Science Vision 15(1), 8-18

Original Research

2015
January-March
ISSN (print) 0975-6175
ISSN (online) 2229-6026

Coldwater fish diversity and abundance of upper reaches of Sonkosh river, Kokrajhar, Assam

Daud Chandra Baro[1*], Subrata Sharma[2] and Dandadhar Sharma[3]

[1]*Department of Zoology, Gossaigaon College, Gossaigaon 783360, Kokrajhar, India*
[2]*Cotton College, Guwahati 781001, Assam, India*
[3]*Department of Zoology, Gauhati University, Guwahati 781014, Assam, India*

Received 27 November 2014 | Revised 26 February 2015 | Accepted 27 February 2015

ABSTRACT

River Sonkosh enters India at Jamduar (longitude of 89°51'39.4" E and latitude of 26°43'59.8" N), Kokrajhar district of Assam. It extends up to the Feshimari-Jaldhuaghat at a longitude of 89° 47'26"E and latitude of 26°22'39"N. Cold water fish assemblages of Sonkosh river was investigated at three upstream stations from April, 2013 to March, 2014. During study period, 65 species of fishes belonging to 6 major orders and 18 families were recorded. The most number of species belongs to family Cyprinidae (29) and followed by Sisoridae (7), Nemacheilidae (6), Cobitidae (4), Channidae (3), Psilorhynchidae (2), Olyridae (2), Badidae (2), Anguillidae (1), Amblycipitidae (1), Bagridae (1), Siluridae (1), Schilbeidae (1), Eresthistidae(1), Belonidae (1), Mastacembelidae (1), Nandidae (1) and Tetradontidae (1). Diversity indices like Shannon-Wiener index (H), Simpson dominance index (D), Simpson index of diversity (1-D), Buzas and Gibson's evenness (E) and Margalef's index (d) were analyzed by using PAST Software (version 2.19).

Key words: Sonkosh river; Himalayan foot hill; Kokrajhar; coldwater fish; diversity.

INTRODUCTION

The coldwater fishery resources comprise of rivers (about 8243 km), natural lakes (920,500 ha) and man-made reservoirs (about 2,65,00 ha) in India. They harbour about 73 fish species in India. Generally, the water bodies situated at high altitudes (above 914 m MSL) whether lakes, reservoirs or streams fall within temperature range of 0 to 20°C, and thus cold water bodies. Temperature is always the main contributing limiting factor for geographical distributions and local occurrences of fishes within a single water course. Amongst the physico-chemical characteristics, low water temperature and fast water currents are the notable limiting factors for the occurrence and survival of the fauna and the flora of cold water environment unless equipped

Corresponding author: Baro
Phone: +91-9508098298
E-mail: dcprabal@gmail.com

with some adaptive features.[1] According to Sehgal,[2] the fish species distribution in the Himalayan streams depends on the flow rate, nature of substratum, water temperature and the availability of food.

Coldwater fishery resources in India lie in Himalayan region (Kashmir, Himachal Pradesh, Uttarakhand, Meghalaya, Assam, West Bengal, Sikkim and Arunachal Pradesh) and Peninsular India (Nilgiri hills in Tamil Nadu and Travancore high ranges in Kerala). Adjacent to India, Nepal and Bhutan are two Himalayan countries are the major contributor of the cold water fishery resources to India. According to the NBFGR, Lucknow, India has total 2,200 fish germplasm resources (Table 1).[1] Cold water fish resources of Himalayan regions was studied by various ichthyologists in the past.[3-10] Shrestha,[8] gave an account of ecology of rare species of Himalayan waters. Menon,[11] related the distribution pattern of Himalayan fish to morphological characteristics which enable them to inhabit the torrential streams. He recognised six major groups: (a) fish dwelling in shallow, clear cold waters in the foothills without any striking modifications to current: *Labeo*, *Tor*, *Barilius* and *Puntius*, (b) fish inhabiting the bottom water layers in deep fast current, with powerful muscular cylindrical bodies: Schizothoracines and the introduced trouts, (c) fish sheltering among pebbles and stones to ward off the strong current: *Crossocheilus diplochilus,* (d) fish sheltering among pebbles and shingles in shallows, with special attachment devices: the loaches *Noemacheilus*, *Botia* and *Amblyceps,* (e) fish which cling to exposed surfaces of bare rocks in slower current, with adhesive organs on their ventral surface for attachment to rocks: *Garra*, *Glyptothorax* and *Glyptosternum* and (f) fish which cling to the exposed surfaces of bare rocks in fast current, with limpet-shaped bodies and mouth, gills and fins highly modified to suit the habitat: *Balitora*. Hora[12] and Menon,[8] studied the evolution of Schizothoracines and concluded that they appeared during the first interglacial period, when turbulent streams formed in Central Asia, necessitating the reduction of scales which is characteristic of Schizothoracines. Primitive forms of this group occur today in South China. During the favourable environmental conditions of the second glacial period they migrated westwards as far as Kashmir and Sistan. The great proliferation of genera and species of the sub-family Schizothoracinae probably occurred during the second and subsequent interglacial periods. Today the Schizothoracines are mainly Central Asiatic in distribution although a few species are present also along the southern. In torrential streams, Sehgal[2] identified several zones on the basis of dominant fish species and the hydrographical features: (i) headwater zone inhabited by rheophilic species of loaches and catfishes (*Noemacheilus gracilis*, *N. stoliczkae* and *Glyptosternum reticulatum*); (ii) large stream zone, formed by the joining of headwater streams, inhabited by *Diptychus maculatus* and *Noemacheilus* spp. In the upper reaches or the most torrential reaches of this zone, rheophilic species of the snow trouts *Schizothoraichthys esocinus*, *S. progastus*, *Schizothorax richardsonii* and *Schizopygopsis stoliczkae* occur. The intermediate reaches of the large stream zones are frequented by *Schizothorax longipinnis*, *S. planifrons* and *S. micropogon*. The least rapid reaches of this zone are occupied by *Garra gotyla*, *Crossocheilus diplochilus*, *Labeo dero* and *L. dyocheilus*; (iii) slow moving meandering zone inhabited by a large number of cold to eurythermal species such as *Barilius* spp., *Tor* spp. cat fishes, homalopterid fish (*Homaloptera* spp.) and snakeheads (*Channa* spp.).

There are many reports of working on fishery resources from rivers and streams of Bhutan. Amongst them Dubey,[13] described the rivers and lakes of Bhutan in detail with data on temperatures and water quality and other factors which affect the fisheries potential. Gurung,[14] gave a survey report on 66 fresh water fish species known to occur in Bhutan. Petr,[15] reported 41 indigenous fish species from rivers and lakes of Bhutan. But no complete study of cold water fish resources and its fishery potential has been done from all the rivers and streams of Indo-Bhutan foot Hill areas. Some brief works have been done by Pathok *et al.,*[16] Goswami *et al.,*[17]

Table 1. Fish germplasm resources of India (Sources-NBFGR, Lucknow)[1]

Sl. No.	Ecosystem	Total fish species
1	Cold water	73
2	Warm water	544
3	Brackish water	143
4	Marine water	1440
	Total	2200

Baro and Sharma,[18] Baro *et al.*,[19] Acharjee *et al.*,[20] yet the Proper scientific information about the diversity, abundances and distribution of cold water fishery resources is meagre. The present study was focused on documenting the cold water fish diversity indices, abundance and distribution in Sonkosh river of Kokrajhar district of Assam in formulating judicious conservation management of the river and its biodiversity.

Materials and Methods

Study area

The river Sonkosh is an important tributary of river Brahmaputra in the western most part of Kokrajhar district of Assam and it is a snow-fed origin from Himalayan Mountain in Bhutan. The district (89°46' to 90°38' east longitudes and between 26°19' to 26°54' north latitudes) is situated in the western part of Assam bounded by Himalayan kingdom of Bhutan on the north, Dhubri district on the south, Chirang and Bongaigaon district on the east and West Bengal state on the west. The district is located in a humid sub-tropical climate that is characteristic of the lower Brahmaputra Valley of Assam. In Bhutan, the river is known as the Puna Tsang Chu below the confluences of several tributaries near the town of Wangdue Phodrang. In India it arises at Jamduar (26°43'59.8" N and 89°51'39.4" E) of Assam and after flowing in a north-south direction for about 70 km, joining the Gangadhar river and finally meet the Brahmaputra river at Dhubri district of Assam. During its course of flow, it makes an interstate boundary between state of Assam and West Bengal and a small island, Bitribari (26°38'N and 89°52' E and 73 m MSL). The physical characteristics, location and morphology of sampling sites of study area are shown in the Table 2. Environmental factors such as monthly mean total rain fall, air temperature, average relative humidity and water temperature is shown in Table 3.

Sampling

The present work is an attempt to study the status of abundance and diversity of coldwater

Table 2. Physical characteristics, location and morphology of sampling sites of river Sonkosh.

Sampling Sites	Distance from Gossaigaon (Km)	Latitude (N)	Longitude (E)	Altitude MSL (m)	River width (Land covered area) (m)	Surface Water Width (Range) (m)	Water Depth (Max. Range) (m)	Substrates
S1	40	26°43'59"	89°51'39"	105	350	140-285	5.5-8.0	Sand, Cobbles, Pebbles, Boulders, Bed rocks
S2	28	26°39'04"	89°53'24"	84	600	200-350	3.0-6.0	Sand, gravels, cobles, Boulders
S3	30	26°38'06"	89°52'02"	73	180	50-105	1.5-4.5	Silt, sand, Gravels, Boulders.

Table 3. Monthly mean of environmental factors and water temperature of Sonkosh river.

Month'year	Total rain fall (mm)	Avg. Rel. Humidity (%)		Air temp. (°C)		Water temp. (°C)
		Morning	Evening	Max.	Min.	
April'2013	204.8	91.8	57.2	28.8	21.6	17
May'2013	410.7	90.5	60.1	30.3	23.1	16
June'2013	319.1	90.9	63.1	32.0	25.4	23
July'2013	893.2	91.2	69.5	31.9	25.2	22
August'2013	450.6	91.3	70.3	32.5	25.6	24
September'2013	630.4	91.2	72.4	32.1	26.3	21
October'2013	181.6	91.3	66.6	30.7	22.9	18
November'2013	0.0	91.5	61.6	29.9	19.7	16
December'2013	0.0	93.4	63.0	25.6	14.3	14
January'2014	0.6	94.7	65.9	23.5	11.0	13
February'2014	64.4	94.2	62.1	23.3	11.0	13
March'2014	16.6	90.6	46.1	29.4	17.5	14

Environmental factors, Source: Meteorological Station, Lower Brahmaputra Valley Zone, RARS, Telipara, Gossaigaon, Kokrajhar, Assam.

fish resources of the river Sonkosh. The survey area was conducted during April, 2013 to March, 2014 at three selected catchments areas as well as the landing sites from the river. They are (S1) Jamduar (26°43'59" N and 89°51'39" E and located above 105 m MSL), (S2) Chaudhuri ghat (26°39'04" N and 89°53'24" E and located above 84 m MSL), (S3) Bitribari (26°38'06" N and 89°52'02" E and located above 73 m MSL). Fishes were collected with the help of local fishermen by using different types of fishing gears namely gill nets, cast net, drag net and battery inverter electro-cutter. Immediately photographs were taken prior preservation since formalin decolorizes the fish colour on long preservation. Formalin solution was preserved by diluting one part of the commercial formaldehyde and nine part of distilled water *i.e.* 10% formalin.[21,22] Fishes were fixed individually in this solution. Smaller fishes were directly placed in the formalin solution while larger fishes were given an incision on the abdomen before they were fixed. The fishes collected and fixed were labelled giving serial numbers, exact locality from where collected, date of the collection, the common local name fish used in this region was labelled on each jar. Classification and identifications done were based on the lines of Jayaram,[23] Vishwanath,[24-26] Talwar and Jhingran,[9] Nath and Dey.[27] The identification of the species was done mainly on the basis of the colour pattern, specific spots or marks on the surface of the body, shape of the body, structure of various fins etc. and also with the help of taxonomic expertise from the Regional Station of Zoological Survey of India, Shillong, Meghalaya and Gauhati University, Guwahati, Assam. Secondary data were also collected through observation and interaction with local people and fishermen communities of embankment areas.

Data analysis

In the first stage of data analysis fish species assemblage was quantified station wise and then statistical comparison was performed with the help of PAST (version 2.19), a software package for Paleontological data analysis written by P.D. Ryan, D.A.T. Harper and J.S. Whalley. Diversity of fishes was analysed using different indices like Shannon-Weiner index (H),[28] Simpson dominance index (D), Simpson index of diversity (1-D), Buzas and Gibson's evenness (E)[29] and Margalef's index (d).[30]

Shannon-Weiner index

$$H = -\sum_{i=1}^{s} P\,i * log\,Pi$$

Where, *S* is the total number of species P_i is the relative cover of i_{th} species. $Pi = \frac{ni}{N}$ where, *ni* = Total number of individuals of each species in each sample and *N* = Total number of individuals of all species in the sample.

Simpson dominance index

D = $\sum \frac{ni(ni-1)}{N(N-1)}$, where, *ni* = Total number of individuals of each species in each sample and *N* = Total number of individuals of all species in the sample.

Simpson's index of diversity = 1-D

Buzas Gibson evenness (E) = e^H'S

Margalef index (d) = (S-1) log of base e N.

Where, d= Margalef index, S= Number of species; N= Total number of individuals.

RESULTS

A total of 6,044 individuals were enumerated which comprises of a total of 65 fish species belonging to 41 genera, 18 families and 6 orders have been recorded from the three upstream stations of Sonkosh river during the study period (Table 4). Maximum number was counted for *Schistura scaturigina* (450 individuals) and minimum for both *Pterocryptis spp.* and *Sisor rabdophorus* (each having 02 individuals), which are 7.44%, 0.03% and 0.03% of total individuals respectively. The occurrence of the fish species belongs to following orders- Anguilliformes, Cypriniformes, Siluriformes, Beloniformes, Perciformes and Tetraodontiformes. Out of these 65 species, (29) belong to family Cyprinidae and followed by Sisoridae (7), Nemacheilidae (6), Cobitidae (4), Channidae (3), Psilorhynchidae (2), Olyridae (2), Badidae (2), Anguillidae (1), Amblycipitidae (1), Bagridae (1), Siluridae (1), Schilbeidae (1), Eresthistidae(1), Belonidae (1), Mastacembelidae (1), Nandidae (1) and Tetradontidae (1) (Figure 1).

The fish species richness, abundances and biodiversity indices of all the three study sites are shown in Table 5. The highest abundance is recorded from site-S2, followed by S1 and S3 and highest richness is recorded from site S1, followed by the site S2 and S3. The Shannon-Weiner index (H), Simpson's index of dominance (D), Simpson' index of diversity (1-D), evenness (E) and Margalef index (d) were calculated according to study sites. Highest Shannon-Weiner index at site S3 (3.54) and S2 (3.53) were recorded and followed by S1 (3.43) shown in (Figure 2A). No significant difference was observed among the stations. The Simpson's dominance index values shows higher at site-S1 (0.043), followed by S2 (0.038) and S3 (0.036) (Figure 2B). The Simpson's index of diversity was recorded as 0.95 for (S1), 0.96 for (S2) and 0.96 for (S3) (Figure 2C). Buzas and Gibson's evenness was calculated as (0.54), (0.61) and (0.66) for S1, S2 and S3 respectively (Figure 2D). Higher Margalef index (d) was calculated at site S1 (7.37) and followed by S2 (7.05) and S3 (6.90) (Figure 2E). Similar to the Shannon-Wiener index, no significant difference was observed for the different indices among the study sites.

CONCLUSION AND DISCUSSION

As the river Sonkosh is a snow fed origin from the eastern Himalayan Mountain, the fish species assemblage occurs overlapping of cold water and warm water at the downstream of Himalayan foot Hill Rivers of Assam. The eastern Himalaya has a greater diversity of cold-water fish resources than western Himalaya.[2] The river Sonkosh has assemblage of naturally occurring indigenous coldwater fish species. Commercially important food fishes like *Anguilla bengalensis, Labeo dyocheilus, L. pangusia Cyprinion semiplotum* are now mostly threatened. Their relative abundance was calculated only 0.4%, 0.8%, 0.4% and 3.9% respectively. Com-

Table 4. List of cold water fish species recorded with their abundances and relative abundances.

Family	Species Name	S1	S2	S3	Abun-dance	Relative Abun-dance (%)
1. Order Anguilliformes						
Anguillidae	*Anguilla bengalensis bengalensis* (Gray, 1931)	13	9	2	24	0.40
2. Order Cypriniformes						
Cyprinidae	*Bangana dero* (Hamilton, 1822)	14	16	8	38	0.63
Cyprinidae	*Barilius barna* (Hamilton-Buchanan, 1822)	100	50	86	236	3.90
Cyprinidae	*B. bendelisis* (Hamilton-Buchanan, 1822)	150	60	100	310	5.13
Cyprinidae	*B. barila* (Hamilton-Buchanan, 1822)	12	10	44	66	1.09
Cyprinidae	*B. vagra* (Hamilton, 1822)	2	4	16	22	0.36
Cyprinidae	*Chela laubuca* (Hamilton,1822)	9	0	28	37	0.61
Cyprinidae	*Chagunius chagunio* (Hamilton, 1822)	80	10	44	134	2.22
Cyprinidae	*Crossocheilus latius latius* (Hamilton, 1822)	86	33	54	173	2.86
Cyprinidae	*C. buramanicus* (Hora, 1936)	50	34	77	161	2.66
Cyprinidae	*Cyprinion semiplotum* (McClelland, 1839)	110	78	50	238	3.94
Cyprinidae	*Danio dangila* (Hamilton-Buchanan, 1822)	11	39	2	52	0.86
Cyprinidae	*D. devario* (Hamilton-Buchanan, 1822)	7	14	0	21	0.34
Cyprinidae	*D. rerio* (Hamilton-Buchanan, 1822)	2	6	6	14	0.23
Cyprinidae	*Devario aequipinnatus* (McClelland,1839)	7	3	12	22	0.36
Cyprinidae	*Gara annandalei* (Hora, 1921)	6	4	0	10	0.16
Cyprinidae	*G. lamta* (Hamilton, 1822)	21	52	14	87	1.44
Cyprinidae	*G. nasuta* (McClelland, 1838)	1	3	0	4	0.07
Cyprinidae	*Labeo rohita* (Hamilton, 1822)	0	0	4	4	0.07
Cyprinidae	*L. dyocheilus* (McClelland, 1839)	6	36	8	50	0.82
Cyprinidae	*L. pangusia* (Hamilton,1822)	9	16	3	28	0.46
Cyprinidae	*L.gonius* (Hamilton,1822)	0	0	4	4	0.07
Cyprinidae	*Neolissocheilus hexagonolepis* (McClelland, 1839)	160	144	20	324	5.36
Cyprinidae	*Puntius chola* (Hamilton, 1822)	3	1	0	4	0.07
Cyprinidae	*P. sarana sarana* (Hamilton, 1822)	5	1	0	6	0.10
Cyprinidae	*Raiamas bola* (Hamilton, 1822)	0	0	7	7	0.12
Cyprinidae	*Schizothorax plagiostomus* (Heckel, 1838)	23	55	0	78	1.30
Cyprinidae	*S. progastus* (McClelland, 1839)	2	1	0	3	0.05
Cyprinidae	*Tor putitora* (Hamilton, 1822)	10	22	9	41	0.67
Cyprinidae	*T. Progeneius* (McClelland, 1839)	8	1	7	16	0.26
Psilorhynchidae	*Psilorhynchus balitora* (Hamilton, 1822)	25	36	48	109	1.80
Psilorhynchidae	*P. sucatio* (Hamilton, 1822)	75	95	40	210	3.47
Nemacheilidae	*Aborichthys elongatus* (Hora, 1921)	90	130	25	245	4.05

Nemacheilidae	*A. kempi* (Chaudhuri, 1913)	10	22	5	37	0.61
Nemacheilidae	*Acanthocobitis botia* (Hamilton, 1822)	29	75	36	140	2.31
Nemacheilidae	*Schistura multifasciata* (Day, 1878)	150	100	40	290	4.80
Nemacheilidae	*S. reticulofasciatus* (Singh & Banarescu, 1982)	1	8	8	17	0.28
Nemacheilidae	*S. scaturigina* (McClelland, 1839.)	120	180	150	450	7.44
Cobitidae	*Botia daro* (Hamilton, 1822)	26	18	2	46	0.76
Cobitidae	*B. dayi* (Hora, 1932)	13	14	4	31	0.51
Cobitidae	*B. rostrata* (Gunthur, 1868)	8	20	0	28	0.46
Cobitidae	*Lepidocephalichthys guntea* (Ham.-Buchanan, 1822)	25	32	30	87	1.43
3. Order Siluriformes						
Amblycipitidae	*Amblyceps mangois* (Hamilton, 1822)	0	0	77	77	1.27
Bagridae	*Batasio fasciolatus* (Ng, 2006)	0	0	22	22	0.36
Siluridae	*Pterocryptis spp.*	0	2	0	2	0.03
Schilbeidae	*Clupisoma garua* (Hamilton, 1822)	7	16	3	26	0.43
Sisoridae	*Bagarius bagarius* (Hamilton, 1822)	2	9	2	13	0.22
Sisoridae	*Gagata cenia* (Hamilton-Buchanan, 1822)	5	55	35	95	1.57
Sisoridae	*Glyptothorax cavia* (Hamilton, 1822)	12	35	8	55	0.91
Sisoridae	*G. telchita* (Hamilton, 1822)	33	58	24	115	1.90
Sisoridae	*Parachiloglanis hodgarti* (Hora,1923)	22	0	0	22	0.36
Sisoridae	*Pseudecheneis sulcatus* (Mc Clelland,1842)	4	0	0	4	0.07
Sisoridae	*Sisor rabdophorus* (Hamilton,1822)	0	2	0	2	0.03
Erethistidae	*Pseudolaguvia ferula* (Ng., 2006)	22	28	20	70	1.16
Olyridae	*Olyra longicaudata* (McClelland, 1842)	8	57	26	91	1.50
Olyridae	*O. kempi* (Chaudhuri, 1912)	11	20	0	31	0.51
4. Order Beloniformes						
Belonidae	*Xenentodon cancila* (Hamilton-Buchanan, 1822)	12	25	20	57	0.94
5. Order Synbranchiformes						
Mastacembeli-dae	*Mastacembelus armatus* (Lacepede, 1800)	110	175	35	320	5.29
Nandidae	*Nandus nandus* (Hamilton, 1822)	15	44	28	87	1.44
Badidae	*Badis assamensis* (Ahl, 1937)	80	125	60	265	4.38
Badidae	*Dario dario* (Hamilton, 1822)	60	105	75	240	3.97
6. Order Perciformes						
Channidae	*Channa gachua* (Hamilton, 1822)	54	70	30	154	2.54
Channidae	*Channa barca* (Hamiliton, 1822)	30	30	55	115	1.90
Channidae	*C. punctatus* (Bloch, 1793)	28	140	65	233	3.85
7. Order Tetraodontiformes						
Tetraodontidae	*Tetraodon cutcutia* (Hamilton, 1822)	0	0	44	44	0.72

Figure 1. Some cold water fish species of river Sonkosh: (A) ***Anguilla bengalensis*** , (B) *Labeo dyocheilus*, (C) *Neolissocheilus hexagonolepis*, (D) *Schizothorax plagiostomus* (E) *Pterocryptis* spp., (F) *Cyprinion semiplotum*, (G) *Olyra kempi*, (H) *Botia daro*, (I) *Glyptothorax cavia* and (J) *Sisor rabdophorus.*

Table 4. List of cold water fish species recorded with their abundances and relative abundances.

Diversity Indices	S1	S2	S3
Species abundance (N)	1994	2428	1622
Species richness	57	56	52
Shannon-Wiener index (H)	3.43	3.53	3.54
Simpson's Dominance Index (D)	0.0432	0.0374	0.0368
Simpson's Index of Diversity (1-D)	0.957	0.9625	0.963
Evenness (e^H'S)	0.546	0.613	0.663
Margalef index (d)	7.37	7.06	6.90

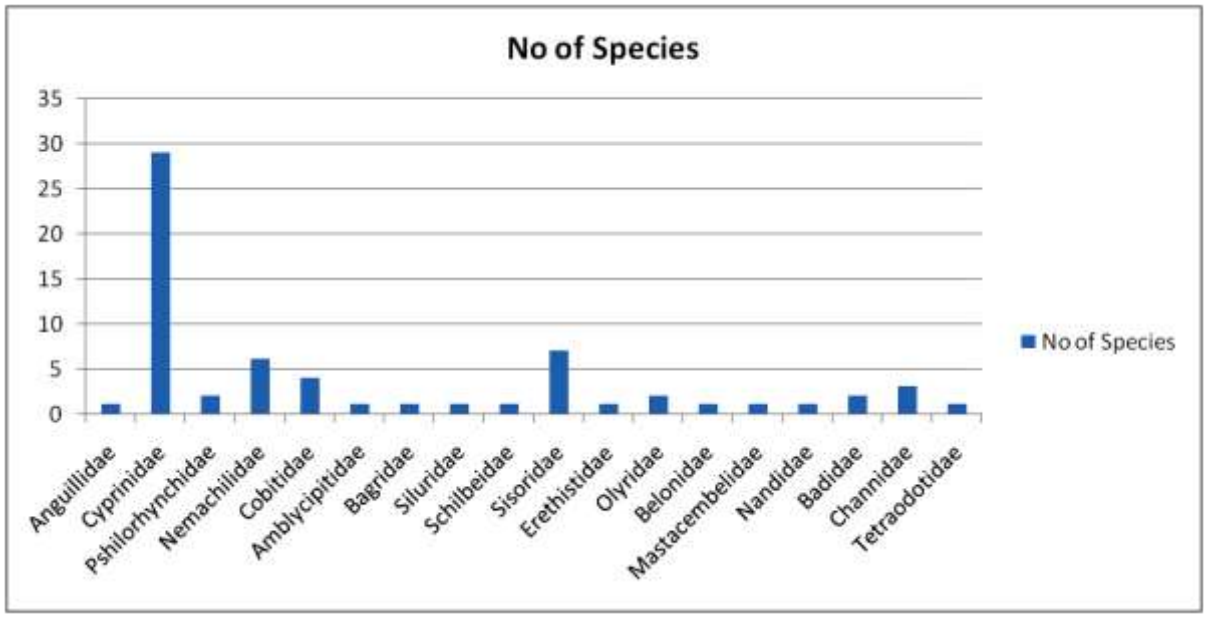

Figure 1. Number of species of fish and their families found in Sonkosh.

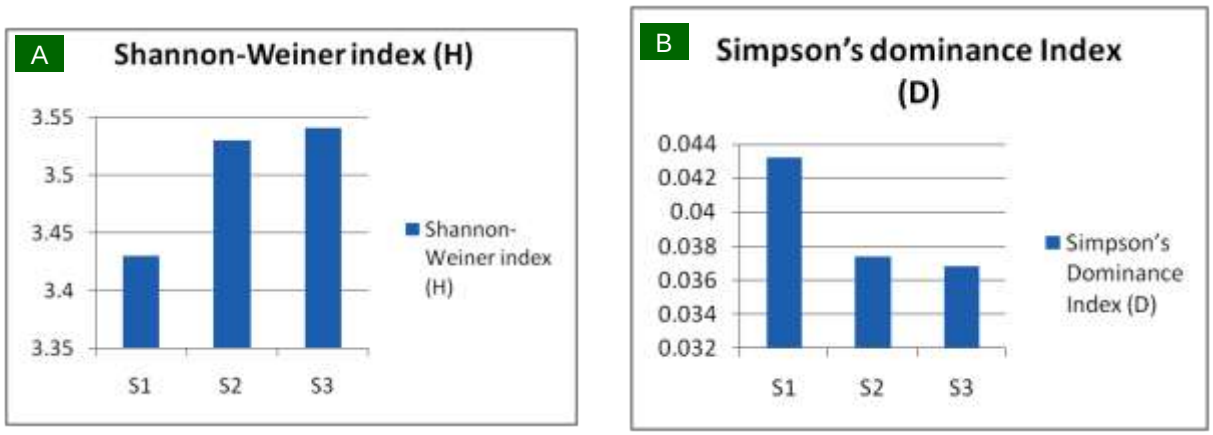

Figure 2. Station wise different fish diversity indices of Sonkosh river. A (Shannon Wiener index), B (Simpson's dominance index).

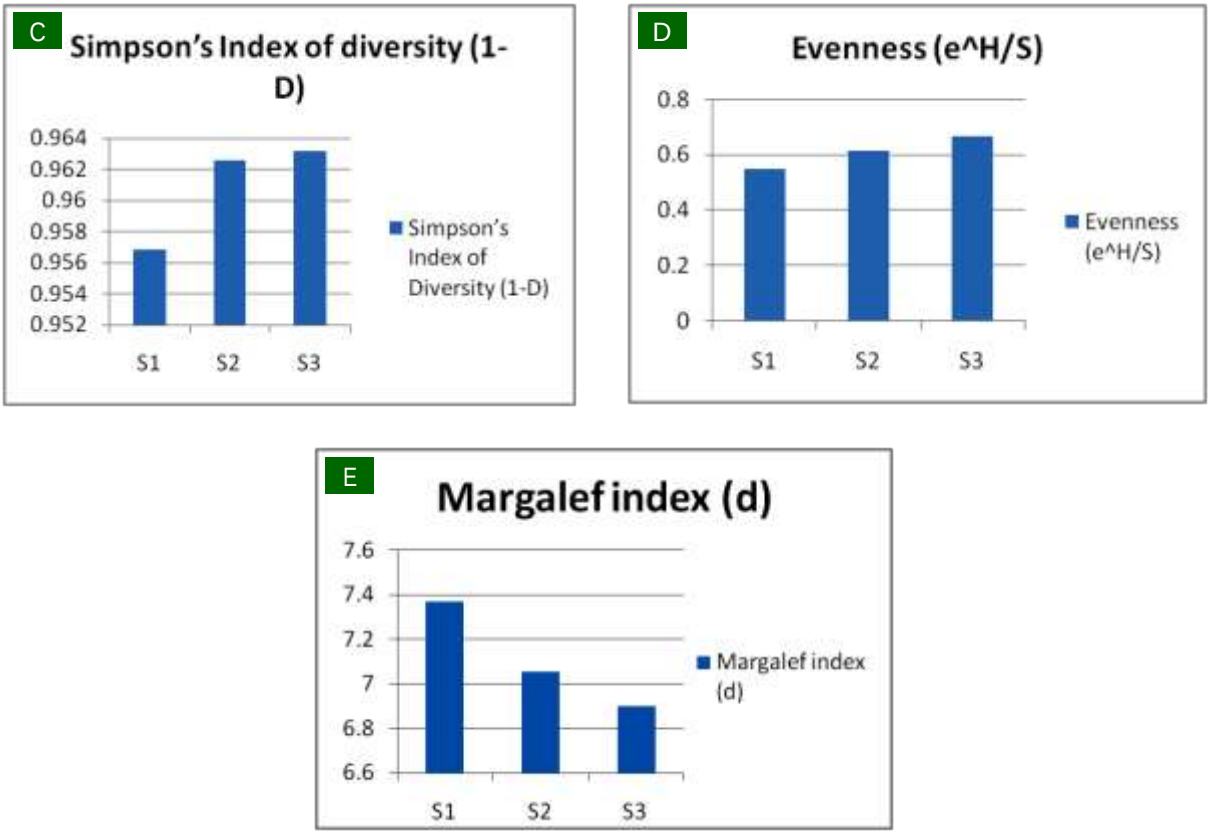

Figure 2 (continued). C (Simpson's index of diversity), D (Evenness) and E (Margalef index).

paratively higher percentage of relative abundance was calculated for *Mastacembelus armatus* (5.29%), a commercially important food fish of the region. Among the game fishes occurrence of *Tor* species are very rare but *Neolissocheilus hexagonolepis* was recorded a good percentage of relative abundance (5.36%). Among the classified important ornamental fishes, *Danio dangila* (0.8%), *D. rerio* (0.2%), *Devario aequipinntus* (0.3%), *Botia daro,* (0.7%), *B. rostrata* (0.4) are observed very low percentage of abundance. One of the most reasons of decreasing abundance is observed to be overexploited for export and local trade.

The eminent threats to aquatic biodiversity of arising from large hydropower project planned in all the major rivers of Bhutan. An assessment of fresh water fish diversity in Bhutan is not only timely but also necessary.[14] The rapid development sweeping over Bhutan and the planned for mega-hydropower projects to harness 10,000 Megawatts by the year 2020,[31] is expected to have a significant impact on the biodiversity of rivers of Bhutan as well as Indo Bhutan foot hill of Assam. The 1200 Megawatts (Sonkosh) Punatsangchu-I and the 1020 Megawatts (Sonkosh) Punatsangchu-II Hydro Electrical Projects are under construction and are sched-

uled to be commissioned by 2018.[32] So making it imperative that a further understanding of ichthyofaunal diversity of Sonkosh river as well as other rivers of Indo-Bhutan foot hill is critically needed.

REFERENCES

1. Gupta SK & Gupta PC (2008). *General and Applied Ichthyology (fish and fisheries).* S. Chand and Company Ltd. Ramnagar, New Delhi-110 055.
2. Sehgal KL (1988). *Ecology and fisheries of mountain streams of the north-western Himalayas*. Thesis for the award of D.Sc. degree, University of Meerut, India.
3. Hora SL (1937). Comparison of the fish fauna of northern and southern faces of the great Himalayan region. *Rec Indian Mus,* 39, 1–250.
4. Hora SL (1939). The game fishes of India. Viii. Mahaseer and large scale barbells of India. i. The putitor mahaseer, the barbus, *Tor putitora* (Hamilton,) *J Bombay Nat Hist Soc,* 41, 272–285.
5. Menon AGK (1962). A distributional list of fishes of the Himalayas. *J Zool Soc*, India. 14, 23–32.
6. Menon AGK (1974). *A Check list of Himalayan and Indo-Gangetic plains*. Special publication no-1. *Inland Fisheries Societies,* Barrakpore, p. 137.
7. Shrestha TK (1990). *Resource Ecology of Himalayan Waters*. Curriculum Development Centre, Tribhuvan University, Nepal, pp. 61–109.
8. Shrestha TK (1990). Rare fishes of Himalayan waters of Nepal. *J Fish Bio,* 37 (supplement A), 213–216.
9. Talwar PK & Jhingran AG (1991). *Inland Fishes of India and Adjacent Countries*. Oxford & IBH Publishing House, New Delhi, 1&2 pp. 115–118.
10. Sarma D, Das DN, Dutta R, Baruah D, Kumar P, Tyagi BC & Mahanta PC (2012). *Cold Water Lakes and Rivers in Arunachal Pradesh, India*. Bull. No.19. Directorate of Cold Water Fishery Research (ICAR), Bhimtal, Uttarakhand, India.
11. Menon AGK (1954). Fish geography of the Himalayas. *Proc Nat Instit Sci India*, 20, 467–493.
12. Hora SL (1955). Tectonic History of India and its bearing on fish geography. *J Bombay Nat Hist Soc,* 52, 692–701.
13. Dubey GP (1978). *Survey of the Waters of Bhutan: Physiography and Fisheries Potential*. Report. FAO, Rome, p. 38.
14. Gurung DB, Dorji S, Tshering U & Wangyal JT (2013). An annoted check list of fishes of Bhutan. *J Threatened Taxa,* 5, 4880–4886.
15. Petr T (1999). Cold water fish and fisheries in Bhutan. FAO Fishes technical paper, FAO, Rome, pp. 6–12.
16. Pathak S, Goswami MM and Sharma NN (2013). Fishes of the genus *Olyra* McClelland (Teleostei-Bagridae) from Indo Bhutan Hill Streams of Assam. *JANS,* 5, 503–509.
17. Goswami UC, Basistha SK, Bora D, Shyamkumar K, Saikia B & Changsan K (2012). Fish diversity of North East India, Inclusive of the Himalayan Indo Burma biodiversity hot spot zones: A checklist on their taxonomic status, economic importance, geographical distribution present status and prevailing threats. *IJBC,* 4, 592–613.
18. Baro DC & Sharma S (2014--). Ichthyofaunal diversity from Sonkosh river, Assam, India. *The Clarion*, 3, 18–24.
19. Baro DC, Sharma S & Baishya RA (2014---). Status of ornamental fish diversity of Sonkosh river, Bodoland Terrritorial Council, Assam, India. *Sci Vis*, 14, 28–33.
20. Acharjee ML & Barat S (2013). Ichthyofaunal diversity of Teesta river in Darjeeling Himalaya of West Bengal, India. *AJEB*. 4, 112–122.
21. Hamilton-Buchanan F (1822). *An Account of the Fishes of River Ganges and its Branches*. Edinburgh and London, vii, p. 405.
22. Misra KS (1962). *Rec of Indian Mus*, 57, 1–320.
23. Jayaram KC (1999). *The Freshwater Fishes of the Indian Region*. Narendra Publishing House, Delhi, pp.1–551.
24. Vishwanath W (2000). *Fishes of North East India*, ICAR Govt. of India, New Delhi.
25. Vishwanath W (2002). *Fishes of North East India. A field guide to species Identification.* Manipur University, NATP Publication.
26. Vishwanath W (2009). Fish diversity of Northeast India. In: *Wetlands North east India,* Zoological Survey of India, pp. 95–113.
27. Nath P & Dey SC (2000). *Fish and Fishery of Northeast India (Arunachal Pradesh).* Narendra Publishing House, Delhi, I, 1–217.
28. Shannon CE and Wiener W (1963). *The Mathematical Theory of Communication*. University Illinois Press, Urbana, p. 36.
29. Harper, DAT, (1999). *Numerical Paleobiology*. John Willy and Sons.
30. Margalef R (1968). *Perspectives in Ecological Theory*. University of Chicago Press, Chicago, III, p.111.
31. Royal Govt. of Bhutan (2010). *Economic Development Policy of Kingdom of Bhutan*, Royal Govt. of Bhutan, Thimphu.
32. Government of India, Ministry of External Affairs (April, 22nd, 2014). Inter-Governmental Agreement between Bhutan and India on development of Joint Venture Hydropower Projects.