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Seasonal Diversity And Spatial Distribution of Finfish in Dulung River Jhargram District, West Bengal, India

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Abstract:

This study investigates the seasonal diversity and spatial distribution of finfish in the Dulung River, Jhargram District, West Bengal, India. Finfish play a crucial role in aquatic ecosystems and are significant for local livelihoods. The aims to establish baseline data on the ichthyofaunal composition and how it varies across seasons and different sections of the river. Fish sampling will be conducted across all four seasons (monsoon, post-monsoon, winter, and pre-monsoon) at multiple designated sampling stations along the Dulung River using various fishing gears. Collected specimens will be identified to species level, and data on their abundance, biomass, and spatial occurrence will be recorded. Concurrently, key physico-chemical parameters of the water (e.g., temperature, pH, dissolved oxygen, conductivity, turbidity) will be measured to assess their influence on fish communities. The collected data will be analyzed using standard ecological indices such as Shannon-Wiener diversity index, Simpson's diversity index, species richness, and Pielou's evenness to quantify seasonal variations in diversity. Spatial distribution patterns will be examined to identify areas of higher biodiversity or specific species aggregations. The findings of this study are expected to provide comprehensive insights into the ecological health of the Dulung River, highlight potential threats to finfish populations, and serve as a valuable resource for developing effective strategies and sustainable management practices for the aquatic biodiversity of the region.

Keywords: *Seasonal Diversity, Finfish, Ecosystem, Specimen, Key Physico-Chemical, Turbidity, Conservation.*

Introduction:

An essential aspect of comprehending the biological dynamics of aquatic environments is studying the seasonal diversity and spatial distribution of finfish. Finfish, which include a diverse range of species in the bony fish and cartilaginous fish classes, have important functions in aquatic food chains. Their variety and spread are affected by an intricate interaction of living and non-living variables that change in terms of space and time. Aquatic ecosystems are distinguished by their abundant biodiversity and productivity, which sustain a wide range of species, such as fish, crustaceans, and aquatic plants. Finfish, being a crucial element of these ecosystems, display a wide range of life histories, ecological niches, and adaptation strategies. The wide range of finfish species is a result of evolutionary processes and variations in the environment. The presence of diverse climatic variables, including differences in temperature, salinity, and nutrient availability, leads to the formation of distinct habitats that sustain various populations of finfish.

The Earth's axial tilt and orbital dynamics cause seasonal shifts, leading to periodic fluctuations in climatic conditions. The seasonal cycles have an impact on primary production, the availability of prey, and the appropriateness of habitats, which subsequently influence the populations of finfish. Temperate zones undergo noticeable seasonal changes, characterized by substantial variations in temperature, which have an impact on the distribution and behavior of finfish species. On the other hand, tropical areas, which have more consistent temperatures, may show distinct seasonal fluctuations that are mostly influenced by shifts in rainfall and water systems.

The arrangement of finfish in space is affected by the diversity of habitats, biogeographical considerations, and ecological interactions. Habitat heterogeneity encompasses the diverse range of physical habitats present in an ecosystem, including variations in substrate composition, water depth, and plant density. These small-scale habitats provide a variety of resources and environmental conditions, which in turn support a wide range of fish groups. Biogeographical variables, such as latitude, longitude, and proximity to coasts, influence water temperature, salinity, and ocean currents, which in turn impact the spatial distribution of finfish.

Ecological theory offers a conceptual structure for comprehending the patterns and mechanisms that govern the variety and spatial arrangement of finfish. Concepts like as niche theory, species-area connections, and meta-population dynamics provide valuable understanding of how species engage with their environment and with one another. Niche theory investigates the mechanisms by which different species coexist and divide resources, whereas species-area connections examine how the number of species changes in accordance to the size of the sampled area. Meta-population dynamics examine how the arrangement of populations in space and the movement of individuals across populations affect the overall connectedness of the population.

An investigation of the variety and geographical spread of bony fish species has significant significance for the preservation and control of these populations. Finfish populations globally face substantial risks from overfishing, habitat degradation, climate change, and pollution. Gaining knowledge about the variables that impact the variety and geographical spread of finfish may provide valuable insights for implementing measures to save habitats, regulate fisheries, and preserve biodiversity. Ecosystem-Based Management (EBM) is a comprehensive strategy that takes into account the interconnections between natural linkages and human activities. Its goal is to preserve the health of ecosystems while also promoting the sustainable use of resources.

Review of Literature:

Haque et al., (2023) one of the most important rivers in Bangladesh is the Jamuna River, which is known for its abundant aquatic life. From the three different places along the river that were chosen for the research, a total of 52 different species of fish were identified. These fish belonged to nine different orders and twenty different families. It is during the dry winter season that fish numbers are at their maximum, while during the monsoon season, they are at their lowest. The mean values of Shannon-Weaver diversity, Margalef's richness, and Pielou's evenness indices, which were reported as 3.29±0.02, 0.58±0.01, and 7.00±0.10, respectively, exhibited variations from one season to the next. In order to analyze the impact that environmental influences have on the organization of the fish assemblage, nonmetric MDS and canonical correspondence analysis were used. The Nonmetric Multidimensional Scaling (nMDS) had been achieved in two groups during the cluster analysis. One of these groups demonstrated the relationship between the fish samples collected during the summer and winter seasons, while the other group contained the species that were collected during the monsoon season among the sampling locations. The fish species that were responsible for the variation in seasonal abundance up to a cumulative dissimilarity of 21.85%, and this dissimilarity was caused by four different species of fish. In order to illustrate the intriguing roles of alkalinity, total dissolved solids, electrical conductivity, and dissolved oxygen in the Jamuna River, a canonical correspondence analysis was performed on the fish population.

Sampson, Ohaturuonye et al., (2023) The study was conducted between January and December of that year. The research was conducted at three different sample stations along the course of the river, which were designated as Stations 1, 2, and in the third place. Different types of fishing gear, including hooks and lines, gillnets, cast nets, and traps, were used in order to conduct the assessment of the fish population. The watercraft that were utilized included a one-man dugout and planked canoes. Standard operating procedure was used in order to calculate species diversity indices. According to the findings, there were a total of 757 fish samples, which included 15 species, 10 genera, 9 families, and 4 orders that were found. With 363 fish specimens, the family Cichlidae secured the greatest ranking as the most numerous fish species. On the other hand, the family Distichodontidae received the lowest ranking, with just five fish specimens. The months of January through March had the most reported species richness (15), while the months of April through June had the number of species that were found to be the least abundant (11). The Simpson's Index (D) value fluctuated between 0.02 and 0.005 during the months of January and March. The range of values was from July to September, when it was 0.02. According to the findings of Simpson's Reciprocal Index (1/D), the diversity of fish species collected between the months of May and August was not as high as the diversity of fish species acquired between September and December. This may suggest that certain anthropogenic activities, such as agricultural and crop farms, construction sites, sewage discharges, timber harvesting, industrial discharge, mining, and sand dredging, that were observed at the study sites tended to increase during the rainy season, which ultimately resulted in a decrease in the diversity of fish. One may say that these activities have some negative consequences on the distribution of fish, the composition of fish, and the amount of fish in the Otamiri River in Nigeria. Consequently, several management measures must to be implemented by the appropriate authorities in order to monitor the actions of humans in the region.

Mehmood, Shahid et al., (2023) The purpose of this research was to explore the present state of the fish fauna of the Sip river with the purpose of analyzing the fluctuation in water quality that has occurred over time. Between the months of August 2017 and July 2018, water samples and fish specimens were gathered on a monthly basis from a total of six different locations. Every single one of the water quality characteristics was discovered to be within the permitted range that is suitable for fish species, with the exception of stations IV and V, where the pollution load rapidly increased. The effects of seasonal shifts in physicochemical parameters, such as water temperature, pH, DO, free CO2, and total alkalinity, were seen to have an impact on the variety of fish species and the overall health of the river. A total of 19 fish species were found throughout the course of the research project. These fish species were classified into 9 families, 13 genera, and 4 orders during the course of the study. The Cyprinidae family is the most abundant, with eleven species, followed by the Ambassidae family, which has two species. Bagridae, Channidae, Gobidae, Heteropneustidae, Nandidae, and Siluridae each reported one species, while the Cyprinidae family is the most abundant. By using a variety of fishing techniques, such as hook and rod methods, cast nets, gill nets, and other fishing gear, a total of 341 individuals of various fish species were successfully captured from the various stations. Among all of the stations that were investigated, the stations with the highest abundance values were V and II, with 112 and 105 people, respectively. The stations with the second highest abundance were I and VI, with 57 and 51 individuals, while the stations with the lowest abundance were III and IV, with 7 and 9 individuals, respectively. Station-V (Pandagaon) reported the highest values of the Shannon-Weiner index (2.454) and Simpson's index (0.906), whereas station-IV (Syampura) recorded the lowest values of both indices (0.529 and 0.345). Both of these indices were measured at Pandagaon. On the other hand, the highest values of Margalef's index (2.793) and Pielou's index (0.9898) were discovered at station-II (Ambhakadim) and station-III (Jiryna), respectively. The findings of the research indicated that the Sip river is home to a diverse collection of ichthyofauna; nevertheless, the variety of fish in the river has been negatively impacted with the introduction of human pressure and illicit fishing methods. The current research will be helpful in improving management and conservation methods for the fish species that are found in the Sip river. It will also give baseline data for an endeavor to update the current state of fish diversity and water quality metrics. In light of this, it is imperative that significant actions be taken into account in order to enhance the long-term viability of water quality and fish activity within the river system.

Kumar, Lohith et al., (2022) Fishes that are not native to the area are among the most significant dangers to the local flora and animals that live in freshwater habitats. Within the context of the River Cauvery in India, the purpose of this research was to get an understanding of the variety, distribution pattern, and composition of the non-native fishes. In order to make a methodical collection of information on fish and water variables, seasonal samplings were carried out at eleven sites that were dispersed over the whole length of the river. There were a total of seven non-native fish species that were documented. These include the Nile tilapia, also known as Oreochromis niloticus, the Mozambique tilapia, also known as O. mossambicus, the African catfish, also known as Clarias gariepinus, the Common carp, also known as Cyprinus carpio, the Grass carp, also known as Ctenopharyngodonidella, the Vermiculated sailfin catfish, known as Pterygoplichthysdisjunctivus, and the Three-spot cichlid, which was reported for the first time from the Cauvery basin. In the middle length of the river, non-native fishes contributed the most to the overall fish capture in terms of weight, accounting for sixty percent of the total contribution. Out of all the non-native species, O. niloticus was the most prevalent, accounting for 71% of the total capture of non-native fish. Cluster analysis of sample sites based on the number of non-native fishes produced two groups with a dissimilarity of 32% and 49%, respectively. It was determined by routine analysis using the similarity percentage (SIMPER) that O. niloticus was the most significant contributor, with a contribution of 87% in group I and 77% in group II, respectively. Canonical Correspondence Analysis (CCA) revealed that the water variables, namely pH, water temperature, total adsorption (TA), flow, dissolved oxygen (DO), and biochemical oxygen demand (BOD), had the greatest impact on non-native fishes. The composition of fishes that are not native to the area did not exhibit any temporal fluctuations, however the geographical differences showed a large amount of heterogeneity. In the river Cauvery, the investigation revealed that the invasion of fish species that are not native to the area is still going on. In order to better manage the non-native fishes that are found in the river, the results of the research will be helpful in developing management strategies. In order to determine the ecological, economic, and social implications of non-native fishes in the Cauvery River, further research is required.

Hu, Wenjia et al., (2022) During the last several decades, there has been discussion on the long-term habitat changes that would occur in marine fishes as a result of climate change. On the other hand, there is still a lack of comprehension of the ways in which the patterns of fish distribution and biodiversity will emerge in the offshore regions of China throughout the course of time. In the current investigation, the maximum entropy (MaxEnt) model was used to make projections about the possible distributions of 21 very significant marine fishes under the current circumstances as well as two climate change scenarios that extend up to the year 2050. Additionally, the expected habitat alterations were used in order to investigate the ways in which communities might be impacted by future environmental changes. It is possible that by the year 2050, nine out of twenty-one fish species would have habitats that have been restricted. These nine fish species were judged to be potential loser species in terms of adapting to climate change, whereas the other twelve fish species were assessed to be prize winners. With a mean habitat centroid shifting distance ranging from 110 to 206.5 kilometers, it was expected that the habitats of twenty different species will migrate in a northerly direction. It has been discovered that the Yangtze River Estuary is likely a geographical barrier that prevents some species from migrating northward. This is a noteworthy finding. The leading edge moved one degree quicker than the following edge during the habitat range shift that was seen inside the research area. This asymmetry was detected with regard to the habitat range shift. Fish refuges have been identified as the Beibu Gulf, Pearl River Estuary, Southwest Taiwan Strait, and Yangtze River Estuary. This suggests that major river estuaries and upwelling systems may have the potential to have a beneficial impact on lessening the susceptibility of biological populations to the impacts of climate change. At the community level, species richness would decrease at lower latitudes, whereas it would rise at higher latitudes. Species turnover was the primary component of temporal beta diversity, and it was shown that species richness would increase at higher latitudes. As a means of assisting in the adaptive conservation and management of fish habitats, our research offers a comprehensive and useful perspective on the influence that climate change will have on the distribution and richness of marine fish species in China.

Rahman, Md et al., (2020) As a result of being contaminated by municipal and residential sewage, the River Shitalakshya, which is regarded to be one of the most notable rivers in the flood plain area of Bangladesh, has become unfit for aquatic species. Therefore, the current research was carried out with the purpose of investigating the water quality metrics, the spatial-temporal abundance of fish species, and the morphological changes that occurred in the river pattern of the Shitalakshya River between the months of July 2015 and June the following year. For the purpose of analyzing and calculating the diversity indices, particular test kits were used to conduct tests on the water quality parameters. Additionally, fish specimens were gathered from set beg nets (SBN) and seine net samples. During the course of the research, the water's temperature varied from 22.8 to 30 degrees Celsius, and the dissolved oxygen (DO) levels were often found to be lower than expected (ranging from 0.64 to 2.94). An overall number of 4579 individual specimens belonging to 23 different species of finfish were discovered, with Anabas testudineus being the species that was determined to be the most prevalent. The Shannon-Wiener Index (H) and Margalef's richness were both accepted with extremely low values, which suggested that the river had poor fish assemblages. This was based on the diversity indexes. Landsat thematic mappers from three years (1988, 1998, and 2008) and the remainder of one (2018) from Landsat OLI and TIRS sensor analysis revealed that the river areas were decreasing as a result of human interference. According to the findings of the current research, the water already contains a significant amount of pollution, and the river regions are also decreasing on a daily basis.

Bashar, Abul et al., (2020) This research was conducted with the purpose of acquiring information on the current state and trend of finfish variety in the Old Brahmaputra river, which is located in Bangladesh. During the period of January 2019 through December 2019, samples were gathered directly from a professional fishing boat using a variety of nets, traps, and hooks. Including four species that are not native to the area, a total of 49 species belonging to six groups were documented. The richness of ichthyo-diversity within the river is represented by a biodiversity index of 3.65854 and a dominance value of 0.030929; nevertheless, Synbranchiformes and Tetraodontiformes were not recorded at any point over the course of the research. A positive link was identified between the water height of the river and the monthly abundance of the species that was discovered, according to the results of a linear regression study. The catch composition of catfishes and snakeheads decreased, however barbs came out on top in comparison to the results of the previous research. According to the International Union for Conservation of Nature (2015), the bulk of the fish that were recorded fell into the category of least concern. However, there were also sections that belonged to the categories of critically endangered, endangered, and vulnerable. It is for this reason that conservation measures need to be implemented in the Old Brahmaputra river in order to maintain the fish variety in a condition that is sustainable.

Statement of the Problem:

The aim of this thesis is to investigate the seasonal diversity and spatial distribution of finfish in the Dulung River, located in the Jhargram district of West Bengal, India. This study seeks to understand how seasonal changes influence the diversity and distribution patterns of finfish species within this river ecosystem. By analyzing environmental variables, fish community structure, and the impacts of anthropogenic activities, the research aims to provide comprehensive insights that can inform sustainable management and conservation strategies for the finfish populations in the Dulung River.

Objectives of the Study:

The general objective of the study is to evaluate the seasonal variation in the diversity of finfish species in the Dulung River and to analyze the spatial distribution patterns of finfish species across different sections of the Dulung River.

Methodology:

Research Design of the Study:

Exploratory research design will be adopted in this study.

Procedure of Fish Samples Collection:

An extensive survey will be conducted in the early morning hours throughout the wet (July–October), winter (November–February), and summer (March–June) seasons, with data to be published monthly for fish sampling. Each month, a new species of fish will be sampled. All the fish samples will be painstakingly collected from each location with the help of local fishermen who will use regional indigenous fishing methods such as cast nets, gill nets, hand nets, hooks, and traps. We will also visit the fish markets that are located on the river bank.

Tools Used for the Study:

In order to collect fish specimens for scientific purposes, researchers will use a variety of fishing gears at different study locations in rivers, lakes, or coastal regions. Consideration of habitat features, target species, and study goals will inform the selection of these tools.

Evaluation of Water Parameters

Following parameters will be evaluated in this study:

- Temperature
- Dissolved Oxygen (DO)
- pH Analysis
- Salinity

Biodiversity Indices Evaluated

We will use MS Excel to compute the biodiversity indices. Below are the formulae that will be used to determine biodiversity indexes.

1. Species Richness
2. Relative Abundance
3. Shannon-Diversity Index
4. Simpson's Index
5. Pielou's Evenness Index
6. Margalef's Index
7. Sorensen's similarity index 'DSC'

Statistical Techniques:

Following statistical techniques will be used in this study: -

Descriptive Statistics

- Arithmetic Mean
- Standard deviation
- Standard Error of Mean
- Variance
- Covariance

Inferential Statistics

- Pearson's correlation
- Correlation coefficient P
- Regression Equations

MANOVA

- Wilk's Lambda test
- Variance-ratio

Multiple-Comparison Test

- Tukey's Post Hoc
- Principal Component Analysis (PCA)

Result And Discussion:

Measurements of water parameters, taxonomic analyses of fish samples taken from the Dulung River, and a review of fish diversity are all detailed in this chapter.

Fish Diversity:

Our investigation on the variety of fish inhabiting the Dulung River has yielded the following findings. Examining and drawing conclusions from a wide variety of diversity indicators is part of this course.

Species Found Whilst Collecting Samples:

We used Nelson's 2016 list to identify and classify all 109 fish species. They were arranged into nineteen orders, forty-four families, and eighty-two genera. With 19 species apiece, Siluriformes and Cypriniformes are the most numerous orders of fish. Clupeiformes and Gobiformes follow with 10 species each, while Perciformes have 8, Acanthuriformes 7, and Anabantiformes 6 species. There are a total of sixteen species belonging to the four orders listed: Pleuronectiformes, Beloniformes, Carangiformes, and Synbranchiformes. Each of the two orders—Spariformes and Mugiliformes—consists of three species. Two species may be found in the families Osteoglossiformes and Cichlidiformes. Outside of the Scorpaeniformes, Moroniformes, and Anguilliformes orders, every other order has just one species. Most fish species are Cypriniformes, which constitute 18.26% of the total. The Siluriformes are at 13.80%, followed by Clupeiformes at 13.42%, Gobiformes at 10.51%, Mugiliformes at 9.40%, Perciformes at 7.87%, Anabantiformes at 5.25%, Carangiformes at 3.72%, Spariformes at 3.40%, Acanthuriformes at 3.25%, Peluronectiformes at 2.97%, Synbranchiformes at 2.22%, Cichlidiformes at 1.78%, and Beloniformes at 1.22%. All of these taxa accounted for less than one percent: In terms of percentage, the following groups are represented: Scorpaeniformes (0.94%), Osteoglossiformes (0.69%), Scombriformes (0.56%), Anguilliformes (0.41%), and Moroniformes (0.37%). With 17.02% of the total, the Cyprinidae were the most numerous fish family. In the family Cyprinidae, you might find seventeen distinct species of fish. The following families entered the picture: Mugilidae with 9.40%, Engraulidae with 7.90%, Clupeidae with 5.37 %, Bagridae with 4.75 %, etc. Next in line were the Sisoridae at 0.06%, followed by the Pristigasteridaeat 0.16%, the Eleotridae at 0.22%, the Mullidae at 0.31%, the Sparidae at 0.34%, the Hemiramphidae at 0.34%, and so on.

The followingAt each of the four sample sites and throughout the year, Chilkigarhs meticulously records every species of fish that have been documented from the Dulung River.

Species distribution data is organized in this table by order and family of fish.

Table 1: Abundance by fish orders

Fish Orders	Spatial Abundance				Seasonal Abundance		
	Chilkigarh	Kankrajhore	Gopiballavpur	Jhargram	Summer	Rainy	Winter
Acanthuriformes	0	7	23	74	12	30	62
Anabantiformes	71	75	22	0	43	49	76
Anguilliformes	5	5	3	0	5	1	7
Beloniformes	20	14	5	0	11	7	21
Carangiformes	0	0	35	84	22	38	59

Cichlidiformes	27	28	2	0	10	27	20
Clupeiformes	50	95	112	173	78	160	192
Cypriniformes	237	302	46	0	95	250	240
Gobiformes	127	153	56	0	90	117	129
Moroniformes	0	0	0	12	0	5	7
Mugiliformes	36	94	75	96	65	112	124
Osteoglossiformes	11	11	0	0	3	8	11
Perciformes	14	44	61	133	33	85	134
Pleuronectiformes	0	31	39	25	28	24	43
Scombriformes	0	0	0	18	4	9	5
Scorpaeniformes	0	17	5	8	6	16	8
Siluriformes	119	192	79	52	91	148	203
Spariformes	0	38	31	40	24	36	49
Synbranchiformes	20	31	18	2	29	11	31
No. of Orders Present	12	16	16	12	18	19	19

Thirteen fish purchasesAccording to the data shown in table 4.1, the places with the highest number of fish orders were Kankrajhore and Gopiballavpur (16 orders each), while the places with the lowest number of orders were Chilkigarh and Jhargram (12 orders each). Seasonally speaking, the summer season had the lowest fish orders, while the winter and rainy seasons had the most.

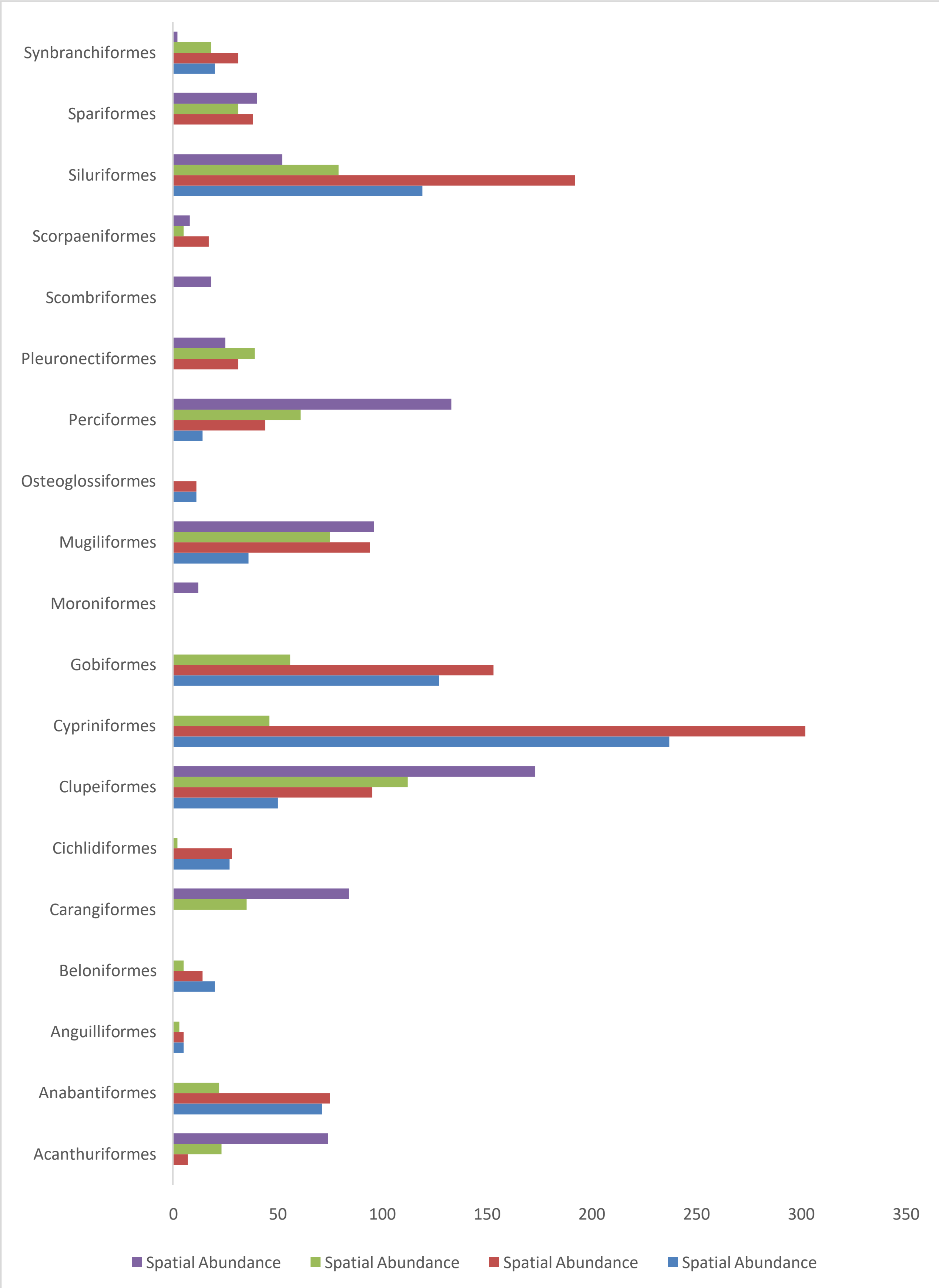

Figure 1. Column Chart of Fish Order-Spatial Abundance

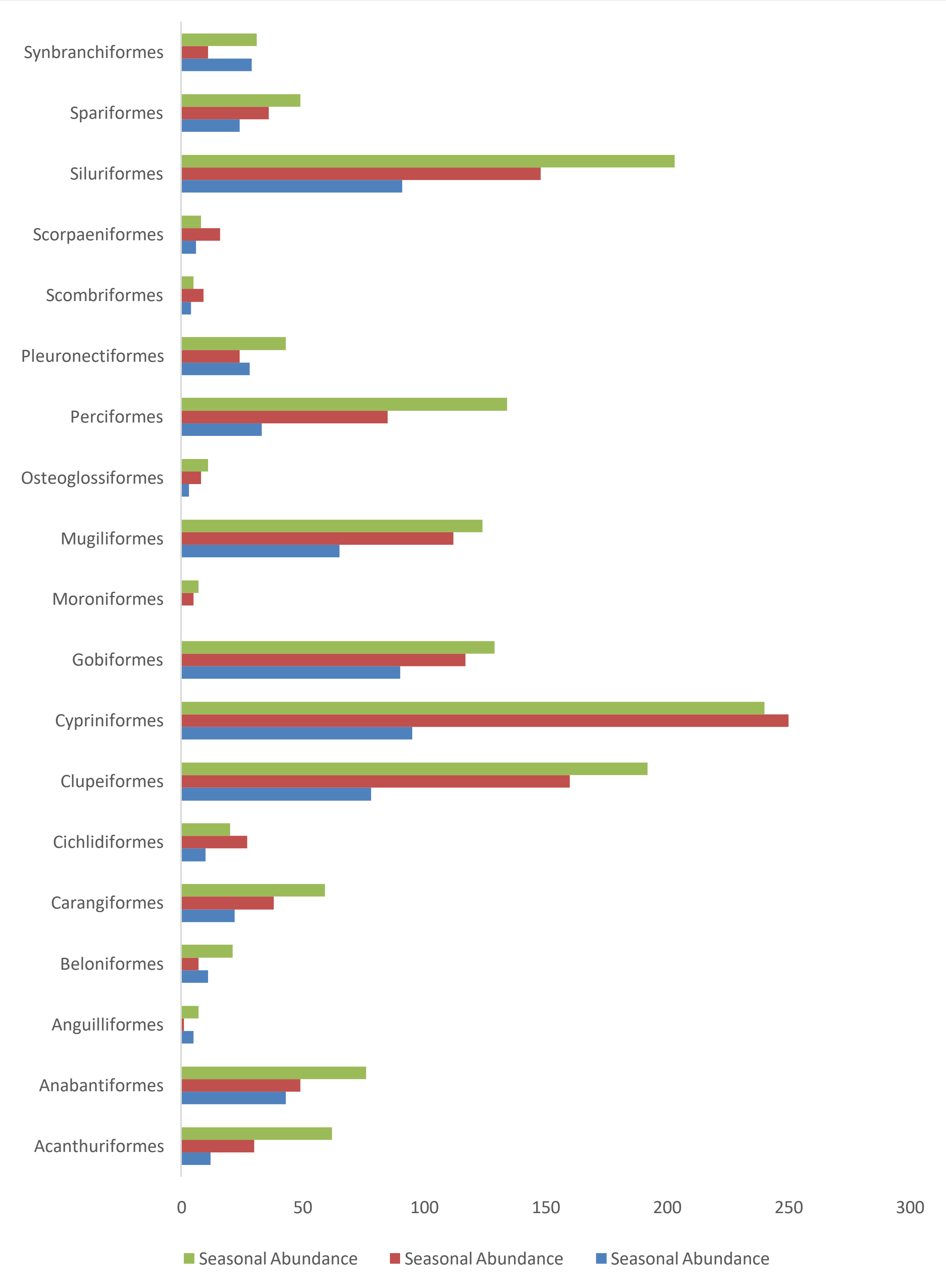

Figure 2. Column Chart of Fish Order-Seasonal Abundance

Kankrajhore is home to all but five of the fish families, whereas Jhargram contains the fewest. In terms of the quantity of eggs in their basket, almost every season has the same amount of Chilli.

Table 2: Abundance by fish families

Families	Spatial Abundance				Seasonal Abundance		
	Chilkigarh	Kankrajhore	Gopiballavpur	Jhargram	Summer	Rainy	Winter
Sciaenidae	0	7	23	74	12	30	62
Anabantidae	11	11	5	0	5	6	16
Osphronemidae	23	23	7	0	15	17	21
Channidae	24	29	8	0	18	15	28
Nandidae	13	12	2	0	5	11	11
Anguilladae	5	5	3	0	5	1	7
Hemiramphidae	8	3	0	0	5	2	4
Belonidae	12	11	5	0	6	5	17
Carangidae	0	0	35	84	22	38	59
Cichlidae	27	28	2	0	10	27	20
Pristigasteridae	0	0	2	3	0	2	3
Engraulidae	35	58	60	100	49	90	114
Clupeidae	15	37	50	70	29	68	75
Cyprinidae	220	279	46	0	92	234	219
Cobitidae	17	23	0	0	3	16	21
Gobiidae	39	65	22	0	36	35	55
Odontobutidae	31	24	13	0	28	23	17
Eleotridae	0	7	0	0	0	3	4
Oxudercidae	4	9	6	0	4	15	0
Ambassidae	53	48	15	0	22	41	53
Drepaneidae	0	0	0	12	0	5	7
Mugilidae	36	94	75	96	65	112	124

Notopteridae	11	11	0	0	3	8	11
Haemulidae	0	4	4	19	3	7	17
Mullidae	0	0	0	10	3	3	4
Latidae	2	5	6	8	3	7	11
Terapontidae	12	18	26	32	7	32	49
Polynemidae	0	17	25	64	17	36	53
Soleidae	0	5	8	0	6	0	7
Cynoglossidae	0	26	31	25	22	24	36
Stromateidae	0	0	0	18	4	9	5
Platycephalidae	0	17	5	8	6	16	8
Bagridae	57	75	20	0	25	51	76
Ariidae	7	19	13	16	14	24	17
Sisoridae	0	2	0	0	2	0	0
Ailiidae	0	10	17	23	7	19	24
Pangasidae	4	6	2	1	2	8	3
Heteropneustidae	15	14	2	0	3	13	15
Clariidae	12	12	2	0	4	14	8
Siluridae	24	54	23	12	34	19	60
Sillaginidae	0	33	31	34	22	33	43
Sparidae	0	5	0	6	2	3	6
Mastacembelidae	18	26	6	2	23	6	23
Synbranchidae	2	5	12	0	6	5	8
No. of Families Present	28	39	35	22	41	22	42

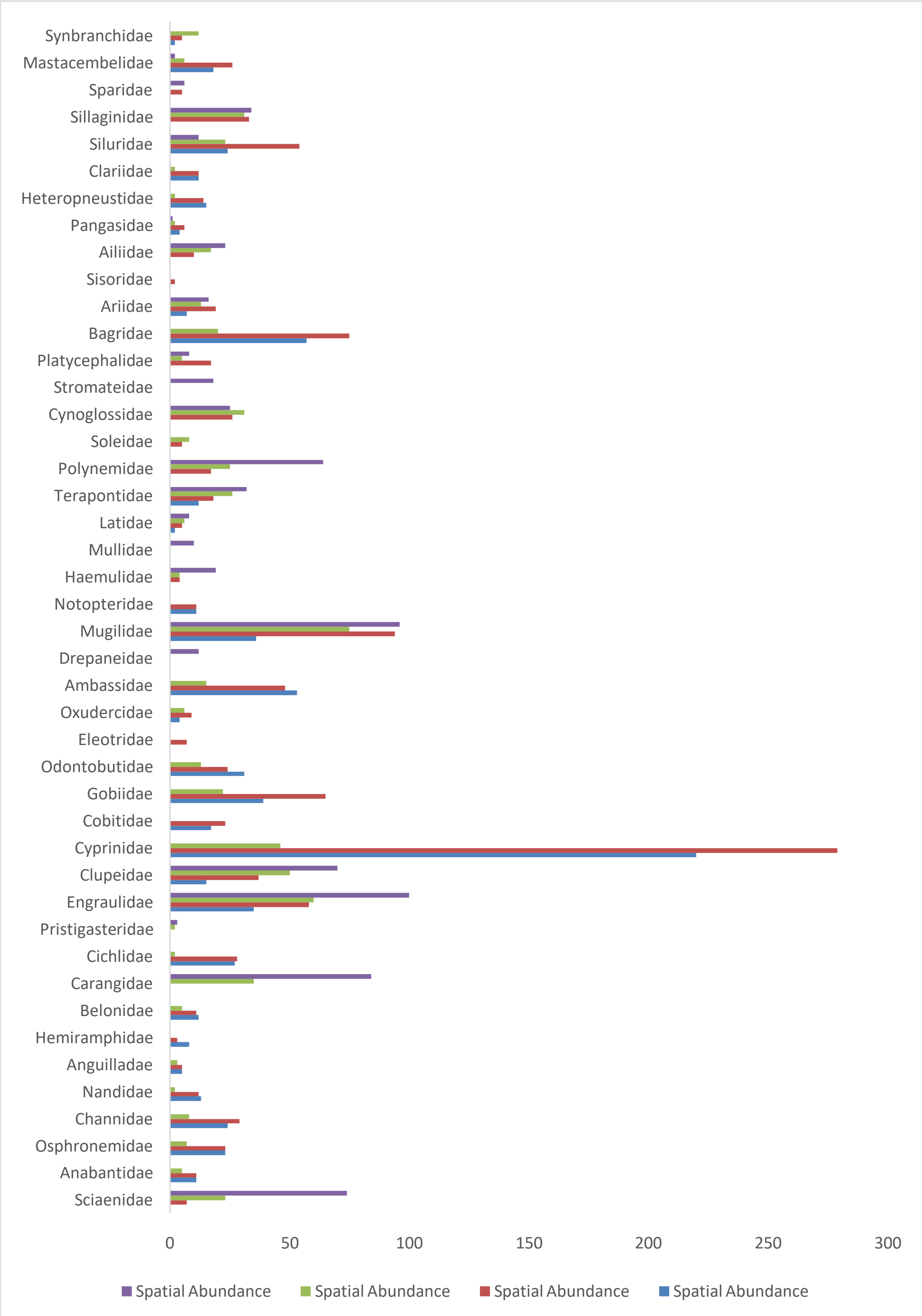

Figure 3. Fish Family-Spatial Abundance

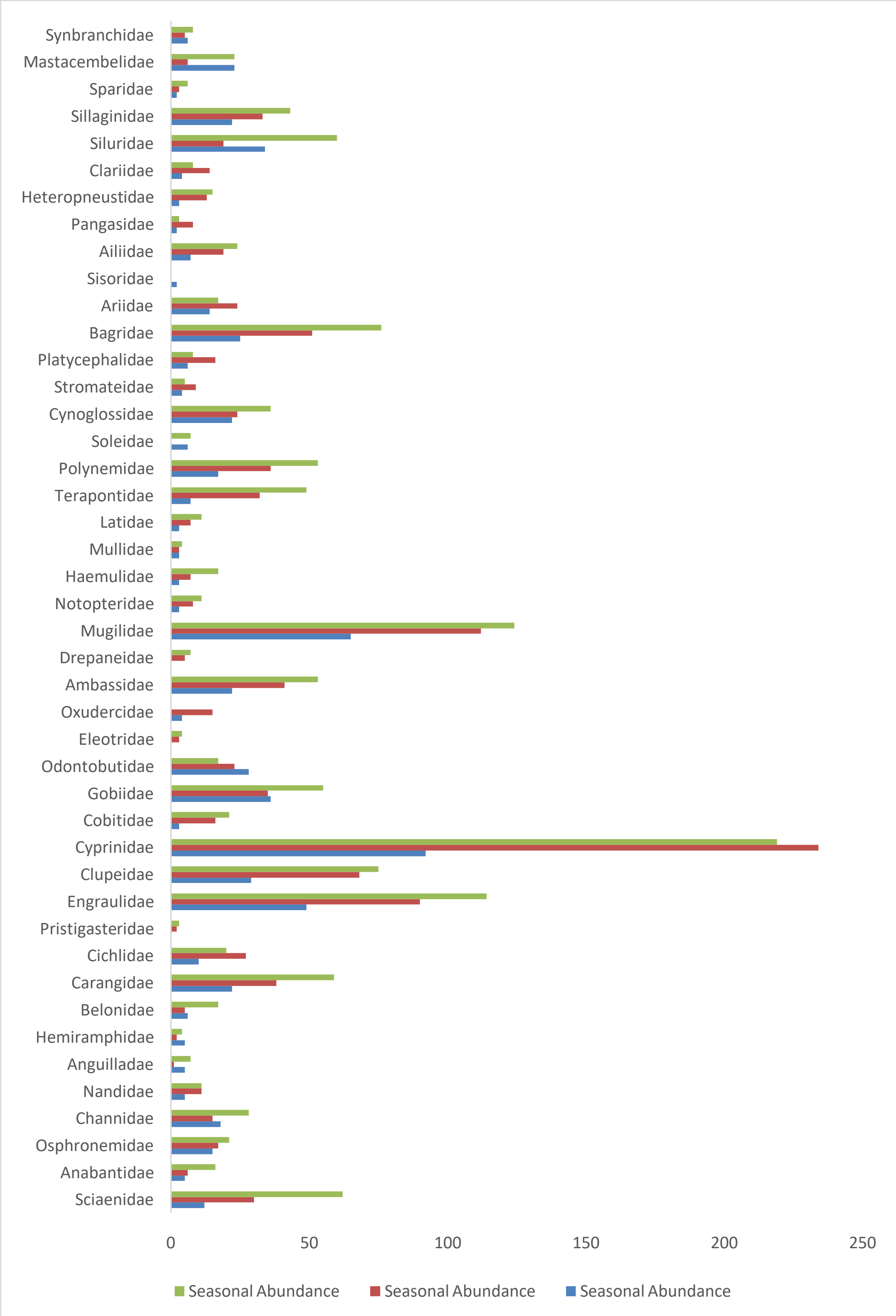

Figure 4. Column Chart of Fish Family-Seasonal Abundance

Relative Abundance of Orders Station wise and Season wise

Table 3: Spatial Relative Abundance of OrderChilkigarhn all four stations and all three seasons

Sl. No.	Order	Spatial Relative Abundance (%)				Seasonal Relative Abundance (%)		
		Chilkigarh	Kankrajhore	Gopiballavpur	Jhargram	Summer	Rainy	Winter
1	Acanthuriformes	0	0.59	3.76	10.3	1.85	2.65	4.36
2	Anabantiformes	9.68	6.6	3.59	0	6.63	4.32	5.35
3	Anguilliformes	0.70	0.44	0.54	0	0.77	0.09	0.49
4	Beloniformes	2.64	1.23	0.82	0	1.69	0.62	1.48
5	Carangiformes	0	0	5.67	11.7	3.39	3.35	4.15
6	Cichlidiformes	3.69	2.46	0.33	0	1.54	2.40	1.38
7	Clupeiformes	6.78	8.36	18.3	24.1	12	14.1	13.5
8	Cypriniformes	32.5	26.6	7.48	0	14.6	22.4	16.9
9	Gobiformes	16.9	13.5	9.15	0	13.9	10.3	9.06
10	Moroniformes	0	0	0	1.67	0	0.45	0.51
11	Mugiliformes	4.90	8.27	12.3	13.4	10	9.93	8.73
12	Osteoglossiformes	1.51	0.97	0	0	0.46	0.71	0.79
13	Perciformes	1.7	3.87	9.92	18.5	5.08	7.5	9.43
14	Pleuronectiformes	0	2.73	6.42	3.49	4.31	2.07	3.05
15	Scombriformes	0	0	0	2.51	0.62	0.79	0.35
16	Scorpaeniformes	0	1.5	0.85	1.12	0.92	1.41	0.56
17	Siluriformes	16.1	16.9	12.6	7.25	14	13.1	14.3
18	Spariformes	0	3.34	5.09	5.58	3.7	3.18	3.48
19	Synbranchiformes	2.71	2.73	2.94	0.28	4.47	0.97	2.21

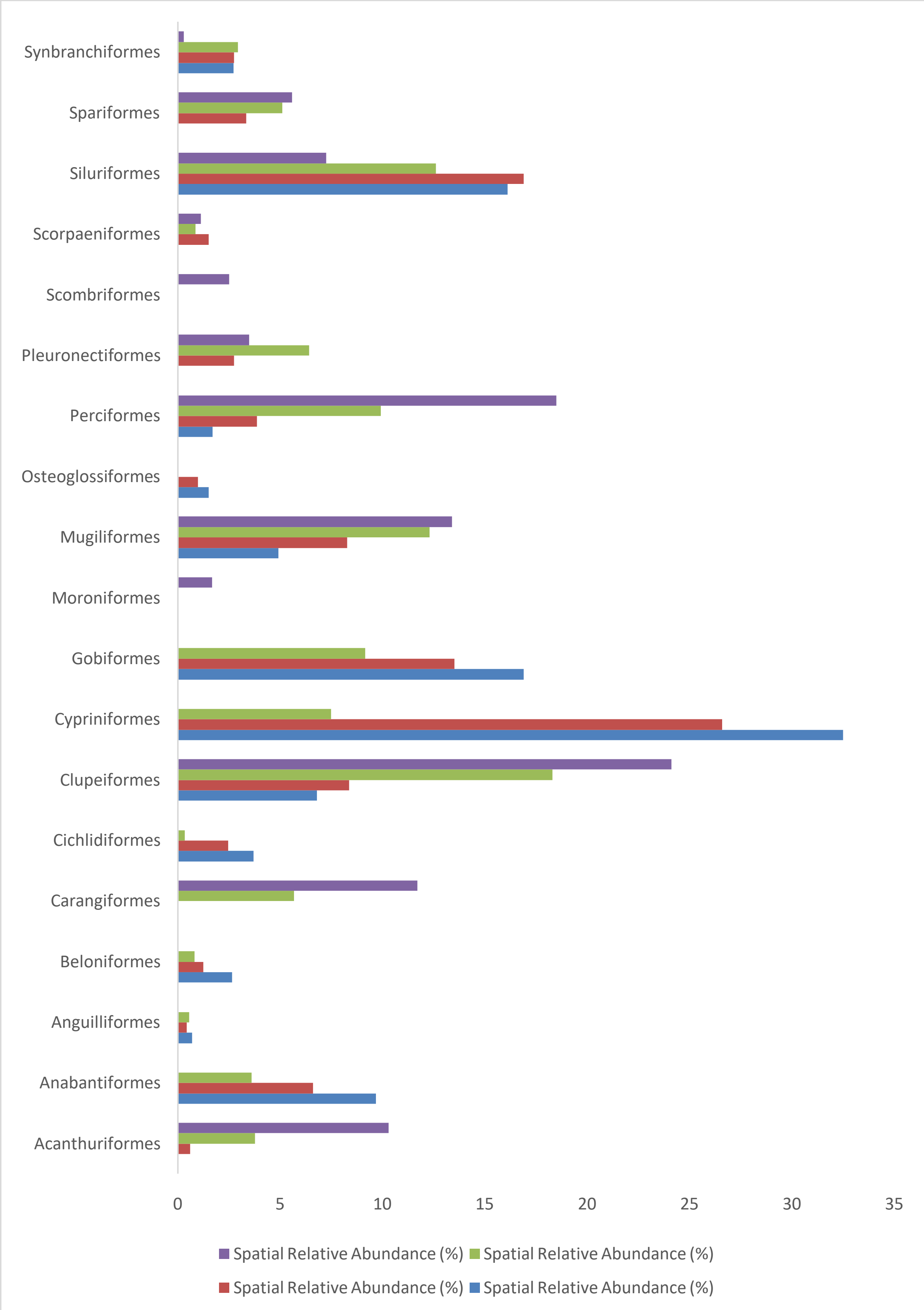

Figure 5. Spatial Relative Abundance of OrderChilkigarhn all four stations are displayed in a scatter-plot with a smoothed line

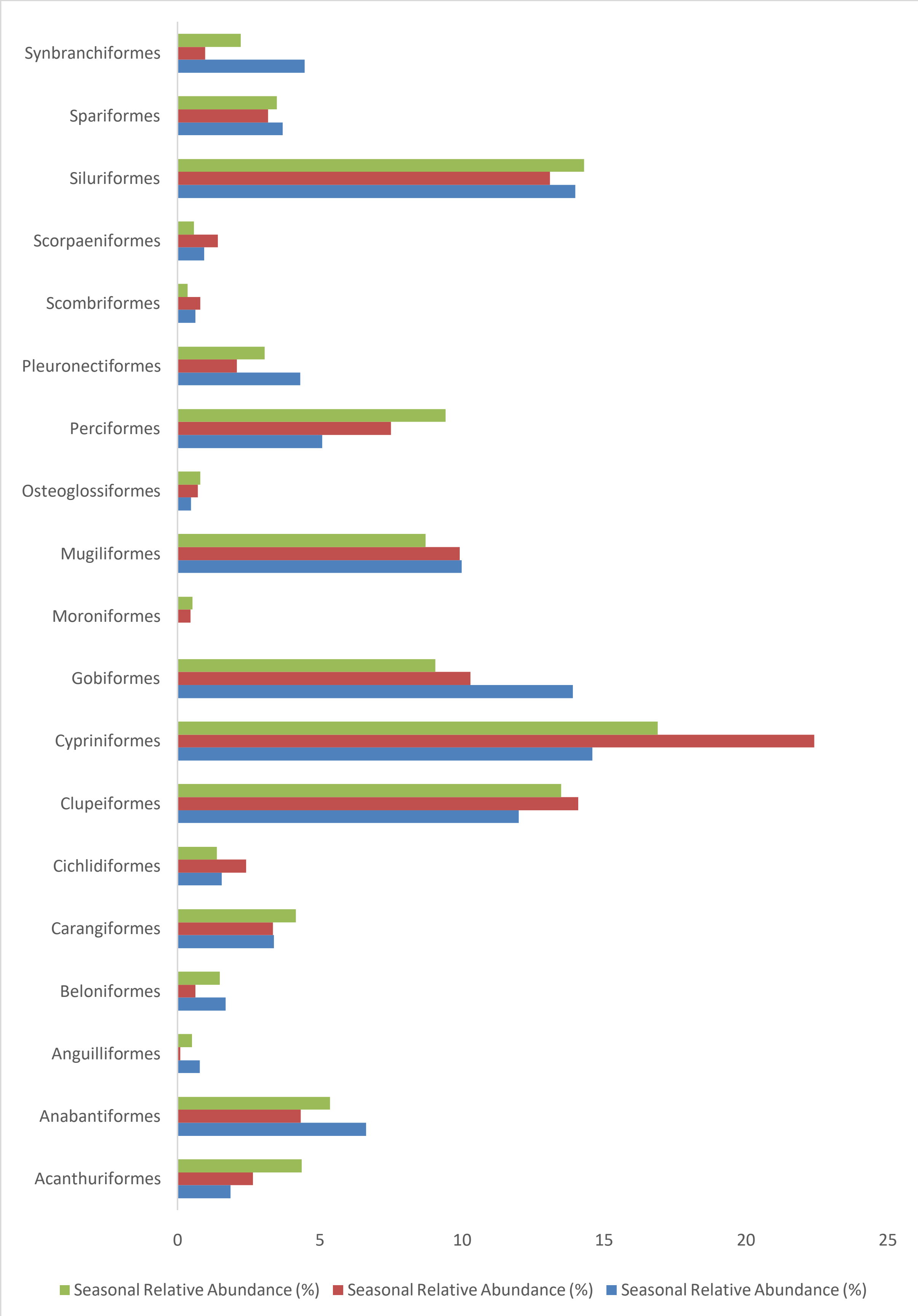

Figure 6. Seasonal Relative Abundance of OrderChilkigarhn all four stations are displayed in a scatter-plot with a smoothed line

Table 4: Spatial Relative Abundance of FamilieChilkigarhn all four stations and all three seasons

Sl. No .	Family	Spatial Relative Abundance (%)				Seasonal Relative Abundance (%)		
		Chilkigar h	Kankrajhor e	Gopiballavpu r	Jhargra m	Summe r	Rain y	Winte r
1	Sciaenidae	0	0.62	3.76	10.3	1.87	2.62	4.32
2	Anabantidae	1.49	0.97	0.82	0	0.75	0.56	1.16
3	Osphronemidae	3.12	2.02	1.14	0	2.29	1.5	1.52
4	Channidae	3.26	2.55	1.31	0	2.77	1.36	1.97
5	Nandidae	1.76	1.06	0.33	0	0.77	0.97	0.80
6	Anguilladae	0.68	0.44	0.51	0	0.77	0.11	0.51
7	Hemiramphidae	1.09	0.26	0	0	0.77	0.20	0.28
8	Belonidae	1.63	0.97	0.82	0	0.92	0.44	1.4
9	Carangidae	0	0	5.72	11.7	3.39	3.32	4.18
10	Cichlidae	3.66	2.46	0.33	0	1.54	2.41	1.37
11	Pristigasteridae	0	0	0.33	0.42	0	0.18	0.19
12	Engraulidae	4.75	5.1	9.8	13.9	7.55	7.93	8.03
13	Clupeidae	2.04	3.25	8.17	9.76	4.47	6	5.30
14	Cyprinidae	29.9	24.5	7.52	0	14.2	20.5	15.4
15	Cobitidae	2.31	2.02	0	0	0.46	1.37	1.48
16	Gobiidae	5.29	5.72	3.59	0	5.55	3.09	3.91
17	Odontobutidae	4.21	2.11	2.12	0	4.31	2.03	1.2
18	Eleotridae	0	0.62	0	0	0	0.26	0.32
19	Oxudercidae	0.54	0.79	0.98	0	0.62	1.32	0
20	Ambassidae	7.19	4.22	2.45	0	3.39	3.62	3.74
21	Drepaneidae	0	0	0	1.67	0	0.44	0.46

22	Mugilidae	4.88	8.27	12.3	13.4	10	9.89	8.73
23	Notopteridae	1.49	0.97	0	0	0.46	0.71	0.77
24	Haemulidae	0	0.35	0.65	2.65	0.46	0.62	1.2
25	Mullidae	0	0	0	1.39	0.46	0.26	0.28
26	Latidae	0.27	0.44	0.98	1.12	0.46	0.62	0.77
27	Terapontidae	1.63	1.58	4.25	4.46	1.08	2.82	3.47
28	Polynemidae	0	1.5	4.08	8.93	2.62	3.18	3.75
29	Soleidae	0	0.44	1.31	0	0.92	0	0.51
30	Cynoglossidae	0	2.29	5.07	3.49	3.39	2.12	2.53
31	Stromateidae	0	0	0	2.51	0.62	0.79	0.32
32	Platycephalidae	0	1.5	0.82	1.12	0.92	1.41	0.57
33	Bagridae	7.73	6.6	3.27	0	3.85	4.5	5.35
34	Ariidae	0.95	1.67	2.12	2.23	2.16	2.12	1.3
35	Sisoridae	0	0.18	0	0	0.31	0	0
36	Ailiidae	0	0.88	2.78	3.21	1.08	1.68	1.70
37	Pangasidae	0.54	0.53	0.33	0.14	0.31	0.71	0.23
38	Heteropneustidae	2.04	1.23	0.33	0	0.46	1.15	1.06
39	Clariidae	1.63	1.06	0.33	0	0.62	1.24	0.56
40	Siluridae	3.26	4.75	3.76	1.67	5.24	1.68	4.22
41	Sillaginidae	0	2.9	5.07	4.74	3.39	2.91	3.05
42	Sparidae	0	0.44	0	0.84	0.31	0.26	0.40
43	Mastacembelidae	2.44	2.29	0.98	0.28	3.54	0.49	1.62
44	Synbranchidae	0.27	0.44	1.96	0	0.92	0.47	0.61

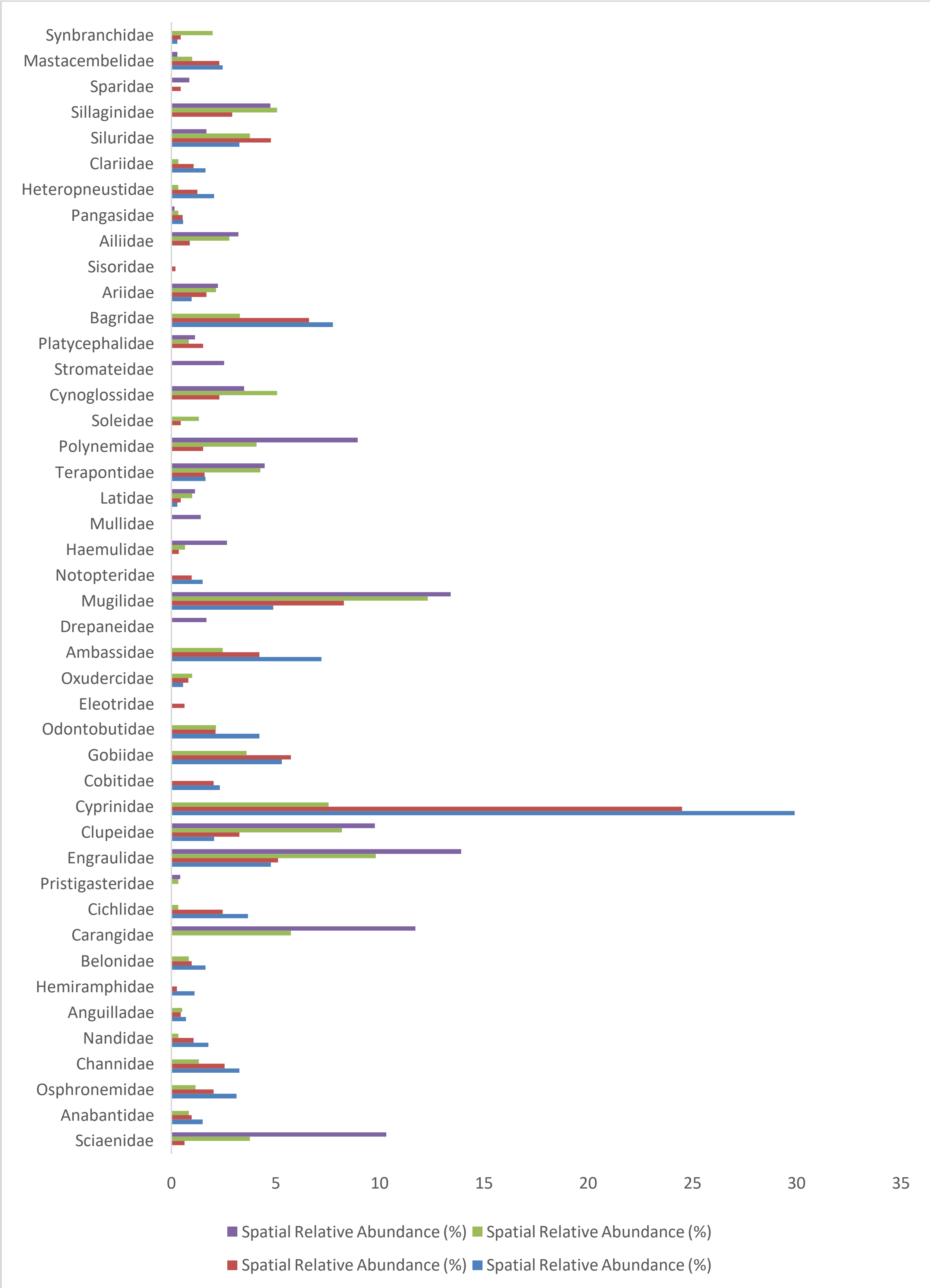

Figure 7. Spatial Relative Abundance of FamilieChilkigarhn all four stations are displayed in a scatter-plot with a smoothed line

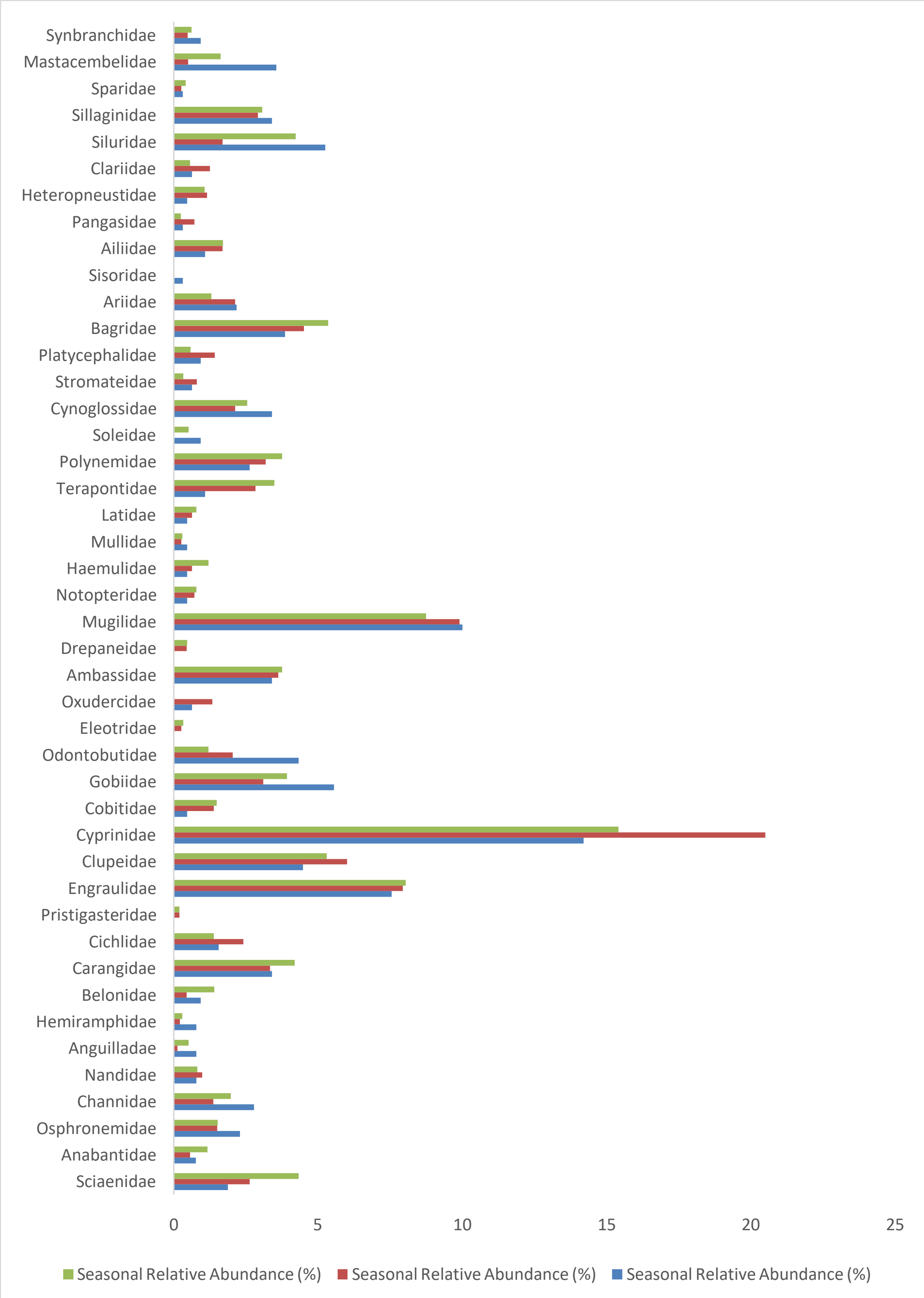

Figure 8. Seasonal Relative Abundance of FamilieChilkigarhn all four stations are displayed in a scatter-plot with a smoothed line

Table 5: Season wise occurrence of fish species

Fish Species	Summer	Rainy	Winter	Fish Species	Summer	Rainy	Winter
M. cuja	2	5	12	S. phasa	17	37	47
O. biauritus	4	3	9	T. polybranchialis	0	3	3
P. semiluctuosa	0	2	3	C. ramcarati	6	8	7
O. cuvieri	3	7	11	C. dussumieri	4	10	15
J. dussumieri	0	9	14	G. chapra	20	32	51
P. diacanthus	1	3	9	H. kelee	2	8	6
J. borneensis	2	1	4	T. ilisha	6	20	18
A. testudineus	5	6	16	T. toli	1	8	0
T. fasciata	15	17	21	P. terio	0	5	3
C. striata	6	0	5	S. sarana	11	23	15
C. punctata	10	11	16	P. conchonius	3	13	10
C. gachua	2	4	7	P. ticto	3	11	13
N. nandus	5	11	11	P. chola	0	19	18
A. bengalensis	5	1	7	P. sophore	14	25	21
H. limbatus	5	2	4	C. mrigala	1	5	3
X. cancila	5	3	11	L. rohita	0	11	0
S. leiurus	0	1	4	L. bata	3	9	12
S. strongylura	1	1	2	L. calbasu	0	3	5
A. melanoptera	5	9	13	L. catla	0	5	0
C. chrysurus	6	8	14	A. mola	25	35	44
M. cordyla	3	6	12	O. cotio	4	20	16
A. atropos	8	15	20	S. phulo	15	21	27
O. mossambicus	6	18	15	S. bacaila	13	19	25
O. niloticus	4	9	5	C. carpio	0	0	7
I. megaloptera	0	2	3	H. molitrix	0	10	0

S. taty	22	32	42	L. guntea	3	12	16
L. thermalis	0	4	5	P. argenteus	4	9	5
P. elongatus	10	16	21	P. indicus	6	16	8
A. bato	15	5	12	R. rita	2	1	0
G. giuris	11	11	22	S. seenghala	0	6	16
G. macrostomus	0	3	0	M. gulio	4	0	14
O. rubicundus	28	23	17	M. vittatus	13	25	22
E. fusca	0	3	4	M. bleekeri	1	6	7
T. cirratus	4	15	0	M. cavasius	5	13	17
P. lala	3	9	8	O. militaris	0	3	3
P. ranga	5	9	23	A. gagora	7	6	5
C. nama	14	23	22	A. platystomus	3	7	5
D. longimana	0	5	7	G. cenia	4	8	4
R. corsula	34	56	53	E. hara	2	0	0
M. cephalus	9	15	19	C. garua	7	19	24
C. parsia	22	41	52	P. pangasius	2	8	3
N. notopterus	3	7	9	H. fossilis	3	13	15
C.chitala	0	1	2	C. batrachus	4	14	8
P. maculatus	3	7	17	W. attu	3	2	6
U. sulphureus	3	3	4	O. bimaculatus	11	4	18
L. calcarifer	3	7	11	O. pabda	5	5	16
T. jarbua	6	18	26	O. pabo	15	8	20
T. puta	1	14	23	S. domina	19	23	29
P. paradiseus	11	25	32	S. sihama	3	10	14
P. sextarius	2	3	6	A. latus	2	3	6
E. tetradactylum	4	8	15	M. pancalus	12	0	14
B. orientalis	6	0	7	M. aral	5	0	6

C. arel	11	12	20	M. armatus	6	6	3
C. lingua	11	7	12	O. cuchia	6	5	8
C. puncticeps	0	5	4				

In July, the most common species are R. corsula, O. rubicundus, A. mola, and S. taty, as seen in the sample table above. When it rains, you're most likely to see R. corsula, C. parsia, S. phasa, and A. mola. The most common season for R. corsula is winter, then C. parsia, G. chapra, S. phasa, and A. mola. Curiously, R. corsula was the top-ranked species over the whole watershed in all three seasons.

Recommendation for further studies:

1. This research on finfish seasonal diversity and spatial distribution in the Dulung River, Jhargram District, West Bengal, not only sheds light on the present condition of aquatic ecosystems but also sets the stage for conservation initiatives and future studies. We can improve our knowledge and control of finfish populations in the area by investigating and implementing some of the many potential future directions.

2. Investigating how finfish populations cope with climate change is an important topic for the future. Climate change and other changes in precipitation patterns are putting more stress on aquatic ecosystems, which may affect finfish populations in rivers like the Dulung and elsewhere. For these communities to survive in the long run, we need to find out how susceptible they are to climate change and then figure out how to manage them adaptively.

3. More and more, people are realizing that coordinated ecosystem management is key to protecting aquatic species. Possible topics for future research include the relationships between riverine finfish populations and macroinvertebrates, aquatic vegetation, and water quality indicators. Researchers may learn more about the dynamics of ecosystems and develop better conservation policies if they take a more holistic view.

4. New technological developments have promising prospects for improving our capacity to monitor and control finfish populations. Data on ecosystem features and land use changes along the Dulung River may be greatly enhanced by remote sensing methods, such as satellite images and drones. Environmental DNA (eDNA) sampling, in a similar vein, may provide a non-invasive way to identify finfish species and track their abundance across time. Researchers and managers may benefit from better data collection and better decisions made when they embrace these technology improvements.

5. One other important thing for future conservation efforts is to get the local community involved. There is considerable potential in community-based systems that enable local stakeholders to actively participate in the management and monitoring of their natural resources. The success of conservation initiatives in the face of changing circumstances is more likely to occur when local people are encouraged to feel ownership and responsibility for the land.

6. The preservation and control of finfish populations depend on well-designed regulatory frameworks and administrative institutions. To better safeguard aquatic biodiversity, future studies should investigate the current policy climate in West Bengal as it pertains to riverine conservation and seek out areas where policies might be revised. Important next steps include building cooperation among

government agencies, non-governmental organizations (NGOs), and local communities and bolstering legislation pertaining to fishing techniques, habitat preservation, and water quality control.

7. In order to gain public support and encourage a spirit of environmental responsibility, it is essential to bring attention to the significance of protecting finfish stocks. Various platforms, including social media campaigns, instructional materials, and seminars, should be used in future outreach attempts to reach varied populations. Collective effort towards the protection of aquatic ecosystems may be inspired by fostering a feeling of admiration and duty for these environments.

8. Conservation and management of shared riverine habitats may be enhanced by collaborative efforts between India and adjacent nations, including Bangladesh. Concerns about transboundary concerns, including water resource management, migratory fish protection, and habitat connectivity, should be the center of future research and collaboration efforts. The best way to ensure the long-term health of the region's finfish populations is to encourage communication and collaboration among the governments that share borders with these fish.

9. Finally, in order to react to changing environmental circumstances and developing threats to finfish populations, it is vital to build long-term monitoring programs and adaptive management frameworks. In order to evaluate trends and the efficacy of conservation efforts across time, it is crucial to gather baseline data on finfish variety, abundance, and habitat preferences. Finfish stocks in the Dulung River may be protected for future generations if we take an active and flexible approach to managing them.

10. Finfish in the Dulung River have a huge and varied future potential for study and protection. We may strive for a future where aquatic ecosystems in West Bengal and elsewhere are more sustainably managed by adopting multidisciplinary methods, making use of technical advancements, involving local people, and encouraging cooperation at all levels. Ensuring the preservation of the Dulung River's natural legacy for the benefit of current and future generations is of utmost importance as we begin this journey. We must stay dedicated to the ideals of conservation, equality, and resilience.

Conclusion:

The geographical distribution and seasonal variety of finfish in the Dulung River, Jhargram District, West Bengal, is an intriguing ecological research that reveals the complex dynamics of aquatic ecosystems. This study has found important new information on the spatial patterns and population fluctuations of finfish in this river system via extensive research and analysis. The findings of this study emphasize the significance of conservation efforts in protecting these fragile ecosystems and the critical role that seasonal changes play in determining the distribution and variety of finfish species.

The research found that the quantity and variety of finfish species in the Dulung River fluctuate with the seasons. Researchers found seasonal variations in species composition by systematic sampling, with certain species being more common at particular periods than others. Finfish populations are affected by environmental elements including temperature, precipitation, and water flow, which highlights how dynamic aquatic ecosystems are. Effective management and conservation methods rely on a thorough understanding of these seasonal fluctuations. This knowledge enables targeted actions to save fragile species during important seasons.

Another fascinating finding was the geographical distribution of finfish inside the Dulung River. These patterns show both natural and human-induced patterns of activity. As a result of their biological needs and adaptation methods, certain species showed a preference for particular environments, including deep pools or shallow riffles. Furthermore, finfish distribution was seen to be impacted by human-caused variables including pollution and habitat loss, underscoring the need for comprehensive river management strategies that account for ecological and socioeconomic concerns simultaneously. Riverine ecosystems in the area may be better conserved and developed sustainably if researchers can map out these geographical trends.

Implications for finfish population management and conservation in the Dulung River and comparable aquatic ecosystems are substantial according to the results of this research. First, in light of environmental stresses like climate change and habitat degradation, it stresses the need of ongoing monitoring and study to trace changes in species composition and abundance over time. In order to detect patterns and act swiftly to reduce any risks to biodiversity, long-term data collecting is crucial. Further, the fundamental reasons of habitat deterioration and pollution constitute serious threats to river ecosystem health; hence, conservation groups, local communities, and government agencies must work together urgently to solve these issues.

In order to fully understand and manage aquatic resources, the study stresses the need of combining traditional ecological knowledge with modern research. As a supplement to scientific studies, local populations often have priceless knowledge about the ecology and behavior of finfish species that may guide conservation efforts. Stakeholders may promote more inclusive and effective resource management techniques based on tradition and science by collaborating with indigenous knowledge holders and include their viewpoints in decision-making processes.

Finally, finfish's geographical distribution and seasonal variety in the Dulung River, Jhargram District, West Bengal, provide light on the intricate dynamics of riverine ecosystems. The need of taking preventative conservation actions for finfish species has been brought to light by this study's thorough investigation and analysis, which has shown the impact of seasonal changes and human activities on these variables. Stakeholders can ensure the long-term health and sustainability of river ecosystems in the area by combining scientific research with traditional ecological knowledge and developing collaborative relationships. All things considered, this study's results add to our knowledge of aquatic biodiversity and provide the groundwork for future policy and decision-making that will help to protect these invaluable natural resources.

Suggestion:

1. **Implement Long-term Monitoring Programs:**To follow changes in species composition and abundance over time, it is vital to establish long-term monitoring programs for the finfish populations of the Dulung River. Insightful population patterns may be uncovered by continuous data gathering, which will also allow for prompt responses to reduce dangers.

2. **Introduce Sustainable Fishing Practices:**To guarantee the preservation of finfish populations, it is important to encourage local people to embrace sustainable fishing techniques. Fishing quota regulation, the promotion of selective fishing methods, and the implementation of seasonal fishing restrictions are all possible measures to save endangered species at their most vulnerable times.

3. **Strengthen Habitat Restoration Efforts:**The ecological balance of the Dulung River may be improved via funding habitat restoration projects. Restoring riparian vegetation, eliminating invasive species, and reducing river sedimentation and pollution are all possible steps in this direction.

4. **Enhance Environmental Education and Awareness:**Get the word out to the public via various outreach activities that highlight the significance of finfish conservation and their role in preserving ecological balance. Community people may be better equipped to take an active role in conservation efforts and become guardians of their natural environment via educational activities.

5. **Enforce Environmental Regulations:**Get the word out to the public via various outreach activities that highlight the significance of finfish conservation and their role in preserving ecological balance. Community people may be better equipped to take an active role in conservation efforts and become guardians of their natural environment via educational activities.

6. **Promote Community Engagement and Participation:**Encouraging community involvement and participation in river management and conservation decision-making processes is crucial. Building community-based groups, holding participatory workshops, and incorporating local knowledge into resource management plans are all ways to do this.

7. **Collaborate with Stakeholders:**Assist local communities, NGOs, academic institutions, and government agencies in working together to create thorough plans for the Dulung River's management. Stakeholders can tackle difficult conservation issues more efficiently by pooling their knowledge and resources.

8. **Invest in Research and Innovation:**In order to better understand the natural dynamics of the Dulung River and find long-term solutions to conservation problems, we need invest in research and new ideas. This might include encouraging cross-disciplinary work, providing financial backing for research, or both.

9. **Promote Ecotourism and Sustainable Livelihoods:**Look at ways to promote ecotourism and sustainable lifestyles in the Dulung River basin that are consistent with finfish conservation activities. By bringing attention to the value of preserving natural habitats and offering financial incentives for conservation, responsible tourism projects may have a positive impact.

10. **Adopt Adaptive Management Approaches:**Adopt methods of adaptive management that can be changed and adjusted in response to fresh knowledge and evolving situations. The protection of finfish populations in the Dulung River will be aided by this cycle of learning and adaptation, which will allow stakeholders to successfully react to new threats and uncertainties.

In order to conserve finfish in the Dulung River, these recommendations use a comprehensive strategy that takes into account ecological and socioeconomic factors, places an emphasis on teamwork and adaptive management techniques, and so on.

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