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Survey on the present status of Fish species diversity in a stretch of Hooghly River of West Bengal, India

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Abstract

The present study has shown that studied Hooghly river sector supported 87 fish species belonging to 12 orders, 39 families and 69 genera. The order Perciformes was dominant with 8 families and 25 number of fish species followed by the order Siluriformes with 8 families and 24 number of fish species. Fish diversity was assessed by calculating the various diversity indices such as Shannon-Wiener index (H'), Simpson's dominance index (C) and evenness index (J). Higher H' value (3.694) observed in post monsoon and lowest (2.398) in monsoon. High evenness value (0.6930) was recorded during monsoon period. Seasonal water quality parameters such as water temperature ($^{\circ}C$), pH, DO, nitrate and phosphates has been recorded and were found suitable for fish population.

Keywords: Fish diversity, Perciformes, Siluriformes, Shannon-Wiener Index, Simpson's Dominance Index

1. Introduction

Survey on the fish species diversity of the Hooghly river stretching from Serampore (Dist. Hooghly, West Bengal, India) to Tribeni (Dist. Hooghly, West Bengal, India) was done since the adjoining stretch of the river represents a transitional stage between the typically estuarine conditions lower down and the purely fresh water stretch above. The term 'Hooghly' is applied to the 174 miles stretch of the tidal portion of the Bhagirathi, the first off-shoot of the Ganga flowing towards the Bay of Bengal. The Bhagirathi, Jalangi and Churni rivers take off from the Ganga to form the Hooghly River. The 180 mile long Hooghly river from sea face to Nabadwip (about 295 km), also often referred as Hooghly estuary, is of special significance for detailed hydro biological studies as the tidal influence is seen all throughout the river due to its funnel shaped surface which is well suited for the optimum tidal flux ^[1].

Estuaries constitute one of the most productive ecosystems of the world as they are naturally characterized by increased availability of nutrients and abundance of primary producers. Estuaries have long been regarded as important sites for fish, both as nursery and overwintering grounds, migration routes and areas which naturally support large number of fishes. The environmental variables such as salinity and distance from the estuary mouth influence the distribution, abundance and community structure of fishes in estuaries. The tidal freshwater areas of estuaries have received little attention in ecological research although they are often heavily stressed by environmental impacts.

'Tidal freshwater areas' included as a distinct part of an estuarine system ^[2]. The biota of tidal freshwater reaches of estuary experiences tidal fluctuations, without influence of salinity. So tidal freshwater reach of the estuary serves as a separate biotope with specific community structure. Literature reveals that these are important sites of physical, chemical and biological processes which may alter riverine input considerably before it reaches the freshwater-seawater interface ^[3]. The freshwater tidal stretches of the estuaries can be extensive, particularly in systems with high riverine input and these areas can support abundant fish and active fisheries ^[4].

Different authors described many fishes of the Ganga system including the Hooghly and its associated creeks ^[1, 5-10]. As for the fishes concerned, they are grouped as residents and transient; the former being present in estuarine waters or fresh water areas throughout the year in some or all size groups and the transients enter and remain in one or more zones for short duration. Up to 1935, the maximum salinity at Palta was less than 0.25 g/l (potable limit) and

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since 1936 it has started rising and in 1966 the maximum salinity at the intake became 3 g/l. During post Farakka barrage salinity recorded from nil from Nurpur (24 Parganas South) to upstream.

No comprehensive studies have been conducted on the catch of fish species with size range during post-Farakka period. Present study aims a detailed analysis of the fish community structure, endemism and species richness in the freshwater zone of the Hooghly estuary by studying gear wise fish catch, diversity and abundance of fish fauna along with the size range of each fish species and conservation status according to our own observations.

2. Materials and Methods

Fish samples were collected throughout two years (March, 2013-February, 2015) by different gears i.e Set barriers, *Bachhadi* net, Cast net, Vesal net, line and hooks. Study was done through a stretch from Serampore (Dist Hooghly) (N 22°45.803' E 088°20.879') to Tribeni (Dist. Hooghly) (N 22°59.728'E 088°24.525) during full moon and new moon period. To investigate the seasonal variation of fish communities this study period (Table 1) is categorized into 3 phases viz. pre monsoon (March-June) with little or no rainfall with very high temperature, the monsoon (July-Oct) with heavy rainfall and relatively lower temperature and post monsoon (Nov-Feb) season with a drastic reduction of temperature and occasional rainfall. Mainly Behundi net (mesh size 15 mm near the mouth to 5 mm at the end), *Bachhadi* net (mesh size 15 mm), Cast net (mesh size 8-20mm), Set barriers (mosquito net) are used for fishing in all sampling sites but there are some devices like line and hooks which are operated to catch specific types of fish species by local fishermen. Fish specimens which are sampled seasonally were identified by taxonomic characterization and preserved in 5% formalin solution for further study. Fishes were identified up to species level [11, 12]. During the study, the length (cm) of each reported fish species was recorded along with the frequency occurrence of each species (only in number, not weight) per catch.

The criteria followed to assign the five conservation categories on the basis of frequency occurrence of each fish species in the catch which is as follows- Abundant (A) - Frequency occurrence 30-40% in the catch; Common (C) – Frequency occurrence 10-30% in the catch, Rare (R) – Frequency occurrence 5-10% in the catch, very rare (VR) – 1-5% in the catch and Rarest (Rt) – occur very occasionally in the catch [13]. The classification of fishes adopted here after the following author [14].

Species diversity was calculated using the Species diversity index (H'), evenness index (J) and index of dominance (D) [15, 16, 17]. Water parameters viz., water pH, DO, nitrate and phosphate were determined following the standard methods [18] (Table 2). Tidal amplitude was also recorded.

3. Results

Total 87 species belonging to 12 orders were observed. Out of 87 species 14 species viz. *Rhinomugil corsula*, *Glossogobius giuris*, *Pseudapocryptes lanceolatus*, *Odontamblyopus rubicundus*, *Platycephalus indicus*, *Sillaginopsis panijus*, *Rita gogra*, *Eutropichthys vacha*, *Ailia coilia*, *Clupisoma garua*, *Salmophasia bacaila*, *Tenualosa ilisha* juvenile, *Corica soborna*, *Setipinna phasa*, *Euryglossa orientalis* are of common occurrence or abundantly available and can be considered as commercial fish species (Table 1). Perciformes and Siluriformes were found to be high species abundant. Total catch of different gears (during pre-monsoon, monsoon and post monsoon period) represent the dominance of *Rhinomugil corsula*, *Glossogobius giuris*, *Pseudapocryptes lanceolatus*, *Odontamblyopus rubicundus*, *Platycephalus indicus*, *Sillaginopsis panijus*, *Rita gogra*, *Eutropichthys vacha*, *Clupisoma garua*, *Salmophasia bacaila*, *Tenualosa ilisha* juveniles, *Corica soborna*, *Setipinna phasa*, *Cynoglossus cynoglossus*, *Euryglossa orientalis*. Among them some has market value and some non-economical fishes are becoming abundant in this region. In the pre monsoon period, the maximum number of species belong to the order Siluriformes (39%) followed by Perciformes (33%), Clupeiformes (13%), Cypriniformes (7%). In the monsoon period the maximum number of species found belong to the order Perciformes (55%) followed by Siluriformes (27%), Clupeiformes (9%), Pleuronecti formes (9%). In the post monsoon period, the maximum number of species belong to the order Perciformes (45%) followed by Siluriformes (19%), Clupeiformes (14%), Cypriniformes (11%). Besides, other orders form few percentages. *Pseudapocryptes lanceolatus* and *Odontamblyopus rubicundus* have been found in a voluminous amount in juvenile stage in post monsoon period. *Glossogobius giuris* is highly abundant in pre monsoon and post monsoon period whereas reduced number of *G giuris* is observed in the monsoon. In the post monsoon Perciformes formed the largest order. *G giuris*, *P lanceolatus*, *O rubicundus*, *P indicus*, *A coilia*, *C garua*, *S bacaila*, *T ilisha*, *S phasa* were found in large numbers and form a major portion of the catch in post monsoon period whereas *R corsula*, *G giuris*, *P lanceolatus*, *O rubicandus*, *P indicus*, *S panijus*, *R gogra*, *E vacha*, *C garua*, *T ilisha* juveniles, *C soborna*, *S phasa* found abundantly in pre monsoon period. Monsoonal catch shows abundance of *R gogra*, *E vacha*, *E orientalis*.

Water pH ranged from 7.4 – 7.6 in the pre monsoon, 7.2 – 8.0 in the monsoon and 7.6 – 8.2 in the post monsoon (Table 2). DO ranged from 7.4 – 8.5 mg/l in the pre monsoon period. Nitrate (mg/l) was in the range of 1.2 – 1.3 mg/l and Phosphate (mg/l) was in the range of 0.052 – 0.094 throughout the study period. Shannon - Wiener diversity index was 0.05525 in pre monsoon, 0.09086 in monsoon and 0.0319 in post monsoon respectively. (Table 3)

Table 1: Diversity of fish species in Hooghly Riverine System

| Order | Families | Name Of Species | Pre monsoon (M-A-M-J) | Monsoon (J-A-S-O) | Post monsoon (N-D-J-F) | |
|----------------|-------------------------------|---------------------------|-----------------------|-------------------|------------------------|----|
| Perciformes | 1.Mugilidae | <i>Rhinomugil corsula</i> | ++ | ++ | +++++ | A |
| | | <i>Sicamugil cascasia</i> | | + | | Rt |
| | 2.Channidae | <i>Channa punctatus</i> | + | ++ | | R |
| | | <i>Channa orientalis</i> | | ++ | | R |
| | 3.Centropomidae | <i>Pseudambasis ranga</i> | + | + | + | VR |
| | 4. Scianidae | <i>Jhonius gangeticus</i> | + | + | ++ | R |
| 5. Anabantidae | <i>Trichogaster fasciatus</i> | + | + | | R | |
| 6.Gobidae | <i>Glossogobius giuris</i> | ++ | +++ | +++ | A | |

| | | | | | | |
|--------------------------------|-----------------------------------|------------------------------------|---------|-------|-------|----|
| | | <i>Periophthalmodon</i> sp. | + | | + | Rt |
| | | <i>Pseudapocryptes lanceolatus</i> | + | +++++ | +++ | A |
| | | <i>Odontamblyopus rubicundus</i> | + | ++++ | ++++ | A |
| | | <i>Apocryptes bato</i> | | + | ++ | R |
| | 7.Platycephalidae | <i>Platycephalus indicus</i> | + | +++++ | +++ | A |
| | 8.Datnioididae | <i>Datnioides quadrifasciata</i> | | ++ | | Rt |
| | 9.Mastacembelidae | <i>Macrornathus aral</i> | | + | | Rt |
| | | <i>Macrornathus pancalus</i> | | + | | Rt |
| | | <i>Mastacembelus armatus</i> | + | + | | Rt |
| | 10.Sillaginidae | <i>Sillaginopsis panijus</i> | + | ++ | +++ | C |
| | 11.Badidae | <i>Badis badis</i> | | + | + | Rt |
| | 12.Eleotridae | <i>Eleotris fusca</i> | + | ++ | ++ | C |
| | 13.Sparidae | <i>Acanthopagrus latus</i> | | + | | Rt |
| | 14.Nandidae | <i>Nandus nandus</i> | | + | | Rt |
| | 15.Polynemidae | <i>Polynemus paradiseus</i> | | + | + | Rt |
| | 16.Scatophagidae | <i>Scatophagus argus</i> | | | + | Rt |
| | 17.Cichlidae | <i>Tilapia nyotica</i> | + | | | Rt |
| | | <i>Etroplus suratensis</i> | | + | | Rt |
| | 18 Centropomidae | <i>Lates calcarifer</i> | + | | | Rt |
| Siluriformes | 1.Siluridae | <i>Ompok pabda</i> | | + | | Rt |
| | | <i>Wallago attu</i> | | + | | Rt |
| | 2.Bagridae | <i>Mystus cavasius</i> | + | + | ++ | C |
| | | <i>Mystus vittatus</i> | | | ++ | VR |
| | | <i>Mystus bleekari</i> | | + | | Rt |
| | | <i>M gulio</i> | + | | | VR |
| | | <i>Sperata aor</i> | + | + | + | VR |
| | | <i>Sperata seeghala</i> | | + | | VR |
| | | <i>Rita rita</i> | ++ | + | + | R |
| | <i>Rita gogra</i> | +++ | + | +++++ | A | |
| | 3.Sisoridae | <i>Gagata gagata</i> | ++ | + | | Rt |
| | | <i>Gagata sexualis</i> | | + | | Rt |
| | | <i>Gagata cenia</i> | | + | + | Rt |
| | | <i>Bagarius bagarius</i> | + | | | Rt |
| | 4. Schilbeidae | <i>Glyptothorax telchitta</i> | | + | | Rt |
| | | <i>Eutropichthys vacha</i> | +++++++ | ++ | +++++ | A |
| | | <i>Silonia silondia</i> | + | + | | VR |
| | | <i>Eutropichthys murius</i> | | + | | Rt |
| | | <i>Ailia colia</i> | + | ++++ | + | A |
| | | <i>Clupisoma garua</i> | + | +++ | +++ | A |
| <i>Neotropius atherinoides</i> | | | + | + | VR | |
| 5.Leiognathidae | <i>Secutor ruconis</i> | | | + | R | |
| 6.Saccobranchidae | <i>Heteropneustes fossilis</i> | + | + | | R | |
| 7.Pangasidae | <i>Pangasius pangasius</i> | | + | | Rt | |
| 8.Gerridae | <i>Gerres oyena</i> | | | ++ | VR | |
| Cypriniformes | 1.Cyprinidae | <i>Esomus danricus</i> | + | | | Rt |
| | | <i>Amblypharyngodon mola</i> | | + | ++ | VR |
| | | <i>Puntius conchonius</i> | | ++ | | R |
| | | <i>Puntius ticto</i> | + | | | Rt |
| | | <i>Ostebrama cotio cotio</i> | | + | | Rt |
| | | <i>Laubuca laubuca</i> | | + | | Rt |
| | | <i>Cirrhinus reba</i> | | + | | Rt |
| | | <i>Cirrhinus mrigala</i> | +++ | | + | C |
| | | <i>Salmophasia phulo</i> | + | ++ | ++ | C |
| | | <i>Salmophasia bacaila</i> | + | +++ | + | C |
| | | <i>Labeo calbasu</i> | | ++ | | R |
| | | <i>Hypophthalmichthys molitrix</i> | + | | | Rt |
| | | <i>Labeo rohita</i> | + | | | Rt |
| | | <i>Labeo bata</i> | | ++ | | R |
| | | <i>Catla catla</i> | + | | | Rt |
| | <i>Rasbora</i> sp. | + | + | | Rt | |
| | <i>Chagunius chagunio</i> | | + | | Rt | |
| 2.Cobitidae | <i>Lepidocephalichthys guntea</i> | | + | | Rt | |
| Clupeiformes | 1.Clupeidae | <i>Tenualosa lisha</i> (juvenile) | | ++++ | +++ | A |
| | | <i>Tenualosa ilisha</i> (adult) | + | + | + | VR |
| | | <i>Gudusia chapra</i> | | ++ | + | R |
| | | <i>Corica soborna</i> | + | + | +++++ | A |

| | | | | | | |
|--------------------|-------------------|--|-----|-----|-------|----|
| | 2.Engraulidae | <i>Setipinna phasa</i> | + | +++ | +++++ | A |
| Atheriniformes | 1.Belonidae | <i>Xenentodon cancila</i> | | + | | Rt |
| | 2.Hemiramphidae | <i>Hemiramphus far</i> | | + | | Rt |
| Cyprinodontiformes | 1.Aplocheilidae | <i>Aplocheilus panchax</i> | | + | | Rt |
| Anguilliformes | 1.Ophichthidae | <i>Pisodonophis boro</i> | + | + | ++ | C |
| | | <i>Anguilla bengalensis bengalensis</i> | | + | + | R |
| | | <i>Amphipnous cuchia</i> | + | | | Rt |
| Plurionectiformes | 1.Cynoglossidae | <i>Cynoglossus cynoglossus</i> | ++ | + | + | R |
| | | <i>Euryglossa orientalis</i> | +++ | + | + | C |
| Syngnathiformes | 1.Syngnathidae | <i>Microphis cunocalus</i> | | + | | Rt |
| Tetraodontiformes | 1.Tetraodontidae | <i>Tetraodon cutcutia</i> | | + | | Rt |
| Osteoglossiformes | 1.Notopteridae | <i>Notopterus notopterus</i> | | + | | Rt |
| | | <i>Notopterus chitala</i> | + | | | Rt |
| Scorpaeniformes | 1.Platycephalidae | Crocodile fish <i>Pterygoplichthys sp</i> | | + | | Rt |

Abundant (A) – Frequency occurrence 30-40% in the catch
 Common (C) - Frequency occurrence – 10-30% in the catch
 Rare (R) – Frequency occurrence 5- 10% in the catch
 Very rare (VR)- Frequency occurrence – 1-5% in the catch
 Rarest (Rt) – Occur very occasionally

Table 2: Physico chemical parameters of the water

| | Pre Monsoon (Mar - Jun) | Monsoon (Jul - Oct) | Post Monsoon (Nov - Feb) |
|------------------|-------------------------|---------------------|--------------------------|
| pH | 7.4 - 7.6 | 7.2 - 8 | 7.6 - 8.2 |
| DO(mg/l) | 7.4 - 8.5 | 7 - 8 | 6.7 - 7.5 |
| Nitrate (mg/l) | 1.2 - 1.3 | 1.1 - 1.2 | 0.6 - 1 |
| Phosphate (mg/l) | 0.052 - 0.08 | 0.052 - 0.094 | 0.08 - 0.18 |

Table-3: Species Diversity Index

| SEASON | C | H' | Hmax | J |
|--------------|---------|--------|--------|--------|
| PRE MONSOON | 0.05525 | 3.0801 | 4.858 | 0.6340 |
| MONSOON | 0.09086 | 2.398 | 3.46 | 0.6930 |
| POST MONSOON | 0.0319 | 3.694 | 5.8073 | 0.6361 |

4. Discussion

Nine (9) species are first documented in the studied region in comparison to the previous works. They are *Datnioides quadrifasciata*, *Etroplus suratensis*, *Mystus bleekari*, *Rita gogra*, *Secutor ruconius*, *Gerres oyena*, *Chagunius chagunio*, *Acanthopagrus latus*, and *Pterygoplichthys sp* (Crocodile fish). They belong different habitats found in the non-residential Hooghly riverine system and are considered as transient species. Except *M bleekari* and *C chagunio* other fish species are considered as totally brackish water fish species. They entered due to tidal influences. *C chagunio* entered during monsoon period. All these species were found in very small amount in this studied region. *Glyptothorax telchitta* is a resident of North regional riverine habitat entered in this region i.e. from upstream to downstream. An ornamental fish i.e crocodile fish is also noticed in *Bachhadi* net and Set barriers in the studied region though very few in numbers. They are suspected to be introduced in riverine water during flooding in monsoon and as a result they utilize this habitat as their residential site. Tidal duration, height of the water, velocities of the water currents, salinity are the prime factors to determine the quality of the fish, their distribution and fishing [9]. Hydrological records in the Calcutta Port commissioner’s office show that the upward thrust of the flow tides into the Hooghly from the sea in summer and post monsoon months is very much greater volume and longer in duration than in monsoon months [9]. The total number of species was highest in post monsoon with respect to pre monsoon and reached its lowest range in monsoon. Availability of fish species also depends on tides and height of the water level. In the Bay of

Bengal southerly breeze starts about February onwards, reaches a peak in the monsoons and ceases in the winter months. Consequent on this the mean sea level at the sea faces starts rising from about February and reaches a peak by September and falls back in winter months. Total 57 species have been found common since 1954. After installation of Farakka barrage (1975), the conditions have been changed where freshwater volume in the Hooghly River has increased and after then the freshwater fishes found their place. Increased freshwater flux has pushed the salinity zones downwards and the freshwater zone has now been extended up to Diamond Harbour (24 Parganas South, West Bengal). As a result habitat conditions have been changed. Brackish water fish species shifted further downstream. Some species viz. *Sicamugil cascasia*, *Glyptothorax telchitta* invaded this zone. They remain unaffected and they have adjusted to the changed water environment. Author [9] mentioned that fish fauna of Hooghly estuary is mainly composed of brackish water fish species due to faster currents of water and flood influx from the estuary between November and June. Significant fluctuations of the salinity with upward driftage of swarms of young by excessive flood influxes results acclimatization of some brackish water fish species to the fresh water environment. For example *Platycephalus*, *Pseudapocryptes*, *Apocryptes*, *Odontamblyopus*, *Cynoglossus*, *Euryglossa* have adapted in the upstream [9]. Author [19] opined that advancing salt water may have influenced the migration of the estuarine form to the upper reaches of the river. A previous study [19] which was carried out from 1936 to 1942 resulted presence of total 110 number of species but in 1954 [9], 2008 [10] there is a

gradual reduction in total number of species was noticed. Present study shows some new species occupied this habitat. In 1954^[9] total 82 species were recorded in the present studied region and there are 48 common species which are observed in this investigation. *Chagunius chagunio* is a new species which is recorded first in monsoon. Total 60 species which were found in 1936-42^[19] are completely absent in the present study (2013-15) but this number is reduced in 1954^[9] and 2008^[10]. *Tenualosa ilisha* which is considered as a significant fish in Ganga River were found to have their presence throughout all seasons and many of them are suspected to be landlocked in riverine fresh water zone for their breeding and nursing purpose. Author^[20] mentioned that during post monsoon season, the water flow recedes and most of the species leave the system leading to a drastic reduction in fish diversity resulting in an assemblage dominated by Gobiids such as *Odontamblyopus rubicundus*, *Apocryptes bato*, *Glossogobius giuris*. *Notopterus notopterus* was observed in all seasons but *Notopterus chitala* was appeared only in the month of April and November, 2014 in the present study. When total number of species is considered, it is expressed that species abundance is gradually decreased year after year due to unsuitable habitat and overexploitation.

Water pollution, fluctuations of temperature, accumulation of toxic substances by industrial drainage, scarcity of food are some causative factors which can reduce their survival rate and ultimately decrease their availability. Highly polluted water mainly affect growth of phytoplankton and zooplankton which are main food of fishes. Overexploitation and misuse of gears become significant causes of diversity loss. After spawning period juvenile fishes can be easily captured in voluminous number by very small mesh sized gears (Behundi Net). Small mesh sized nets will capture all sizes of fishes, a major share of which are liable to be discarded and such practices affect the biodiversity. Fishing during high tide needs to be prohibited because large quantities of juvenile fishes easily captured in high tide. Overall studies on the diversity of fishes suggest that continuous documentation is very essential for determining the status of fishery^[21]. This will help to take fruitful strategies to conserve vulnerable fishes in future.

In the present study, significant observation is the reduction in the maximum size of most of the fishes. It is worthwhile to mention that 19 species showed reduction in size of more than 70%. Some of them are *Rhinomugil corsula*, *Platycephalus indicus*, *Wallago attu*, *Mystus cavassius*, *Mystus gulio*, *Sperata aor*, *Sperata seenghala*, *Rita rita* etc. There has been ecological degradation in the Ganga river basin due to soil erosion, discharge of city effluents, industrial pollution and urbanization resulting in reduction in the maximum size of most of the fishes as compared to the maximum size reported^[11]. But in the present study reduction of size in the fishes is mainly due to use of nets with small mesh size where exploitation of the small sized fishes are maximum. Some of the fishes breed in this region as larvae or small sized fishes of some species are found in this region. For example catch of *Rhinomugil corsula* showed the range of 2.5 to 12 cm; *Pseudapocryptes lanceolatus* showed the range of 2 to 12.5 cm; *P. indicus* showed the range of 3 to 25 cm. During the present study maximum number of fish species was recorded from low land areas or bank of the river by set barriers. In low and middle land areas freshwater diversity was found to be very high^[22]. It is due to deep water bodies which allow niche segregation in order to enable the fishes to live without facing more intra and inter specific competitions. It is important to

note that some brackish water fish species such as flat fishes became adapted in the freshwater upstream.

Present water condition is the main factor for determining the fish diversity and their abundance. An important water parameter which can mostly affect the survival of the fish fauna is salinity change. In 1972^[1] reported that gradual increase in salinity due to decrease in Ganga water discharge through Bhagirathi-Hooghly channel was the main cause of existence of some marine species and unsuitable environment for some fresh water species. Situation has been changed after commissioning of Farakka barrage (1975). Before the commissioning of the Farakka barrage, the Ganga delivered almost its entire discharge into the Padma river (which flows through Bangladesh), thereby depriving a perennial supply of freshwater to the Bhagirathi-Hooghly river system. This resulted in heavy siltation and when coupled with the ingress of saltwater from the Bay of Bengal during high tides, many estuarine and marine species started their distribution towards the upper stretches of the estuary and displaced the freshwater fishes which were not able to cope up with the changed ecological conditions and thus converting the fish fauna of the Hooghly estuary into predominantly a marine element^[23]. Farakka Barrage was commissioned in 1975 (at the border of Malda and Murshidabad districts in West Bengal, India) with the objective of increasing the volume of freshwater discharge in river Bhagirathi, and consequently in the Hooghly estuary so as to protect the Calcutta port from siltation. The increased freshwater influx to the Hooghly estuary resulted in the extension of freshwater zone, thereby pushing the true estuarine zone towards the mouth and marine zone getting restricted to the area near the mouth of the estuary^[24]. During pre-Farkka period the freshwater zone extended from Nabadwip (Head part of Hooghly) to Nurpur (near Diamond Harbour) with the length of about 220 km (74% of the total length of estuary) and true estuarine conditions begin to appear from Diamond Harbour onwards^[25]. Author^[26] stated that (during pre Farakka barrage) the saline mass coming from the mouth and the pollutants constantly discharged in the rivers are to be flushed out by the head water discharge. In the freshet season flushing of the estuary is no problem, but during dry season the shortage or non-availability of the upland discharge gives opportunity to the salinity intrusion to become progressive.

Species diversity index is used as an indicator for resolution of an ecosystem and environmental condition. Shannon – Wiener index has a direct relationship with the species diversity, whereas index of dominance has an inverse relationship. Present study reveals highest H' value (3.694) in post monsoon and lowest (2.398) in monsoon. Monsoonal H' is lowest which may be due to non-operation of many gears in the monsoon period as the water level remains high. In the monsoon period high tide level ranged from 5.73 to 5.88 m and low tide level ranged from 1.29 to 2.26 m in the studied region. Generally H' value ranges between 1.5 to 3.5 and this index are rarely greater than 4. When H' increases both richness and evenness index of a community increases^[27]. On the other hand species diversity index (H') of greater than 1 express stable environment for survival. Estimation of C represents highest dominance index in post monsoon and lowest in monsoon. Higher evenness value (0.6930) was recorded during monsoon period. The diversity indices indicate good correlation with overall species richness across the sites and could be utilized by the biodiversity conservation managers for prioritization of sites of conservation and habitat restoration.

Physico-chemical parameters are found within the suitable range. Water pH values are found above 7.0 which is reasonably good for fish population. Low pH < 5.0 can be severely reduce aquatic species diversity [28]. DO level was found more than 6.0 at the study sites because in the running water system DO remains higher. Optimum value for good water quality is 4 to 6 mg/l of DO, which ensures healthy life in a water body [29]. Nitrate and Phosphate level in the water indicates that water is suitable for plankton production. The overall water quality parameters indicated that water is suitable for fish life.

Present ichthyofaunal study indicates that habitat loss and environmental degradation has seriously affected the fish fauna. Tidal freshwater reaches are important areas for fish, therefore the protection of these habitats is a matter of major concern since they contribute significantly to the total biodiversity of the entire estuarine ecosystem.

5. Conclusion

87 fish species belonging to 12 orders, 39 families and 69 genera recorded from the studied Hooghly river sector. Among them 14 species are of common occurrence and can be considered as commercial fish species. Nine (9) species are first documented in the studied region in comparison to the previous works. Some of the brackish water fish species enters due to tidal influences and are considered as transient species. Some brackish water fish species viz. *Platycephalus*, *Cynoglossus*, *Euryglossa* etc. became adapted in the studied freshwater region. Total 57 have been found common since 1954. Numbers of rarest fish species are increasing. Species diversity index (H') was highest (3.694) in post monsoon and lowest (2.398) in monsoon period. The overall water quality parameters indicated that the water is suitable for fish life.

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7. References

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