IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Fish Abundance With Relation To Water Quality Of Langting Hill - Stream In Dima Hasao District, Assam

Nilu Paul[1], Karishma Hazarika[1], Rajashree Borthakur[1] and Ajit K Tamuli[1]

[1] Department of Life Science and Bioinformatics, Assam University Diphu Campus, Assam, India

Abstract:

Assam is the land of rivers and streams. Considering the very high ecological diversity of the water assets and the blessings of the river and stream network, most of the cities and towns development in this state occurred close to the rivers and streams. Species diversity is acknowledged as foremost trait of ecosystem functioning. Seasonal variation of fish assemblage structure with physico-chemical parameters in Langting stream, Dima Hasao district, Assam were studied based on survey and analysis, conducted during March 2021 to February 2022. During the four seasons each with three different stations were selected for data collection. Shannon diversity index, the Simpson index and Margalef diversity index have been used to access the diversity. To explore the fish assemblage structure, fish samples were collected in seasonal basis from three sites of the stream by using cast net and gill net. A total of 1335 individuals belonging to 5 orders, 20 genera, 12 families and 27 species were collected from the selected sites. 11 species out of total 27 species found in Langting river, belong to order Siluriformes followed by Cypriniformes (10), Perciformes (3), Synbranchiformes (2) and Beloniformes (1). The most abundant species was *Nandus nandus*. For the season-wise and station-wise diversity of fish, the topmost Shannon"s diversity index (3.25) during post-monsoon at station 1, Simpson index (0.98) in all seasons and stations, Margalef diversity index (7.03) during pre- monsoon at station:1were recorded. The CCA analysis showed that the fishes like *Labeo cabsu* (C6), *Punitus sophore* (C7), *Punitus tict* (C8), *Bagarius bagarius* (C14) and *Anabus testudineus* (C24) were found to be strongly correlated with Free Carbon dioxide, furthermore, species like Rita rita (C11), Ompak pabda (C15), Wallago attu (C17) and Europiichthys vacha (C18), showed negative correlation towards water temperature (WT), dissolved oxygen (DO), pH, Alkalinity and Turbidity. Present study could be accountable for further exploration of fish diversity, water parameters or other relevant topics in future. Imposing fisheries regulations to reduce human activities are inevitable to sustain multitudinous fisheries.

Keywords: *Fish diversity, physicochemical parameters, water quality, Langting stream, conservation status.*

Introduction:

To shape the earth and control the climate water plays an important role as the most precious resource. Freshwater biodiversity is declining at an alarming rate, which is consistently above that estimated for terrestrial ecosystems (Dudgeon *et al*., 2006; Reid *et al*., 2019). The uncontrolled escalation of world population accompanied by rapid urbanization, industrialization, increased demand for food (Chamie, 2004) and the subsequent exploitation and pollution has already stressed freshwater resources leading to deterioration in water quality, a reduction in water quantity and degradation of freshwater biodiversity habitats (Jewitt, 2002; Hassan *et al*., 2005), as a result the deterioration of water satisfaction and depletion of aquatic life are in great threat. Water is a widely known and essential resource, regulating the climate and profoundly influencing life on earth (Gorde & Jadhav, 2013). The natural elements of water is usually characterized by its chemical and biological components. Stressors or the pressures that human being exert on aquatic systems through their use of the surrounding environment are commonly the chemical, physical and biological components of the ecosystem. The environmentalists in India and all over the globe are concerned about the deterioration of water quality in natural water bodies. Fishes are the group of vertebrates which share many common characters that helps them to adapt in the various aquatic ecosystem. While many investigations aimed at detecting environmental and ecological changes within aquatic ecosystem have focused primarily on water quality and the associated biota (eg. Aquatic plants, invertebrate), there are relatively few studies based solely on fishes (Costa *et al*., 1992; Dennison *et al*., 1993).

In the current study, hill- stream viz Langting of Dima Hasao (a hill district in Assam) had been selected for accounting the fish diversity with relation to water quality. The Dima Hasao district of Assam is endowed with untapped potential for fish and other aquatic communities in terms of vast aquatic resources like rivers, streams, wetlands, lakes and ponds. The ichthyo-diversity of this region is unique from the zoogeographical point of view whereas, the fish biodiversity of the selected stream is the first victim of the stress. Fish are pivotal point of the aquatic food web and its human consumption make them important for assessing contamination. Due to non-availability of any significant published study on fishes in Dima Hasao district, the baseline data acquired from the result will be of utmost use for the development of the selected stream. This study seeks to execute an influential plan to find seasonal and station-wise variations and diversity of fish in the Langting stream and determine the relationship between the assemblage of fish and water standards in this river system. Similarly, endeavors to explain the parallel relations among seasonal variations and fish diversity.

Justification of the study:

One of the most important studies for a country like ours is the study of variety in connection to habitat kinds and water quality. The seasonal fluctuation and types of habitat for fish, as well as their diversity, are well understood through this study. It is a lamentable fact that till date no elaborate updated information is available about fish diversity and the variation in water quality of the hill streams of Dima Hasao district. So, it is suggested that there is a lacuna in the study of fish diversity as well as water quality health status of selected hill stream – Langting of Dima Hasao district, Assam. On this account, the present study was set in motion to fulfill all these missing parts to some extent and we surmise that, this study will be convenient for commencers as well.

Aims and objectives:

Aim:

The overall aim of this study therefore, was to undertake an evaluation of diversity of fish with relation to water quality status in selected hill stream (Langting stream) of Dima Hasao district. As no comprehensive work has been put on record about the hill streams of Dima Hasao district till date hence an attempt is being made to conduct a detailed survey on the stream with an exclusive reference to limnological and conservational aspects.

Objectives:

The following objectives were set to achieve the overall aim:

1. To study the physico-chemical parameters of selected stream.
2. To investigate the fish abundance with relation to water quality in Langting stream of Dima Hasao district, Assam.

Materials and Methods:

Study area:

Geologically, Dima Hasao district (Fig.-1) is made up of metamorphic rocks with a fringe of cretaceous and tertiary deposits. The Dima Hasao district comprises enough forest and deforestation is a continuous process for agriculture expansion and commercialization, introduction of horticulture, urbanization, human interference etc.

The present study area is Langting of Dima Hasao district of Assam. Selected stream is Langting. Langting stream originates from Semkhor village (located at the northern fringe of Barail), the border area of Nagaland, Manipur and Dima Hasao and confluents to Diyung river (originates from Borail range).

Sampling Sites

Three sampling sites were selected from upstream to downstream covering a length of 3 km of Langting stream (Fig.-2). All the sites were at a distance of 1 km from each other. The selected parameters were studied on seasonal basis. The stretches were demarcated into three sampling stations viz: S_1, S_2 and S_3. These study sites were based on accessibility and physical habitat similarity.

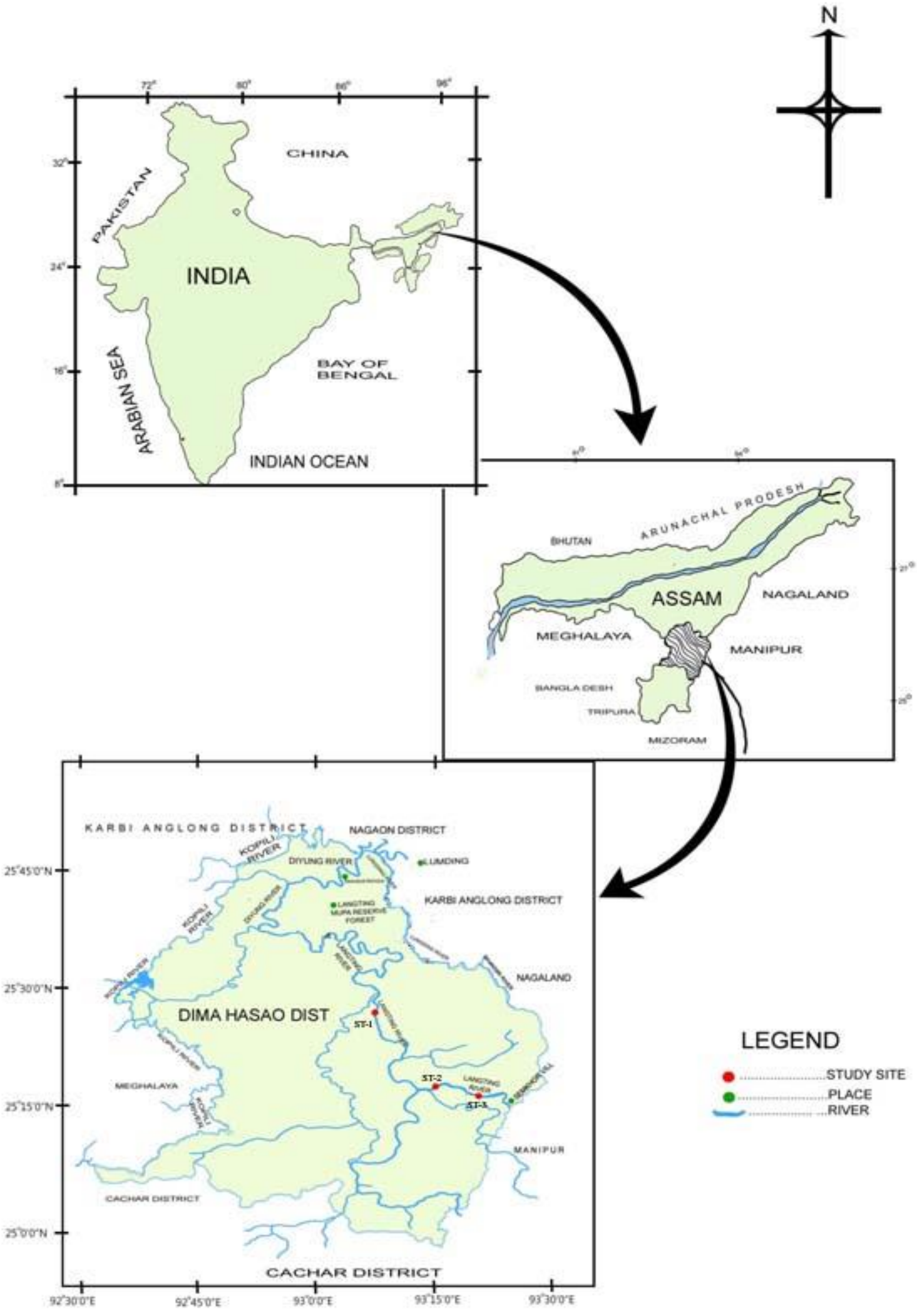

Figure:1. Location of Langting town in Dima hasao district, India;

Physical status of selected stream:

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Physical habitat measurements were assessed including longitude, latitude, and altitude (GPS).

Sampling site	GPS position	Altitude (m)
S1	25˚28′52″N 93˚49′9″E	147
S2	25˚26′40″N 93˚6′99″E	145
S3	25˚29′48″N 93˚6′45″E	140

Station 1of Langting stream: 25˚28′52″N, 93˚49′9″E, altitude - 147 m above sea level. It is within the Langting area of Forest IB Ghat

Station 2 of Langting stream: 25˚26′40″N, 93˚6′99″E, altitude-145 m above sea level. This station is popularly known as N. K. Saw Mill Ghat and its inhabitants use river water for different domestic utilities.

Station 3 of Langting stream: 25˚29′48″N, 93˚6′45″E, altitude-140 m above sea level. This station at Langting Bazar Ghat is adjacent to a railway pumping station and NH-21. Surrounding impacts include run-off from roads and informal settlements, livestock farming and other agricultural practices.

Fig.-2. Segmental view of the sampling sites (Langting river)

Period of study:

The hydrobiological survey of the rivers was conducted seasonally from (March,2021 to February ,2022). The water samples were collected from the study sites on seasonal basis and simultaneously, fishes were also gathered seasonally.

Methodology:

Sampling:

Water Sampling:

Collection of water samples was undertaken according to the standard methods for examination of water (APHA, 1995). Water samples used for the analysis of chemical variables, were collected in plastic container of 250 ml. Water samples were collected facing upstream of the river as recommended in APHA *et al.*, (1971) and the bottles were filled to the neck allowing no head space and transported to the laboratory in an ice-filled cooler box. Samples were preserved at 4^0 C in the laboratory for chemical analysis. All chemical analyses were performed within 24 hours of sample collection.

Fish sampling:

Local fishing experts facilitated the collection of fishes with the help of traditionally fishing gears such as cast nets, gill nets etc. Fixation of fishes was done in 4% to 10% formaldehyde, following replacement in 70% ethanol for permanent preservation, and deposition at the Life Science and Bioiformatics Departmental Museum, AU, Diphu Campus, Assam (India).

Water quality analysis:

Only, certain parameters were observed and recorded.

On-Spot water analysis:

Water temperature:

Water temperature was recorded by mercury thermometer, of 0°C to 100°C range. The water temperature was reckoned by immersing the bulb of the thermometer into the surface water after taking into the beaker at 5 different strata in a sampling site and average value of temperature was noted.

pH:

pH values of the water sample were recorded instantly after collection by an ISO certified(Hanna Instruments-Italy) digital pH meter.

Laboratory water analysis:

Alkalinity:

Total alkalinity of water sample was tested using IS: 3025 (Part 23) method. 100 ml of water sample was taken, to which 3 drops of phenolphthalein indicator were added. It was then titrated against sulphuric acid (0.02 N) till colour changed from pink to colourless. A few drops of methyl orange were added till the appearance of yellow colour. Titration was continued till colour changed from yellow to orange.

Calculations were done using formulas given below:

$$\text{Phenolpthalein alkalinity (as CaCo3)} = \frac{\text{V1} \times \text{normality of H2SO4} \times 1000 \times 50}{\text{Volume of sample taken}}$$

$$\text{Total alkalinity (as CaCO3)} = \frac{\text{V2} \times \text{normality of H2SO4} \times 1000 \times 50}{\text{Volume of sample taken}}$$

Equivalent weight of $CaCO_3$ = 50

V1 = Volume of the acid consumed for phenolphthalein end point

V2 = Volume of the acid consumed for methyl orange end point

To convert sample from ml to l results were multiplied by 1000ml/l.

Dissolved Oxygen (DO):

Dissolved oxygen of water samples was determined by method IS:3025 (Part 38). Manganous sulphate solution was prepared by dissolving 400 g of $MnSO_4.2H_2O$ in freshly boiled and cooled distilled water. The volume was raised to one litre by adding distilled water. Alkaline iodide sodium azide solution was prepared by adding sodium iodide solution (500 g of sodium hydroxide and 135 g of sodium iodide in 1000 ml of distilled water) and sodium azide solution (10 g of sodium azide mixed in 40 ml of distilled water). Sodium thiosulphate stock solution was prepared by dissolving sodium thiosulphate (25 g) in 1000 ml boiled distilled water. Starch was used as an indicator and was prepared by adding 2 g of starch in boiling distilled water to prepare starch indicator. Sample was collected from the field in BOD bottle filled upto the rim. 2mL of manganese sulfate and 2 mL of alkali-iodide-azide reagent were added to the water sample by inserting calibrated pipette just below the surface of liquid. On the presence of oxygen, brownish precipitates were formed, to which 2 ml of concentrated sulfuric acid was added. 203 mL of the solution was taken in a flask and titration was carried using sodium thiosulphate solution. Starch was used as an indicator. The end point was change of colour from blue to colourless.

$$\text{Dissolved oxygen}\left(\frac{\text{mg}}{\text{l}}\right) = \frac{\text{Volume of sodium thiosulphate } \times 0.2 \times 1000}{\text{Volume of sample taken}}$$

Free carbon dioxide FCO_2:

Free carbon dioxide was estimated using Warburg's titrimetric method. 100 ml of water sample was taken in a flask, to which 0.5 ml of phenolphthalein was added. Appearance of pink colour indicated absence of free carbon dioxide. Absence of pink colour indicated presence of free carbon dioxide. It was further titrated with N/22 Na2CO3 till pink colour appeared. Readings of the amount of Na2CO3 were multiplied by 10 to get the value of free carbon dioxide in mg/l.

Identification of fishes:

Identification of fish species follows Talwar and Jhingran (1991), Nath and Dey (1997), Jayaram (1999, 2010), Vishwanath *et al*., (2007), and Vishwanath *et al*., (2014). The latest scientific names of the fish species were followed after the monthly updated website www.calacademy.org/res/ichthyo/catalogue .The threat criteria of the collected fish species were assessed as per IUCN (2012).

Statistical analysis:

(a) Statistical tools used for studying the Physico-chemical parameters:

(i) Seasonal Variations and average seasonal variations of physico-chemical parameters in the selected stream were illustrated by graphs and all the graphs were drawn using Microsoft Excel.

(ii) To establish the degree of association between various physical and chemical parameters, Pearson's correlation matrix was calculated using XLSTAT.

Formulae to calculate the diversity:

The different formulae used to calculate the diversity indices are:

(a) Shannon-Wiener Diversity Index (H) (Shannon and Wiener, 1963)

$$H = -\sum_{s=1}^{s}(p_i)logp_i)$$

Where "p_i" is the proportion of individuals in the "i^{th}" taxon of the community and "s" is the total number of taxa in the community

(b) Simpson's Diversity index (Simpson, 1949):

$D = 1-[\Sigma n_i (n_i -1)] / N (N-1)$

$n_i =$ Number of individuals belonging to i species

N =Total number of individuals

(c) Margalef Diversity index(Margalef, 1958):

It is calculated as

Margalef's index d = (S-1) / log N

Where, S = Total number of taxa

N = Total number of individuals.

Statistical tools used for studying the fish assemblage:

The family-wise percentage occurrence of fishes and diversity indices like Shannon Diversity Index, Simpson's Diversity index, Margalef's index were calculated using EXCEL.

Formulation of strategy for conservation of stream habitat:

In India, the ecology of hill streams of the major river systems is poorly known.
Based on biological assessment further management plan can be developed to improve water quality of Langting stream.

Habitat destruction is a serious environmental problem. For the protection of aquatic resources and fauna particular in the Dima hasao district , there is need to remove various stresses on the aquatic resources. Some of the suggestive measures are-habitat restoration, declaration of fish sanctuaries suitable infrastructure development for restoration programme, long term freshwater monitoring to develop ongoing estimates of the abundance, populations, and for the design of conservation and management programs. Further, Governments around the world have to set strict regulations in order to preserve natural living areas. Only then will it be possible to sustain biodiversity and also to ensure the ecological balance on a global scale.

Results:

Assessment of Seasonal variations of physicochemical parameters:

In the present investigation, seasonal variation of certain physico-chemical parameters of Langting stream had been studied along with monitoring of water quality.

Table- (1) comprises seasonal variation of the physicochemical parameters of the stream during the period from March-2021 to February -2022.

Water Temperature:

The growth of organisms and physicochemical behavior of biotic components of aquatic ecosystem is temperature -dependent. There is a conspicuous declining trend of water temperature from monsoon to winter in different stations. The seasonal variation indicated that the water temperature followed the specific seasonal pattern of ambient temperature fluctuation. The lowest (14.7 °C) water temperature was found at station-2 in winter and highest (25.6 °C) at station-1 in monsoon.

Turbidity:

The maximum and minimum values of turbidity were derived as 4.81 NTU during monsoon at station-1 and 2.36 NTU during pre-monsoon at station-1.

pH:

pH values in Langting stream , both the maximum and minimum were recorded as 8.03 at station-1 during winter and 7.08 at station-1 during monsoon respectively. pH of a water body is a conspicuous indicator of water quality (vide Fakayode, 2005). During the entire field work, the assessed data on pH of the water of different sectors of the stream was noticed to be in between neutral to alkaline range.

Dissolved Oxygen:

DO is not only an indispensible parameter of water quality but also an index of physical and biological process operating on in water . It is evolved in the present study that the lowest and highest values of DO were recorded as 5.06 mg/l at station-2 in post-monsoon period and 7.17 mg/l at station-1 in monsoon season respectively.

Free CO_2:

Langting stream recorded the maximum and minimum values of free CO_2 as 5.3 mg/l at station-1 during monsoon season and 4.18 mg/l at station-3 during pre-monsoon season respectively.

It has to be noted that the variation of FCO_2 is due to the absorption by the primary producer (plant) for photosynthesis and on account of the manifold activities of other living organisms.

Alkalinity:

Alkalinity implies a total measure of substance in water that has acid-neutralizing capacity. The maximum value of alkalinity was estimated to be 167.14 mg/l at station-3 in monsoon season and the minimum value was calculated to be 80.9 mg/l at station-1 winter season.

Waste discharge from nearby surface results in surface alkalinity, whereas, the chief sources of natural alkalinity are carbonate-rich rocks, loaded with silicates and phosphate. The domestic consumption demands the alkalinity value less than 100mg/1.

Table-1. Seasonal variation of the physicochemical parameters in Langting stream

Parameters	Seasons	St-I	St-II	St-III
Water temp(ºC)	Pre monsoon	22.1	21.4	21.8
	Monsoon	25.6	24.9	25.2
	Post-monsoon	17.4	16.9	17.2
	Winter	15.3	14.7	15.7
Turbidity	Pre monsoon	2.36	3.26	4.07
	Monsoon	4.81	3.01	3.41
	Post-monsoon	3.9	2.72	2.54
	Winter	2.81	2.59	2.57
pH	Pre monsoon	7.43	7.5	7.48
	Monsoon	7.08	7.45	7.40
	Post-monsoon	7.76	7.65	7.62
	Winter	8.03	7.6	7.81
D.O.(mg/l)	Pre monsoon	7.15	7.07	7.12
	Monsoon	7.17	7.1	7.15

	Post-monsoon	5.11	5.06	5.1
	Winter	6.22	6.16	6.2
Free CO_2(mg/l)	Pre monsoon	4.44	4.7	4.18
	Monsoon	5.3	5.27	4.87
	Post-monsoon	4.55	4.47	4.51
	Winter	4.72	5.27	4.74
Alkalinity(mg/l)	Pre monsoon	130.43	125.53	137.4
	Monsoon	164.8	144.79	167.14
	Post-monsoon	103.9	104.7	112.45
	Winter	80.9	87.88	95.78

Inventory of selected fishes for monitoring of water quality:

Fish assemblage structure:

The investigation process had witnessed 27 fish species belonging to 5 orders, 20 genera, and 12 families have been recorded from the three stations of Langting stream. The 11 species out of 27 species located in Langting stream, belong to order Siluriformes followed by Cypriniformes (10), Perciformes (3), Synbranchiformes (2) and Beloniformes (1). The ensuing table (2) delineated various fish species collected from the stream.

Table:2-Fish species and their order, family, IUCN and CAMP status

Order	Family	Species	IUCN 2012	CAMP 1998
1.Cypriniformes	1.Cyprinidae	1. *Cabdio jaya* (Hamilton, 1822)	LC	VU
		2. *Amblypharyngodon mola* (Hamilton, 1822)	LC	LRlc
		3. *Labeo bata* (Hamilton, 1822)	LC	LRnt
		4. *Labeo rohita* (Hamilton, 1822)	LC	LRnt
		5. *Labeo boga* (Hamilton, 1822)	LC	LRnt
		6. *Labeo calbasu* (Hamilton, 1822)	LC	LRnt
		7. *Punitus sophore* (Hamilton, 1822)	LC	LRnt
		8. *Puntius ticto* (Hamilton, 1822)	LC	LRnt
		9. *Esomus danricus* (Hamilton, 1822)	LC	LRlc
		10. *Botia dario* (Hamilton, 1822)	LC	LRnt
2. Siluriformes	2.Bagridae	11. *Rita rita* (Hamilton, 1822)	LC	LRnt
		12. Mystus tengara (Hamilton, 1822)	LC	LRnt
		13. *Mystus bleekeri* (Day, 1877)	LC	VU
	3. Sisoridae	14. *Bagarius bagariu* (Hamilton, 1822)s	NE	VU
	4. Siluridae	15. *Ompak pabda* (Hamilton, 1822)	NT	EN
		16. *Ompok pabo* (Hamilton, 1822)	NT	NE
		17. *Wallago attu* (Bloch & Schneider, 1801)	LC	LRnt
	5. Schilbeidae	18. *Eutropiichthys vacha* (Hamilton, 1822)	NE	EN
		19. *Ailia coila* (Hamilton, 1822)	NT	VU
	6. Amblycipitidae	20. *Amblyceps mangois* (Hamilton, 1822)	LC	LRnt
	7. Olyridae	21. *Olyra longicaudata* (Hamilton, 1822)	LC	LRnt
3. Perciformes	8. Channidae	22. *Channa punctata* (Bloch, 1793)	LC	LRnt
	9. Nandidae	23. *Nandus nandus* (Hamilton, 1822)	LC	LRnt
	10. Anabantidae	24. *Anabas testudineus* (Bloch, 1792)	DD	VU
4. Beloniformes	11. Belonidae	25. *Xenentodon cancila* (Hamilton, 1822)	LC	LRnt
5. Synbranchiformes	12. Mastacembelidae	*26. Macrognathus aral* (Bloch & Schneider, 1801*)*	LC	LRnt
		27. *Macrognathus pancalus* (Hamilton, 1822)	LC	LRnt

Number of orders=5, Number of families=12, Number of genera=20, Number of species=27

LC-Least concerned, NT-Nearly threatened, NE-Not evaluated, DD-Data Deficient, VU-Vulnerable EN-Endangered, LRlc-Lower risk least concerned, LRnt-Lower risk near threatened

IUCN status of the species:

Among 27 species found in Langting stream, 21species are found least concerned followed by 3 species nearly threatened. 2 species found not evaluated and 1species is data deficient. The number of species found in different category of IUCN status is listed in table-3

Table:3. IUCN status of fish species found in the stream

	Least concerned (LC)	Nearly threatened (NT)	Data Deficient (DD)	Not evaluated (NE)
Total numbers	21	3	1	2
Percentage	77.78	11.11	3.70	7.41

CAMP status of the species:

Among 27 species found in Langting stream, 17 species are found lower risk near threatened followed by 5 species Vulnerable, 2 species lower risk least concerned, 1 species found endangered and 1 species found not evaluated. The number of species found in different category of CAMP status are listed in table-4.

Table:4. CAMP status of fish species found in the stream:

	Lower risk near threatened (LRnt)	Lower risk least concerned(LRlc)	Endangered(EN)	Not evaluated (NE)	Vulnerable(VU)
Total numbers	17	2	1	1	5
Percentage	62.96	7.41	3.70	3.70	18.52

LC-Least concerned, NT-Nearly threatened, NE-Not evaluated, DD-Data Deficient, VU-Vulnerable EN-Endangered, LRlc-Lower risk least concerned, LRnt-Lower risk near threatened

Many economically important large fish species found in the studied stream , some of which are *Labeo rohita, , Labeo calibasu, Wallago attu, Rita rita* etc. Some ornamental fishes like *Botia Dario* and all *punitus species etc.* were also found.

Number and percent compostition of Families, Genera and species under various orders of fish fauna in Langting stream:

Number and percent composition of Families, Genera and species under various orders of fish fauna in Langting stream during the study period are listed below in table-5.

Table:5. Number and percent composition of Families, Genera and Species under various orders in Langting stream:

Order	Families	Genera	Species	% of Families in an Order	% of Genera in an Order	% of Species in an Order
Cypriniformes	1	6	10	8.33	30	37.04
Siluriformes	6	9	11	50.00	45	40.74
Perciformes	3	3	3	25.00	15	11.11
Beloniformes	1	1	1	8.33	5	3.70
Synbranchiformes	1	1	2	8.33	5	7.41

Species-wise fish distribution in Langting stream:

Table: 6. An account of station-wise number of fish species found in Langting stream

Sl. No	*Species*	Pre-monsoon				Monsoon				Post-monsoon				Winter			
		S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total
		Order:Cypriniformes															
1	*Cabdio jaya*	1	1	1	3	1	0	1	2	1	1	2	4	2	2	1	5
2.	*Amblypharyngodon mola*	2	1	3	6	2	1	4	7	3	2	5	10	1	1	4	6
3	*Labeo bata*	0	1	1	2	1	1	2	4	3	0	3	6	2	1	2	5
4	*Labeo rohita*	1	1	2	4	2	1	3	6	3	1	4	8	2	1	2	5
5	*Labeo boga*	1	0	1	2	2	1	2	5	2	1	3	6	1	2	2	5
6	*Labeo calbasu*	1	1	1	3	2	1	1	4	2	2	3	7	2	2	2	6
7	*Punitus sophore*	1	1	1	3	1	1	1	3	2	2	2	6	0	2	2	4
8	*Puntius ticto*	1	1	1	3	2	2	2	6	2	2	3	7	1	0	3	4
9	*Esomus danricus*	1	0	1	2	2	1	2	5	2	2	2	6	2	2	3	7
10	*Botia dario*	1	0	1	2	2	1	1	4	2	2	2	6	2	1	3	6
	Order: Siluriformes																
11	*Rita rita*	1	0	2	3	2	1	3	6	3	2	3	8	3	1	3	7
12	*Mystus tengara*	2	0	2	4	3	2	4	9	4	3	7	14	3	2	5	10
13	*Mystus bleekeri*	1	0	3	4	3	1	2	6	2	2	4	8	2	1	5	8
14	*Bagarius bagarius*	1	1	2	4	1	1	1	3	3	2	3	8	2	2	2	6

Sl. No	Species	Pre-monsoon				Monsoon				Post-monsoon				Winter			
		S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total
15	*Ompak pabda*	1	1	2	4	1	1	2	4	3	1	3	7	2	1	2	5
16	*Ompok pabo*	1	0	2	3	1	0	2	3	3	1	2	6	2	2	1	5
17	*Wallago attu*	1	0	3	4	2	2	3	7	3	1	4	8	2	0	4	6
18	*Eutropiichthys vacha*	2	0	2	4	1	0	4	5	2	1	4	7	2	2	4	8
19	*Ailia coila*	2	1	3	6	2	2	4	8	3	2	5	10	3	0	4	7
20	*Amblyceps mangois*	1	1	3	5	1	2	3	6	3	1	3	7	0	2	3	5
21	*Olyra longicaudata*	1	2	3	6	2	1	3	6	3	2	5	10	1	1	3	5
Order- Perciformes																	
22	*Channa punctata*	2	1	2	5	2	1	2	5	3	3	7	13	3	1	3	7
23	*Nandus nandus*	1	1	2	5	2	2	3	7	3	3	9	15	2	2	1	5
24	*Anabas testudineus*	3	2	3	8	2	4	2	8	3	3	7	13	2	0	4	6
Order- Beloniformes																	
25	*Xenentodon cancila*	1	0	5	6	1	0	6	7	2	0	8	10	3	4	7	14
Order- Synbranchiformes																	
26	*Macrognathus aral*	2	0	2	4	4	2	3	9	5	2	6	13	3	2	4	9
27	*Macrognathus pancalus*	2	0	3	5	3	2	2	7	4	2	5	11	2	1	3	6

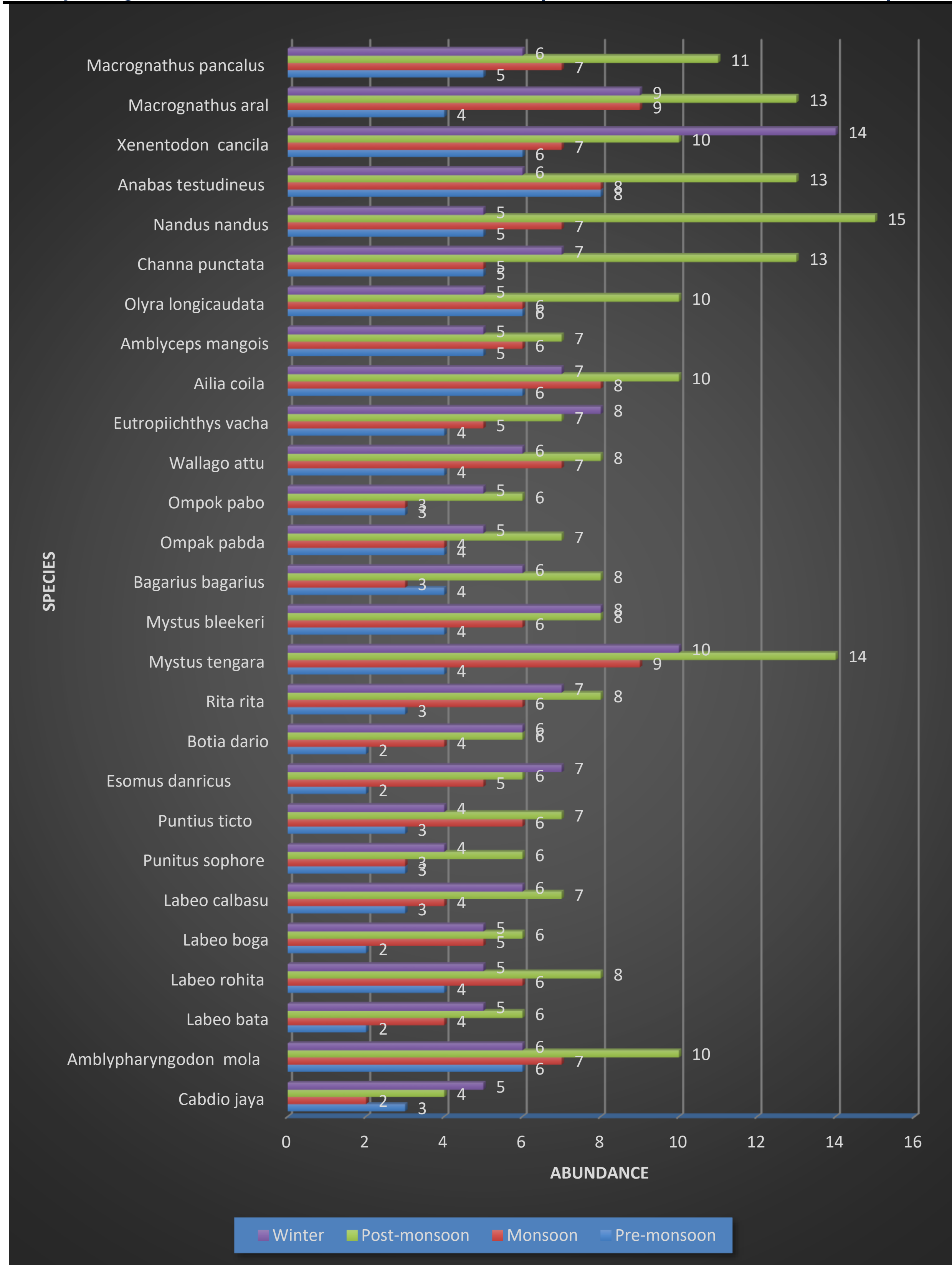

Fig-3. Abundance of fishes found in different orders in Langting stream.

Order-based distribution of fish fauna:

The number of fishes under various orders found in the stream in different seasons during the study period are listed below in table-7.. The pie diagram of abundance of order of fishes are also shown in figure 4. It is observed that the percentage of fishes found is highest in order Siluriformes followed by Cypriniformes, Perciformes, Symbranchiforme and Beloniformes. This finding is strongly agreed with the findings of Kostori *et al*., (2011) and Galib (2015).

Table:7.Number of fishes found in different orders in Langting stream

Sl.No	Order	Pre-monsoon	Monsoon	Post-monsoon	Winter	Percentage of fishes
1	Cypriniformes	30	46	66	53	29.19
2	Siluriformes	47	63	93	72	41.17
3	Perciformes	18	20	41	18	14.52
4	Beloniformes	6	7	10	14	5.54
5	Synbranchiformes	9	16	24	15	9.58

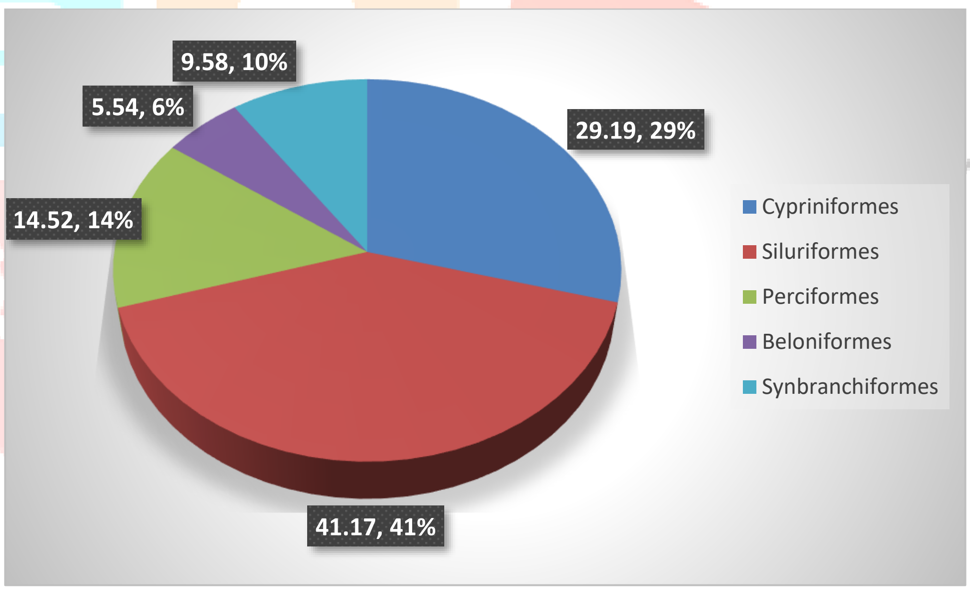

Fig-4. Percentage of fishes found in different orders in Langting stream.

Season and order-wise occurrence of the fish species:

Following is the presentation of station and order-wise occurrence of the fish species:

1. **Cypriniformes:** In this order, fish species belonging to 1 family (Cyprinidae) is found in Langting stream. The family Cyprinidae was represented by10 species. It is to be noted that all the species are found in maximum number during post-monsoon season and all the species are found in all seasons.

2. **Siluriformes:**There 6 families found in Langting stream. These are

a) Bagridae: Langting stream had recorded three fish species belonging to this family. All the species of this family were noticed in Langting stream in all seasons. All these species found were found maximum in number during post-monsoon season.

b) **Sisoridae:** Langting stream had sheltered one species *Bagarius bagarius.* This fish species were found in all seasons.

c) Siluridae: Langting stream reported three fish species of this family and *Ompok pabda*, *Ompok pabo* and *Wallago attu* were collected from all stations. Of these, *Wallago attu* is found more than that of other two species.

d) Schilbeidae: There are two species namely *Eutropiichthys vacha and Ailia coila found* in Langting stream. All the species are found in maximum number durin post-monsoon season.

e) Amblycipitidae: The presence of single species of this family Amblyceps mangois was reported and it was found maximum in number during post-monsoon season..

f) Olyridae: Only one species of this family i.e. *Olyra longicaudata* was reported from all stations of Langting sream.

3. Perciformes:3 families under this order are found in Langting stream.These are

a) Channidae: One species of this family was represented from Langting stream. The species found was *Channa punctata.* .But maximum number of species *Channa punctata* is found during post-monsoon and winter.

b) Nandidae: *Nandus nandus*, the only species of this family were found in Langting stream in all seasons.

c) Anabantidae: *Anabas testudineus*, the only one species of this family, was found in all seasons.

4. Beloniformes: Only one family is found under this order. This is-

Belonidae: Langting stream had accommodated *Xenentodon cancila* and the same was found in all stations..

5. Synbranchiformes: There was one family of this order found in Langting stream. This is-

a) Mastacembelidae: *Macrognathus aral and Macrognathus pancalus* , species of this family, that were located in Langting stream in all seasons but maximum number of these species found in post-monsoon. *Macrognathus pancalus* had outnumbered *Macrognathus aral* .

Fish species richness, Species abundance and relative abundance and diversity indices:

There is a direct correlation between species richness, relative abundance and diversity of a particular area with the environmental features of that area. The seasonal variation is also noticed in species richness, abundance and diversity on account of fluctuation of these parameters in each season of the year. One could observe the seasonal as well as altitudinal variation in species richness, abundance and diversity during the field work.

The following are the diversity indices, calculated as season and station-wise:

Shannon-Weiner diversity indices (H):Shannon Weiner diversity index considers both the number of species and the distribution of individuals among species of Langting stream. The value of H: usually falls between the values 1.5 to 3.5 and it rarely surpasses the value of 4.5. A value near 4.6 would indicate that the numbers of individuals are evenly distributed between all the species. During the study period, the highest value of H was found 3.25 at station-1 during post-monsoon. The lowest value of H was found as 2.67 at station-2 during pre-monsoon season. In each case of the highest value of H, diversity index is involved with high diversity of individuals and the lowest value involved with low diversity of individuals. The main causes of variations of diversity indices are seasonal variations of nutrients, effectiveness of breeding activities, atmospheric air currents, environmental conditions and seasonal migrations. This findings is closely related to with the findings of Iqbal *et al.,(*2015) who recorded H value from 2.90 to 3.12 in Konoskhaihoar in Sunamganj. Murugan and Prabaharan(2012) recommended that low diversity(H) occurs in pre-monsoon due to shrinkage of water spread of the water body and highest diversity(H) in post-monsoon due to sufficient water and ample amount of food resources.

Simpson's index of dominance (D) : Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so diversity increases. The value of **D** ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity.

Margalef's index (Ma): Margalef's richness is the simplest measure of biodiversity and is simply a count of the number of different species in a given area. This measure is strongly dependent on sampling size and effort. In this study, the lowest and highest value of Margalef's index was observed as 4.94 at station-2 during pre-monsoon and 7.03 at station-1 during pre-monsoon. Galib *et al*., (2013) calculated fish species richness value in the Choto Jamuna River of Bangladesh and found values varied from 6.973 to 8.932 and it almost agrees with our present study. The Margalef's index may deviate from actual diversity value to some extent because it does not confound the evenness and species richness value properly and it is dependent on sample size (Nair *et al*., 1989). This may occur as a result of reduced water depth due to lack of rainfall, which disturbed fishermen to employ their fishing gears more effectively (Iqbal *et al.,* 2015). In addition, ecological conditions also have an effect on the distribution of the fish species.

Table: 8. Species richness and species abundance of Langting stream

Seasons	Species richness			Species abundance		
	St-1	St-2	St-3	St-1	St-2	St-3
Pre-monsoon	6	5	7	35	17	57
Monsoon	7	3	7	50	34	68
Post-monsoon	7	5	7	74	46	114
Winter	5	3	7	52	38	82

Table:9- Shannon-Weiner index (H), Simpson's index of dominance (D) and Margalef's index (Ma) of Langting stream

Stations	H				D				Ma			
	Pre-monsoon	Monsoon	Post-monsoon	Winter	Pre-monsoon	Monsoon	Post-monsoon	Winter	Pre-monsoon	Monsoon	Post-monsoon	Winter
S_1	3.18	3.22	3.25	3.17	0.98	0.98	0.97	0.98	7.03	6.65	6.04	6.07
S_2	2.67	3.04	3.15	3.05	0.92	0.98	0.98	0.97	4.94	5.67	6.27	6.32
S3	3.10	3.19	3.10	3.20	0.97	0.97	0.96	0.97	6.43	6.16	5.49	5.90

Correlation between physico-chemical parameters and fish abundance of different orders:

Table:10 Correlation between physico-chemical parameters and fish abundance during pre-monsoon season

Para	Wat T	TUR	pH	DO	FCO_2	ALKA	Cyprini-formes	Siluri-formeS	Perci-formes	Belon-iformes	Synbra-nchiformes
WT	1.000										
TUR	-0.454	1.000									
pH	-0.948!!	0.715**	1.000								
DO	0.998**	-0.399	-0.926!!	1.000							
FCO2	-0.569!	-0.473	0.277	-0.619!	1.000						
ALKA	0.484	0.559*	-0.180	0.537*	-0.995!!	1.000					
Cypriniformes	0.569*	0.473	-0.277	0.619*	-1.000	0.995**	1.000				
Siluriforme	0.452	0.589*	-0.144	0.506*	-0.991!!	0.999**	0.991**	1.000			
Perciformes	0.715**	0.298	-0.454	0.756**	-0.982!!	0.958**	0.982**	0.947**	1.000		
Beloniformes	0.269	0.736**	0.052	0.327	-0.945!!	0.973**	0.945**	0.981**	0.866**	1.000	
Synbranchiformes	0.807**	0.159	-0.577!	0.842**	-0.945!!	0.907**	0.945**	0.892**	0.990**	0.786**	1.000

Para.= parameters; Wat.T= water temperature; TUR=Turbidity; pH= Phosphate; DO= dissolved oxygen;; FCO_2= free carbon dioxide; ALKA=Alkalinity

*Significant positively

**Highly significant positively

! Significant negatively

!! Highly significant negatively

.

Table:11 Correlation between physico-chemical parameters and fish abundance during monsoon season

Para	WT	TUR	pH	DO	FCO2	ALKA	Cyprini-formes	Siluri-formeS	Perci-formes	Belon-iformes	Synbra-nchiformes
WT	1.000										
TUR	0.974**	1.000									
pH	-0.950!!	-0.996!!	1.000								
DO	0.948**	0.851**	-0.801!!	1.000							
FCO2	0.144	0.364	-0.445	-0.179	1.000						
ALKA	0.764**	0.598*	-0.525!	0.930**	-0.528!	1.000					
Cypriniformes	0.683*	0.500	-0.422	0.880**	-0.624!	0.993**	1.000				
Siluriforme	0.249	0.023	0.065	0.545*	-0.923!!	0.815**	0.877**	1.000			
Perciformes	-0.904!!	-0.977!!	0.992**	-0.721!!	-0.553!	-0.415	-0.305	0.189	1.000		
Beloniformes	0.074	-0.154	0.240	0.388	-0.976!!	0.700*	0.779**	0.984**	0.359	1.000	
Synbranchiformes	0.994**	0.993**	-0.978!!	0.908**	0.250	0.690*	0.600*	0.143	-0.945!!	-0.034	1.000

Para.= parameters; Wat.T= water temperature; TUR=Turbidity; pH= Phosphate; DO= dissolved oxygen;; FCO2= free carbon dioxide; ALKA=Alkalinity

*Significant positively

**Highly significant positively

! Significant negatively

!! Highly significant negatively.

Table:12 Correlation between physico-chemical parameters and fish abundance during post-monsoon season

Para	WT	TUR	pH	DO	FCO2	ALKA	Cyprini-formes	Siluri-formeS	Perci-formes	Belon-iformes	Synbra-nchiformes
WT	1.000										
TUR	0.724**	1.000									
pH	0.665*	0.997**	1.000								
DO	0.976**	0.558*	0.487	1.000							
FCO2	0.993**	0.799**	0.746**	0.945**	1.000						
ALKA	0.030	-0.667!	-0.727!!	0.246	-0.085	1.000					
Cypriniformes	0.596*	-0.122	-0.203	0.756**	0.500	0.821**	1.000				
Siluriforme	0.650*	-0.053	-0.135	0.799**	0.559*	0.779**	0.998**	1.000			
Perciformes	0.115	-0.602!	-0.666!	0.327	0.001	0.996**	0.866**	0.829**	1.000		
Beloniformes	0.350	-0.392	-0.467	0.545*	0.240	0.947**	0.961**	0.939**	0.971**	1.000	
Synbranchiformes	0.771**	0.120	0.038	0.891**	0.693*	0.659*	0.971**	0.985**	0.721**	0.866**	1.000

Para.= parameters; Wat.T= water temperature; TUR=Turbidity; pH= Phosphate; DO= dissolved oxygen;; FCO2= free carbon dioxide; ALKA=Alkalinity

*Significant positively

**Highly significant positively

! Significant negatively

!! Highly significant negatively.

Table:13 Correlation between physico-chemical parameters and fish abundance during winter season

Para	WT	TUR	pH	DO	FCO2	ALKA	Cyprini-formes	Siluri-formeS	Perci-formes	Belon-iformes	Synbra-nchiformes
WT	1.000										
TUR	0.040	1.000									
pH	0.585*	0.834**	1.000								
DO	0.737**	0.705**	0.979**	1.000							
FCO2	-0.904!!	-0.462	-0.875!!	-0.955!!	1.000						
ALKA	0.430	-0.885!!	-0.481	-0.293	-0.004	1.000					
Cypriniformes	0.854**	-0.486	0.077	0.277	-0.550!	0.837**	1.000				
Siluriforme	0.963**	-0.229	0.347	0.529*	-0.757!!	0.656*	0.962**	1.000			
Perciformes	0.976**	0.255	0.747**	0.866**	-0.975!!	0.224	0.721**	0.882**	1.000		
Beloniformes	0.636*	-0.746!!	-0.253	-0.052	-0.246	0.970**	0.945**	0.820**	0.454	1.000	
Synbranchiformes	0.993**	-0.075	0.488	0.655*	-0.850!!	0.531*	0.908**	0.988**	0.945**	0.721**	1.000

Para.= parameters; Wat.T= water temperature; TUR=Turbidity; pH= Phosphate; DO= dissolved oxygen;; FCO2= free carbon dioxide; ALKA=Alkalinity

*Significant positively

**Highly significant positively

! Significant negatively

!! Highly significant negatively.

Canonical Correspondence Analysis:

In the correlation of abundance of fish species towards different environmental variables were different and the positioning the 27 fish species in relation to environment is shown in fig-5 The fishes like *Labeo cabsu(*C6*), Punitus sophore*(C7*), Punitus tict(*C8*), Bagarius bagarius(*C14) and *Anabus testudineous(*C24) were found to be strongly correlated with Free Carbon dioxide. Furthermore, species like Rita rita(C11), Ompak pabda(C15), Wallago attu(C17) and Europiichthys vacha(C18), showed negative correlation towards water temperature(WT), dissolved oxygen(DO), pH, Alkalinity and Turbidity.

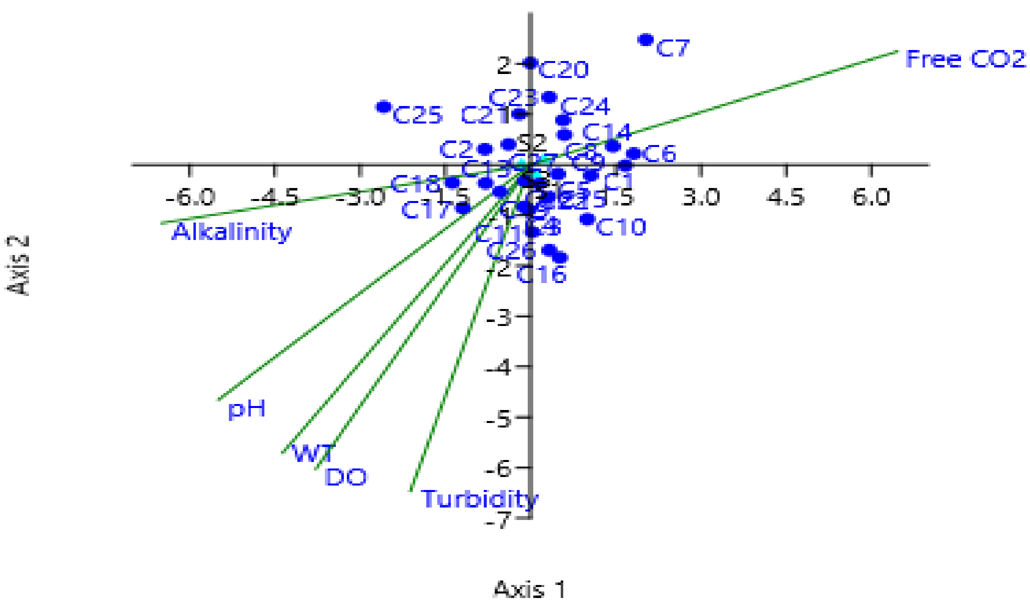

Fig:5 Canonical Correspondence Analysis

Discussion:

Various physical and chemical characteristics of lotic waters are known to be directly affected by climatic and geological conditions of the catchment area (Docile *et al*., 2016). Water temperatures in the stream varied in accordance with seasons. The lowest (14.7 °C) water temperature was found at station-2 in winter and highest (25.6 °C) at station-1 in monsoon. This is due to station-1 and station-2 is surrounded by agriculture lands and also anthropological activity at these regions is high. In the Langting stream, anthropogenic activities are the major cause of water pollution. During the entire field work, the assessed data on pH of the water of different sectors of the stream was noticed to be in between neutral to alkaline range.

Maximum fish abundance was recorded in postmonsoon at station -3 and maximum fish richness was noticed in all seasons at station-3. It is observed that the percentage of fishes found is highest in order Siluriformes followed by Cypriniformes, Perciformes, Symbranchiforme and Beloniformes. This finding is strongly agreed with the findings of Kostori *et al*., (2011) and Galib (2015). Many fish species are extinct due to water pollution. Water quality and fish health depend on each other. Fishes mainly die because of human interference at the streamside. Water pollution changes fish's behavior. Impure stream water blocks fish migration.. Various chemical pollutants slowly affect the fish population. As a result, fish suffers from pollution related diseases like liver damage, gill disease, neoplasia, hyperplasia, epidermal papilloma, ulceration and fin/tail rot. In the present investigation, a total of 27 fish species belonging to 5 orders, 12 families and 20 genera were found. The maximum number of species belonging to family Siluridae (11 species) followed by the family Cyprinidae (10 species). Family Perciformes, Beloniformes and Synbranchiformes represented with 3, 1 and 2 species respectively. Average Shannon index (H) in Sampling Station 1 is higher than Station-2 and station-3. Among the all fish species, *Ompok pabo*, *Ompok pabda* and *Aila coila* are Near Threatened (NE) according to IUCN status and *Mystus bleekeri, Bagarius bagaria, Aila Coila* and *Anabus testudineus* are Vulnerable (VU) categories according to CAMP status. The maximum numbers of species were recorded from low land areas (station-3). According to *Shaikh et al*., (2011) in low land areas fresh fish abundance was found to be very high. It is due to deep water bodies allow segregation in order to enable the fishes to live without facing more intra and inter specific competitions. Another reason of finding more abundance of fish species at station 3 is that the Langting stream is a tributary of Diyung river and Sampling stations 1 and 2 are surrounded by agriculture lands and anthropological activity of this region is high. On the other hand station-3 is surrounded by plants on both sides of the stream bank. Anthropological activity of this region is low.

Conclusion:

Habitat loss of environmental degradation has seriously affected the fish fauna of hill streams of Dima Hasao district, Assam. Due to multiple uses of fisheries resources, fishing has become a major industry and a large number of these aquatic communities are under a big threat of extinction. Hill streams of Dima Hasao district have been under tremendous pressure from anthropogenic activities like the uncontrolled and unethical fishing of juveniles and broad fishes which have direct impact on the number of fish population.

The fish species are sensitive indicator of change within the system. Diverse fish community affirmly provide evidence of good water quality which was uncommon during the present study. Hence the eco-health of stream Langting suggests that by estimating a number and diversity of fish species should be correlated with the ecological condition. Regular monitoring of the stream is required for the maintenance of the ecology and biotic population of the selected stream.

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Graphical representation of fish species found in Langting stream:

Cabdio jaya

Amblypharyngodon mola

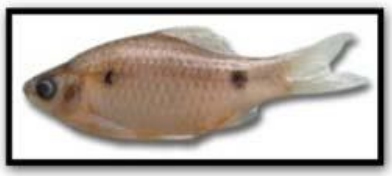
Labeo bata

Labeo rohita

Labeo boga

Labeo calbashu

Punitus sophore



Puntius ticto

Esomus danricus

Botia dario

Rita rita

Mystus tengara

Mystus bleekeri

Bagarius bagarius

Ompok pabda

Ompok Pabo

Wallago attu

Eutropiichthys vacha

Ailia coila

Amblyceps mangois

Olyra longicaudata

Channa punctata

Nandus nandus

Anabas testudineus

Xenentodon cancila

Macrognathus aral

Macrognathus pancalus