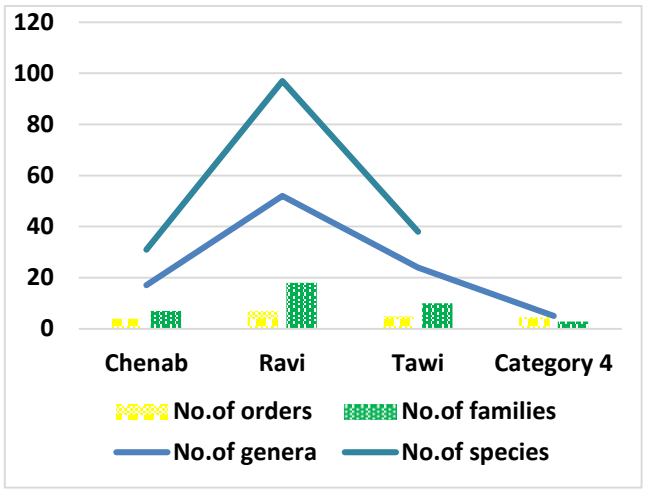
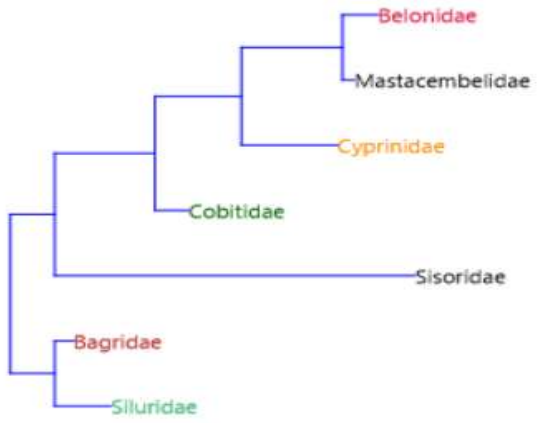
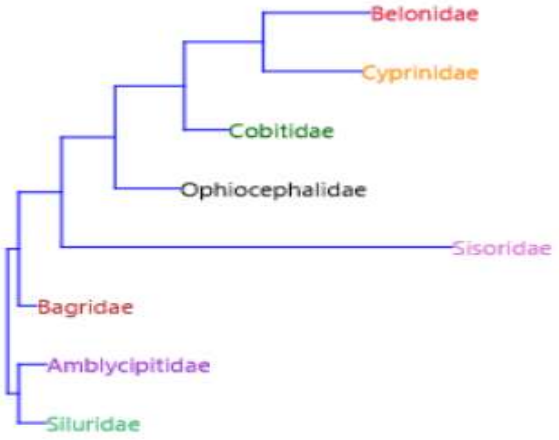


Fig. 15: Comparison of fish diversity of major lotic water bodies of the Jammu region

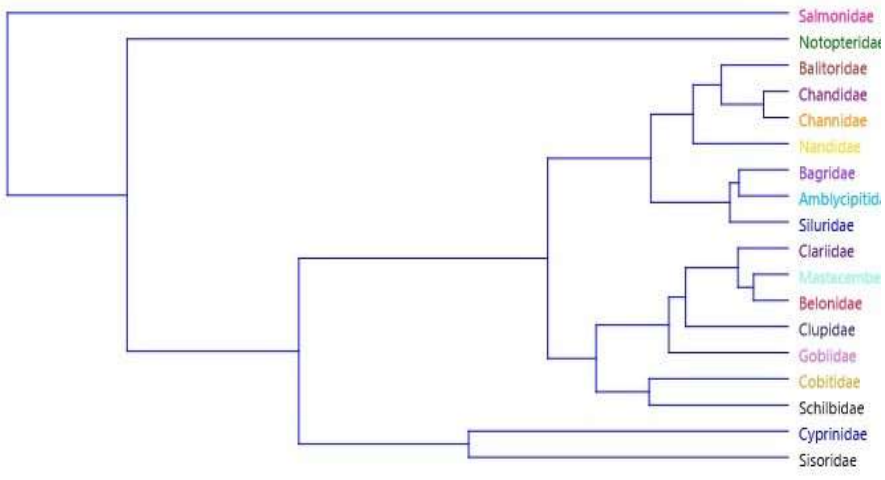
In order to manage the freshwater fisheries of vulnerable water bodies of the region, it is necessary to study the ecosystem health, Ichthyofaunal community structure, and distribution patterns, as well as to develop improved management and conservation measures. Consequently, a conservation strategy must be devised well in advance to exploit the region's water resources in the most efficient manner, not only to maintain the populations of these endangered and vulnerable species, but also to ensure the region's continued economic viability. Illegal fishing techniques, such as the use of dynamite, bleaching powder, chemicals such as insecticides, pesticides,



a)



b)



c)

Fig. 16: Phylogenetic trees (classical clustering based on physico-chemical parameters (water temperature, pH, and depth range) of major rivers of Jammu region a) Chenab, b) Tawi, and c) Ravi

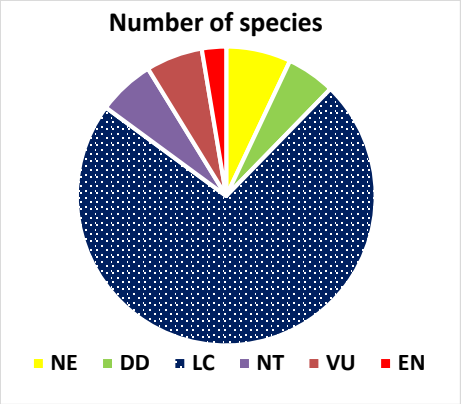


Fig. 17: IUCN status of fish fauna of Jammu region

electro-fishing, and small-mesh nets, as well as the indigenous method of fish capture through "fundha" (galloping) must strictly be regulated. Even fishing license holders do not adhere to the prescribed protocol and engage in overfishing, thus prevent the river environment from recovering its native community structure. Also, it is important to implement immediate conservation measures, such as minimizing pollution, avoiding the destruction of fish breeding grounds, and constructing hatcheries to produce huge quantities of trout, snow trout, and golden Mahseer for aquaculture (Balkhi and Bhatt 2022). Hydroelectric projects that do not rely on massive reservoirs should be prioritised since they reduce damage to the ecosystem while also being more cost-effective to build (Bhatt and Pandit, 2015).

Community fish sanctuaries: The Jammu region is endowed with a variety of fish sanctuaries that are home to numerous endangered fish species. Fish sanctuaries, especially in Udhampur and Reasi such as Bawa Pahar, Jib stream, Mansar lake, Salan Bawali, Ban Ganga stream, etc. which have proved one of the most effective methods of *in situ* conservation of fauna while also preserving the harmony between man and nature. In these sanctuaries, not only fishing is prohibited, but they are also venerated as God, demonstrating a straightforward yet effective method of germplasm protection (Sharma *et al.*, 2016).

Fisheries and aquaculture must be integrated into national climate change adaptation plans. The fisheries sector is likely to suffer as a result of the adaptation of measures implemented by other sectors, such as increasing usage of dams and hydropower in catchments with heavy rainfall, if not well planned. Further, the emergency recovery plan for freshwater biodiversity developed by scientists/experts (echoed in the Convention on Biological Diversity 5th Global Biodiversity Outlook, 2010) need to be followed. This plan has successfully been implemented in many parts of the world to fix the species loss problem. The nuisance of exotic carp, which threatens the survival of native species, must be controlled. Urgent counseling/meetings with religious communities and local stakeholders must be held so that the plan to transfer the excess fishes, control excessive feeding, and harvest fish, can be implemented expeditiously.

Conclusion: On the basis of present assessment it is established that aquatic ecology of Jammu region inhabits 158 fish species; wherein river Ravi contributes the most. The elements contributing to wide fish diversity in the region is the presence of enormous lentic and lotic waterbodies and wide variations in climate. The Jammu region is endowed with many water bodies that provide vast opportunity for fisheries. The region's resources are not utilized in a sustainable manner as many water bodies are either polluted or its fish fauna is overexploited, while the rest are unexplored. Upper reaches of Jammu region, where vast sources of lotic water bodies occur, is not explored well, thus little is known about the composition, distribution, and population dynamics of ichthyofauna in them. The problem is compounded by the lack of awareness and the region's inaccessibility due to less transit amenities. Therefore, a balance needs to be struck between the explored and unexplored resources. The aesthetic value of ornamental fishes supports a multibillion-dollar industry worldwide. Hence, new opportunities may be created to exploit them as an important cash crop besides food and forage fishes.

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