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Original Research Paper

Assessing Fish Population Diversity in Rangazak and Challou River of Manipur, India

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Abstract

Two ecologically significant ecologically poorly known hill-stream systems within the Indo-Myanmar Biodiversity Hotspot in the Chindwin-Irrawaddy basin on the Chindwin coast of the Indo-Myanmar frontier, which feed the Indo-Myanmar coast, are the Rangazak and Challou rivers, in the northern part of Ukhrul District, Manipur, India. The first systematic evaluation of fish diversity in these rivers is reported in the study and aimed at to provide a baseline information on biodiversity tracking, conservation and sustainable management of the local aquatic resources. Three sites were sampled each in the rivers (dry season (February-April 2025) and monsoon season (May-July 2025)) with a common effort of cast nets, gill nets, scoop nets, angling and hand collection. Community evenness was estimated on the basis of the Shannon-Wiener diversity, Pielou evenness and Margalef richness indices. The total number of fish species was 24 representing 18 genera and 7 families (Cyprinidae was the highest species rich family). The composition of the community changed between seasons with the cyprinids (62.9% in Rangazak; 50.9% in Challou) being the prevailing group in the dry season and the rheophilic loach Schistura (Nemacheilidae) dominating in Rangazak in monsoons (52.5%). The indices showed moderate diversity (H 0-1.82-1.99), moderate evenness (J0-0.60-0.64) and high species richness (D-3.10-3.43) that were promoted by monsoon flooding and fish movement, breeding migration and assemblage renewal. The presence of several species that are sensitive to the environment like Glyptothorax, Pseudecheneis, Schizothorax and Tor are indicative of the fact that the rivers are highly environmentally intact but there is the scarcity of economically significant species (Tor, Neolissochilus, Semiplotus) and increasing human pressures on the system through destructive fishing and disturbance of habitats that make the rivers particularly significant as far as conservation is concerned.

Keywords:- Species Composition, Fish Diversity, Species Richness and Distribution Pattern

INTRODUCTION

Two rivers, Rangazak River and Challou River in the northern region of the Ukhrul District, Manipur are two ecologically significant systems in the Indo-Myanmar Biodiversity Hot spot and are important lifelines to residents living in this area. These streams have become invaluable in subsidizing agriculture as well as supplying fish which is a staple food to the residents. Due to the richness in water and to the foothill terrain features, this area is called Raphei meaning foothills blessed with abundant water. It is important to note that the two rivers are geographically isolated of the major river systems of Manipur, and have no immediate hydrological connections, steep topography, forested catchments and reduced industrial disturbance has enabled them to sustain a unique assemblage of hill-stream fish species (Acharjee & Barat, 2014). This seclusion has restricted the scientific exploration leading to minimal known data of their fish fauna.

The topography of the area with falling river tracts, deep pools, and riffles-interested portions forms a not only habitat mosaic harboring multiple species, which are adapted to swift hill stream environment (Gogoi et al., 2024). They also observe that a number of species have a

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flattened morphology and adhesive organs as well as an adaptation of the fin characteristic of rheophilic fishes in Northeast India (Saxena and Chandy 1966; Hussain and Bordoloi 2018). Consequently "it is paramount to study the ichthyofauna composition of these rivers, not solely with a view to record the biological values of these water bodies but also with the view to crafting meaningful conservation and management plans such that the local people who are majorly dependent on these waters as subsistence fish can be provided with.

Fish constitute one of the most divergent vertebrate families worldwide, comprising about 36,484 species, 18,495 of which can be found in freshwater (Fricke et al. 2023). They are also one of the most exploited aquatic organisms (Tornwall et al. 2015), due to their nutritional, socio-economic and cultural significance to human communities (Özturk et al. 2021). Freshwater ecosystems are a vital biodiversity component on Earth, despite occupying less than 1 percent of the Earth (Dudgeon et al. 2006; Sedeno-Díaz and Lopez-Lopez 2012) despite having an abundance of almost 13000 freshwater fish species found in 2,513 genera (Levque et al. 2008). Meanwhile, fresh water fishes are extremely sensitive to the changes in the habitat quality and quantity, which makes them one of the endangered vertebrate groups on the planet (Darwall and Vie 2005). Due to their sensitivity to environmental conditions based on their abundance and composition, they are used extensively as bioindicators of water quality, flow regimes and connectivity of rivers within a river network (Chovance et al. 2003).

Globally, there are known incidents of overexploitation causing erosion of freshwater fish habitats, water pollution, climate change, and over-pumping of water resources (Foote et al. 2020). It is therefore important that diversity, distribution and abundance of freshwater fish species can be known so that conservation and management strategies can be guided. By analyzing spatial and temporal patterns of the fish evidence, ecological processes can be viewed to influence community structure (Galacatosa et al. 2004). Regular evaluations play a crucial role in protecting water resources particularly in the face of mounting human-induced demands (Das et al. 2021).

In India, the Northeast area is known to be among the wealthiest freshwater fishes diversity regions in the country (Ramanujam et al. 2010). Goswami et al. (2012), presented 422 fish species in this region which included Himalayan and Indo-Burma biodiversity hotspots. According to recent research, the rich fish germplasm of Northeast India is on the brink of extinction with threats of increasing anthropogenic disturbances (Dutta et al. 2018). The once rich species in the wild are now becoming scarce and it is mainly caused by loss, exploitation and degradation of the habitats, unsustainable fishing activities and illegal harvesting.

Ukhrul District has a low number of studies that have been historically based on ichthyofauna. The first document on fish fauna in the present Ukhrul district dates back to Chaudhuri (1912), and the next, Hora (1937) investigated fish specimens of the Khunukong and Namya rivers located in the eastern part of Ukhrul, in his research on the upper Chindwin drainage. Further details of the rivers to the north, especially Chalou and Rangazak or Laniye would not be available until many decades later, and the most recent file of all 44 species of fish in the area was given by Kosygin and Vishwanath (2005). Other than these few sources and contributions, very few sources exist in regard to the fishes of Rangazak River and Challou River.

The natural response of fish diversity to environmental variability and growing human impact is a fluctuating phenomenon. The fish are highly varied in morphology, physiology and ecological behaviour thus allowing them to inhabit a large variety of ecological conditions (Nelson, 1912). Nonetheless, the accelerated population growth and the escalating strain on natural resources has resulted in mounting pressures to the aquatic ecosystems, which present considerable challenges on the aquatic resources (Noss and Peters1995; Folkerts1997; Cordell et al.1998; Melvin et al. 2022) The growing hostility has led to the dwindling numbers of fish stocks around the world as a consequence of overfishing (Allan et al., 2005; Priyanka and Dwivedi 2025). The degradation of riverine ecosystems along with the biodiversity has emerged as one of the issues of concern globally (Dunn 2004).

With these issues in mind, it is highly time to consider systematic conservation of fish resources and more objective scientific study of fish resources, in particular in less well-known regions. In Manipur, the natural fish communities are influenced by physically differentiated terrain, unique physiographic features, and diverse patterns of watersheds. A number of scientists have recorded fish species of different aquatic environments in the area (Hora1936; Kosygin and Vishwanath, 1998; Ao et al., 2008; Goswami et al., 2012). However, extensive surveys have not been performed in most of the drainage systems in the district as it is the case in Ukhrul drainage systems. The inaccessibility of the northern rivers and the ecological individuality, that more species continue to exist in hill streams are probably undocumented and lack of an elaborate inventory points to a serious knowledge deficit.

In this regard, the current research was conducted to explore and document the fish diversity of Rangazak River and Challou River in the north of Ukhrul District. By recording the existing species, the survey will demonstrate useful baseline data which can help to conduct future biodiversity surveys, conservation measures, and sustainable utilization of the local water resources.

MATERIALS AND METHODS

Study Area

This present study was carried out in two important hill-streams of Northern Ukhrul District, Manipur—the Rangazak River and the Challou River (Fig. 1).The Rangazak River, located at 25.5364356° N and 95.709655° E with an elevation of about 586 m, stretches for nearly 100 km. and Challou River located at 25°14'19.14"N and 94°37'48" and flows for about 91 km through the northern part of Ukhrul. The Rangazak River (Tizu River) and the Challou River (Thetsu River) have northward flow, where the rivers converge at Mercy Bridge, at the Melluri District, Nagaland and is an important drainage of the Chindwin-Irrawaddy.

The rivers are both perennial hill streams with their source in the Shirui-Kashung mountain range of Shirui Village, and flow through steep woody banks over long rocky and boulder beds, cascades, rapid and riffle, shallow covers, isolated shallow to deep pools, clear cold water in dry

seasons and turbid rapid flow in monsoon. These environmental gradients lead to a rich assemblage of Indo-Myanmar hill-stream ichthyofauna. These two rivers, therefore, over time have been known to possess an incredibly vast fish diversity, due to the unique geography and river arrangement as well as to the natural environments of the surrounding landscape, in combination with which they create the main freshwater base of Raphei region of northern Ukhrul, Manipur in India.

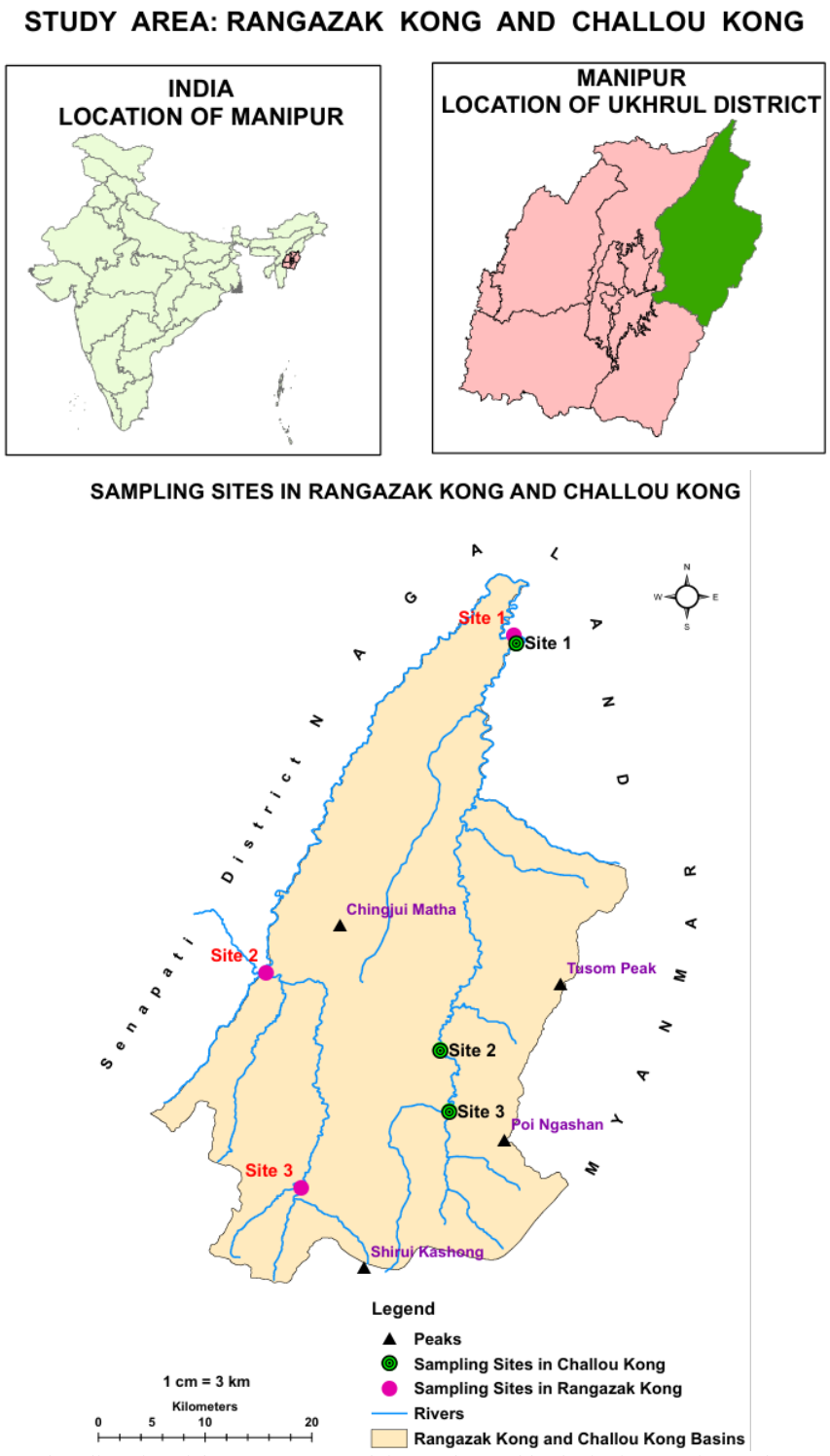


Fig 1. Study Area and sapling site of the present research in Northern Ukhrul District, Manipur—the Rangazak River and the Challou River.

Fish Collection and Identification

Each site had a pair of fish samples during both the dry season (December to February 2024) and the monsoon season (May to July 2024) to obtain seasonal variability in collection in terms of species composition. Principal sampling was done during the month of December and

until mid-February-2025- the season of the pre-monsoon. To local fishers, this is typically the best time of the year to go fishing since the water levels are low and the river is more transparent making the fish easier to detect and catch. It is also easier to exploit a greater variety of more traditional methods of fishing in the conditions of these months and this assists in gaining a more complete record of the species present. A radius of approximately 300 meters of each set locality was used to collect fish to make sure that a sufficient area was covered by the set locality. The same number of fishers (5) was taken as sampling effort during the entire surveys, similar environmental conditions, coverage of riffle" run and pool habitats and 3 hours of homogeneous fishing per location.
In the current study, fish were collected in three sampling sites in each rive: -

1. Rangazak River:
Sampling site 1= 25°38'25.61"N & 94°35'1.24"E
Sampling site 2 = 25°21'19.99"N & 94°22'30.08"E
Sampling site 3= 25°10'26.50"N & 94°24'15.06"E

2. Challou River:
Sampling site 4 = 25°38'2.40"N & 94°35'8.56"E
Sampling site 5 = 25°17'24.96"N & 94°31'17.35"E
Sampling site 6 = 25°14'19.14"N & 94°31'43.80"E

Fish Gears & Methods
Sampling was done in collaboration with experienced local fishermen, who have in the past known and understand the proper use of traditional fishing techniques and the scientific technique to achieve maximum species detection at the microhabitats level. Their knowledge of the rivers greatly contributed to locating and catching different species. To ensure that a wide variety of fish were collected, several types of nets were used, and the five fishermen were assigned different fishing methods based on their experience: one used a casting net, two used gill nets, one did angling and one used a scoop net along with hand collection. The present study involved the collection of samples with the following gears and methods:

1. Standard Methods:
Casting nets (mesh size: 7.5 mm)
Scoop nets (mesh size: 2 mm)
Gill nets (mesh size: 10-15 mm)

2. Indigenous Methods
Angling: For large-bodied predators like *Misassembles*, *Channa*, *Cyprinids*, *Tor* etc. and for epipelagic and pelagic taxa (eg. *Barilius*)
Hand collection by overturning boulders/stones for benthic taxa *Glyptothorax, Schizura,*

Identification and Taxonomic Verification
The identification was made by using standard taxonomic references (12, 15, 16), such as those made by Talwar and Khingan (1991), Jayaram (2010), Vishwanath et al. (2014) and Sarma (2017). Nomenclature was cross-validated with the Catalog of Fishes and Fish Base to obtain the updated validity and synonyms and also the conservation status of each species was verified using the IUCN Red List (2024).

In sample, information which included the total number of fish that were caught, the cooler pattern, body markings as well as the exact point of collection were noted in the field. Live photographs were taken in order to record their natural coloring.

Diversity Study
In order to determine the structure of fish communities of the study area, the following ecological indices were assessed in the two river system:

1. Shannon–Wiener Diversity Index (Shannon and Weiner 1948)
The diversity of species in the two river system of Rangazak River and Challou River in the present study was evaluated using the formula given below:

$$H' = -\sum (n/N) \log (n/N)$$

Where,
H′ represents Diversity index, **n** is the number of individual species, **N** is the total number of all the species present in the community
The Shannon Wiener Diversity Index has values ranging between 0 and 4.5 and beyond. Index value 0 means that there is only one species in the community; Index value ranging between 0-1 means that the community is of low diversity, Index value ranging between 1-3 means that the community is of moderate diversity and Index value over 3 means that the community is of high diversity.

2. Palou's Evenness Index (Pileous 1966)
Specific evenness of species was tested about the distribution in the two river system of Rangana River and Challow River using the formula:

$$J' = H'/\log S$$

Where,
J′ represents Evenness Index, **H′** is the Shannon-Weiner Index, and **S** is the total number of species.
Where J = Evenness Index, H = Shannon-Weiner Index and S is the total number of species. Evenness Index Pielou (J) is 0- 1. Index value 1 indicates perfectly balanced community, Values between 1-0.9 indicates extremely balanced community, 0.89-0.7 indicates well balanced community, 0.69-0.5 indicates moderate evenness or relatively balanced, 0.49-0.25 unbalanced community, 0.24-0.00 indicates highly dominated community.

3. Margalef's Richness Index (Margalef 1958)
The richness of species of the two river system, Rangazak River and Challou River was evaluated by using the formula:

$$D' = S-1/\log N$$

Where,
D Hy D is the Richness Index of the Margalef S, and N is the number of observed species, and N is the number of species in the community.
The Richness Index of Margalef is at 0-5. Value less than 2.0 indicates low species richness, values between 2.1-3.0 indicate moderate species richness, values between 3.1-4.9 indicates high species richness, and values above 5 indicates exceptionally high species richness.

Statistical Analysis

The analysis of data was done with one way analysis of variance (ANOVA) with significance level being accepted at $P < 0.05$.

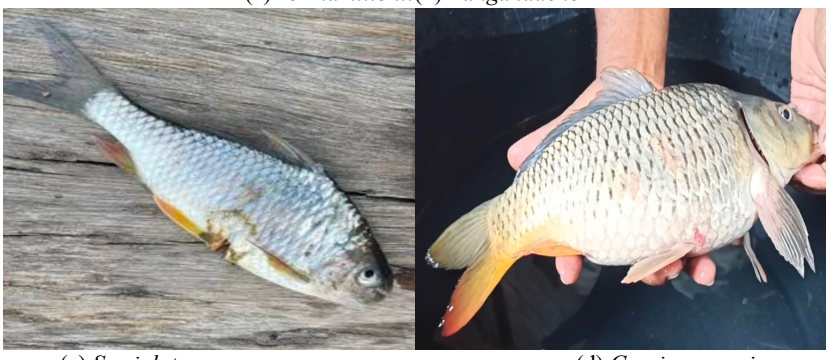
RESULTS

Species Composition

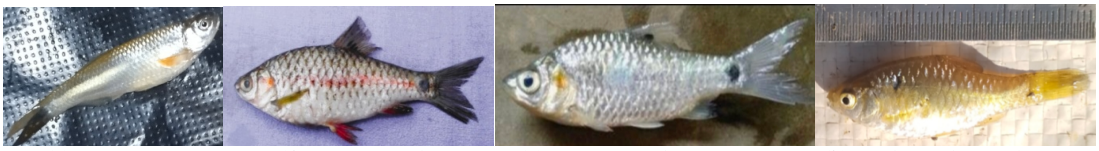
In this current investigation of the spellings of fish flora in the monsoon and dry seasons in the Rangazak River and the Challou River, a total of 24 fish species (18 genera and 7 families) were recorded. The flora composition is made up of: Anguilla spp. (family). (Channidae), Mastacembelus spp. (Mastacembelidae), Schistura spp. (Nemacheilidae), Lepidocephalus spp. (Cobitidae), from family Siluridae; Amblyceps spp. and Myersglanis spp., Glyptothorax spp. and Pseudecheneis spp. from family Sisoridae and finally from family Cyprinidae which includes; Bangana spp., Barilius spp., Cyprinus spp., Danio spp., Esomus spp., Garra spp., Neolissochilus spp., Pethia spp., Puntius spp., Raiamasspp, Rasboraspp, Schizothoraxspp, Semiplotus spp., and Tor spp. (Fig 2). The current study was performed in the dry season (between February and April) and the Monsoon season (between June and August) of the two river systems where a wide range of individual species biomass/count/catch was observed. In this present attempt to determine species composition, a total of 1020 and 1366 samples (number of individuals) were collected for the dry month while 965 and 883 samples was collected in the monsoon season from sampling sites of Rangazak and Challou River, respectively.

Fig 2 (a-v). Documentation of individual fish species from Rangazak and Challou River

(a) *Tor hamiltonii*(b) *Banganadeno*



(c) *Semiplotus* (d) *Cyprinus carpio*



(e) *Esomus* (f) *Puntiussophore* (g) *Puntiussophore* (h) *Pethiamelanoculata*

(i)*Riamas* (j) *Schistura*

(k)*Barilius* (l) *Garra* (m)*Channa* (n)*Lepidocephalus* (o) *Rasbora*

(p) *Anguilla* (q) *Mastacembelus*

(r) *Amblyceps* (s) *Schizothorax* (t) *Myersglanis* (u)*Pseudecheneisukhrulensis* (v) *Neolissochilus*

In the dry season, the % composition of species in Rangazak River was dominated by Cyprinidae with 62.9% followed by Nemacheilidae (22.16%), Channidae (6.86%) and others (Fig 3). There were 12 species of cyprinidae of which Baralius spp. It was found that (36.8%) was the dominant species followed by Puntius spp. (9.7%), Garra spp. (9.6%), Raiamasspp (2.2%) and others (Table 5.1). Schistura spp. with 22.4% of the population representing Nemacheilidae was the second predominant species in the population. The other minor composition of the species in Rangazak River were observed to be contributed by Channa spp. This was in (6.8%) followed by Lepidocephalus spp. of Cobitidae

(3.6%) followed by Mastacembelus spp. (2.8%) and others (Fig 5a).

Cyprinidae was the dominant species in the % composition of species in Challou River with 50.9% and Nemacheilidae was the second with (34.48) and Channidae was third with (6.15) and the rest with (3.7). There are 11 species of Cyprinidae with the predominant population composition of Baralius spp. at 31.9 per cent., and Puntius spp. after that. (7.6%), Garra spp. (4.6%), Pethia spp. (2.8%) and others (Table 5.2).

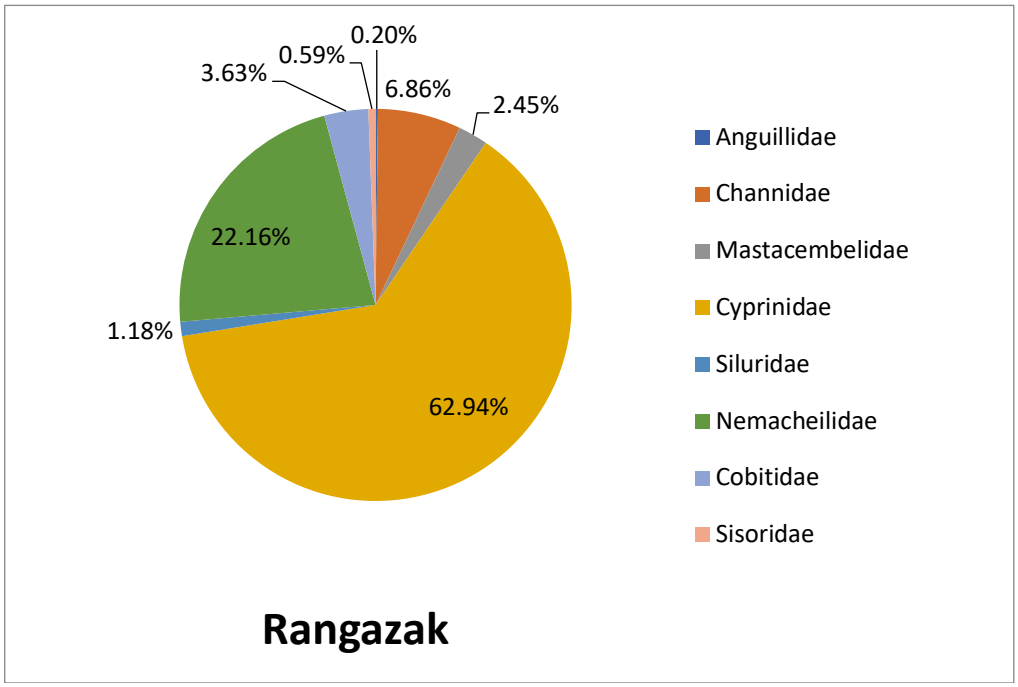


Fig 3: Percentage composition of species during Dry season in Rangazak River

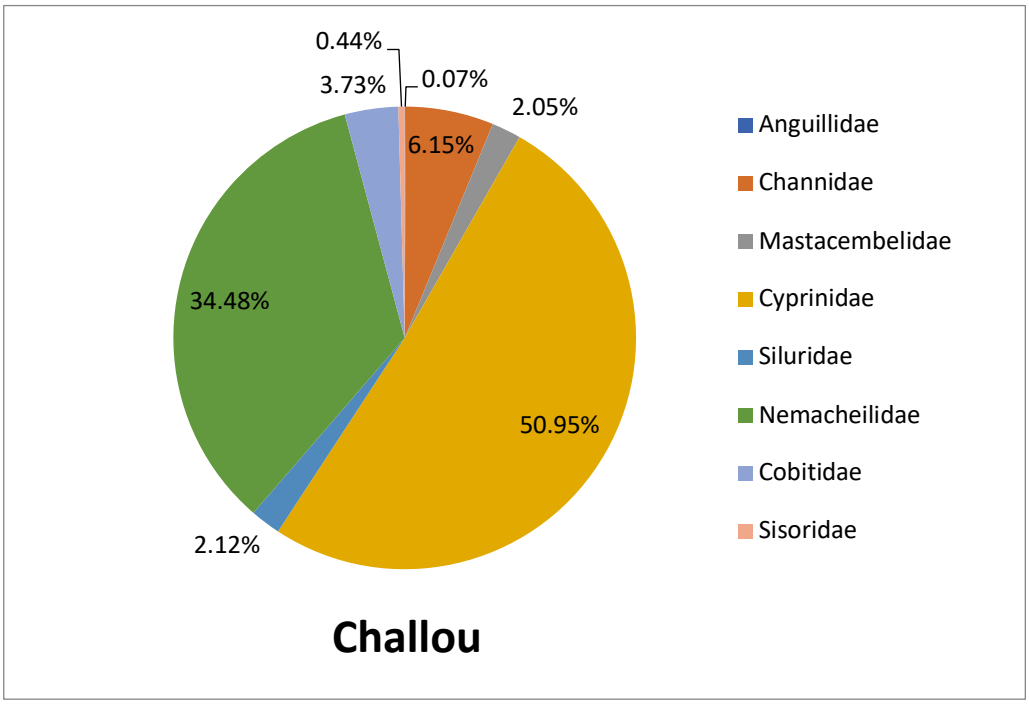


Fig 4: Percentage composition of species during Dry season in Challou River

Fig. 5 (a) Fish species recorded from Rangazak River during dry season

Fig. 5 (b) Fish species recorded from Challou River during dry season

Schistura spp. form Nemacheilidae was noted to be the most dominant and had 34.48% of the population. Channa spp was the next species that was prominent, and the other species that followed included Lepidocephalus spp and Mastacembelus spp. (Table 5.1).The population of Anguila spp and Glyptothorax spp was observed to be the least populated with 0.08% in Challo River. Other species like Anguila spp in Rangazak; Tor spp had the same with 0.19 and 0.09 respectively.

In the current research, two rivers system were different in the nature of the dry season of the river, where some species are found to suit a specific site in the sampling. This was not only indicated by the difference in the number of individual species caught but also the lack of particular species at specific sites as revealed by the table (5.1). Particularly, species such as Cyprinus spp. which was absent in Rangazak was present in Challou at the same time Brachydanio spp. was absent in Challou while found in Rangazak River. Further, within the same river site specific abundance in species representation are prominently indicated. In site 1 of Rangazak, about 18 fish species were identified whilst site 2 and 3 identified only

15 and 13 species respectively. Similarly, in Challou River 19 species were recorded in site 1 while only 12 species were observed in site 2 and 3. Outstanding number of species were caught in particular sapling location in site 1 and 2 of Challou River of Baraliusspp and Schisturaspp respectively. In this season, both the river failed to record any species of namely Semiplotusspp and Neolissochilus spp.

Table 5.1. Species of fish caught during the DRY SEASON from February to April 2025 in Rangazak and Challou River.

Fish species	Rangazak River					Challou River				
	Sampling Sites			Total (n)	% Composition	Sampling Sites			Total (n)	% Composition
	site 1	site 2	site 3			site 1	site 2	site 3		
Amblyceps	8	3	0	11	1.09	2	21	0	23	1.73
Anguila	2	0	0	2	0.19	1	0	0	1	0.08
Bangana	2	1	0	3	0.29	3	0	1	4	0.30
Barilius	130	94	147	371	36.8	202	156	78	436	32.83
Brachydanio	0	1	0	1	0.09	0	0	0	0	0.00
Channa	22	35	13	70	6.95	18	43	23	84	6.33
Cyprinus	0	0	0	0	0	1	0	0	1	0.08
Danio	0	0	1	1	0.09	1	3	0	4	0.30
Esomus	0	3	1	4	0.39	0	0	5	5	0.38
Garra	26	49	23	98	9.74	15	19	29	63	4.74
Glyptothorax	3	1	0	4	0.39	1	0	0	1	0.08
Lepidocephalus	9	16	12	37	3.67	12	23	16	51	3.84
Mastacembelus	10	7	8	25	2.48	4	5	19	28	2.11
Myer Sglanis	1	0	0	1	0.09	6	0	0	6	0.45
Neolissochilus	0	0	0	0	0	0	0	0	0	0.00
Pethia	7	16	12	35	3.47	17	12	10	39	2.94
Pseudecheneis	1	0	1	2	0.19	3	2	0	5	0.38
Puntius	41	28	30	99	9.84	32	52	21	105	7.91
Raiamas	6	14	3	23	2.28	7	10	16	33	2.48
Raspora	2	1	0	3	0.29	0	0	0	0	0.00
Schistura	47	104	75	226	22.46	56	304	111	471	35.47
Schizothorax	2	0	1	3	0.29	3	0	1	4	0.301
Semiplotus	0	0	0	0	0	0	0	0	0	0.000
Tor	1	0	0	1	0.09	2	0	0	2	0.151
Total (N)	312	370	327	1020	100%	384	629	330	1366	100%

The composition of fish species in Monsoon exhibited a considerable difference in the two river system, compared to Dry season. The proportion composition of species in Rangazak River was dominated by Nemacheilidae which had 52.54% by single species namely Schistura. This was then Cyprinidae (35.7%) in which there were 15 species. One of the cyprinidae species Baralius spp was also found to be the most dominant with 12.9% then Garra spp (6.4%), Puntius spp (4.6%) and the rest of the species (Table 5.1). Other sources include form Channidae (4.4%), Mastacembelidae (3.9%), Cobitidae (2.4) and others (Fig 6).The pattern of species assemblages during monsoon in Challou River was similar to that during the dry season with Cyprinidae becoming the dominant species (50) and Nemacheilidae (36.6) and Mastacembelidae (7.58) significantly to Channidae (3.05), Cobitidae (1.18) and others (Fig 7). Nemmacheilidae is again represented by single species viz Schistura spp. while cyprinidae is represented by 12 species which is dominated by Baralius spp. (25.2%), then came Puntius spp. (7.5%), Garra spp (4.07%), Schizothorax spp. (2.1%) and other species (Table 5.2). Mastaclembelidae that was represented by Mastcembelus spp. constituted 7.5% of the species composition followed by Channa spp that constituted 3.05. Other representative of the species are represented in the figure (7) given below.

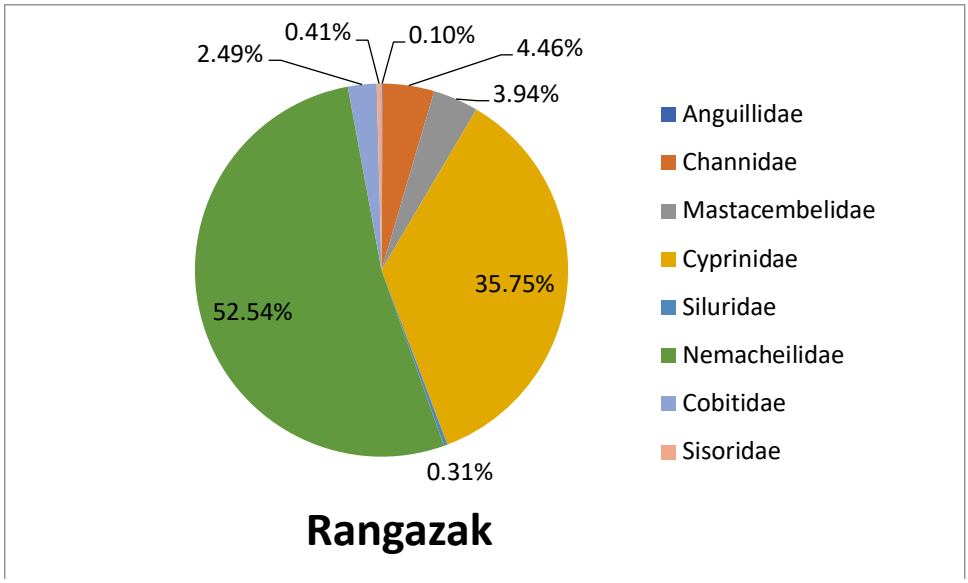


Fig 6: Percentage composition of species during Monsoon in Rangazak River

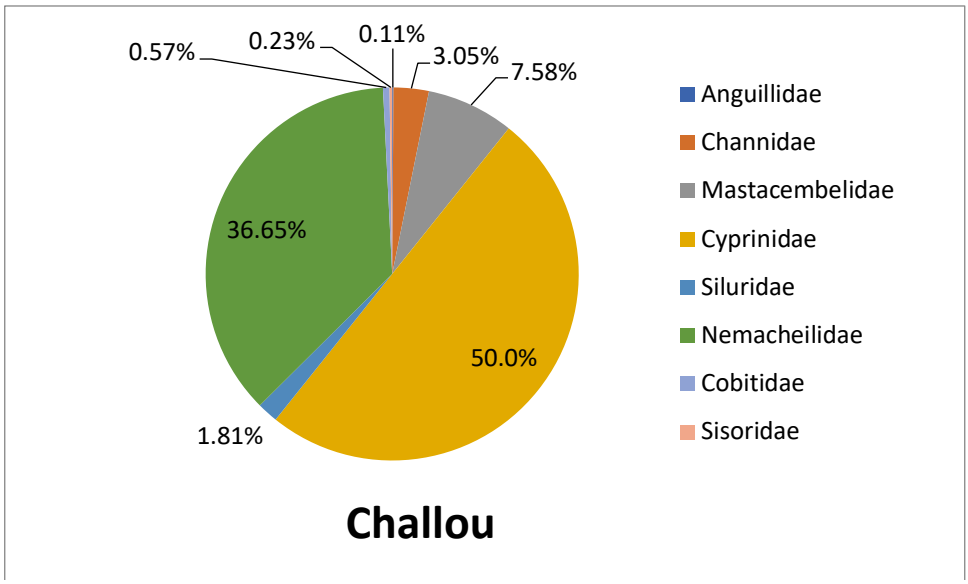


Fig 7: Percentage composition of species during Monsoon in Challou River

Site specific assemblages of species appear to be much higher at specific sampling sites in the monsoon sampling. This was showcased by registering a count of 20 species in site 1, site 2 (19 species) and site 3 (15 species) out of 24 species in Rangazak River.

Fig 8 (a). Fish species recorded from RangazakRiver during wet season

Fig 8 (b). Fish species recorded from Challou River during wet season

On the same note, site 2 had the most species (17 species) in Challou River followed by site 2 (16 species), then site 3 (10 species). Also, Schistura spp. exhibited an abundance in site 2 of Rangazak. Similarly, for Challou River Schisturaspp and Baraliusspp was recorded in site 2 (Table 5.2).

The use of seasonal variation in species composition of Rangazak and Challou River revealed the emergence of new species of monsoon which had previously not been observed in the dry season. These species are Schizothorax spp., Semiplotus spp. and Cyprinusspp seen in Rangazak. What is interesting, is the seeming absence of such species in the Challou River as Raspora, Esomus, Anguila and Myer Sglanis as monsoon. The two river system revealed no significant difference in the yield of the catch in the two seasons in the present study. However, it is important to observe that the species assemblage was higher for monsoon in Ranazak while the catch in number was higher in dry season. Nevertheless, monsoon yielded a lower species assemblage than catch seasonal, which was dry season.

Table 5.2. Species of fish caught during the MONSOON from February to April 2025 in Rangazak and Challou River.

Fish species	**Rangazak River**					**Challou River**				
	Sampling Sites			Total (n)	% Composition	Sampling Sites			Total (n)	% Composition
	site 1	site 2	site 3			site 1	site 2	site 3		
Amblyceps	2	0	0	2	0.21	3	12	1	16	1.81
Anguila	1	0	0	1	0.10	0	0	0	0	0.00
Bangana	2	3	1	6	0.62	12	2	4	18	2.04
Barilius	54	41	30	125	12.95	27	164	32	223	25.25
Brachydanio	1	1	2	4	0.41	3	0	0	3	0.34

Channa	5	23	15	43	4.46	11	13	3	27	3.06
Cyprinus	12	5	3	20	2.07	13	7	12	32	3.62
Danio	1	0	0	1	0.10	0	3	0	3	0.34
Esomus	0	0	1	1	0.10	0	0	0	0	0.00
Garra	21	28	13	62	6.42	5	23	8	36	4.08
Glyptothorax	0	1	3	4	0.41	0	1	0	1	0.11
Lepidocephalus	4	13	7	24	2.49	0	2	3	5	0.57
Mastacembelus	18	12	8	38	3.94	31	24	12	67	7.59
Myer Sglanis	0	1	0	1	0.10	0	0	0	0	0.00
Neolissochilus	1	0	0	1	0.10	0	0	0	0	0.00
Pethia	6	12	10	28	2.90	4	2	1	7	0.79
Pseudecheneis	0	0	0	0	0.00	1	0	0	1	0.11
Puntius	12	13	20	45	4.66	20	14	33	67	7.59
Raiamas	4	2	3	9	0.93	3	7	7	17	1.93
Raspora	0	1	0	1	0.10	0	0	0	0	0.00
Schistura	12	443	52	507	52.54	20	203	101	324	36.69
Schizothorax	8	1	6	15	1.55	10	6	3	19	2.15
Semiplotus	7	2	0	9	0.93	1	3	2	6	0.68
Tor	13	5	0	18	1.87	9	2	0	11	1.25
Total (N)	184	607	174	965	100%	173	488	222	883	100%

Species diversity

The number of fish species in the participated river system in the present study was significantly correlated with season. The evaluation of the community in the Shannon Weiner Index indicate that there was increased diversity of species in the river system in the Monsoon than in the dry season. The index value showed a maximum value of 2.4 in the monsoon while in the dry season the highest value was recorded at 1.9. Nonetheless, the Shannon index assessment of the different sampling sites of Shannon showed the different values of the index in the two seasons. The river Ranazak River recorded a high percentage 1.98(at site 1) and 1.99 during dry season compared to the other sampling points of Challou River. Challou River showed the lowest figure of 1.63 in the sampling site 2 (Fig 5.8). The Monsoon season diversity study demonstrated that the index of diversity significantly rose at certain sampling locations. The sampling site 1 of Challou River rose to 2.43 in monsoon compared to 1.75 in dry season whereas sampling site 3 showed that the index value decreased to 1.83 (Fig 5.9). Rangazak River diversity index value on the other hand, went up by a significant margin in monsoon in sampling site 3, between 1.67 and 2.18 and an immediate significant decrease of the value was noticed in site two between 1.99 and 1.19. The total species diversity index of RangazakRiver was found to be better when the ChallouRiver was in the dry season with index value at 1.94 and 1.84. But in monsoon, both Rangazak River saw higher index of diversity at 1.99 and 1.82 in both Challou River (Table 5.3).

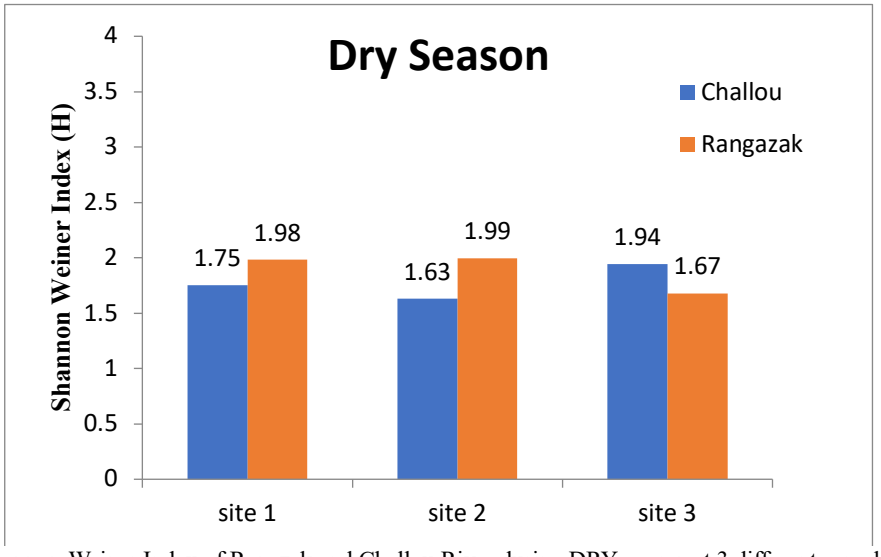


Fig 9. Shannon-Weiner Index of Ranazak and Challou River during DRY season at 3 different sampling sites

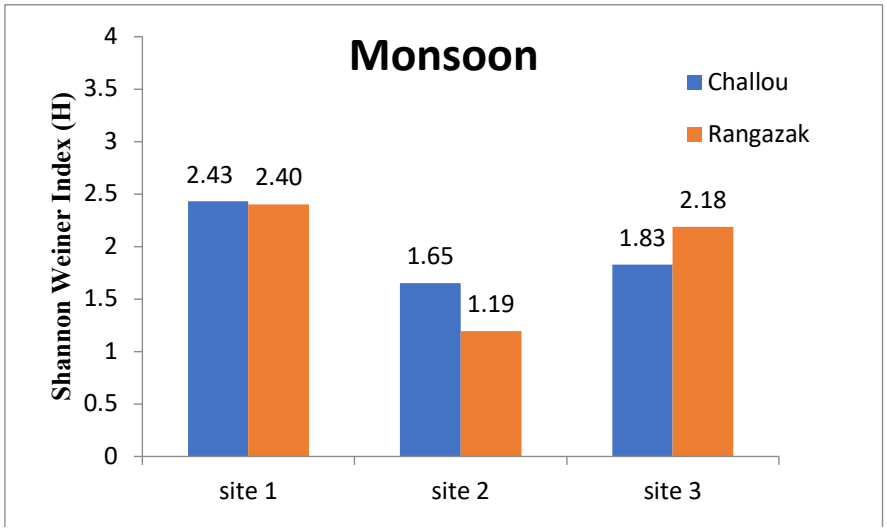


Fig 10. Shannon-Weiner Index of Ranazak and Challou River during Monsoon at 3 different sampling sites

Species Evenness

The speciation of species line along the river system in the current study that was calculated using Peilou Index (J) exhibited a great seasonal fluctuation at various sites of sampling. There was a high to moderate evenness in the dry season. The high evenness recorded during the dry season was at 7.8 at site 3 of Challou River followed by 7.4 at site 2 of Rangazak River. The remaining sampled sites of both the river systems had a moderate evenness in the species distribution (Fig 5.7). During monsoon, site 1 and 3 exhibited a high evenness of population distribution at the sites 0.82 and 0.81 respectively in Rangazak. Site 1 of Challou River had the highest value of evenness at 0.88. Significantly low evenness was observed for site 2 of Rangazak at 0.41 which had high evenness earlier in dry season (0.74). Moderate evenness was observed for site 2 and 3 of Challou River at 0.58 and 0.68, respectively (Fig 5.8). The general distribution of the species along the river was average to both the river system during the dry and monsoon seasons (Table 5.3).

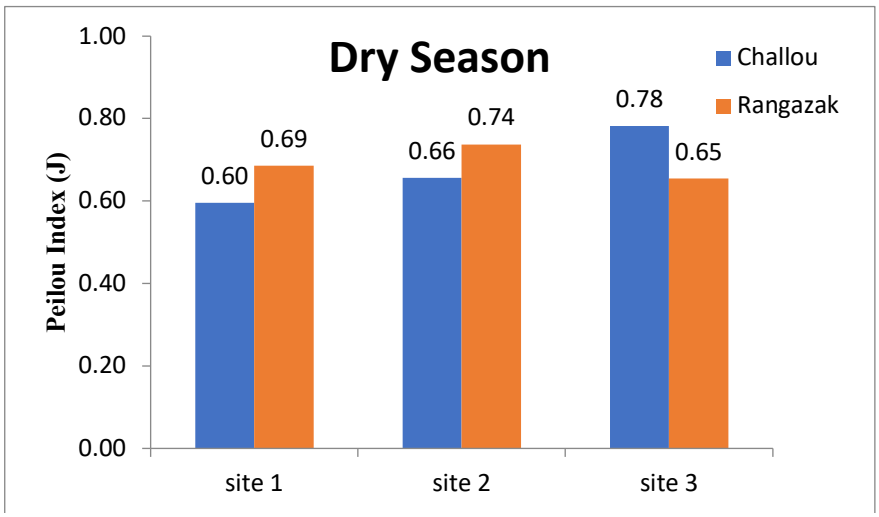


Fig 11. Pielou Index of Ranazak and Challou River during DRY season at 3 different sampling sites

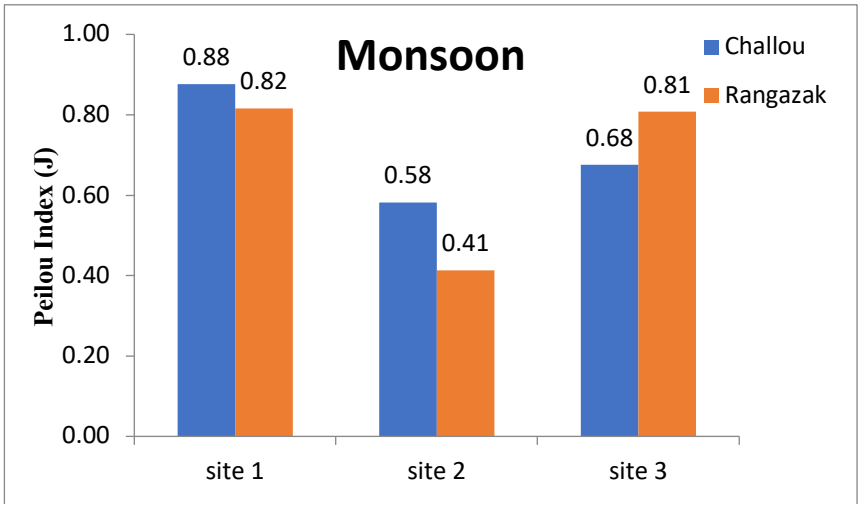


Fig 12. Pielou Index of Rangazak and Challou River during Monsoon at 3 different sampling sites

Species Richness

The margalef index of the Rangazak and Challou river indicated the evidence of constant rich population of flora. The two river reached a high species richness when it was in dry season and monsoon season (Table 5.3). In dry season, Rangazak recorder a higher index value at 3.43 as compared to Challou River with 3.10. However, Site specific examination of species showed a higher value for Challou River as compared to other sites (Fig 5.9). Some of the sampling locations on Challou River revealed low richness of site 2 and 3. In the case of Rangazak, the richness of the species to the sampling sites was moderate in all the sites (Fig 5.9).

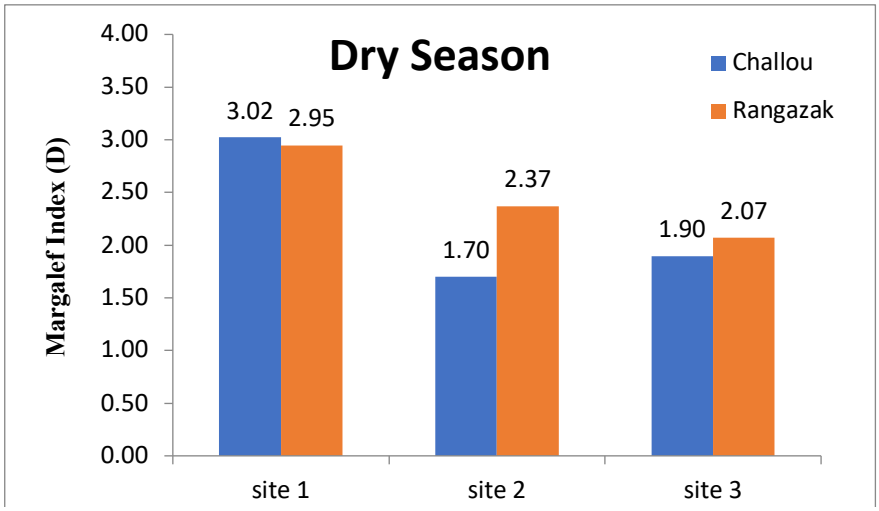


Fig 13. Margalef Index (D) of Ranazak and Challou River during Monsoon at 3 different sampling sites

The two river systems in the monsoon sampling showed high levels of species richness. The species richness index of the challou River species was the highest with 3.98 as compared to 3.34 in Rangazak (Table 5.3). Despite the environmental Margalef richness Index showing the highest margalef richness index on Challou River, the sampling site specific data actually had a high index of species richness at Rangazak site 1. All the rest of the sampling sites had an intermediate value of richness index. Site1 of Challou River was the second highest with Rangazak site 3 as the third. Site 2 of Rangazak River had the lowest number of 2.30 (Fig. 5.10).

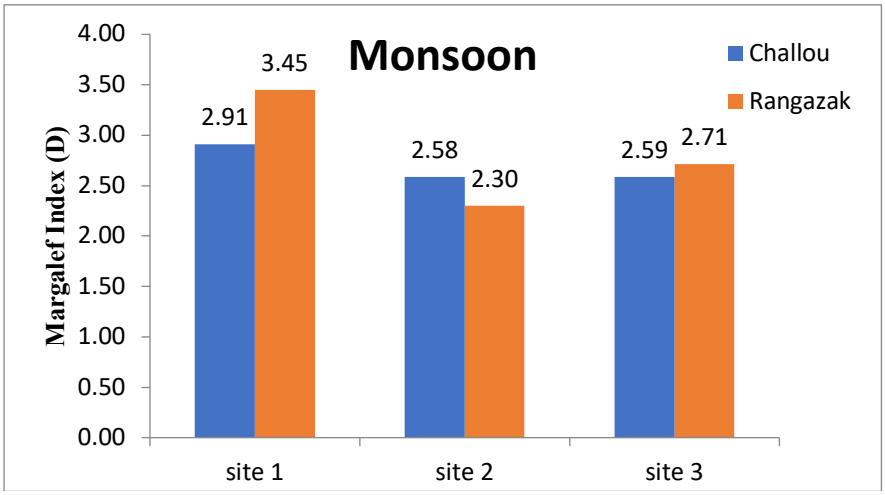


Fig 14. Margalef Index (D) of Ranazak and Challou River during Monsoon at 3 different sampling sites

Table 5.3: Diversity, Richness and Evenness of species of Rangazak and Challou River during dry and Monsoon season

Indices	Rangazak River		Challou River	
	Dry Season	Monsoon	Dry Season	Monsoon
Shannon-Weiner's Diversity (H′)	1.94	1.82	1.82	1.99
Peilou's Evenness (J′)	0.64	0.60	0.63	0.60
Margalef's Richness (D′)	3.43	3.34	3.10	3.34

DISCUSSION

The total ichthyofaunal enumerations of "Rangana River and Challow River are typical of Northeastern India hill-stream states with high fish diversity and taxonomic composition that are similar to other river systems located in the Indo-Burman biodiversity hotspots (Vishwanath, 2017; Barman et al., 2020).

Fish Diversity and Distribution in Rangazak River and Challou River

During the current study that was conducted in the monsoon and dry seasons, a total of 24 fish species were observed in the Rangazak River and Challou River representing 18 genera and 7 families (Table 1). The data shows distinct spatial and seasonal difference in occurrence of species in the six sampling sites. The most common family in the two rivers was Cypriniformes (exemplified by Barilius, Schistura, Garra, Pethia, Puntius, Raiamas, and Lepidocephalus). Siluriformes (such as Amblyceps), Glyptothorax, and Pseudecheneis were also abundant, especially in high gradient upstream parts with rocky substrates and abundant riffles as is characteristic of the Indo-Burman hill streams of Manipur. Channa and Mastacembelus made up the Perciformes, and were very common in midstream and lower reaches. The preliminary observations and local expertise suggest that there are many native and regionally important species.

Species Composition and Diversity

Some of the dominant genera recorded of these included Barilius, Schistura, Garra, Mastacembelus, Channa, Lepidocephalus, Pethia and Raiamas where the former were found in virtually all sampled sites implying that this group of taxa is widely ecologically tolerant and can significantly contribute to the total fish composition of both rivers. Schistura as a genus was a hugely dominant member of the benthic guild with a minor component of the benthic guild, Barilius, taking over the mid-water column. They are widely found in clear hill streams of fast flow-usually found in the northern region of Ukhrul.

The ichthyofauna of the pair of rivers included taxa of relatively unspecialized hill-stream cyprinids as well as highly specialized rheophilic species. Other genera like Barilius, Puntius, Pethia, Raiamas, Cyprinus and Danio do not have the special adhesive/attachment structures (Jayaram 2010); but have streamlined body shapes, tapered rear peduncles and fully developed forked rear caudal fins thus adapting them to swim efficiently in shallow marginal habitats (Talwar and Jhingran 1991). The highest abundance of these species was documented during the dry season when the velocity of the flow is low and the water is clear, which promotes their activity and thus captures better.

The catfishes of the hills - Glyptothorax and Pseudecheneis - were partly discovered in steep and rocky sections of all the stations. They have well-evolved adhesive organs (thoracic adhesive organs of Glyptothorax and modified thoracic folds of Pseudecheneis), which make them resistant to great currents. Other species also have morphological adaptations to allow them to occupy torrential environments, suctorial oral discs (Garra), and depressed bodies with lengthened pectoral fins (Schistura). This finding is in accordance with classical accounts of adaptations of hill-stream fishes as suggested by Hora (1922). On the other hand, other species like Bangana, Schizothorax and Anguilla exhibited few and specific occurrences that are not accessible. Anguilla was observed in just the lower location of Rangazak, indicating its attraction into deeper pools, and comparatively stiller water. In the same way Bangana and Schizothorax, a Himalayan cold water taxon were also extremely infrequent, only present at certain times of the year, confirming previous relationships that some

migratory species of hill stream fish are present during monsoon months when they can more readily pass upstream.

The locations of study were diverse in terms of habitat, with mid-elevation riffles (approximately 600 800 m above sea level) to steeper and high-gradient stretches (900 1200 m) containing cascades and boulder beds and narrow channels. Multiple species such as Barilius, Schistura, Garra, Channa, Puntius, and Pethia could be seen in all sampling points, as well as across both rivers, indicating their capacity to ecological stability, and adaptability towards a broad spectrum of environmental factors (Jayaram, 2010). On the contrary, other species were characterized by obvious habitat choices and their more confined distributions. Amblyceps and Glyptothorax inhabited only riffles with fast movement and with boulders. Pseudecheneis was only documented in several locations alongside the monsoon season and in a very small number which are in line with its high reliance on torrent habitats. Cyprinus and Esomus were however found predominantly in slower streams such as calm and shallow marginal pools (Talwar and Jhingran, 1999).

The survey that was conducted during the dry season, between February and April 2025 indicated significant differences in fish diversity, abundance, and patterns of distribution between Rangazak River and Challou River. Rangazak River counted 1020 individual fish and Challou River counted 1343 individuals with the same techniques used to fish and in the same season. The disparity in fish abundance can be explained by differences in water retention capacity, structure of the habitats, flow regime, availability of pools and ecological condition of two river systems (Sarkar et al., 2012). The extremely good presence of Schistura in this river shows that this is mostly shallow rocky, creviced, and benthic microhabitats when low water conditions prevail and the stone loaches can live there. Besides the observations made above, it is remarkable that in both of the mentioned rivers, Cyprinid fishes occupied fundamentally significant percentages of the fish populations. Several species like, Puntius, Garra, Pethia, and Raiamas were greatly distributed in all the study sites that had spatial differences in its abundance. Their ecological flexibility to various flow regimes and feeding sites is reflected in the wider role of Cyprinids in the two river systems.

Moreover, the site wise pattern of distribution proved to put in unequal spatial abundance to the study sites in both rivers in the dry season. The unbelievable abundance of fish at Site 2 of the two rivers is an indication that the stretches may have served as an ideal dry season refuge in relation to good heterogeneity of habitat, deeper pools and greater water retention where fish congregate more. Also, a number of fish species were also of very low abundance in both rivers under the current study that could be an indicator of either a rarity, or habitat specialization, seasonal movement, low population density migratory behavior or fishing pressure. It is notable that there are some important ecological and economic fishes that lacked or were very few in the rivers during the period of survey like Tor, Neolissochilus and Semiplotus. Their relative scarcity could reflect overexploitation, habitat degradation and the blocking of migratory pathways by small dams, barrages and other instream structures as well as diminished river discharge that combine to limit fish movement and access to important places of spawning, feeding and nursery areas along with seasonal movement to inaccessible habitats.

Distribution Pattern of Fish Species between Rangazak River and Challou River

Schistura turned out to be the most powerful fish species in the wet season in both the river systems. Nevertheless, its prevalence was incredibly superior in both rivers than other fish species.Schistura species were strongly aggregated in Site 2 (443 individuals) indicating strong preference in rocky riffles, crevices and fast-flowing microhabitats created during wet season in Rangazak River. The higher discharge and the oxygenated condition in monsoon was more likely to promote the growth of the bottom dwellings loaches. The highest abundance at Site 2 of Challou River with 203 individuals of Schistura once again suggests the presence of similar benthic environments and stable substratum environment in the river at the time of monsoon.

The survey in a monsoon period(May to July 2025) showed that the abundance of fishes, the composition of fish species, and the distribution pattern of fish in the Rangazak River and Challou River differed significantly. During the monsoon season a significant influence on the fish distribution patterns in both rivers was based in increased water discharge, availability of food and habitat and increase in breading grounds. The fact that Barilius is highly abundant in both rivers implies that they had access to rapid flowing and well-oxygenated habitat almost throughout the monsoon season (Cline et al., 2013). Nevertheless, the species were spatially segregated across the rivers, which suggests that the species tended to have local preferences by flow velocity, substrate structure, and food supply.

In addition to these discoveries, Cyprinid fishes remained a significant part of the fish fauna in the season of the monsoons. There was distribution of Species like Puntius, Garra, Pethia and Raiamas at several locations within both rivers. The extended spread of the cyprinid fishes in the monsoon season might relate with the expansion of the habitat and the growth of feeding capacity of the monsoon water discharge. The larger sizes of fishes like Cyprinus, Tor, Semiplotus and Schizothorax in the monsoon season than in the dry season of both rivers could be an indicator of the seasonal breeding migration and better habitat growth. The latter observation confirms the observations of numerous workers about migration of cold water species in the months of May to July to breed in the Hill streams of Himalayan Rivers (Nautiyal 2014; Shrestha 2019).

Despite their similarity of total fish assemblage during the monsoon season both rivers, namely Rangazak River and Challou River, were found to be less dominant in terms of rheophilic fish like Schistura and other cyprinids and large bodied fishes respectively in varied habitats. Numerous species of benthic taxa especially those species inhabiting high flow habitats such as Schistura, Garra, and Amblyceps exhibited much greater abundance in the monsoon season. This may have been potentially due to the higher water volume, the inflow of nutrients and habitat connectivity at this time that may have contributed to higher fish movement and feeding. The old ecological observations of the local fishers of these two rivers also reported that the monsoon rainy season boosts the

movement and spawning of fish in these rivers, as well as increasing accessibility of fish habitats, hence playing a significant role in increasing fish diversity and abundance, making the rivers active and productive. Nevertheless, in the dry season schooling species of mid water (Barilius, Puntius, Pethia) were found more abundant as the turbidity and water depth decreased with subsequent increases in sampling visibility and sample efficiency. Some of the species like Danio, Esomus, and Pethia had quite stable densities in both seasons and were inclined to be found in relatively slow and shallow margins during the dry months. It is known that these small-bodied fishes prefer slow moving areas, where fine detritus and planktons are more abundant. Bangana dero and Raiamas guttatus, interestingly, occurred sporadically at all seasons, but were most commonly distributed during the monsoon at some sites, which supports the idea that these fishes can make transient upstream migrations in the larger river systems to which they belong (such as the Chindwin) during the high-flow period - a finding also described by Chaudhuri (1919) and Gregory (1925) of trans-boundary migratory cyprinids. The observation of the present study seems to agree with the Stamou et al., (2018) that hydraulic conditions influences habitat distribution due to velocity and water depth along with the water quality factors which influence the diversity, distribution and richness of species of the habitat (Kang et al., 2017).

Species Richness of Rangazak River and Challou River

The sign of stable rich population in the two river system of the present study during the season of the dry season as well as during the season of monsoon is also an indication of inherent richness of the fish fauna of the region. The Raphei area as an integral part of North-Easter region described as a hot spot for high species richness with high degree of endemism might have been resulted from isolation and evolution leading to in situ diversification (Darlington 1957). In addition, variable climatic conditions, of being perennial water bodies are some of the factors contributing to high species richness of the aquatic fauna (Kar 2003). The seasonal effect of species in relation to species richness revealed in the current study is consistent with the findings of Hora (1951) and Kottelat et al., (2012). The trend in species richness of various sampling site of Rangazak and Challou Rivers is an expression of the type of habitat that might harbor the fish species. The sampling sites of the present study exhibits variation of elevation, width, flow dynamics, water quality, geomorphology which could set ecological boundaries for the fish species. As in the discussion, the current study site can be found in a mass of habitat scattered across a variety of elevation that can be potentially crucial to the rich variety of species and community sustainability. Perhaps, the ability of the fish species to exploit or adapt to different ecological niche of the present study area at different seasons could be one of the factors for the richness or stability of the fish population in the present study. Similar, observations of species richness influenced by gradient, elevation, flow velocity, and width of stream are reported by Sen (2003), Kar (2006), and Tamang et al., (2010).

The results of Hora (1951) and Kottelat et al., (2012) is consistent with the present study finding where Cyprinidae was observed to be the most species rich group within the freshwater ecosystem in the North east India. On the same note, other freshwater species that led to the high species richness of the area have been reported by Goswami et al. (2012) and Sarma et al., (2018) to include Channidae and Nemacheilidae, Bragidae, Sisoridae and Cobitidae. Our current findings were in line with this report. The present study on species recorded indicate distinct biogeographic similarity with the Chindwin dealdrage. This was found on the occurrence of species like Barilius, Schistura, Garra and Raiamas that have wide distributions throughout northeastern India, and the few species with restricted distribution (e.g. some forms of Schistura, Bangana, Myersglanis) confirm earlier results that the upper Ukhrul streams are biogeographically connected to Chindwin basin. Additionally, quite a few species (Garra spp., Schistura spp., Glyptothorax spp.) are probably micro-endemic or only found in the Indo-Burman uplands. It is these taxa that support previous findings that the Ukhrul streams are of great upland significance in offering high evolutionary and phylogenetic diversity. The presence of such Himalayan foothill species as Tor, Schizothorax, and Semiplotus indicate the biogeographical complexity of the area together with such Indo-Burman species as Amblyceps, Lepidocephalus and Garra. The current evidence confirms the post Himalayan river system hypothesis of Gregory (1925), who argues that historical hydrological interactions between the Tsangpo-Brahmaputra and Chindwin river systems did exist and that these related to possible faunal exchange and the formation of the modern ichthyofaunal assemblage.

CONCLUSION

In general, analysis demonstrates that the Rangazak and Challou rivers bear an ecologically rich hill-stream fish community influenced greatly by their altitude and habitat structure and seasonal hydrology. The greater abundance and richness of them in the monsoon underline ecological significance of seasonal floods in the movement of fishes and renewing pollution. Preference of rheophilic genera and prevalence of migratory taxa is an indicator of the conservation role of these rivers in the Chindwin drainage system.

The availability of environmentally sensitive taxa including Glyptothorax, Pseudecheneis, Schizothorax and Tor suggests both river systems are yet to lose a relatively high level of ecological intactness. Nonetheless, new approaches posed by human activities, such as chemical runoffs in hill farming, damaging fishing techniques, and intensifying riverbank interactions have serious repercussions to these delicate fish communities. Various benthic species were represented in a very low abundance, and they were sensitive to habitat changes and degradation, which is the primary indicators of ecological stress in the river systems, and the necessity of environmental conservation and treatment actions.

It is noteworthy that the data of fish abundance used by the two seasons in the current study are mostly founded on records of catches collected during the field samples and thus might not necessarily reflect on the actual abundance of fish species in the river systems. Sampling methods and reactions of fishing gears used in the collection of sampling are critical factors, which determine the effectiveness of fish capture. Some species

of fish that are naturally abundant in the river have the potential to be poorly represented in the catch because of their behavior, morphology, habitat preference or evasion. Fish in deep pools or submerged plants or crevices, fast-flow riffles, or a benthic microenvironment are often hard to harvest with typical fishing techniques. Equally" nocturnal, cryptic and highly mobile species, such as burrowing species, may not be sampled even though they are likely to occur in large numbers within the sampled eco-system. Thus, a low catch frequency or a low number of abundance organisms in a sample does not necessarily imply a decrease in population or ecological rarity. Therefore, the present study concludes further, investigation would bring out a clearer picture of the fish community in the two river system.

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