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Assessment of Physico-Chemical Characteristics and Fish Diversity of Hill streams in Karbi Anglong district, Assam, India

Teronpi Valentina[1]*, Singh H T, Tamuli Ajit K and Teron Robindra
[1]Department of Life Science and Bioinformatics, Assam University- Diphu Campus, Diphu, Karbi Anglong, Assam, 782 460, INDIA

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Abstract

A study was carried out during March 2011 to November 2013 to assess the limnological parameters and diversity of fish fauna of three hill streams of Karbi Anglong district, Assam. The parameters studied included air temperature, water temperature, dissolved oxygen (D.O.), electrical conductivity, total dissolve solid (TDS), turbidity, free CO_2, phosphate and alkalinity. The study recorded 62 species of fish represented by 7 orders, 15 families and 32 genera. Shannon-Weiner diversity index of fish ranged from 3.28 to 3.88 which is indicative of rich fish diversity. However, interview with local fishermen have brought to light that there is decline of catches of many fish species in recent times. The fish fauna of the study area face serious threats from siltation, unscientific fishing, particularly use of pesticides, and pollution. There is an urgent need to conserve hill streams of Karbi Anglong district and adopt sustainable fishing practices. Report of the present study will be useful for monitoring water quality, fish diversity, threat perceptions and serve as baseline information for further research in the region.

Keywords: Hill streams, fish diversity, limnological parameters, Shannon-Weiner index, conservation.

Introduction

The north east region of India is a biodiversity rich region[1] and is considered as one of the hotspots in the world when it comes to fresh water fish diversity[2]. The diversity is attributed to the recent geological history and the Himalayan orogeny which played an important role in the speciation and evolution of groups inhabiting mountain streams[3]. Though the region has been considered as repository of freshwater fishes, gaps in the knowledge of fish diversity still exist. Many workers have attempted to document the fish fauna of the region but these reports are far from complete[4]. Today the fish diversity and associated habitat management is a great challenge[5] due to various anthropogenic activities which have precipitated in loss and degradation of fish habitat. The loss of any genetic resource from the gene pool will mean irreparable damage to the intricate web of life[6]. There is thus a need to take up effective management practices. Rational management requires a wholesome knowledge of various components of the ecosystems[7]. It further requires preparation of complete inventory of fish diversity in all freshwaters of the region; inventory at both local and regional level is useful for evaluation of fish diversity and conservation status and the nature and magnitude of threat can be identified[8,9]. Moreover, information on diversity and ecology of natural fish stock, particularly their distribution pattern, habitat preferences, biodiversity status, etc. has great bearing on their sustainable utilization and highly essential for adopting effective conservation measures.

Karbi Anglong district in Assam is endowed with myriads of rheophilic rivers and torrential hill streams but the streams of the region have not been scientifically studied and its fish fauna have remained largely under explored. Reports[10,11] on the fish diversity on rivers of Karbi Anglong district are incomplete and fragmentary. Major impediment towards elucidation of fish diversity from the district has been the location of the hill streams in high elevated areas often covered with thick forest. Further, the hill streams are under intense pressure from human-induced disturbances which have jeopardized its faunal components. Assessment of limnological characteristics and diversity of fish fauna of the hill streams are the objectives of the present communication.

Material and Methods

Study Area: Karbi Anglong district ($25^0$33' N to $26^0$35' N and $92^0$10' E to $92^0$50'E) in Central Assam, covering an area of 10,434 sq km, is bounded by Golaghat district in the east, Meghalaya state and Morigaon district in the north and Dima Hasao district and Nagaland state in the south. The district can be broadly divided into two physiographic units *viz*. hills and plains. About 85% of the district is covered by hills; the highest peak with an altitude 1360 m is located in Singhason hill range. Three river systems of the district were selected for the present study (figure-1). Sites were chosen on the basis of accessibility and differences in physical habitat. The geographical co-ordinates of the rivers under study are as follows: Longnit River (Site-1): 26^o04'10.07" N 93^o23'99"E, Elevation: 300m, Jamuna River (Site-2): 26^o02'59.60" N 93^o10'57.10"E, Elevation: 101m, Amreng River (Site-3): 25^o45'40.80" N 92^o45'45.60"E, Elevation: 125m

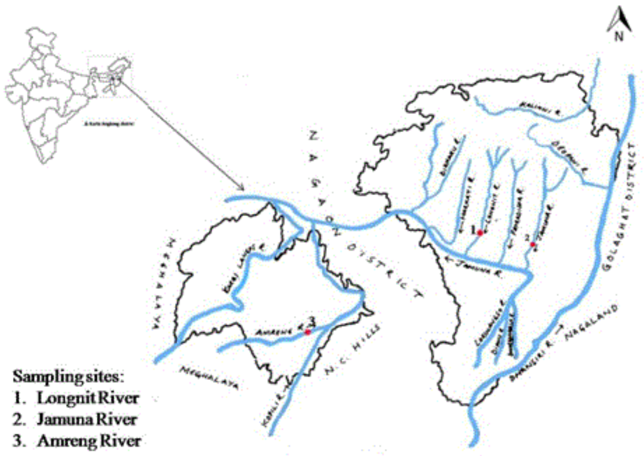

Figure-1
Drainage map of Karbi Anglong district, Assam showing the Rivers under study

Methods: The study was carried out during a span of two years (March 2011 to November 2013). In each river three sampling sites were randomly identified and water samples were collected from the rivers during three seasons in a year- i. pre-monsoon (March-June), ii. monsoon (July-October) and iii. Post-monsoon (November-February). The collected samples were carried to the laboratory for analysis of water variables. The parameters such as air temperature and water temperature of the study site were recorded *in situ*. Other parameters like dissolved oxygen (D.O.), electrical conductivity, total dissolve solid (TDS), turbidity, free CO_2, phosphate, and alkalinity were analysed in laboratory following Standard Methods[12].

Experimental fishing was done by employing experienced fishermen using electrofishing and indigenously used fishing gears. For fish sampling, each site was further divided into five sub sites along the stretch of about 3 km. Representative specimens of all fish species collected were immediately preserved in 10% formalin and taken to the Department of Life Science, Assam University, Diphu Campus and maintained in laboratory for future reference. The specimens were identified using standard literatures[13,14] and online database[15].

The commonness or rarity of a species in the rivers under study was determined using relative abundance (RA) which was calculated as follows:

$$RA = \frac{\text{Number of samples of particular species} \times 100}{\text{Total number of species}}$$

Fish diversity in the rivers was calculated using Shannon-Wiener index which is given by the formula:

$$H = -\sum_{i=1}^{n} Pi \ln(Pi)$$

Where: H= Shannon-Wiener index of diversity; P_i= proportion of species i relative to the total number of species.

Evenness in the population of the species was determined using Shannon's equitability (E_H).It is given by:

$$E_H = H / lnS$$

Where, H= Shannon-Wiener index of diversity; S = total number of species in the habitat (Species Richness)

Number of species observed during the study was considered as species richness.

Results and Discussion

Physico-chemical parameters: The study of physical and chemical characteristics of water provides a considerable insight into the quality of water of awaterbody[16] which in turn determines its faunal diversity. Mean seasonal variations of physico-chemical parameters for a period of two years for the three sampling sites under study are presented in table-1. Physico-chemical parameters were almost similar in the sampling sites under study; however, the parameters showed marked seasonal variation. It was observed that atmospheric temperature and water temperature followed identical annual trends, showing optimum values for both the parameters during the monsoon and minimum were during post-monsoon (winter). Highest atmospheric temperature of 32.95^{o}C was recorded from Jamuna river (site-2) followed by 32.03^{o}C and 31.1^{o}C from Amreng river (site-3) and Longnit river (site-1) respectively. Water temperature recorded was found to be highest from Site-1 (28.53^{o}C) and lowest from site-3 (19.77^{o}C). During pre-monsoon water temperature was found moderate and the mean water temperature was lower than the atmospheric temperature throughout the study period indicating strong influence on the former by the later. Turbidity was registered highest (4 NTU at Site-2) during monsoon and lowest (2.33 NTU at Site-1) during pre-monsoon. The increased turbidity during monsoon season may be attributed to surface runoffs from the catchment areas following a heavy downpour which brings in suspended solids into the water bodies. Similar observation was also reported from the lotic habitats of upper Brahmaputra basin[17]. The pH of the rivers recorded were found to be slightly alkaline throughout the study period and showed narrow range of variation between sampling stations. The pH showed a decreasing trend during the monsoon which gradually increased towards post-monsoon season. Maximum average of pH was recorded from Site-2 (8.73) and minimum from Site-3 (6.68). Similar observations were also obvious in the hill streams of Wokha district of Nagaland[18] and Namsang stream of Arunachal Pradesh[19]. The main source of pH in the rivers under study was probably due to use of detergent for bathing and washing. Low pH during the monsoon maybe attributed to dilution of the rivers caused by influx of freshwater brought about by heavy rains. Conversely, high pH during winter months may be attributed to low water level. TDS was found to be highest during pre-monsoon (48.6 µS/ppm from Site-2) and lowest during the monsoon (24.67 µS/ppm from Site-3). This trend may be attributed to the reason that during pre-monsoon periods the river water recedes thereby increasing the solute concentrations. The observed values of TDS were within the permissible level. Maximum value of electrical conductivity was recorded from Site-2 (72.41 µS/ppm) with the least value recorded from Site-3 (51.97 µS/ppm). Differences in electrical conductivity result mainly from the concentration of the charged ions in solution, and to a lesser degree from ionic composition and temperature[20]. Concentration of dissolved oxygen was high during post-monsoon and low during monsoon with the maximum concentration recorded from Site-3(8.22 ppm) and minimum concentration recorded from Site-2(4.85 ppm). The values were moderate and in accordance with the statement that most of the tropics is characterised by water temperature that corresponds to low oxygen content at saturation due to high metabolic rates[21]. Higher concentration of DO during the winter months (post-monsoon) may be due to low water temperature, which increases oxygen holding capacity of water. The reason for low concentration of DO during monsoon may be due to high metabolic rate of aquatic organisms. FCO_2 was maximum during monsoon (9.43ppm from Site-2) and minimum during post-monsoon (4.52ppm from Site-1). Similar trend of DO was observed by other workers[22]. Low values of phosphate were recorded in the present study which varied within a narrow range (0.02 ppm to 0.10 ppm), this is indicative of unpolluted status of the rivers and less anthropogenic activities in the sampling sites. The highest value was recorded from Site-2 (0.1ppm) during post-monsoon and least value from Site-1 and Site-3 (0.02ppm) during monsoon. In the present study alkalinity was represented by bicarbonate alkalinity. Alkalinity showed maximum during monsoon (47.60 ppm from Site-3) while it showed low value during the post-monsoon (24.23 ppm from Site-2).Such lower alkalinity values were also reported from the rivers of Meghalaya[23].Alkalinity is influenced by geology, salts and certain plant activities.

The present study recorded sixty two fishes represented by seven orders, fifteen families and thirty two genera from the rivers under study. Systematic list, relative abundance and conservation status of the species is presented in table-2. Order Cypriniforms showed maximum diversity contributing to 78.13 % of species followed by Siluriformes (10.94 %) and Perciformes (4.69%). Whereas, least diversity was shown by orders Anguilliformes (1.56%), Beloniformes (1.56%), Synbranchiformes (1.56%) and Tetraodontiformes (1.56 %). Studies by other workers[24,25] in different water bodies also found Cyprinids to be the most dominant group. Assessment of the conservation status of the 62 fish as per IUCN red list[26] showed one species as Endangered (EN), five species as Vulnerable (VU), three species as Near Threatened (NT) and the remaining fifty five species as Least Concern(LC) with one species falling under Data Deficient (DD).

Table-1
Physico-chemical characteristics (Mean±SD) of three Rivers during the study period 2011-2013

Seasons	Stations	Air tempt. (°C)	Water tempt. (°C)	Turbidity (NTU)	pH	TDS (ppm)	Conductivity (µS/cm)	DO (ppm)	Free CO_2 (ppm)	PO_4^{-3} (mg/l)	Alkalinity (ppm)
Pre-monsoon	Site-1	28.73 ±0.47	24.57 ±0.55	2.67 ±0.50	7.73 ±0.10	45.80 ±1.11	70.20 ±0.75	6.90 ±0.20	4.52 ±0.18	0.04 ±0.01	28.07 ±0.40
	Site-2	28.55 ±0.64	26.43 ±0.51	3.30 ±0.26	8.33 ±0.11	48.60 ±0.60	72.41 ±1.75	6.47 ±0.20	4.94 ±0.20	0.06 ±0.01	27.13 ±0.25
	Site-3	27.95 ±1.48	21.67 ±0.83	2.33 ±0.49	7.43 ±0.19	44.55 ±0.97	67.64 ±0.34	7.24 ±0.41	5.03 ±0.15	0.05 ±0.01	26.70 ±0.20
Monsoon	Site-1	31.1 ±0.14	28.53 ±0.47	3.47 ±0.21	7.13 ±0.15	27.69 ±2.06	52.33 ±1.75	5.25 ±0.36	7.25 ±0.21	0.02 ±0.01	47.10 ±0.36
	Site-2	32.95 ±2.47	28.30 ±0.52	4.00 ±0.10	7.5 ±0.44	26.74 ±0.65	53.39 ±2.29	4.85 ±0.16	9.43 ±0.57	0.03 ±0.01	44.57 ±0.40
	Site-3	32.03 ±0.91	27.80 ±0.26	3.03 ±0.06	6.68 ±0.19	24.67 ±0.66	51.97 ±2.25	5.1 ±0.30	6.93 ±0.21	0.02 ±0.01	47.60 ±0.62
Post-monsoon	Site-1	25 ±1.77	20.97 ±0.35	3.07 ±0.38	8.31 ±0.15	45.86 ±0.86	68.23 ±0.59	8.22 ±0.22	5.39 ±0.29	0.09 ±0.01	26.23 ±0.78
	Site-2	24.95 ±0.49	21.47 ±0.50	3.50 ±0.10	8.73 ±0.06	44.71 ±1.18	69.86 ±3.02	7.98 ±0.50	6.04 ±0.15	0.10 ±0.03	24.23 ±0.61
	Site-3	22.67 ±2.31	19.77 ±0.25	2.64 ±0.44	8.10 ±0.26	43.31 ±1.13	66.59 ±2.23	8.35 ±0.10	4.60 ±0.36	0.08 ±0.01	25.93 ±0.12

The RA of small indigenous fish *Devario aequipinnatus* (5.09%), *Amblypharyngodon mola* (4.36%), *Barilius bendelisis* (4.65%) and *Schistura skimaiensis* (4.22%) was found to be high in the rivers under study indicating its abundance and dominance. Species under different conservation categories like *Devario assamensis* (VU) and *Tor tor* (NT) showed high RA with values 3.05% and 3.15% respectively, which indicates the stability of their population in spite of natural and anthropogenic threats in the sampling sites. Other species with fairly high RA were *Garra nasuta* (3.20%), *Danio rerio* (3.78%), *Psilorhynchus balitora* (3.59%), *Lepidocephalichthys guntea* (3.97%), *Xenentodon cancila* (3.73%) and *Channa gachua* (3.49%). It has been observed that highest number of catch was recorded during winter and post-monsoon compared to the other seasons. Probable reason may be attributed to receding water level of the rivers, which enhances the fish-catch intensity.

Shannon diversity index showed high values (table-3) with narrow range of variation from 3.43 to 3.88. Highest value of H was recorded from river site-1 (3.88) suggesting maximum diversity followed by Site-3 (3.28) and site-1(3.43). The higher diversity index indicates a balance between total species and total individuals of every species. Shannon's equitability (E_H) index which was used to measure the evenness of species varied from 0.68 to 0.78 with maximum value recorded from site-1 followed by site-2 and site-3. High diversity in sampling sites may be correlated to the physical habitat of the rivers which changes almost constantly along its stretch, it alternate between rapid riffles and shallow short pools, which leads to increase in diversity of physical habitat resulting in greater habitat niches.

Conclusion

On the basis of above findings, it can be inferred that the rivers investigated during the present study, are still free from pollution and the record of sixty two fish species indicates a rich fish diversity. However, interview with local fishermen brought to light on some concerns. They reported a decline in catches during recent years which clearly imply that the fish fauna of the region is under threat. Destruction and degradation of fish habitat and over exploitation are the potential threats to fish population besides other drivers. Sand mining and boulder removal cause a significant destruction in habitat which is a common sight in the rivers under study. *Jhum* cultivation in catchment areas causes influx of silt into the streams which also leads to the destruction of habitat. Unscientific fishing like use of chemical pesticides, fishing during breeding season further aggravates the problem. Use of chemical pesticides is of particular significance, it causes loss of not only fish but the entire aquatic community as pesticides are carried along the stretch of the river killing the non-target species as well. Further, chemical laced water pose risk to human and animals. Other anthropogenic activities like disposal of domestic waste from semi-urban area, widespread use of detergent for bathing and washing adversely affects fish population. Pollution due to coal mining is blamed for decline in fish species in Kopili river system. Paucity of data from these rivers clouds the estimation of fish decline rate in the recent years. There is an urgent need to further study hill streams of Karbi Anglong district for better management and conservation. The present study will help in monitoring water quality, fish diversity, threat perceptions and serve as baseline information for further research in the region. This will impress on general people and government agencies the need and urgency to conserve hill streams of Karbi Anglong district and adopt sustainable fishing practices.

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Table-2
The systematic list of fish species collected in different rivers under study (2011-2013)

Name of the species	Family	Threat status	Total catch	Relative abundance (%)
Anguilla bengalensis (Gray)	Anguillidae	NT	12	0.58
Amblypharyngodon mola (Hamilton)	Cyrinidae	LC	90	4.36
Cabdio jaya (Hamilton)	Cyrinidae	LC	9	0.44
Cabdio morar (Hamilton)	Cyrinidae	LC	9	0.44
Barilius barila (Hamilton)	Cyrinidae	LC	21	1.02
Barilius bendelisis (Hamilton)	Cyrinidae	LC	96	4.65
Opsarius dogarsinghi Hora	Cyrinidae	VU	9	0.44
Opsarius barna (Hamilton)	Cyrinidae	LC	21	1.02
Opsarius tileo (Hamilton)	Cyrinidae	LC	15	0.73
Bariliusvagra(Hamilton)	Cyrinidae	LC	16	0.78
Davario aequipinnatus (McClelland)	Cyrinidae	LC	105	5.09
Devarioassamensis(Barman)	Cyrinidae	VU	63	3.05
Devario devario (Hamilton)	Cyrinidae	LC	33	1.60
Devario naganensis Chaudhuri	Cyrinidae	VU	21	1.02
Puntius sophore (Hamilton)	Cyrinidae	VU	42	2.04
Danio dangila (Hamilton)	Cyrinidae	LC	15	0.73
Danio rerio (Hamilton)	Cyrinidae	LC	78	3.78
Esomus dandrica (Hamilton)	Cyrinidae	LC	21	1.02
Rasbora rasbora (Hamilton)	Cyrinidae	LC	29	1.41
Bangana dero (Hamilton)	Cyrinidae	LC	6	0.29
Chagunius chagunio (Hamilton)	Cyrinidae	LC	23	1.11
Labeo pangusia (Hamilton)	Cyrinidae	NT	14	0.68
Labeo bata (Hamilton)	Cyrinidae	LC	12	0.58
Labeo dyocheilus (McClelland)	Cyrinidae	LC	13	0.63
Neolissocheilus hexagonolepis (McClelland)	Cyrinidae	NT	9	0.44
Tor putitora (Hamilton)	Cyrinidae	EN	7	0.34
Tor tor (Hamilton)	Cyrinidae	NT	65	3.15
Crossocheilus latius (Hamilton)	Cyrinidae	LC	52	2.52
Crossocheilus burmanicus Hora	Cyrinidae	LC	6	0.29
Garra gotyla (Gray)	Cyrinidae	LC	15	0.73
Garra lamta (Hamilton)	Cyrinidae	LC	26	1.26
Garra lissorhynchus (McClelland)	Cyrinidae	LC	14	0.68
Garra naganensis Hora	Cyrinidae	LC	17	0.82
Garra nasuta (McClelland)	Cyrinidae	LC	66	3.20
Garra kempi Hora	Cyrinidae	LC	12	0.58
Psilorhynchus balitora (Hamilton)	Psilorhynchidae	LC	74	3.59
Psilorhynchus hameloptera HoraandMukherji	Psilorhynchidae	LC	20	0.97
Psilorhynchus sucatio (Hamilton)	Psilorhynchidae	LC	12	0.58
Acanthocobitis botia (Hamilton)	Nemacheilidae	LC	55	2.67
Schistura naganensis (Menon)	Nemacheilidae	VU	23	1.11
Schistura rupecula McClelland	Nemacheilidae	LC	7	0.34
Schistura skimaiensis (Hora)	Nemacheilidae	LC	87	4.22
Botia almorhae Gray	Botiidae	LC	4	2.08
Botia dario (Hamilton)	Botiidae	LC	43	1.36
Botia histrionica Blyth	Botiidae	LC	28	1.65
Botia rostrata Günther	Botiidae	VU	34	0.19
Lepidocephalichthysirrorata(Hora)	Cobitidae	LC	16	0.78
Lepidocephalicthys annandalei Chaudhuri	Cobitidae	LC	51	2.47
Lepidocephalicthys guntea (Hamilton)	Cobitidae	LC	82	3.97
Amblyceps mangois (Hamilton)	Amblycipitidae	LC	14	0.68
Conta conta (Hamilton)	Erethistidae	DD	10	0.48
Erethistes pusillus Muller andTroshel	Sisoridae	LC	12	0.58
Glyptothoraxcavia(Hamilton)	Sisoridae	LC	8	0.24

Glyptothorax saisii (Jenkins)	Sisoridae	VU	5	0.39
Glyptothorax platypogonides (Bleeker)	Sisoridae	LC	17	0.82
Glyptothorax telchitta Blyth	Sisoridae	LC	24	1.16
Xenontodoncancila(Hamilton)	Belonidae	LC	77	3.73
Mastacembelus armatus (Lacepède)	Mastacembelidae	LC	84	4.07
Badis badis (Hamilton)	Badidae	LC	16	0.78
Glossogobius guiris (Hamilton)	Gobiidae	LC	57	2.76
Channa gachua Bloch and Schneider	Channidae	LC	72	3.49
Leiodon cutcutia (Hamilton)	Tetradontidae	LC	14	0.68

EN- Endangered, VU- Vulnerable, NT- Near Threatened, LC- Least Concern, DD- Data Deficient

Table-3
Community structure of the rivers under study

Diversity indices	Sampling sites		
	Longnit	**Jamuna**	**Amreng**
Species richness	47	29	46
Total catch	146	112	149
Shannon-Weiner index (H)	3.88	3.28	3.43
Species evenness	0.78	0.70	0.68

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