DIVERSITY AND HABITAT ECOLOGY OF INDIGENOUS FISH SPECIES IN RATARGUL SWAMP FOREST SYLHET BANGLADESH

A Thesis
By

SUBRATA KUMAR DAS
Examination Roll No.1402030505
Registration No. 0999
Session: 2009-2010
Semester: July-December, 2015

MASTER OF SCIENCE
In
Fish Biology and Genetics

Department of Fish Biology and Genetics
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December 2015

TOWARDS
MY PARENTS

December 2015

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The Author

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ABSTRACT

Ratargul swamp forest is only the freshwater swamp forest of Bangladesh which supports diverse fisheries communities compared to others. The present study was conducted from April to October 2015 to assess the status of indigenous fish species of Ratargul swamp forest along with relevant hydrological and ecological aspects. A total 62 fish species comprising 28 threatened species were recorded from the study area. Cypriniformes (37.46%) was the most dominant order followed by Siluriformes (35.123%), Perciformes (19.456%), Synbranchiformes (3.298%), Clupeiformes (2.282%), Beloniformes (1.161%), Osteoglossiformes (0.725%), Tetraodontiformes (0.462%) and Anguiliformes (0.026%). Among the identified fish species 19.98% was recorded as threatened according to IUCN (International Union for Conservation of Nature). The Mean Shannon-Wiener diversity index, Margalef richness index, Pielou's evenness index and Simpson dominance index were found to be 3.690±0.191, 9.497± 1.314, 0.971±0.003 and 0.982±0.003, respectively. In case of SIMPER (Similarity Percentages) analysis the highest number of similar species was found during July to August and the lowest during April to October. At the similarity of 76.9%, four groups were attained where June, July, August and September showed in a cluster while April, October and May showed separate clusters. Non-metric Multidimensional scaling shows 60% similarity for all months. On the other hand, 70% similarity observed among all the months except April. Environmental parameters such as photoperiod, rainfall, relative humidity, temperature, transparency, dissolved oxygen, p^H, ammonia and nitrite were determined and found in acceptable limit for fisheries communities. Diversity of plankton assemblage were assessed and a total of 34 planktons belonging to Chlorophyceae (10 taxa), Bacillariophyceae (4 taxa), Cyanophyaceae (6 taxa), Euglenophyceae (2 taxa), Rotifer (4 taxa), Cladocera (5 taxa), Copepods (2 taxa) and Protozoans (2 taxa). A total of 8 major groups of benthos were identified including Oligichaetes, Polychaetes, Gastropods, Bivalvia, Copepods, Isopods, Crab and Prawn larvae. A total of 20 different species were identified which belongs to Emergent (15 taxa), Floating (3 taxa) and Submerged (2 taxa). It may be concluded that Ratargul swamp forest is enriched with fish biodiversity having 28 threatened fish species of Bangladesh.

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LIST OF ABBREVIATIONS

Abbreviations	Elaborations
c	Simpson dominance index
CCA	Canonical Correspondence Analysis
CPUE	Catch Per Unit Effort
CR	Critically endangered
^{0}C	Degree Celsius
COD	Chemical Oxygen Demand
d	Margalef species richness
DO	Dissolve Oxygen
DoF	Department of Fisheries
EN	Endangered
FAO	Food and Agricultural Organization
FEPA	Federal Environmental Protection Agency
GDP	Gross Domestic Product
FADs	Fish Attracting Devices
H'	Shannon-Weiner diversity index
IUCN	International Union for Conservation of Nature
J'	Pielou's evenness index
L	Liter
nMDS	Non-Metric Multidimensional Scaling
NGO	Non- Government Organization
PAST	Paleontological Statistics
PRIMER V6	Plymouth Routines Multivariate Ecological Research
SIMPER	Similarity Percentages Analyses
SS	Suspended Solids
TS	Total Solids
TH	Total Hardness
TDS	Total Dissolved Solids
VU	Vulnerable
WHO	World Health Organization
%	Percent

CHAPTER ONE

INTRODUCTION

Biodiversity is the quantity, variety and distribution across biological scales ranging through genetics and life forms of populations, species, communities and ecosystems (Mace *et al*., 2005). It is often used as a measure of the health of biological system and its conservation regarded as one of the major issues for sustainable development. Aquatic biodiversity especially freshwater biodiversity is now in a state of crisis due to the human exploitation with overfishing, pollution and developmental activities.

Bangladesh is exclusively endowed with rich and extensive inland and marine water resources, which mainly includes floodplains, haors, baors, beels, rivers, estuaries, swamp forest and vast marine waters. There are about 3,925,290 hectares inland open water, 774,055 hectares closed water and 166,000 km^2 marine water in the Bay of Bengal (DoF, 2013). Bangladesh is ranked third largest in inland fisheries in Asia after China and India. These ecological habitats are very rich in natural productivity and support a diverse flora and fauna, among which fish is considered the most important natural resources.

Due to having variety of water resources, Bangladesh is blessed with a wide range of freshwater and marine biodiversities. The country endowed a wide variety of` indigenous freshwater fish species. Inland Waterbodies of Bangladesh are known to be the habitat of 289 species of indigenous fish, 13 exotic fish, 56 prawns, about 26 freshwater mollusks and 150 birds (DoF, 2012). Bangladesh presently stands fifth producing freshwater fish and sixteenth largest producer of capture fisheries in the world (FAO, 2014). Total fish production is 3.54 million metric ton and contributed 3.69% of our GDP, 22.60% of agricultural sector and 2.09% to foreign exchange earnings (DoF, 2015). According to FAO (2014), people of Bangladesh meet 57% of their animal protein demand by consuming fish. In addition l0% people of this country are directly or indirectly involved at this sector.

Bangladesh is endowed with both saltwater and freshwater swamp forests, Ratargul is one of them. It is situated at Guainghat in Sylhet of Bangladesh. It is only the freshwater swamp forest of Bangladesh and a few of the world. It is popularly dubbed as the “Sundarban of the East” received much more public and media attention recently. Ratargul area was declared as reserved forest under the Asham Forest Act in 1932 and an area of 292.60 acres was declared as reserved forest vide notification number 1774 R dated June 9, 1932. In the past these areas were allocated to “Pollarding Working Circle” under Sylhet forest division (Choudhury *et al*.

2004). Geographically it is located on the bank of Goyain River which is on the north of Surma River. The Goyain River ultimately drains into the Surma River. The area gets flooded from the Indian hill tracts with the course of Goyain River. Presently the area of this freshwater swamp forest chunk is approximately 504 acres. This evergreen forests remain submerged 20 to 30 feet water in some part during monsoon season. The water level remain approximately 8 to 10 feet in some part of the forest rest of the years. The ecosystem is enriched with icthyofauna, wetland plants, mammals, avifauna, and reptiles. According to forest officials, once there were about 73 plant species, 20 species of reptiles, 26 species of mammals and 175 species of birds in the forest. The forest ecosystem is also supporting the habitat of numerous freshwater indigenous fish species. Diversity and availability of these fish species depend on many factors such as water quality, planktonic organisms, benthic organisms, aquatic weeds and so on.

The physico-chemical parameters of water are very important as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Swingle, 1969). The healthy aquatic ecosystem is depended on the physico-chemical and biological characteristics (Venkatesharaju *et al*., 2010). The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem. Biological potentiality of an aquatic ecosystem depends on the biomass of plankton (Ahsan *et al*., 2012). Phytoplankton are the primary producers for the entire aquatic body and comprise the major portion in the ecological pyramids. Zooplankton is also an important component in aquatic system, whose function is to act as primary and secondary links in the food chain (Hutchinson, 1967). Most of the fishes take these constitute directly as their food. The larvae of carps feed mostly zooplankton (Dewan *et al.,* 1977). These constitute also act as an indicator of water population. The qualitative and quantitative abundance of plankton and its relation to environmental condition has become a prerequisite for fish production (Chowdhury *et al.,* 2007). On the contrary macrobenthos also an important and integral component of aquatic ecosystems which lives on, in or near the bottom of water bodies. Benthic organisms serve as direct food for other higher trophic organisms and act as ecological engineer in recycling the organic matter and other debris (Assadujjaman *et al.* 2012). Macrozoobenthos have been extensively used for the assessment of the ecological integrity and biomonitoring of aquatic habitats (Acharyya and Mitsch, 2000). These organisms link the producers and with higher tropic levels. On the other hand plant species known as aquatic weeds play a significant role in bioavailability and habitat ecology of fish species. Aquatic weeds grown entirely or partly in water bodies has adverse physical, chemical or biological effects on aquatic ecosystem resulting economic and aesthic losses (Basak *et al*., 2015). It is often reduce the effectiveness of waterbodies for fish production. Besides they also serve as shelter and act as food of some fishes. The availability of aquatic weeds may create an awkward situation for aquatic organisms.

The Ratargul swamp forest known as the amazon of Bangladesh plays a significant role in earning and supplying food to the poor fishing community of the adjacent area. But diversity and habitat ecology of indigenous freshwater fish of this swamp forest is declining day by day. However, no methodical study has been known on the fish diversity, habitat ecology, catch composition, seasonal variation of fish availability and the causes of decreasing diversity of Ratargul swamp forest which will consequently limit establishment of biodiversity conservation strategies.

Therefore, considering the above mentioned facts and reasons the present research work set up to assess the structure of fish assemblage with relevant hydrological and ecological aspects.

Research objectives

The specific objectives of this research are:

- To assess the diversity of indigenous fish species;
- To determine the physicochemical parameters of the water body and
- To estimate the abundance of phytoplankton and zooplankton of the ecosystem.

CHAPTER TWO
REVIEW OF LITERATURE

The objectives of writing a review of literature are analyzing the past to prepare for the future (Webster and Watson, 2002). A review of prior, relevant literature is an essential feature of any academic project. An effective review creates a firm foundation for advancing knowledge. Webster and Watson (2002: 18) argued that, a successful literature review constructively informs the reader about what has been learned. Review succeeds when it helps other scholars to make sense of the accumulated knowledge on a topic. To build a theoretical ground of my study, I did a comprehensive review of literature. The main findings of the review are presented below:

2.1 Fish diversity

Alam *et al.* (2013) conducted a study about fish distribution and biodiversity status in upper halda river, Chittagong, Bangladesh. In that present survey, the overall fish distribution and biodiversity from the upper portion of Halda River along with its two tributaries were studied. The sampling stations were Nazirhat Bridge, Sattarghat Bridge and Garduara. Fishes were collected directly from sampling stations two times in a month during the period of January to December, 2012. The species diversity was analyzed using the following diversity indices: Simpson dominance index; Simpson index of diversity; Shannon–Weiner index; Evenness index and Margalef index with the help of software PAST (Pale ontological Statistics Software Package for Education and Data Analysis). Totally 4,337 individuals of fish were counted. 63 species belongs to 24 families and 51 genera were recorded. The most abundant family was Cyprinidae, having 817 individuals (18.84%) followed by Gobiidae family with 629 individuals (14.50). Simpson index of diversity, Shannon–Weiner index and Margalef index showed higher values at sampling site S3**.**

Ahmed *et al.* (2004) carried out a research in shakla beel which is situated in the northeastern Region (Brahmanbaria district) of Bangladesh. The study was carried out to assess the ecological aspects of beel ecosystem. They documented phytoplankton diversity in the beel represented by three group's *viz.* Chlorophyceae, Myxophyceae and Bacillariophyceae in order of abundance. They recorded 52 fish species belonging to 36 genera, 20 families and 1 species of prawn so far from the beel. They identified 11 species belonging to 11 genera and 10 families of aquatic weeds from the beel.

Ali *et al.* (2014) conducted a study on the Chitra River to explore the diversity and to check the conservation status of fish fauna from august 2011 to July 2012. They recorded 53 species of fish under 10 orders and 23 families. Cypriniformies were most leading order constituting 33.96% of total fish production followed by Siluriformies (22.64%), Perciformes (24.53%), synbranchiformes (5.66%), Clupeiformes (1.89%), Osteoglossiformes (1.89%), Beloniformes (1.89%), Mugiliformes (3.77%), Anguiliformes (1.89%) and Teraodontiformes (1.89%).

Arefin (2013) implemented a research in the Narsunda River Kishoreganj Sadar, Kishoreganj district the Narsunda River Kishoreganj Sadar for a time period of 6 months (April-November, 2012). He documented 23 threatened fish species having 9 vulnerable, 11 endangered and 3 critically endangered species out of 54 threatened fresh and brackish water fishes of Bangladesh.

Barman (2013) studied the temporal distribution of fish assemblage in the Karnafully river estuary from April, 2013 to December, 2013. He documented 41 species of fish belonging 20 families of which *Harpodon nehereus* (20.54%), *Panna microdon* (17.44%), *Coilia ramkorati* (14.42%), *Johnius macropterus* (10.90%) were found to be most dominant species. The Shannon-Wiener diversity index, Margalef richness index, Pielou's evenness index and Simpson dominance index were found to be 2.67, 4.57, 0.95 and 0.97 respectively. The diversity index showed significant differences in temporal fish assemblage structure.

Basher *et al.* (2009) studied about freshwater catfishes of the Barnai River, Rajshahi for a period of 13 months. The data were collected from the fish landing center, fish market and the fishermen. Secondary data were also collected from the related literature and GO's and NGO's personnel. They identified 6 families of which 3 critically endangered (CR), 9 endangered (EN), 5 available and 1 threatened species reported by IUCN. The non-availability and less availability of some of the species can define the alarming of the biodiversity of the studied area.

Bhakta and Bandyopadhyay (2007) carried out a study on the Churni rivere to ascertain the qualitative and quantitative abundance of exotic fish species inhabiting the river. Extensive survey showed that eight exotic fish species under 3 orders, 4 families and 6 genera were listed from the Churni River. Results also demonstrated that 5–8% exotic fish of total catch was present in the Churni River where, both *Oreochromis mossambicus* (2.5–3.2%) and *Cyprinus carpio* (2–3%) have established highest populations and African catfish (*Clarias gariepinus)* showed lowest population among all exotic fish species.

Chakrabarti (2007) recorded a total of 72 aquatic animal species including 64 species of fish, 3Species of prawn, 1 species of crab and 4 species of turtles in Some Shari River of Netrokona District.

Chakrabarti and Mirza (2006) identified 57 species of fishes, three species of prawn, one species of crabs and four species of reptiles from the Nethai River in Bangladesh. About 10 types of fishing gear and craft were found in operation. Increasing rate of seine net (Kapuri jal) and gill net (current jal) were identified as detrimental gear killing including different species during post spawning periods. The increasing rate in exploitation of the water bodies a thread to aquatic biodiversity of the Nethai River. The total production of upper and lower stretch was decreased from 82.79 to 37.25 mt and 92.82 to 41.45 mt within five years and the total production had sharply decreased from 100% to 42.62% and 100% to 44.07% over the same period. As a result, a number of commercial important fish species like as major carps, mohasher (*Tot tor, Tor putitora*), nandina (*Labeo nandina*), olive barb (*Puntius sarana*) and reptiles (*Kachuga kachuga* and *Morenia petersi*) was extinct.

DoF (2005) reported that our tropical water bodies sustain large varieties of fishes a featurewhich was just contrary to the temperature regions where the number of fish species were lessbut their size and quality are quite large. There were a total of 12 species of exotic fish and 24 species of prawn. In addition 475 species of marine fish and 36 marine shrimp had been recorded in Bay of Bengal.

Faroque (2006) stated that Baobela beel possessed a rich biodiversity of aquatic fauna having 43 species of fish, of which 29 are common 5 endangered, 9 critically endangered. Twelve locally extinct species were also recorded. Among non- piscine biodiversity 4 species of prawns, 5 species of mollusks, 6 species of aquatic insects, 4 species of amphibians, and 5 species of reptiles were identified.

Halder *et al.* (1991) reported a total of 66 indigenous and 5 exotic species of fishes belonging to 49 genera available Kaptai Lake.

Haroon *et al.* (2002) recorded a total of 92 species of fish and prawn from the Sylhet - Mymensingh basin. *Puntius spp.* was the most dominant group comprising 19% of the total catch and contribution of cat fishes, Gangetic major carps, minnows, snakeheads were 18%, 16%, 13 % and 11% respectively of the total catch.

Hossain (2013) studied on fish biodiversity conservation in the Choto Jamuna River Badalgachhi, Naogaon district, for a time period of 6 months (May-October, 2012). He identified 25 threatened fish species having 10 vulnerable, 12 endangered and 3 critically endangered species out of 54 threatened fresh and brackish water fishes of Bangladesh.

Islam *et al*. (2015) conducted a study for a period of one year from April 2013 to March 2014 in the Payra River, Patuakhali, Bangladesh. They recorded a total of 114 fish species under 12 orders and 36 families in the River. On the basis of availability, the recorded species were categorized into four statuses and obtained as available (43.86%), less available (29.82%), rare (18.42%) and very rare (7.89%). Result of the study identified nine species as very rare which may extinct near future resulting declination of the fish diversity. Overfishing, indiscriminate fishing of larvae and juveniles, siltation and pollution were identified as the major worries linked with the declination of fish diversity. Study suggested that the activities which have harmful impact on fisheries resources need to be decreased and should be restricted to save our valuable fish diversity in the Payra River.

IUCN Bangladesh (2003) recorded a total of 54 threatened indigenous fish species in the country including 14 vulnerable, 28 endangered and 12 critically endangered fish species.

Mallik (2011) studied the fish assemblage of Estuarine Set Bag Net in the Matamuhuri River estuary of Cox's bazar district with reference to some water quality parameters. From the Matamuhuri River estuary a total of 2774 individuals consisting of fishes, shrimps and crabs were collected during the study. They represent 69 species belonging to 34 families. The most dominant family was found to be Gobiidae (13 species) followed by Penaeidae (10 species), Portunidae (4 species), Clupeidae (3 species), Cynoglossidae (3 species), Mugilidae (2 species), Palaemonidae (2 species), Potamidae (2 species).

Mohsin and Haque (2009) carried out a research on Mahananda River at Chapai Nawabganj sadar upazilla from the period of October 2006 to November 2007. The aim of the study was to find out the open water fish diversity in Mahananda River. About 56 fish species were found and identified during the investigation under 9 order, 20 families and 42 genera. Among 56 species 20 species are found under the order cypriniformies, 17 species were found under the order Siluriformies, 10 species were found under the order Perciformies, 3 species were found under the order Clupeiformies , 2 species were found under the order Channiformies and a single species was found under the order Synbranchiformies, Tetraodontiformoies Beloniformies and Cypriniodontiformies each.

Nath and Deca (2012) conducted a study to find out the fish biodiversity and socio-economic condition of fishermen in Borulia *haor* areas, located in Nikli upazila under the district of Kishoregonj. A total of 47 fish species belonged to 19 families and 31 genera were identified from the haor. Among 8 common groups of fishes 7 species of carps, 12 species of catfishes, 4 species of snakeheads, 3 species of eels, 8 species of minnows, 2 species of clupeids and 7 miscellaneous species were recorded. Comparing dominancy of abundance among common groups of fishes, minnows (28.23%), carps (22.66%) and snakeheads (20.21%) took first, second and third position respectively considering weight. Numerically minnows (73.75%), catfishes (6.23%) and perches (5.84%) were first, second and third dominant groups respectively.

Nuruzzaman (1997) conducted a study in Tanguar *hoar* of Sunamganj district and recorded 104 species of fish fauna there.

Patra (2011) studied about fresh water catfish fauna of the Karala River in Jalpaiguri District of West Bengal from February 2009 to January 2010. A total of seven species belonging to six genera and six families were identified. Bagridae was the dominant family with two representatives, whereas Amblycepitidae, Chacidae, Olyridae, Sisoridae and Siluridae were each represented by single species. Maximum fish diversity was recorded higher in Hakim Para (H′ =1.266) as compared with DasPara (H′ =1.218) and Aquiduct (H′ =1.04). The evenness index at three sampling stations indicates uneven distribution of catfish in this tributary, possibly due to the irregular depth of river, occurrence of submerged vegetation and physicochemical water characteristics.

Rahman *et al.* (2012) conducted a study about biodiversity of Padma distributary of the Ganges River, Northwestern Bangladesh. They conducted the research fortnightly in the Padma River during March 2009 to February 2010 from fishermen catch landed at different fish landing centers between Binodpur and Godagari, Rajshahi, northwestern Bangladesh. A total of 80 species of fish under 9 orders and 24 families were recorded. Cypriniformes were most dominant order constituting 35% of the total fish population followed by Siluriformes (32.50%), Perciformes (17.50%), Clupeiformes (5.00%), Synbranchiformes (3.75%), Osteoglossiformes (2.50%), Beloniformes (1.25%), Mugiliformes (1.25%) and Tetraodontiformes (1.25%). Among the species found during the present study, 12.50% were vulnerable, 21.25% were endangered and 8.75% were critically endangered. Major threats to fish biodiversity include habitat destruction and defragmentation, water pollution, indiscriminate harvesting of fry and fingerlings, construction of barrages, construction of embankments by the Ganges-Kobadak project, sedimentation.

Raj (2002) reported fresh water fish diversity and conservation measure in India suggested taking necessary action like establishment of sanctuary determination of the environmental requirements of the species etc.

Uddin (2015) conducted a research on the fish diversity of Kushiara River at Monumukh point. He carried out the research for one year from July 2013 to June 2014 to assess the present status of diversity of fish fauna and water quality parameters. He documented 58 fish species including 26 threatened species and 6 exotic species from the study area. He recorded cyprinidiae as the most diversified fish family comprising 14 species followed by 6 species of bagridae and 5 species of schilbeidae. The highest number of species was *Puntius ticto* (5.37%) followed by *Amblyopharyngodon mola* (4.82%) and *Mystustengra* (4.78%). Among the identified fish species 44.63% was recorded as threatened according to IUCN and 5.49% was exotic species in respect of number. The seasonal highest catch 1991.54 kg was recorded in the winter and the lowest 558.671 kg in the summer. The value of diversity index ranged from 3.446 (Summer) to 3.676 (Monsoon), richness index ranged from 6.41 (Winter) to 5.536 (summer) and evenness index ranged from 0.903 (Postmonsoon) to 0.948 (Monsoon).

Valentina *et al.* (2015) carried out a study from 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 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.

2.2 Hydrological parameter

Alam (2013) identified available microbial species with hydrological condition and effects of hydrology on their occurrence in the Karnafully river estuary. He collected data between March 2012 and June 2012 and analyzed through plate count method. Water temperature ranges from 26.5 to 32^{0}C; salinity 0.0 to 5.0 ppt; pH 7.5 to 7.9 and Dissolved Oxygen (DO) 2.28 to 2.91

mg/l in water samples were estimated by the author. Salinity was found as main influential factor for occurrence of microbial species at the Karnafully River estuary.

Akpan-Idiok *et al.* (2012) has studied surface composite water samples from seventeen different locations along the Okpauku River were analyzed for various water quality parameters. The results revealed that the water quality parameters showed significant ($p \leq 0.05$) variations among the different locations on the river except for the ammonia-nitrogen and iron. However, the physic chemical parameters of the river at different locations were below the WHO and FAO limits for drinking and irrigation water uses except for the temperature, turbidity and pH.

Bhuyain (1998) investigated the hydrological parameters on the intertidal seashore water of Cox's Bazar. The range of DO, Alkalinity, NO2-N, PO4-P, were 0.969 to 5.93 ml/l, 13.283 to 106 ppm, 0.182 to 0.734 μg/l, 0.0314 to 0.168 μg/l, respectively.

Chowdhury (1998) recorded the physico-chemical parameters of water in the coastal water of Cox's Bazar. He found the range of water temp, salinity, TSS, DO, pH, NO2-N, PO4-P, where 21.3 to 29.7°C, 10.3 to 33 ppt, 2.45 to 29.83 mg/l, 4.1 to 7.85 ml/l, 7.05 to 8.10, 0.077 to 1.520 μg at/l, 0.206 to 1.804 μg at/l respectively.

Das (2005) found out the physico-chemical parameters of soil and water of four selected stations at Banshkhali, Chittagong. Among the physico-chemical parameters of water, water temperature, salinity, pH, DO, TDS, TSS and transparency were recorded as 28 to 30.6oC, 15 to 31ppt, 7.2 to 8.9, 4.5 6.6 ml/l, 93.8 to 225.86 mg/l and 25 to 54 cm respectively. Among the soil quality parameters soil pH, organic carbon and organic matter were recorded as 6.60 to 7.54, 0.40 to 0.58%, and 0.69 to 1.07% respectively and soil classes were loamy, sandy loamy, sandy clay loam.

Fella Hamaidi-Chergui *et al.* (2013) studied to determine the monthly variations of physicochemical parameters in water samples from Chiffa River at Blida, North West of Algeria from April to August 2006. Water samples were analyzed for physico-chemical parameters and the results showed their monthly variations as follows: pH 7.5 to 7.6, electrical conductivity 0.87 to 1.06 mS/cm, nitrate 0 to 7.00 mg/l, nitrite 0 to 0.28 mg/l, ammonia 0 to 0.03 mg/l phosphate 0 to 0.94 mg/l, sodium 19.3 to 47.0 mg/l, chloride 35.7 to 52.0 mg/l, calcium 90.3 to 104.7 mg/l, magnesium 27.3 to 37.7 mg/l, organic matter 0.4 to 3.9 mg/l, chlorophyll a 0.7 to 132.3 mg/l, and bicarbonate 219.3 to 248.7 mg/l. The analyzed physico-chemical parameters were almost not exceeded the maximum permissible limit of WHO and Algerian Water Quality Guidelines.

Kalita, *et al.* (2011) studied on assessment of fish-biodiversity of Koya Kujiya Beel, Abhayapuri, Assam in Relation to Certain Physicochemical and Anthropogenic Factors. He identified total 45 species of fishes. He established that most of the physico-chemical and biological attributes provide congenial environment for fish growth in the beel. The fish catch statistics revealed that the population status of the fish species has been found to be gradually declining in this study.

Khan (2005) studied the temporal and spatial variation in species diversity in fishes in the Karnafully river estuary, Chittagong. Regression analysis showed that Secchi disk depth (Transparency), Dissolved oxygen, Salinity and Alkalinity were positively correlated with species abundance, and CO2, SiO3-Si, NO2-N, PO4-P, HCO3, water temperature, pH were negatively correlated with species abundance.

Mushahida-Al-Noor and Kamruzzaman (2013) the physical and chemical condition of Rupsha River of Khulna and Edaphic factors of the study area was chemically analyzed for 12 months (January-December, 2011).They obseved temporal variation of water temperature between summer (33.1±3.79 ºC at July) and winter season (11.6±5.89 ºC at December) and transparency was lower in June (15.7±3.61cm) and higher in December (42.4±8.72cm). They recorded turbidity level of the Rupsha River was lower in December (14.2±5.29 NTU) and higher in June (26.22±3.61 NTU). They observed pH of the water of the river was lower in June (7.58±0.14) and higher in December (8.58±0.29) and dissolved oxygen was higher in December (6.71±0.06 mg/l) and lower in June (5.09±0.06 mg/l).

Namdev and Singh (2012) investigated on physico-chemical properties of water of Yamuna river at Hamirpur (U.P.) has revealed that the distribution and bioaccumulation of lead in water, sediments and fish fauna indicated that the concentration of lead is derived from industries at Kalpi, sewage water and fly ash from industries at Sumerpur near Hamirpur. They recorded temperature, pH, total hardness, nitrogen, phosphorus, potassium, calcium and total lead were 17.71±1.837, 8.29±0.64, 197.8±3.768, 3.93±1.27, 2.133 ±0.373, 34.16±3.45, 81.13 ±0.664, and 1.16±0.43 respectively.

Oketola *et al.* (2013) implemented a research on River Ogun to measure water quality using multivariate statistical techniques. Water quality parameters were recorded from 8 sampling points during 6 year sampling periods (*i.e.*, 2000, 2005, 2006, 2009, 2010, and 2011). The samples were analyzed for 14 phys- ico-chemical parameters and heavy metals such as temperature, pH, total solids (TS), total dissolved solids (TDS), sus- pended solids (SS), oil and grease, dissolved oxygen (DO), chemical oxygen demand (COD), Cl−1, alkalinity, total hardness (TH) and heavy metals (Cd, Cu, Fe, Ni, Pb, Mn, and Zn).

Panigrahi and Biswas (2014) carried out a studyto evaluate the status of water quality parameters in Nabaganqa River, Jhenidah, and the south western part of Bangladesh during the period from June 2012 to May2013. They observed that temperature and pH were within the standard limit and alkalinity, COD, Hardness, Free CO2, Organic carbon exceed permissible limit

Rashid (1999) recorded water quality of the Bakkhali river estuary where the range of water temperature, pH, salinity, PO4 –P, Alkalinity, TDS and TSS were 21.3 to 30.40 OC, 5.8 to 8.1, 34.71 ppt, 0.071 to 0.233 mg/l, 61 to 135 mg/l, 251.93 to 586.09 mg/l, 91.17 to 213.25 mg/l respectively. He studied the water quality and commercially important Ichthyo-fauna on the Bakkhali river estuary respectively and the river has been changed day by day for discharging different types of pollutants in the river from the industries situated on the bank of the river.

Ramoss *et al.* (2006) studied the temporal and spatial distribution of larval fish assemblages in the Lima estuary (Portugal). In this study a total of 12903 larvae, belonging to 20 families 12 and 50 taxa where collected, with a mean abundance of 8 individuals per 100 m3. Fish larvae should a seasonal trend with abundances increasing during spring and summer. Overall result suggest that the Lima estuary larvae fish assemblage has a strong seasonality controlled the presence of temporary estuarine resident, while environmental aspects controlled the general abundance trend of the resident species.

Sarwar (2010) studied on the Karnafully River Chittagong, Bangladesh. He observed the mean values of water temperature, total suspended solids (TSS), total dissolved solids (TDS), total solids (TS), turbidity, dissolved oxygen (DO), bio-chemical oxygen demand (BOD), chemical oxygen demand (COD), pH, electric conductivity and total alkalinity were 23ºC, 365.87 mg/l, 8018.8, 8518.33 mg/l, 31.54 FTU, 1.55 mg/l, 6.65 mg/l, 13961 µs/cm, 247.47 mg/l, 560.27 mg/l and 4.8 mg/l respectively in the study area.

Shah and Pandit (2012) investigated to monitor the water quality over a period of one year on monthly basis at five study sites in the lake. They recorded the overall surface water temperature ranged from 2.20C to 32.4 C transparency from 0.2 m to 2.2 m; depth from 0.3 m to 5.5 m; pH from 7 to 8.8; dissolved oxygen from 3.4 mg/l to 11.5 mg/l ; total alkalinity from

47mg/l to 257 mg/l ; free CO2 from 8 mg/l to 28mg/l ; chloride from 8.4 mg/l to 29 mg/l ; ammoniac nitrogen from 49 µg/l to 542 µg/l; nitrate nitrogen from 146 µg/l to 483 µg/l, orthophosphate 13.0 µg/l to 36 µg/l and total phosphate from 102 µg/l to 297 µg/l.

Singh *et al.* (2013) assessed some physico chemical parameters of the Yamuna River at Mathura. They collected and analyzed samples for two consecutive years 2011 and 2012. They revealed pH of river ranged from a minimum 7.2 and 8.3 in summer D.O 3.0 to10.4 in winters B.O.D. 14.0 to 52.7 in summers and C.O.D. 11.4 to 35.2 in winter's whileas T.D.S. 460 to 553 in rains.

Thirupathaiah *et al*. (2012) studied to estimate the status of physico-chemical characteristic of Lower Manair Reservoir at Karimnagar District, Andhra Pradesh. They analyzed and recorded Monthly changes in physico- chemical parameters such as water temperature, pH, turbidity, transparency, total dissolved solids, total hardness, chlorides, phosphate, nitrates, dissolved oxygen and biological oxygen demand for a period of one year from September 2009 to August 2010. The results obtained from that study area indicated that physico-chemical parameters of the water were within the permissible limits and can be used for domestic, irrigation and pisciculture.

2.3 Planktonic Assemblage

Ahsan *et al*. (2012) conducted a study in the the Ganges-Meghna river system route. They documented 58 taxa of Plankton of which, 19 taxa (32.76%) were of phytoplankton and 39 taxa (67.24%) of zooplankton. They recorded phytoplankton group belonged to Cyanophyceae (6 taxa), Chlorophyceae (7 taxa) and Bacillariophyceae (6 taxa) while zooplankton including Protozoa (10 taxa), Rotifera (19 taxa), Copepoda (4 taxa), Cladocera (5 taxa) and Ostracoda (1 taxon).

Chowdhury *et al*. (2007) carried out a study about Seasonal variation of the plankton populations with some water quality parameters of Borobila beel freom July 2003 to June 2004. They recorded total plankton ranged from 98.3×104 to 35.0×105 cells/l with mean values of 19.67±9.77×105 cells/l. They listed a total of 51 genera of planktons were recorded belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae, Crustacea and Rotifera. They figure out the phytoplankton, Euglenophyceae was the most dominant group and contributing 33% of total phytoplankton in Borobila beel.

Chughtai *et al*. (2011) investigated the monthly variations in planktonic life of river Chenab as affected by sewage of Multan City by analyzing frequency of occurrence, relative abundance and diversity index of plankton life. They divulge phytoplankton were abundant as compared to Zooplankton. They documented 86 Phytoplankton genera among them 13 were of Cyanophyta, 34 of Chlorophyta, 28 of Chrysophyta, 3 of Cryptophyta, 5 of Euglenophyta and 3 genera of Pyrrhophyta.They figure out eighteen genera of Zooplankton including 12 of Protozoan, 5 of Rotifers and one genus of Cladoceran and diversity index of phytoplankton ranged from 3.34 to 6.79 and diversity index of zooplankton ranged from 0.51 to 2.58.

Ferdous *et al*. (2012) conducted a research in the River Buriganga to examine the physic chemical parameters and biological aspects of tannery effluents sewage from October 2009 to September 2010. They recorded 27 genera of phytoplankton belonging to the families Cyanophyceae, Bacillariophyceae, Chlorophyceae, Euglenophyceae and Cryptophyceae.

Patil *et al.* (2015) investigated temporal and spatial changes in zooplankton diversity of five major wetlands from Ajara tahsil of Maharashtra. They recorded total 23 species of zooplanktons comprising 13 species from Gavase wetland, 14 species from Dhangarmola wetland, 14 species from Yarandol wetland, 7 species from Khanapur wetland and 16 species from Ningudage wetland. They revealed rotifer was dominant at all wetlands except Ningudage wetland, where it was copepod.

Shinde *et al.* (2012) conducted a research on seasonal variations and biodiversity of zooplankton in Harsool Savangi dam, Aurangabad, India. They listed a total of 25 genera having 10 rotifers, 8 cladocerans 5 copepods and 2 ostracods.

Ogbuagu and Ayoade (2012) investigated planktonic abundance and diversity of the Imo River in Etche, a Niger Delta region of Nigeria `between March 2007 and February 2009. They recorded 43 phytoplankton genera and a mean density of 1859 cells/ml. They documented dominant phytoplankton was the Bacillariophyceae (53.25%), followed in order by Cyanophyceae (21.25%), Chlorophyceae (10.33%), Chrysophyceae (4.84%), Pyrrophyceae (4.57%), Xanthophyceae (3.39%) and Euglenophyceae (2.42%) and zooplankton was made up of 7 taxa and a mean density of 433 organisms/ml. The order of dominance was the Cladocera (25.87%), Copepoda (20.55%), Protozoans (19.17%), Rotifera (18.71%), fish eggs and larvae (9.24%), Crab larvae (4.62%), and Beetle larvae (0.69%).

2.4 Benthic Composition

Asadujjaman *et al*. (2012) carried out a research in Hatiya and Nijhum Dweep Islands and recorded 10 major groups of macrobenthos. The macro benthos included polychaetes (45.03 %), oligochaetes (16.65 %), and shrimp larvae (13.93 %), crab (9.63 %), gastropods (3.56 %), isopods (1.15 %), bivalves (1.15 %), copepods (0.73 %), annelids (0.42 %), amphipods (0.63 %) and others (7.12 %). Polychaete was dominant by contributing 45.03 % of total macrobenthos.

Chakma *et al.* (2015) implemented a study in earthen pond of Noakhali district and identified 10 major taxa namelyPolychaetes, Oligochaetes, Gastropods, Amphipods, Bivalve, Diptera, Crab, Isopods, Prawn larvae and Copepod. Oligochaetes were found dominant (49 -75%) in all the experimental ponds. This study reveals that macrobenthic fauna and their density are variable among the freshwater ponds.

Dittmann (2001) carried out a research in mangroves of Missionary Bay, North Queensland, and Australia and identified 39 taxa of benthic organisms. Oligochaeta were more abundant in mangrove sediments.

Mustafa *et al.* (2013) conducted a study at three water bodies of Dhaka (Ramna Park Lake, Baldah garden Pond and Naya bazar pond) from December 2011 to May 2012. A total of 15 genera of benthos were found in Ramna Park Lake, 7 in Baldah garden pond and 9 in Naya bazar pond. The species diversity was more in Ramna Park Lake than in others as the water of Ramna Park Lake seems to be less polluted.

CHAPTER THREE
MATERIALS AND METHOD

Methodology plays a crucial role in any scientific research. Appropriate methodology enables the researcher to collect valid and reliable information and to analyze the information properly in order to get research results. The method of data collection depends upon the nature, aims and objectives of the study undertaken.

3.1 Study area

The study was conducted at Ratargul swamp forest which is located under the Goyainghat upazilla in Sylhet district, Bangladesh. It is situated at about 45 km on the North-west of Sylhet town on the bank of river Goyain.The Goyain River ultimately drains into the Surma River. The administrative beat office of Ratargul is at latitude 25˚00.025´N and longitude 91˚58.180´ E.

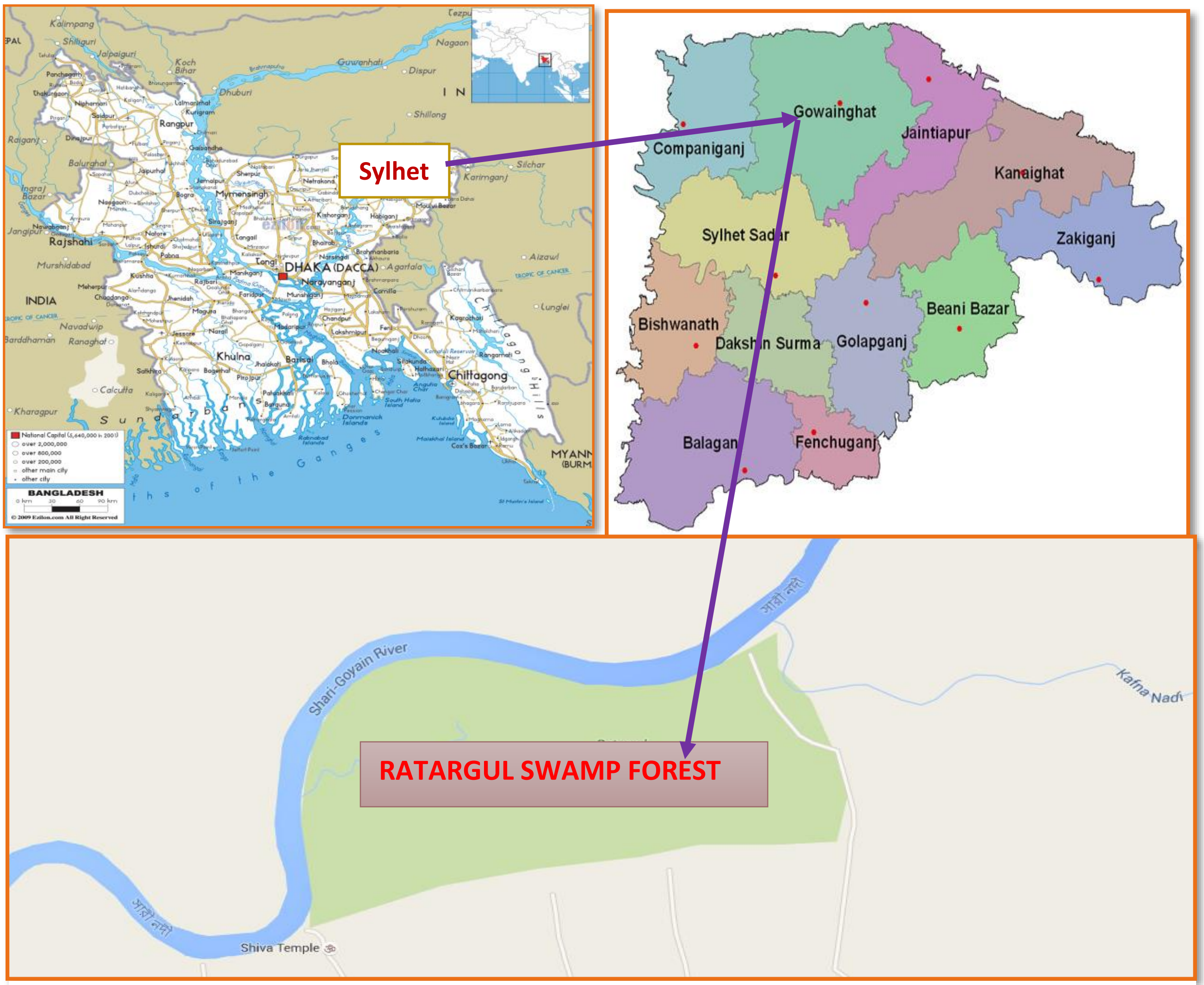


Figure 3.1: Map showing study area in Ratargul swamp forest under Sylhet district of Bangladesh.

3.2 Study period

The study was carried out for seven months during April 2015 to October 2015. Though water remains year round in some parts of the forest but fishing is done mainly from April to November. Hence the study was conducted at that time period.

3.3 Data collection protocol

There are several methods of collecting data and information. In the present investigation both perception study and sampling method are employed.

3.3.1 Interview

Interview is a data collection strategy used across many disciplines. Interview is very popular among the most familiar strategies for collecting qualitative data. In-depth interview "permits the researcher to explore fully all the factors that underpin participants answer: reasons, feelings, opinions, and beliefs" (Legard et al. 2003: 141). Interviews were prepared for collection of relevant data in accordance with the objectives of the study.

3.3.1.1 Individual interview

Using a semi-structured questionnaire, total fifty individual interviews were conducted with fishers, stakeholders, retailors and local aged people. Individual interviews were conducted on their fishing boat, working areas nearby study area, or in the adjacent fish market.

Figure 3.2: Individual interview with fishers

3.3.1.2 Focus Group Discussion

In the present study FGD was conducted with fishers, boatman and adjacent community. FGD was used to get an overview of particular issues such as existing fishing systems, ecosystem of the swamp forest, previous condition, causes of the reduction of fish availability etc. Total eight

FGD sessions were conducted in the study area where each group size of FGD was six to ten fishers.

Figure 3.3 Group discussion with fishers and local community.

3.3.1.3 Key informant interview

Key informants were selected for their knowledge and role in a setting and their willingnessand ability to serve as translators, teachers, mentors and/or commentators for the researcher (Poggie, 1972). Cross-check interviews were conducted with key informants such as knowledgeable persons of fishing community, government fisheries officer, government forestry officer, journalist and NGO workers. In total six key informant interview were conducted in the present study.

3.3.2 Direct sampling

3.3.2.1.1 Fish sampling

To estimate the fish diversity of Ratargul swamp forest, number of each species of fish were counted weekly throughout the entire study period from on spot, landing centers (Motor ghat and Ratargul ghat) and adjacent fish market (Shaheber Bazar, sunaimuri Bazar, motorghat Bazar). Firstly, it was a difficult job to count the number of fish species. Fishers and local retailers were unwilled and bored to give the chance of handling and counting fish. Later, they were requested and convinced to realize the importance of that research and capable to count the number of fish.

3.3.2.1.2 Collection and identification of fish sample

The fishes were collected during sampling and counting. Collected sample were preserved in 5% formalin and transferred to the laboratory of Fish Biology and Genetics, Sylhet Agricultural University. In laboratory, samples were sorted, rinsed with tap water, color was observed and identified up to species level. The fish were identified by dint of the species classification proposed by Shafi and Quddus, 1982; Talwar and Jhingran, 1991; Fish base, 2013.

3.3.2.1.3 Photography

Photographs of each fish were taken by using digital camera. Fresh and robust fishes were selected for taking photographs. Finally, the photographs were further enhanced and edited by using computer.

3.3.3.2 Methods of physicochemical analysis

Water samples of Ratargul swamp forest were collected from the three spots viz. north, west and south point during last week of each month throughout the entire experimental time span at 8 A.M - 9.30 A.M in clean black plastic air tight bottles. Water samples were collected from 0.5m deep of the water surface. Water quality parameters were determined in the boat immediately after collection of sample. Physical parameters such as temperature and turbidity were measured by centigrade thermometer (div=0.1°C) and Secchi disc (25cm radius) respectively. Chemical parameters such as dissolved oxygen, p^{H}, ammonia, ammonium ion, and nitrite were measured by using HACH Test Kit (Model: FF-2, Cat No. 2430-01; Company: HACH Company World Headquarters, Loveland, Colorado, USA). Monthly data about some edaphic factors like photoperiods, rainfall and relative humidity were collected from local meteorological station of Sylhet.

Figure 3.4: Determination of water quality parameters in study area.

3.3.3.3 Methods of plankton analysis

Plankton samples were collected from the investigation area during last week of each month throughout the whole experimental time period at 8 A.M - 9.30 A.M. Collection of plankton was made by sieving 50 liters of habitat water from approximately 8 - 10 cm below the surface level passed through a 25 µm mesh net and finally concentrated to 25 ml. Then samples were preserved with 5% formalin solution and brought to the laboratory of Fish Biology and genetics of SAU for further experimentation. To avoid sunlight, samples were kept in a dark place for one day to facilitate the precipitation process. Finally, samples were observed under electric microscope (Olympus Xcam-Alpha, Germany) to identify planktons both qualitatively and quantitatively. Each sample was stirred smoothly just before microscope examination. Planktons were identified by keys given by Needham & Needham (1974), Bellinger (1992) and APHA (1998). The formula for calculating the number of organisms per litre of the sample using the drop count method is as below:

Total plankton count per litre = A × (1/L) × (n/v)

A = number of organisms per drop

L = volume of original sample (l)

n = total volume of concentrated sample (ml)

v = volume of one drop (ml)

In the present study,

n = 25 ml

L = 50 litre

25 drops = 1 ml

v = 1/25 ml = 0.04

Figure 3.5: collection of plankton in study area

3.3.3.4 Method of macro benthic analysis

The macro benthic samples were collected from study area with hand-held mud corer during the study period (April-October, 2015). The corer was pushed into the sediment and sediment of the corer was taken in bucket. The sediment samples of bucket were mixed with water. Then the mixed water passed through a hand-sieve with 0.5 mm mesh. The sieved organism were preserved in the plastic pot with 10% buffered formalin and labeled and then transferred to laboratory for further analysis. For identification, the samples were taken into a round transparent Petri dish (diameter 10 cm and depth 2 cm) and placed on a white paper background for the easy contrast of vision. Organisms were sorted and identified up to major taxa and preserved in small vials by using small brush or forceps. Electric microscope (Olympus Xcam-Alpha, Germany) with digital camera (model No: XSZ21-05DN) was used to identify and capture the image of benthos. An attempt has been made to determine quantity and identify the macro benthos up to genus or species level but due to technological limitation, lack of fund and appropriate literature it was not possible.

Figure 3.6: Benthos collection from study area.

3.3.3.5 Assessment of aquatic weed diversity

The ecosystem was visited, during these visits the flora found in the forest were observed and noted. The relative abundances were assessed while walking through the ecosystem. The samples of aquatic weed were collected from different site of the swamp forest. Collected samples were transferred to the laboratory of Fish Biology and Genetics. Identification was done by only eye observation with the help of secondary literature. Identification was done up to possible taxonomic groups. Finally, the results were tabulated.

3.3.3.6 Secondary document analysis

The secondary documents were collected for information about situation or events that are not covered by empirical investigation (Islam, 2012; Hammersley & Atkinson 1995). Secondary information were collected from district forest office of sylhet, upazilla and district fisheries office of sylhet, scientific articles, governmental reports, and newspaper reporting etc. Internet search engine were employed to retrieve these documents. This secondary information was helpful in collecting background information and filling small gaps in empirical evidence.

3.4. Diversity analysis

Diversity of the species cluster was analyzed by dint of the Shannon-Wiener index (*H′*) (Shannon and Weaver, 1963), species richness was measured by Margalef index (*d*) (Margalef, 1968), evenness was measured by Pielou's index (*J′*) (Pielou, 1966), and dominance was measured by Simpson index (*c*). The value of Shannon-Wiener diversity index and Margalef richness index, Pielou's evenness index and Simpson dominance index were calculated by using the following formula:

3.4.1 Shannon-Weiner diversity index (*H′*):

$$H' = SUM\ [Pi \times \log (\mathrm{Pi})]$$

Where,

H' = Shannon Wiener index

Pi = ni/N

ni = no. of individuals of a species

N = Total number of individuals

3.4.2 Margalef species richness (*d*):

$$d = (S\text{-}1)/\log (N)$$

Where,

S = Total species

N = Total individuals.

3.4.3 Pielou's evenness index (*J′*):

$$\boldsymbol{J'} = \frac{H(s)}{H\ (\max)}$$

Where,

H (s) = the Shannon-Wiener information function.

H (max.) = the theoretical maximum value for H(s) if all species in the sample were equally abundant.

3.4.4 Simpson dominance index (*c*):

$$\mathbf{C} = \sum_{n=1}^{s} \frac{ni}{N}$$

Where,

ni = number of individuals in the 'each' species

N = total number of individuals

S = total number of species

3.5 Statistical Analysis

Similarity percentages analyses (SIMPER) (Clark, 1993) were used to observe the percentage contribution of each taxon to the average dissimilarity between the various season combinations. Hierarchical agglomerative clustering with group-averaging linking and Non-Metric Multidimensional Scaling (nMDS) was performed to determine similarities among fish abundance (Clarke and Warwick, 1994) and analysis were based on the Bray-Curtis similarity measure (Bray and Curtis, 1957). All the multivariate analyses were performed using the software PRIMER V6 (Plymouth Routines Multivariate Ecological Research) (Clark and Warwick, 1994). Statical analysis was performed with the aid of the computer software SPSS version 20. Significant results were further tested using Duncan's New Multiple Range test (DMRT) to identify significance differences in water quality parameters.

3.6 Plan and overview of activities:

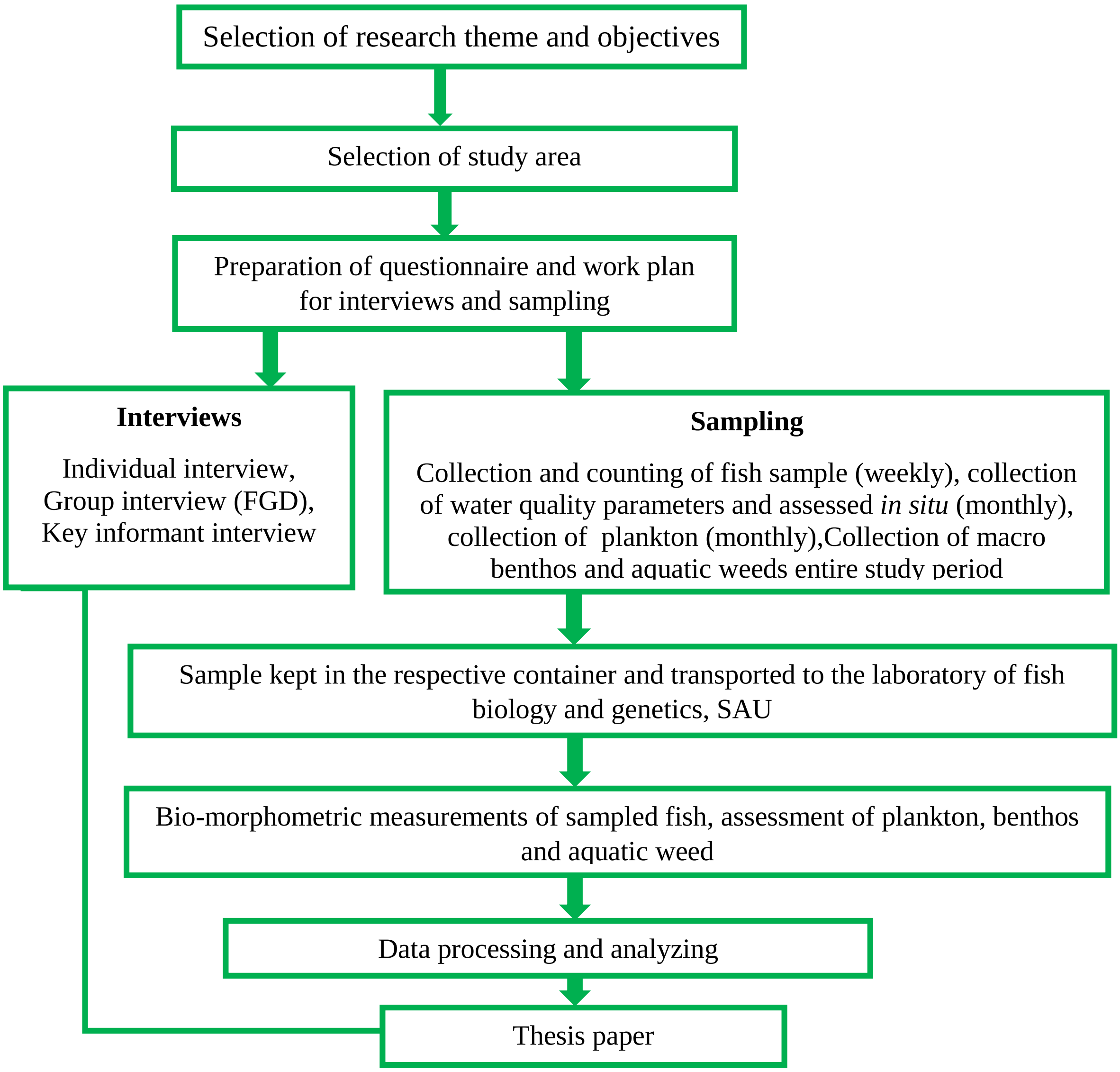


Figure 3.7: Flow Chart of methodology followed in the present study.

CHAPTER FOUR
RESULT AND DISCUSSION

4.1.1 Fish biodiversity of Ratargul swamp forest

A total of 62 species of fishes belonging to 9 orders under 27 families were recorded which supports with findings of Alam *et al.* (2013), Ali *et al.* (2014), Rahman *et al.* (2015) and Mohsin and Haque (2009). Alam *et al.* (2013) carried out an investigation on Upper Halda River and recorded 63 species belonging to 24 families. Mohsin and Haque (2009) investigated on Mahananda River and recorded 56 fish species under 9 orders and 20 families. Ali *et al.* (2014) conducted a research on Chitra River and recorded 53 species of fish under 10 orders and 23 families. Rahman *et al.* (2015) carried out a research in Talma River and identified 56 species under 8 order and 21 families.

During the study period Cypriniformes were found the most leading order contributing 37.46% of the total fish assemblage followed by Siluriformes (35.123%), Perciformes (19.456%), Synbranchiformes (3.298%), Clupeiformes (2.282%), Beloniformes (1.161%), Osteoglossiformes (0.725%), Tetraodontiformes (0.462%) and Anguiliformes (0.026%). The finding coinside with the findings of Ali *et al*. (2014). They estimated Cypriniformes were most leading order constituting 33.96% of the total fish population followed by Siluriformes (22.64%), Perciformes (24.53%), Mugiliformes (3.77%), Clupeiformes (1.89%), Synbranchiformes (5.66%), Osteoglossiformes (1.89%) and Tetraodontiformes (1.89%).

A list of different fish species with their details information are shown in Table 4.1.

Table 4.1: List of different fish species with their order, family, scientific name, common name, local name, individual percentage, order percentage, family percentage and IUCN status

Sl. No.	Order	Family	*Scientific Name*	English Name	Local Name	Individual %	Order %	Family %	IUCN Status
1	Anguiliformes	Anguillidae	Pisodonophis boro	Rice-paddy Eel	Bamas	0.0264	0.026	0.0264	NT
2	Beloniformes	Belonidae	*Xenentodon cancila*	Fresh water gar fish	Kakhila	1.042	1.161	1.042	NT
3		Hemiramphidae	*Hyporamphus limbatus*	Congaturi halfbeak	Ekthota	0.119		0.119	NT
4	Clupeiformes	Clupeidae	*Gudusia chapra*	Indian river shad	Chapila	2.269	2.282	2.282	NT
5			*Tenualosa ilisha*	Indian river shad	Ilish	0.013			NT
6	Cypriniformes	Cobitidae	*Lepidocephalus guntea*	Guntea loach	Gutum	2.322	37.463	3.496	NT
7			*Somileptus gongota*	Gongota loach	Bagha gutum	0.211			NT
8			*Botio Dario*	Bengal loach	Rani	0.857			EN
9			*Nemachilus botia*	Zipper loach	Kholoi muchuri	0.106			DD
10		Cyprinidae	*Labeo rohita*	Indian major carp	Rui	0.488		33.967	NT
11			*Catla catla*	Indian major carp	Catla	0.725			NT
12			*Labeo kalbasu*	Black rohu	Kalibaush	0.580			EN
13			*Labeo gonius*	Kuria labeo	Ghonia	0.198			EN
14			*Cirrhinus cirrhosus*	Indian major carp	Mrigal	0.145			NT

Sl. No.	Order	Family	*Scientific Name*	English Name	Local Name	Individual %	Order %	Family %	IUCN Status
15			*Cirrhinus reba*	Reba carp	Lachu	1.068			VU
16			*Osteobrama cotio*	Cotio	Dhela	0.066			EN
17			*Amblypharyngodon mola*	Mola carplet	Mola	4.287			NT
18			*Puntius ticto*	Firefin barb/ticto barb	Tit punti	1.439			VU
19			*Puntius sarana*	Olive barb	Sarpunti	0.185			CR
20			*Puntius sophore*	Spot fin swamp barb	Jat punti	19.325			NT
21			*Esomus danricus*	Gangetic scissortail rasbora	Darkina	5.461			DD
22	Osteoglossiformes	Notopteriidae	*Notopterus notopterus*	Bronze featherback	Foli	0.699	0.725	0.725	VU
23			*Notopterus chitala*	Humped featherback	Chitol	0.0263			EN
24	Perciformes	Ambassidae	*Parambassis ranga*	Ranga chanda	Lal chanda	4.129	19.456	4.129	VU
25		Anabantidae	*Anabas testudineus*	Climbing perch	Koi	3.219		3.219	NT
26		Chandidae	*Chanda ranga*	High finglassy perchlet	Lamba chanda	2.256		2.256	VU
27		Channidae	*Channa marulius*	Giant snakehead	Gozar	0.264		4.325	EN

Sl. No.	Order	Family	*Scientific Name*	English Name	Local Name	Individual %	Order %	Family %	IUCN Status
28			*Channa striatus*	Snakehead murrel	Shol	0.712			NT
29			*Channa punctatus*	Spotted snakehead	Taki	2.954			NT
30			*Channa orientalis*	Asiatic snakehead	Cheng	0.369			VU
31			*Channa barca*	Barca	Pipla shol	0.026			CR
32		Gobiidae	*Glossogobius giuris*	Bar eyed goby	Bele	0.765		0.765	NT
33		Mugilidae	*Rhinomugil corsula*	Corsula mullet	Halla	0.132		0.132	NT
34		Nandidae	*Nandus nandus*		Meni/veda	1.200		1.200	VU
35		Osphronemidae	*Colisa chuna*	Honey gourami	Koiya Chata.	0.317		3.311	NT
36			*Colisa fasciatus*	Sunset gourami	Colisha	2.994			NT
37		Sciaenidae	*Johnius coitor*	Coitor croaker	Poa,	0.119		0.119	NT
38	Siluriformes	Ariidae	*Arius gagora*	Gagora catfish	Gagla	0.079	35.123	0.079	NT
39		Bagridae	*Aorichthys aor*	Long-whiskered catfish	Ayer/aor	0.171		24.44	VU
40			*Aorichthys seengghala*	Giant river catfish	Guizza ayre	0.066			EN
41			*Rita rita*	Rita	Rita	0.277			CR
42			*Mystus bleekeri*	Gantatic mystus	Gulsha	2.572			NT

Sl. No.	Order	Family	*Scientific Name*	English Name	Local Name	Individual %	Order %	Family %	IUCN Status
43			*Mystus tengra*	Stripped dwarf catfish	Bujuri tengra	17.847			NT
44			*Mystus vittatus*	Striped dwarf catfish	Tengra	3.508			NT
45		Chacidae	*Chaca chaca*	Indian chaca	Cheka	0.0263		0.026	EN
46		Clariidae	*Clarias batrachus*	Walking catfish	Magur	1.279		1.279	NT
47		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	Shing	1.714		1.714	NT
48		Schilbeidae	*Eutropiichthys vacha*	Batchwa bacha	Bacha	0.435		5.513	CR
49			*Ailia puctata*	Jamuna ailia	Baspata	1.279			VU
50			*Ailia coila*	Gangetic ailia	Kajuli	1.517			NT
51			*Clupisoma garua*	Garua bacha	Ghaura	0.844			CR
52			*Neotropius atherinoides*	Indian potasi	Batasi	1.438			NT
53		Siluridae	*Wallago attu*	Freshwater shark	Boal	0.871		1.993	NT
54			*Ompok pabda*	Pabdah catfish	Madhu pabda	1.016			EN
55			*Ompok bimaculatus*	Indian Butter catfish	Kani pabda,	0.106			EN

Sl. No.	Order	Family	*Scientific Name*	English Name	Local Name	Individual %	Order %	Family %	IUCN Status
56		Sisoridae	*Bagarius yarrellii*	Gangetic goonch	Baghair	0.066		0.079	CR
57			*Conta conta*	Conta catfish	-----------	0.013			DD
58	Synbranchiformes	Mastacembelidae	*Mastacembelus pancalus*	Striped spiny eel	Guchi baim	0.963	3.298	3.245	NT
59			*Macrognathus aculeatus*	One striped spiny eel	Tara baim	1.899			VU
60			*Mastacembelus armatus*	Tire-track spiny eel	Shal baim	0.383			EN
61		Synbranchidae	*Monopterus cuchia*	Gangetic	Kuiccha	0.053		0.053	VU
62	Tetraodontiformes	Tetraodontidae	*Tetraodon cutcutia*	Ocellated pufferfish	Potka	0.462	0.462	0.462	NT

***** IUCN status Bangladesh (2000); CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Not Threatened; DD: Data Deficient.**

4.1.1.1. Cypriniformes

A total of 16 fish species were documented belonging to the order of Cypriniformes which contributing 37.46% of the total fish assemblage. Galib *et al.* (2013) recorded 18 species of fishes under Cypriniformes comprising 34.92% of all the number of species in the Choto Jamuna river of Bangladesh which was congruent with the present findings. Only two families of Cypriniformes were identified where Cyprinidae (33.967%) was the most dominant family followed by Cobitidae (3.496%). *P. sophore* was the highest catch contributing 19.325% and *O. cotio* was the lowest catch constituting 0.066%. Among this 16 species of fish; 7 species were threatened of which 4 species were endangered, 2 were vulnerable and 1 species was critically endangered according to IUCN 2000.

4.1.1.2 Siluriformes

There were 20 species of fish were recorded under the order siluriformes which contributing 35.123% of total fish population. Eight families were recorded under the order siluriformes of which Bagridae (24.44%) contributing the highest catch and chacidae (0.026%) contributing the lowest catch of total fish assemblage. Galib *et al.* (2013) documented 28.57% Siluriformes comprising 9.52% Bagridae and 6.35% Schilbeidae from Choto Jamuna river. *M. tengra* was the highest catch constituting 17.847% and *C. conta* was the lowest catch constituting 0.013% of total fish catch. Ten threatened and 9 non threatened species of fish were observed under the order siluriformes. Among 10 threatened species of fish, 4 were endangered, 2 were vulnerable and 4 were critically endangered according to IUCN 2000.

4.1.1.3 Perciformes

Fourteen species of fishes belonging to the order perciformes were documented which contributing 19.456% of total fish catch. Galib *et al.* (2013) recorded 19.05% Perciformes from Choto Jamuna River which was closest to the findings of present study. Nine families were recorded of which ambassidae the most was leading family and contributing 4.129% of total fish assemblage. Six threatened and 8 non threatened species of fish were recorded from the study area. Among six threatened species 1 was endangered, 4 were vulnerable and 1 was critically endangered according to IUCN 2000.

4.1.1.4 Synbranchiformes

Two families comprising 5 species belonging to the order Synbranchiformes contributing 3.298% of the total fish assemblage. Four threatened species of fishes were recorded from the study area according to the IUCN 2000. Sharif (2015) recorded three species under the order

Synbranchiformes contributing 3.78% of the total catch composition which is congruent with the present findings.

4.1.1.5 Osteoglossiformes

Two fish species of notopteriidae were recorded under the order of Osteoglossiformes comprising 0.725% of total fish catch. Among them *N. notopterus* was vulnerable and *N. chitala* was endangered according to IUCN 2000.

4.1.1.6 Clupiformes

Two species *G. chapra* and *T. ilisha* were recorded under the order clupeiformes contributing 2.28% of the total fish population. Both of this species are not threatened in Bangladesh according to IUCN 2000.

4. 1.1.7 Beloniformes

Two species *X. cancila* and *H. limbatus* were recorded under the order beloniformes contributing 1.161% of the total fish population. Both of this species are not threatened in Bangladesh according to IUCN 2000.

4.1.1.8 Tetraodontiformes

T. cutcutia was the only species belonging to Tetraodontidae contributing 0.462% of total fish species and it was not threatened in Bangladesh according to IUCN 2000.

4.1.1.9 Angiliformes

Pisodonophis boro was the only species belonging to Anguillidae contributing 0.026% of total fish species and it was not threatened in Bangladesh according to IUCN 2000.

4.1.2 Contribution of order and families

The dominant family was Cypriniformes contributing 37.46% of the total fish assemblage followed by Siluriformes (35.123%), Perciformes (19.456%), Synbranchiformes (3.298%), Clupeiformes (2.282%), Beloniformes (1.161%), Osteoglossiformes (0.725%) Tetraodontiformes (0.462%) and Anguiliformes (0.026%). This finding is coinside with the findings of (Sharif, 2015) who reported Siluriformes was dominant order comprising 36% followed by Cypriniformes (35%), Perciformes (15%) and Synbranchiformes (4%), Decapoda (4%), Osteoglossiformes (3%), Clupeiformes (2%) and Beloniformes (1%).

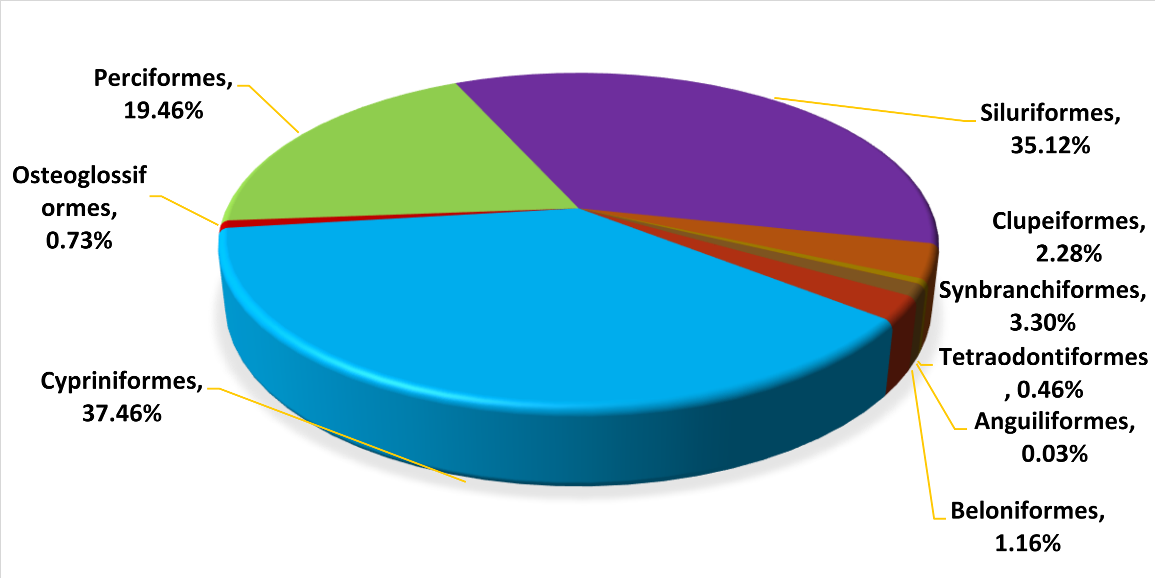


Figure 4.1: Contribution of different orders in biodiversity of Ratargul swamp forest

The most dominant family was cyprinidae comprising 33.97% of total catch followed by Bagridae 24.44%, Schilbeidae 4.33%, Channidae 4.33%, Ambassidae 4.13%, Cobitidae 3.50%, Osphronemidae 3.31%, Mastacembelidae 3.25%, Anabantidae 3.22% etc.

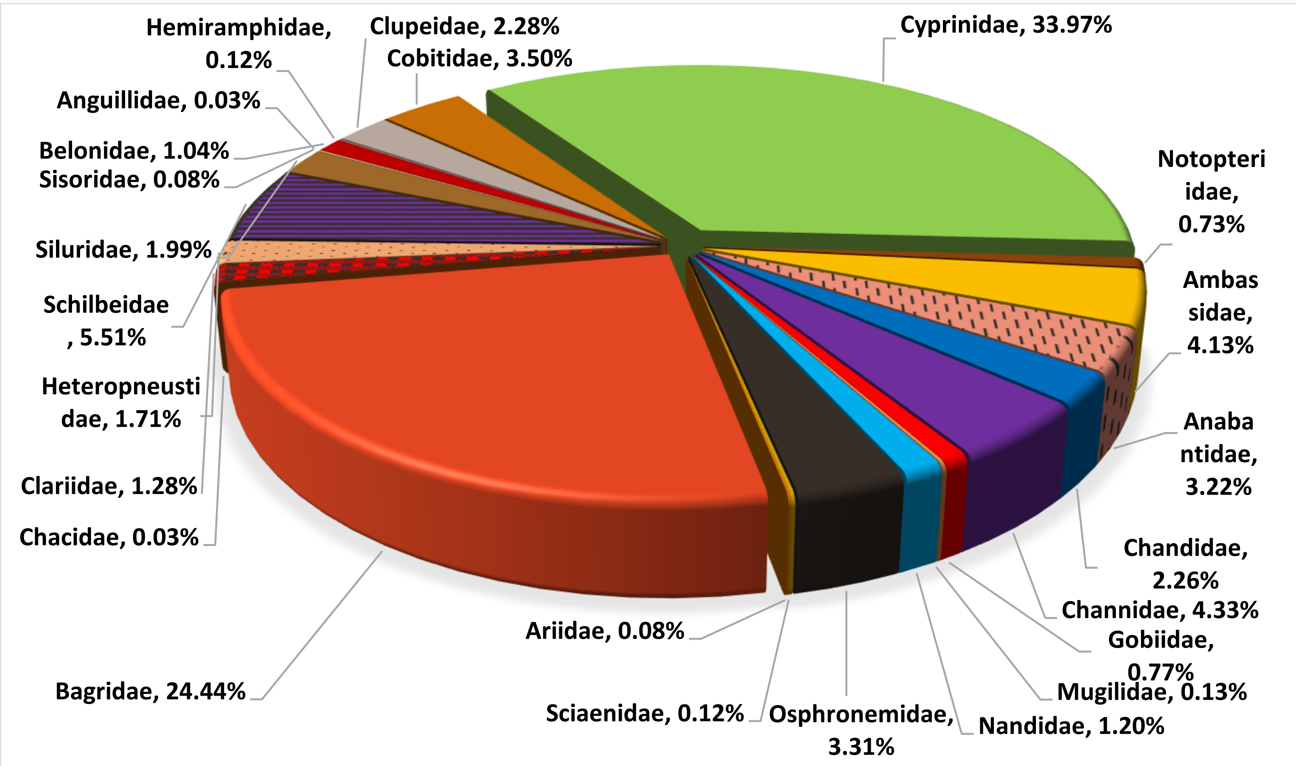


Figure4.2: Contribution of different families in biodiversity of Ratargul swamp forest

4.1.3 Monthly abundance of fish species

The highest catch was observed in October 46% and lowest catch was in April 6% of total catch composition.

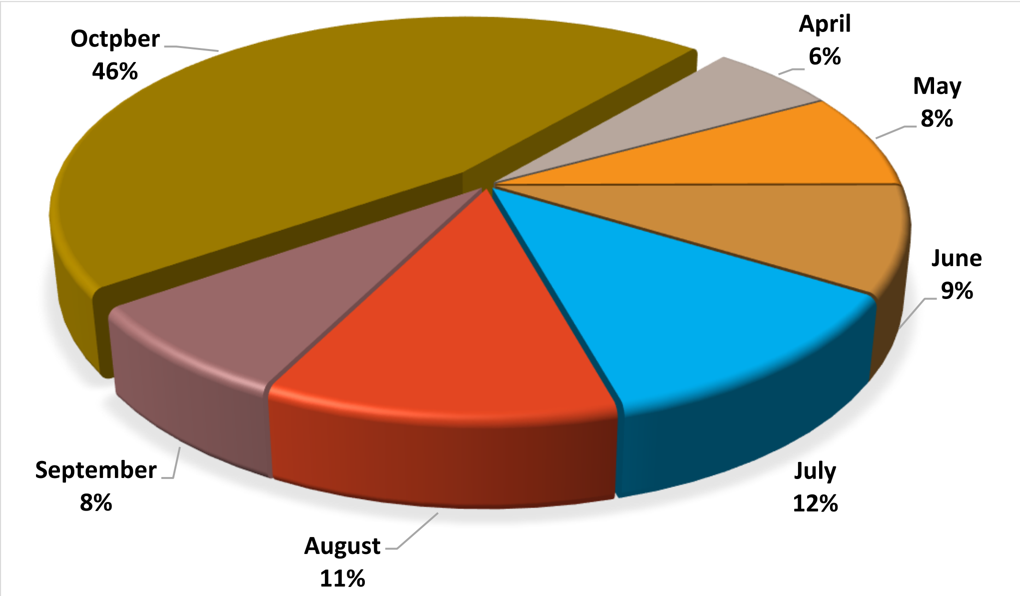


Figure 4.3: At a glance Month-wise fish catch composition of Ratargul swamp forest

4.1.4 Status of threatened fish species

The study area was suitable for breeding, feeding and nursing grounds for a number of threatened fish species. Hence a large number of threatened fish species are still present in the study area. Total 28 threatened fish species were found in the study area of which 6 were critically endangered (CR), 11 were endangered (EN), 11 were Vulnerable (VU) according to IUCN (2000). These findings is closely similar to the documents of Hossain (2013). He revealed 25 threatened species were threatened of which 3 were critically endangered (CR), 12 were endangered (EN), 10 were Vulnerable (VU) through a research on Chuto Jamuna River.

Table 4.2: Status of observed fish species according to IUCN (2000)

Status	Total number of species	Observed (%)
Vulnerable(VU)	11	14.56
Endangered(EN)	11	3.59
Critically endangered(CR)	6	1.83
Data deficient(DD)	3	5.58
Not threatened (NT)	31	74.43
Total	62	100

4.1.4.1 Status of critically endangered fish species

Six critically endangered fish species were recorded from the study area during the experimental period. Among them *C. garua* was the most leading species which contributed 0.84% followed by *E. vacha* (0.44%), *R. rita* (0.28%), *P. sarana* (0.19%),*B. yarrellii* (0.07%),*C. barca* (0.03%) showed in figure. Sharif (2015) reported seven species were critically endangered contributing *C. garua* (2.2%) followed by *R. rita* (1.51%), *P. pangasius* (0.74%), *E. bacha* (0.73%), *C. barca* (0.6%), *P. sarana* (0.53%) and *B. yarrellii* (0.34%) which congruent with the present findings.

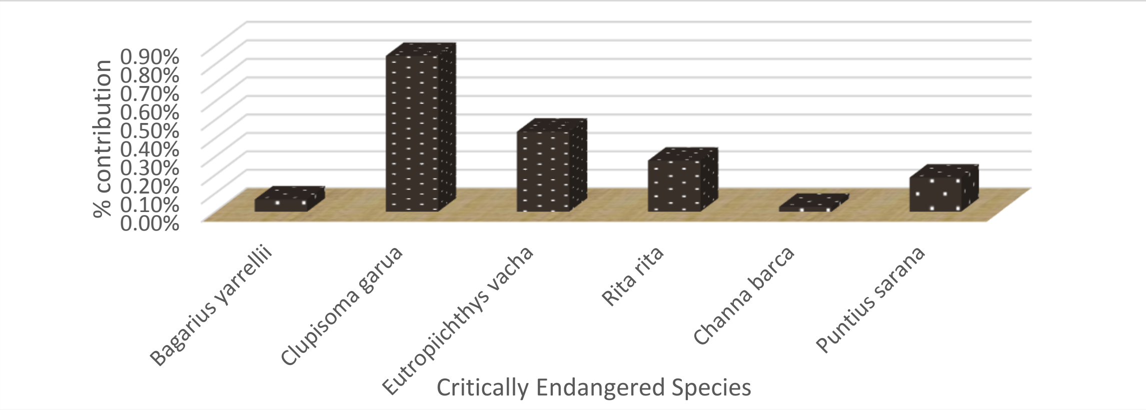


Figure 4.4: Status of Critically Endangered (CR) fish species assemblage

4.1.4.2 Status of endangered fish species

Total eleven endangered species of fishes were recorded from the study area which contributed 3.59% of total fish catch. Among them *O. Pabda* was the highest catch (1.02%) followed by*B. Dario* (0.85%), *L. kalbashu* (0.58%), *M. armatus* (0.26%), *C. marulius* (0.26%), *L. gonius* (0.19%), *O. cotio* (0.06%), *A. seenghala* (0.06%), *N. chitala* (0.026%) and *C. chaca* (0.026%) showed in following figure.Sharif (2015) documented eleven species were endangered contributing *L. kalbasu* (2.87%) followed by *B. dario* (2.76%), *E. danricus* (2.62%), *M. armatus* (2.51%), O. *bimaculatus* (1.86%), *N. chitala* (1.71%), *A. seenghala* (1.38%), *O. pabda*

(1.23%), *O. cotio* (0.75%), *C. marulius* (0.6%) and *C. chaca* (0.32%)which is harmonious with the present findings.

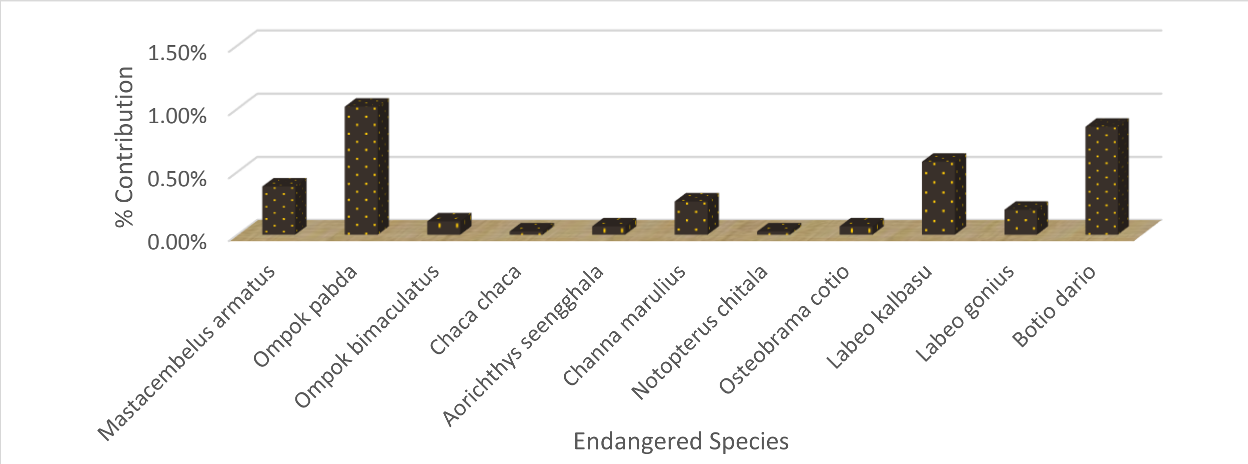


Figure 4.5: Status of Endangered (EN) fish species assemblage

4.1.4.3 Status of vulnerable species

Eleven vulnerable species of fishes were recorded from the study area which contributed 14.56% of the total fish catch. Among them *P. ranga* (4.12%) was the highest catch followed by *C. ranga* (2.25%), *M. aculeatus* (1.89%), *P. ticto* (1.43%), *A. punctata* (1.27%), *N. nundus* (1.2%), *C. reba* (1.06%), *N. notopterus* (0.69%), *C. orientalis* (0.36%), *A. aor* (0.17%), *M. cuchia* (0.05%) showed in following figure. Sharif (2015) identified eight vulnerable fish species which is almost near to the present findings.

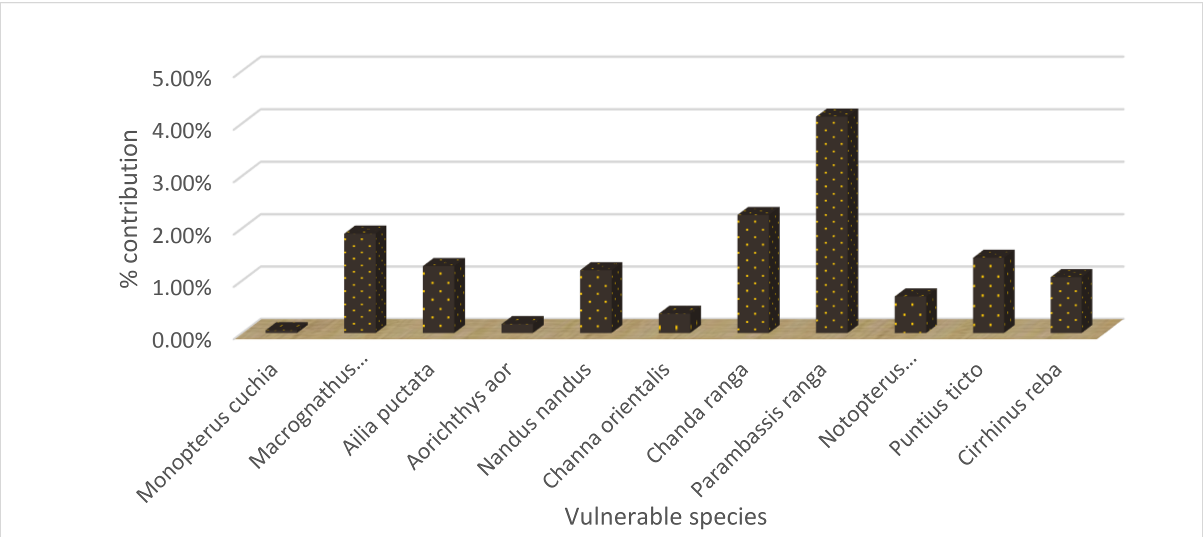


Figure 4.6: status of vulnerable (VU) fish species assemblage

4.1.5 Fishing gear used in study area

A total 8 types of nets, 6 traps, 2 wounding gears, 2 hook and lines were documented from the study area. Use of poisoning also observed from the study area in October when depth of the water body decreased. Besides, illegal fishing by current jal was also observed. These detrimental fishing methods reduce the availability and fish biodiversity of the study area. Sayeed *et al.* (2010) conducted a research on Chalan *beel and* revealed 34 different types of fishing gear including nets (11), Traps (l1), hooks and lines (4), wounding gears (4), FADs (3) and hand fishing (1).

Table 4.3: List of fishing gear used in the study area.

Category	**English Name**	**Local Name**	**Target species**
Net	Gill net	Current jal	SIS
	Gill net	Shutar jal	All
	Drag net	Dora jal	All
	Drift net	Fet fula jal	All
	Cast net	Jhaki jal/ ural jal	All
	Lift net	Dharma jal	All
	Push net	Thela jal	SIS
	Set bag net	Fatail jal/behundi jal	All
Traps	Fishing traps	Ghui	Big fish
		Baga	SIS
		queen	SIS
		Runga	SIS
		Bana	SIS
		Cheng	SIS
Wounding gear	Wounding gear	Koch	All
		Teta	All
Hook and lines		Chip borshi	Carnivore
		Tana borshi/ lar borshi	Carnivore
Hand fishing			All
Poisoning			All

Figure 4.7: Different types of fishing gear used in study area

4.1.6 Fish biodiversity indices

4.1.6.1 Shannon-Weiner diversity index (*H'*)

The Shannon Weiner diversity index (*H'*) ranged from 3.31(April) to 3.87(October) with mean value of 3.690±0.191.

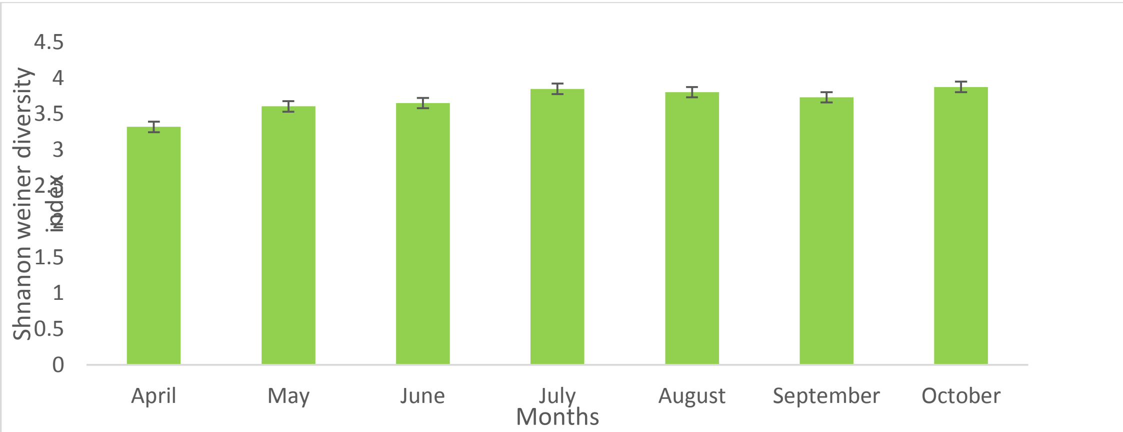


Figure 4.8: Shannon-Weiner diversity index (*H'*) in months

4.1.6.2 Margalef species richness (*d*)

The Margalef species richness (*d*) oscillated from 6.83(April) to 10.64 (July) with a mean value of 9.497± 1.314.

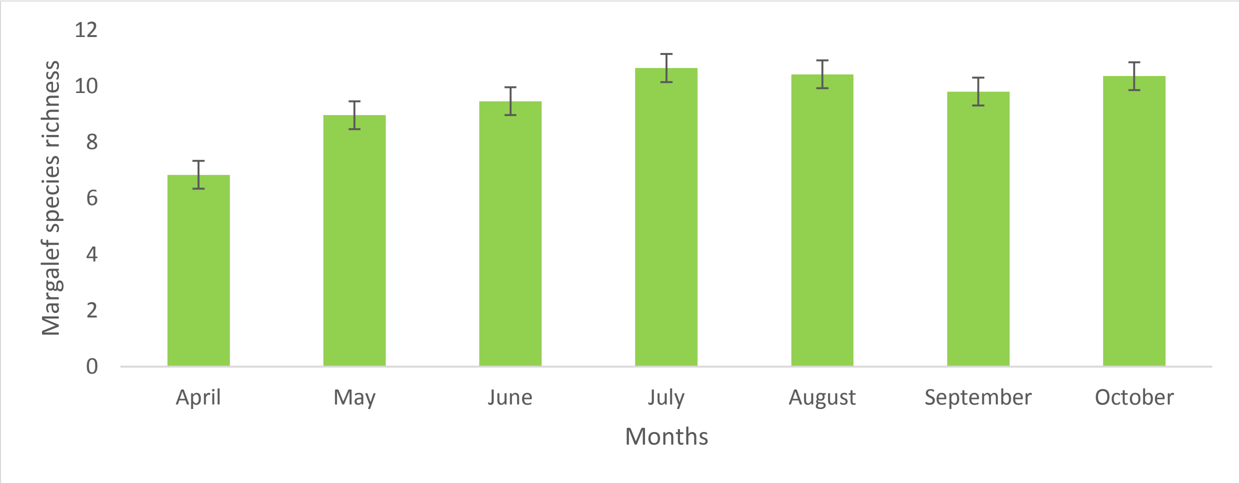


Figure 4.9: Margalef species richness (*d*) in months

4.1.6.3 Pielou's evenness index (*J'*)

The highest Pielou's evenness index (*J'*) 0.964 was recorded in June and lowest 0.975 was in April with a mean value of 0.971±0.003.

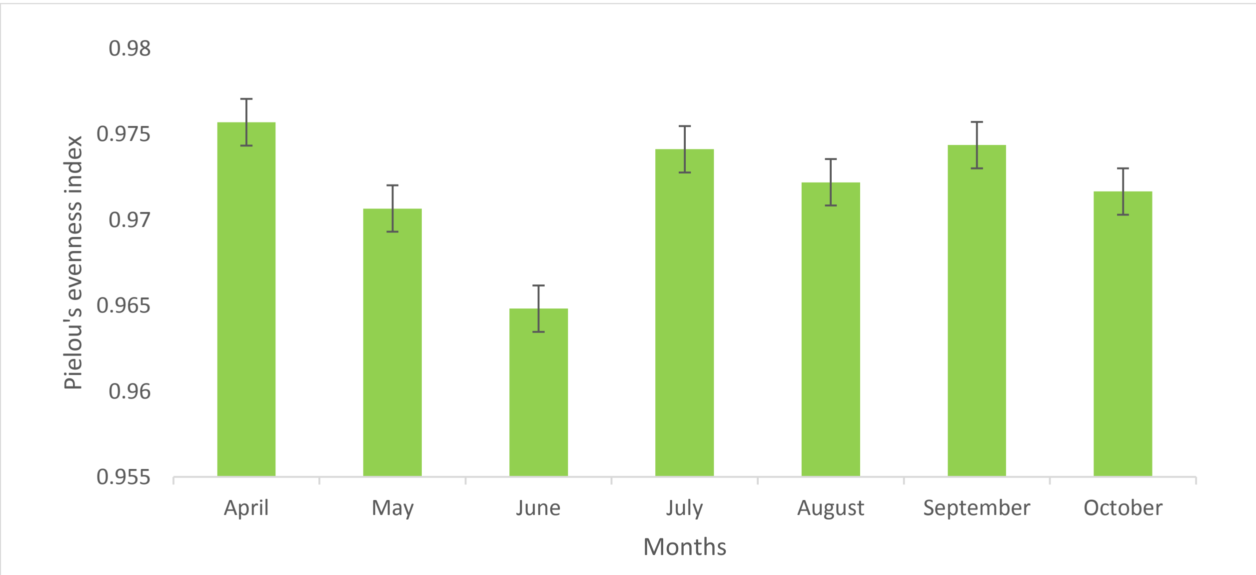


Figure4.10: Pielou's evenness index (*J'*) in months

4.1.6.4 Simpson dominance index (*c*)

The peak Simpson dominance index (*c*) value 0.985 was witnessed in July amd minimum 0.975 in April with a mean value of 0.982±0.003.

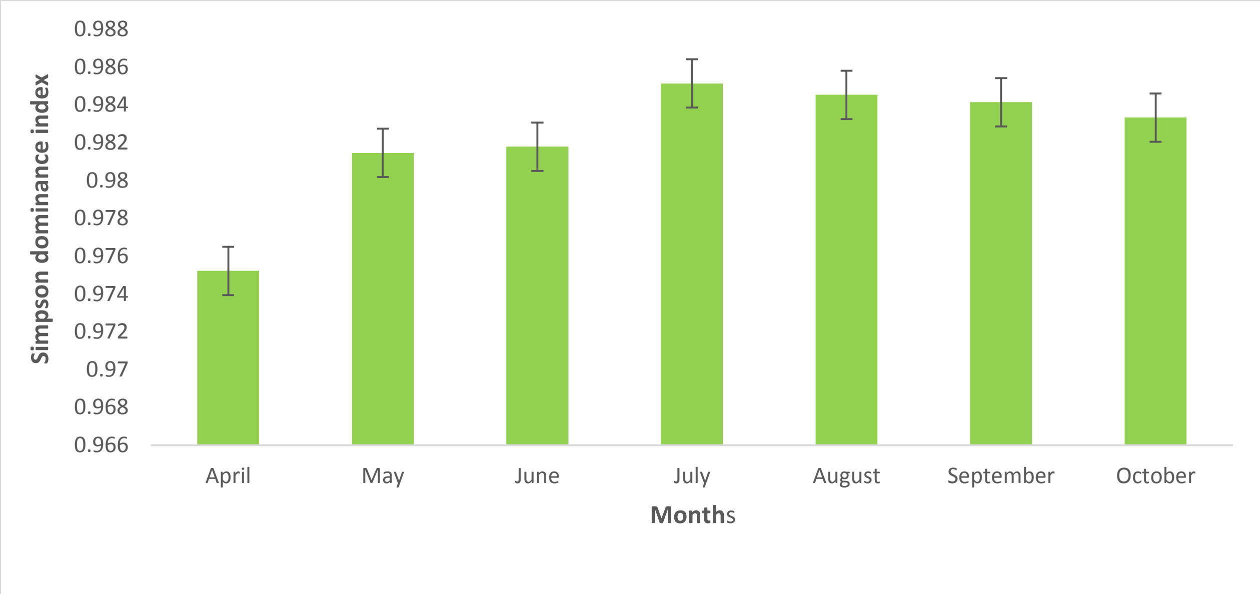


Figure4.11: Simpson dominance index (*c*) in months

A biodiversity index seeks to characterize the diversity of a sample or community by a single number (Magurran, 1988). The concept of the species diversity involves two components: the number of species or richness and the distribution of individuals among species. However, the formal treatment of the concept and its measurement is complex (Williamson, 1973). Shannon–Wiener diversity index considers the richness and proportion of each species while Evenness and Dominance indices represent the relative number of individuals in the sample and the fraction of common species respectively.

Shannon-Weiner diversity index (*H'*) shows moderately diverse fish assemblage in Ratargul Swamp Forest. Highest diversity index was observed in October while lowest in April. In October, depth of water body reduces and fish catch increased. That's why diversity showed highest in October. Margalef species richness (*d*) index was highest in July. This is may be due to the spawning season for many of the fishes. Hence species richness was highest in July. Fish species are more evenly distributed in April compared to other months according to Pielou's evenness index in the study area. Simpson dominance index was highest in July indicates species dominancy was highest in July compared to other months.

Hossain *et al.* (2012) reported higher Shannon diversity index values found in December (3.144875) where low during April (2.788875). Rahman (2015) reported that the value of H' ranged from 1.06 (June) to 1.51 (October), D varied from 5.34 (July) to 7.41(October), and c ranged from 0.65 (May) to 0.73 (October) of Talma River. This findings is in harmony with the present findings.

4.1.7 Fish species assemblage

4.1.7.1 Similarity Percentage (SIMPER) between months

SIMPER analysis divulged the average percent dissimilarity of species between different months. In the present study, it was revealed that 32.15% dissimilarity observed between April and May, 40.34% dissimilarity observed between April and June, 29.07% dissimilarity observed between May and June, 36.06% dissimilarity observed between April and July, 23.46% dissimilarity observed between May and July, 23.00% dissimilarity observed between June and July, 37.87% dissimilarity observed between April and August, 23.78% dissimilarity observed between May and August, 33.96% dissimilarity observed between April and September, 24.37% dissimilarity observed between June and August, 17.71% dissimilarity observed between July and August, 22.46% dissimilarity observed between July and September, 26.72% dissimilarity observed between May and September, 20.55% dissimilarity observed between June and September, 30.51% dissimilarity observed between June and October, 22.61% dissimilarity observed between August and September, 41.65% dissimilarity observed between April and October, 32.16% dissimilarity observed between May and October, 21.80% dissimilarity observed between July and October, 27.03% dissimilarity observed between August and October, 30.70% dissimilarity observed between September and October. Species contribution below 2.5% was not taken into consideration.

Table 4.4: SIMPER analysis showing % dissimilarity between different months with their contributing fish species

Groups April and May Average dissimilarity = 32.15%		**Groups April and June Average dissimilarity =40.34%**		**Groups May and June Average dissimilarity = 29.07%**	
Species	**Cont. (%)**	**Species**	**Cont. (%)**	**Species**	**Cont. (%)**
A. mola	5.86	*C. reba*	4.99	*A. mola*	6.53
O. pabda	4.58	*M. aculeatus*	4.75	*H. fossilis*	4.73
C. catla	4.14	*C. batrachus*	4.1	*C. chuna*	4.73
C. batrachus	4.14	*G. giuris*	4	*N. atherinoides*	4.38
C. reba	3.87	*A. puctata*	3.88	*N. notopterus*	3.95
A. puctata	3.87	*O. pabda*	3.88	*G. giuris*	3.7
P. ranga	3.39	*C. striatus*	3.49	*M. pancalus*	3.56
W. attu	3.2	*C. catla*	3.33	*M. aculeatus*	3.33
C. striatus	3.2	*N. atherinoides*	3.33	*M. armatus*	3.06
C. punctatus	2.86	*P. ranga*	3.29	*S. gongota*	3.06
C. cirrhosus	2.76	*C. ranga*	3	*L. guntea*	2.64
M. aculeatus	2.76	*L. rohita*	2.95	*C. cirrhosus*	2.64
C. marulius	2.76	*C. chuna*	2.95	*P. sarana*	2.64
N. nandus	2.76	*N. nandus*	2.87	*T. cutcutia*	2.64
M. pancalus	2.76	*W. attu*	2.71	*C. garua*	2.64

L. guntea	2.58	*H. fossilis*	2.71	*C. reba*	2.57
		C. punctatus	2.71		
		T. cutcutia	2.71		
Groups April and July Average dissimilarity = 36.06%		**Groups May and July Average dissimilarity = 23.46%**		**Groups June and July Average dissimilarity = 23.00%**	
Species	**Cont. (%)**	**Species**	**Cont. (%)**	**Species**	**Cont. (%)**
M. aculeatus	5.27	*A. mola*	6.54	*H. fossilis*	5.49
C. batrachus	4.37	*M. pancalus*	4.63	*G. giuris*	5.49
C. reba	4.3	*M. aculeatus*	4.58	*P. ranga*	4.78
A. puctata	4.3	*P. sarana*	4	*N. atherinoides*	4.67
W. attu	4.3	*P. ranga*	3.89	*E. vacha*	4.21
C. catla	3.74	*L. gonius*	3.69	*N. notopterus*	4.21
C. punctatus	3.3	*R. rita*	3.69	*T. cutcutia*	3.63
L. rohita	3.21	*C. chuna*	3.69	*C. orientalis*	3.26
O. pabda	3.21	*E. danricus*	3.66	*S. gongota*	3.26
E. vacha	3.03	*C. orientalis*	3.31	*N. botia*	2.81
P. sarana	2.84	*L. rohita*	3.09	*N. nandus*	2.63
L. gonius	2.61	*C.cirrhosus*	2.85		
R. rita	2.61	*M. armatus*	2.85		
C. marulius	2.61	*N. botia*	2.85		
		W. attu	2.75		
Groups April and August Average dissimilarity = 37.87%		**Groups May and August Average dissimilarity = 23.78%**		**Groups April and September Average dissimilarity = 33.96%**	
Species	**Cont. (%)**	**Species**	**Cont. (%)**	**Species**	**Cont. (%)**
L. guntea	4.54	*A. mola*	6.28	*M. aculeatus*	5.25
O. pabda	4.24	*C. chuna*	5.3	*W. attu*	4.75
W. attu	4.16	*M. armatus*	4.91	*C. striatus*	4.5
C. catla	3.98	*C. orientalis*	4.44	*A. puctata*	3.85
A. puctata	3.87	*L. rohita*	3.99	*N. atherinoides*	3.85
L. rohita	3.77	*N. notopterus*	3.82	*M. armatus*	3.85
M. aculeatus	3.65	*L. guntea*	3.82	*L. rohita*	3.64
C. reba	3.38	*P. sarana*	2.96	*C. reba*	3.64
C. batrachus	3.38	*R. corsula*	2.96	*C. catla*	3.41
M. armatus	3.38	*W. attu*	2.61	*G. giuris*	3.41
C. striatus	3.23			*O. pabda*	3.14
C. garua	3.05			*R. corsula*	3.14
M. pancalus	3.05			*J. coitor*	3.14
P. ranga	2.92			*C. punctatus*	2.89
C. chuna	2.86			*C. batrachus*	2.82
Groups June and August Average dissimilarity = 24.37%		**Groups July and August Average dissimilarity = 17.71%**		**Groups July and September Average dissimilarity = 22.46%**	
Species	**Cont. (%)**	**Species**	**Cont. (%)**	**Species**	**Cont. (%)**
L. guntea	6.38	*M. pancalus*	7.21	*N. notopterus*	5.22
H. fossilis	6.01	*L. guntea*	5.38	*N. atherinoides*	4.68
N. atherinoides	5.15	*P. ranga*	5.33	*E. vacha*	4.23

M. pancalus	5.15	*N. notopterus*	4.39	*G. giuris*	4.1
C. garua	4.99	*C. garua*	3.84	*P. sarana*	3.96
G. giuris	4.41	*C. cirrhosus*	3.39	*L. gonius*	3.65
C. orientalis	4.17	*C. punctatus*	3.2	*M. bleekeri*	3.27
C. ranga	3.42	*M. aculeatus*	2.76	*C. garua*	3.27
S. gongota	3.23	*A. aor*	2.69	*C. batrachus*	2.82
C. cirrhosus	2.78	*O. bimaculatus*	2.69	*S. gongota*	2.82
E. vacha	2.78	*A. gagora*	2.69	*N. botia*	2.82
R. corsula	2.78	*O. cotio*	2.69	*P. ranga*	2.57
		L. gonius	2.69		
Groups May and September Average dissimilarity = 26.72%		**Groups June and September Average dissimilarity = 20.55%**		**Groups June and October Average dissimilarity = 30.51%**	
Species	**Cont. (%)**	**Species**	**Cont. (%)**	**Species**	**Cont. (%)**
A. mola	5.6	*H. fossilis*	6.28	*N. atherinoides*	5.37
N. notopterus	5.18	*T. cutcutia*	5.82	*H. fossilis*	5.35
N. atherinoides	4.65	*R. corsula*	4.53	*P. ranga*	4.56
M. armatus	4.44	*J. coitor*	4.53	*E. vacha*	3.88
C. garua	4.2	*P. sarana*	3.5	*C. ranga*	3.87
M. pancalus	4.2	*C. orientalis*	3.5	*G. giuris*	3.56
C. chuna	3.62	*X. cancila*	3.5	*X. cancila*	3.31
R. corsula	3.62	*C. reba*	3.07	*N. nandus*	3.31
J. coitor	3.62	*M. bleekeri*	2.78	*C. garua*	3.31
M. aculeatus	3.25	*L. gonius*	2.78	*C. orientalis*	3.22
C. fasciatus	2.85	*C. cirrhosus*	2.78	*T. cutcutia*	3.12
C. orientalis	2.8	*O. bimaculatus*	2.78	*E. danricus*	2.78
S. gongota	2.8	*B. yarrellii*	2.78	*A. aor*	2.76
L. rohita	2.8	*C. batrachus*	2.78	*P. sophore*	2.57
E. danricus	2.59	*P. ranga*	2.78		
G. giuris	2.53	*C. fasciatus*	2.78		
A. testudineus	2.5				
Groups August and September Average dissimilarity = 22.61%		**Groups April and October Average dissimilarity = 41.65%**		**Groups May & October Average dissimilarity = 32.16%**	
Species	**Cont. (%)**	**Species**	**Cont. (%)**	**Species**	**Cont. (%)**
C. garua	6.74	*M. aculeatus*	4.05	*A. mola*	6.62
L. guntea	6.13	*C. batrachus*	3.86	*N. notopterus*	4.08
M. pancalus	5.88	*A. puctata*	3.77	*P. ranga*	3.87
N. atherinoides	5.44	*O. pabda*	3.35	*L. guntea*	3.48
G. giuris	3.19	*E. vacha*	3.14	*A. testudineus*	3.29
E. vacha	2.94	*C. striatus*	2.93	*M. aculeatus*	3.19
P. sarana	2.94	*C. punctatus*	2.91	*R. rita*	3.14
S. gongota	2.94	*C. reba*	2.81	*C. orientalis*	3.14
T. cutcutia	2.55	*M. tengra*	2.68	*M. pancalus*	2.88
		A. coila	2.68	*S. gongota*	2.82
		R. rita	2.6	*N. nandus*	2.61
		H. fossilis	2.51	*L. gonius*	2.55
		A. mola	2.5		

Groups July and October Average dissimilarity = 21.80%		Groups August and October Average dissimilarity = 27.03%		Groups September and October Average dissimilarity = 30.70%	
Species	**Cont. (%)**	**Species**	**Cont. (%)**	**Species**	**Cont. (%)**
N. notopterus	5.32	*L. guntea*	6.18	*N. atherinoides*	5.25
E. danricus	4.4	*P. ranga*	4.6	*C. garua*	4.09
L. guntea	3.89	*M. pancalus*	4.06	*E. vacha*	3.79
S. gongota	3.67	*A. mola*	3.28	*A. mola*	3.23
A. mola	3.55	*S. gongota*	3.07	*P. ranga*	3.11
A. testudineus	3.47	*A. aor*	2.93	*E. danricus*	2.77
N. atherinoides	3.15	*A. testudineus*	2.66	*M. bleekeri*	2.76
C. ranga	3.03	*X. cancila*	2.6	*C. batrachus*	2.7
P. sophore	3.01	*C. punctatus*	2.55	*C. ranga*	2.65
C. garua	2.75	*E. danricus*	2.53	*G. giuris*	2.63
X. cancila	2.65			*P. sophore*	2.56
H. limbatus	2.57			*L. gonius*	2.55

In the present study, highest dissimilarity was observed between April and October 41.65% and major contributing species are *M. aculeatus* (4.05%), *C. batrachus*(3.86%),*A. puctata*(3.77%) and lowest between July and August 17.71% and major contributing species are *M. pancalus*(7.21%),*L. guntea*(5.38%), *P. ranga*(5.33%). So it can be said that highest number of similar species was found between July and August and lowest between April and October. Rahman (2014) reported that highest number of similar species was found between post monsoon and winter and lowest between winter and summer in Monumukh Point of Kushiara River. This finding somewhat harmonious to the present findings.

4.1.7.2 Cluster analysis:

Four marked separation observed in the abundance of fish in different months are showed in figure. At the similarity of 76.9%, four groups were attained where June, July, August and September showed in a cluster while April, October and May showed separate cluster respectively.

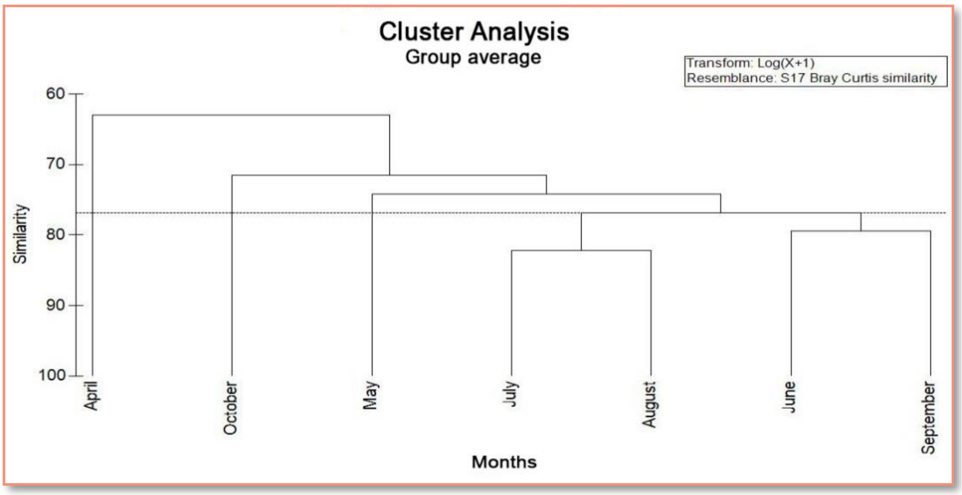


Figure 4.12: Cluster analysis based on Bray-Curtis similarity matrix of different months

4.1.7.3 Non-metric Multidimensional Scaling (nMDS):

Non-metric Multidimensional scaling **(**nMDS) was employed to hit off similarities among fish abundance. Non-metric Multidimensional scaling shows 60% similarity for all months. On the other hand, 70% similarity observed among all the months except April and it formed a distinct group. However, at 80% similarity all the months formed separate groups.

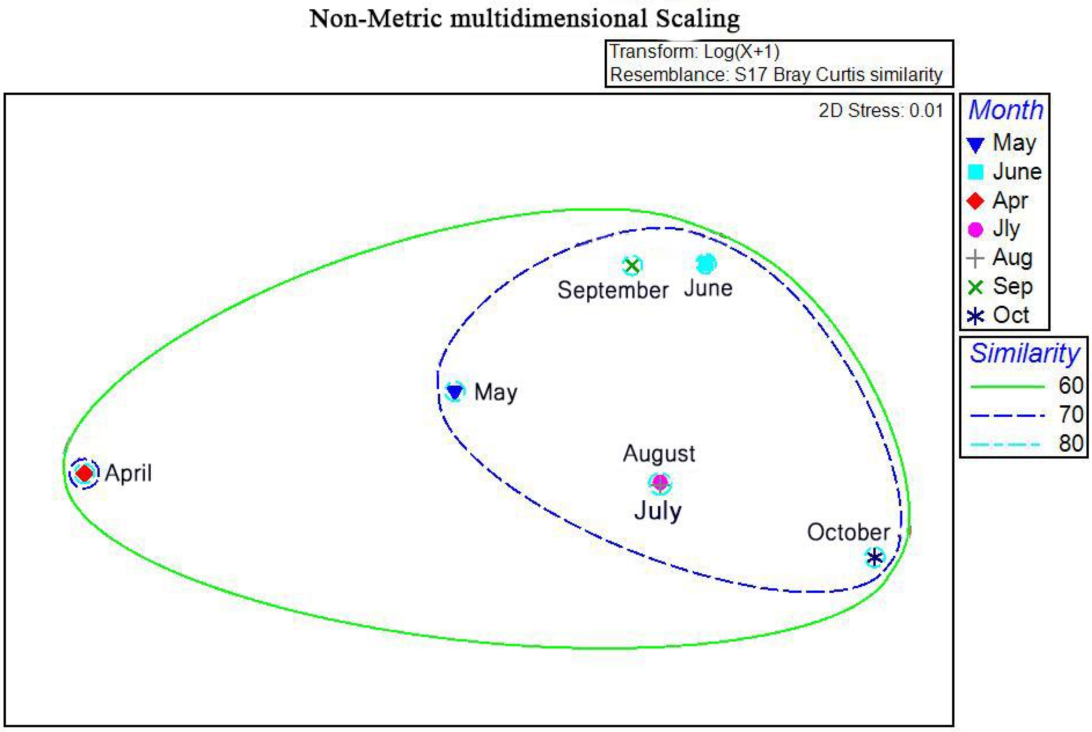


Figure 4.13: 2-dimensional ordination in nMDS showing similarity of different months

4.2. Environmental parameter

Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of sufficient fish food organisms. The physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Swingle, 1969). Various edaphic and physico-chemical parameters of different sampling spots are shown in Table 1 and 2.

Table 4.5: Monthly mean edaphic factors of the study area

Parameters	Month							Range	Mean value ± SD
	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.		
Photoperiod (hrs./day)	4.9	4.88	2.83	3.06	3.19	4.26	6.7	2.83-6.7	4.26±1.377
Rainfall (mm)	18.45	24.26	28.04	21.56	30.12	20.92	1.82	30.12-1.82	20.739±9.288
Relative Humidity (%)	2.33	2.45	2.73	2.52	2.68	2.67	2.23	2.33-2.73	2.516±0.190

(Source: Meteorological station of Sylhet, 2015).

4.2.1 Photoperiod

Photoperiod in the study area differed from 2.83 hrs. to 6.70 hrs. Per day with a mean value of 4.26±1.377 hrs. Lowest value observed in June and highest value in October.

4.2.2 Rainfall

Rainfall in the study area varied from 1.82 mm to 30.12 mm per day with mean value 20.739±9.288 mm. Highest value of rainfall observed in October and lowest in August. Rainfall is the most important cyclic phenomenon in tropical countries as it brings important changes in the hydrographical characteristics of the aquatic environments (Ashok *et al.*, 2008).

4.2.3 Relative Humidity

Relative Humidity in the study area varied from 2.33% to 2.73% per day with a mean value of 2.516±0.190%. Highest value was observed in June and lowest value in October.

Table 4.6: Month wise physico-chemical factors of the study area

Parameters	Month						
	April	**May**	**June**	**July**	**August**	**September**	**October**
Air Temperature (^{0}C)	26.67 ± 0.58	28.00 ± 1.00	28.33 ± 0.57	29.00 ± 1.00	30.00 ± 0.00	29.33 ± 0.58	29.66 ± 1.15
Water Temperature (^{0}C)	25.00 ± 1.00	26.07 ± 0.57	26.67 ± 1.15	27.67 ± 0.58	28.67 ± 0.58	27.33 ± 0.58	28.33 ± 1.52
Turbidity (cm)	28.00 ± 2.65	30.67 ± 3.05	30.33 ± 3.51	32.00 ±3.60	28.00 ± 2.00	20.67 ± 2.08	16.33 ± 2.08
P^H	7.83 ± 0.29	7.43 ± 0.45	7.2 ± 0.30	7.4 ± 0.2	7.77 ± 0.25	7.57 ± 0.11	8.00 ± 0.2
Dissolved Oxygen (mg/l)	5.67 ± 0.58	5.33 ± 0.58	4.67 ± 0.58	5.00 ±.00	6.33 ± 0.58	6.67 ± 0.58	5.67 ± 0.58
NH_3 (mg/l)	0.02 ± 0.004	0.016 ± 0.005	0.009 ± .006	0.01 ± 0.00	0.01 ± 0.006	0.02 ± 0.002	0.01 ± 0.002
NH_4^+ (mg/l)	0.51 ± 0.11	0.59 ± 0.11	0.73 ±0.06	0.52 ± 0.04	0.42 ± 0.06	0.63 ± 0.07	0.70 ± 0.08
Nitrite (mg/l)	0.04 ± 0.05	0.01 ± 0.00	0.04 ±0.04	0.39 ± 0.04	0.03 ± 0.02	0.01 ± 0.002	0.037 ± 0.05

(Source: *in situ* observation)

4.2.4 Temperature

Temperature is defined as the degree of hotness or coldness in the body of a living organism either in water or on land (Lucinda and Martin, 1999). During the study period air temperature varied from 26.67 ± 0.58 (ºC) to 30.00 ± 0.00 (ºC). The water temperature varied from 25.00 ± 1.00 (ºC) to 28.67 ± 0.58 (ºC). Present findings almost harmonious with the findings of Safi *et al.* (1978), Islam *et al*. (1974) and Mushahida and Kamruzzaman (2013). Safi *et al.* (1978) observed average temperature 25.8 ºC in the river Meghna near Daudkhandi. Islam *et al*. (1974) reported average water temperature in the Karnafully estuary was 27.52 ºC. Mushahida and Kamruzzaman (2013) observed variation of water temperature from 33.1±3.79 ºC to 11.6±5.89 ºC and air temperature from 36.5±2.65 ºC to 13.5±3.50 ºC in the Rupsha River.

4.2.5 Turbidity

Turbidity in the study area differed from 16.33 ± 2.08 (cm) to 32.00 ±3.60 (cm). Highest value was observed in July and lowest value in October. There was a significant difference observed among the month. According to Bhatnagar *et al*. (2004) turbidity range from 30-80 cm is good for fish health; 15-40 cm is good for intensive culture system and < 12 cm causes stress. According to Santhosh and Singh (2007) the secchi disk transparency between 30 and 40 cm indicates optimum productivity of a pond for good fish culture. Kamal *et al.* (2007) reported 52.5±2.05 cm and 15.00±0.47 cm and 37.25±3.20 cm transparency for highest, lowest and average respectively from the Mouri river of Khulna which is more or less similar and support the statement of present study.

4.2.6 P^H

P^H is one of the most important factors that serves as an index of contamination. The P^H value of the study area typically constant and differed from 7.2 ± 0.30 to 8.00 ± 0.2. Highest value was observed in October and lowest value was in June. According to Santhosh and Singh (2007**)** the suitable pH range for fish culture is between 6.7 and 9.5 and ldeal pH level is between 7.5 and 8.5 and above and below this is stressful to the fishes. It seems that P^H value of investigated area almost remain in standard condition for aquatic organisms especially for fish. Roy (1955) observed the pH value of Hoogly to be more or less stable with the range of 8.3 to 8.4, which is an another example of buffering capacity and it support the statement of present study.

4.2.7 Dissolved oxygen

Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of aquatic organisms. Dissolved oxygen in the study area differed from 4.67 ± 0.58 (mg/l) to 6.67 ± 0.58 (mg/l). Highest value was observed in September and lowest value was in June. It seems that Dissolved oxygen value of research area slightly higher and this is might be due to the denser aquatic vegetation. According to Bhatnagar and Singh (2010) and Bhatnagar *et al*. (2004) DO level >5ppm is essential to support good fish production. Bhatnagar *et al*. **(**2004) also suggested that 1-3 ppm has sublethal effect on growth and feed utilization; 0.3-0.8 ppm is lethal to fishes and >14 ppm is lethal to fish fry, and gas bubble disease may occur. It reveals that Dissolved Oxygen level of studied area remains within the tolerable range for aquatic life especially fish**.** Kamal *et al.* (2007) reported average dissolve oxygen value 7.25ppm in the Mouri river of Khulna which was supports the present finding.

4.2.8 Nitrite nitrogen

Nitrite nitrogen of the studied area varied from 0.01 ± 0.00 (Mg/L) to 0.39 ± 0.04 (Mg/L). Stone and Thomforde (2004) suggested that the desirable range of nitrite is 0-1 mg/ L and acceptable range less than 4 mg /L. It seems that the nitrite value of investigated area exist in acceptable range**.** Laxminarayana (1965) recorded 1.85 mg/l nitrite in stretch of Moosi which was higher than present study.

4.2.9 Ammonia and Ammonium ion (mg/l)

Ammonia values of research area differed from 0.009 ± .006 (Mg/L) to 0.02 ± 0.004 (Mg/L) and ammonium ion values ranges from 0.42 ± 0.06 (Mg/L) to 0.73 ±0.06 (Mg/L). Both ammonia and ammonium ion was calculated in the presence of pH and temperature. The amount of ammonia and ammonium ion was relatively low throughout the study period. Bhatnagar and Singh (2010) recommended the level of ammonia (<0.2 mg/ L) suitable for pond fishery and present findings exist in the acceptable limit.

4.3 Planktonic Assemblage

It is recognized that the planktons can be an index to compare the relative productivity and fishery potential of different waterbodies. They play a pivotal role in the food chain of fishes. In the present study, a Total of 34 planktonic taxa (88.77%) were identified of which 22 taxa (11.23%) were of phytoplankton and 12 taxa of zooplankton. Phytoplankton group belonged to Chlorophyceae (10 taxa), Bacillariophyceae (4 taxa), Cyanophyaceae (6 taxa) and Euglenophyceae (2 taxa) while zooplankton including Rotifer (4 taxa), Cladocera (5 taxa), Copepods (2 taxa) and Protozoans (2 taxa).

Table 4.7: Generic status of plankton with their different groups documented from Ratargul Swamp Forest during the study period.

<table>
<tr><th colspan="2">Phytoplankton</th><th>Zooplankton</th></tr>
<tr>
<td>Bacillariophyceae
Navicula
Cymbella
Cyclotella
Synedra
Cyanophyaceae
Gleocapsa
Microcystis
Spirulina
Oscillatoria
Anabaena
Gomphospheria</td>
<td>Euglenophyceae
Euglena
Phacus
Chlorophyceae
Ankistrodesmus
Chlorella
Closterium
Microspora
Pediastrum
Scenedesmus
Spirogyra
Staurastrum
Tetraedron
Ulothrix</td>
<td>Rotifer
Asplanchna
Brachionus
Keratella
Filinia
Cladocera
Sida
Moina
Daphnia
Diaphanosoma
Bosmina
Copepods
Cyclops
Diaptomus
Protozoans
Difflugia
Arcella</td>
</tr>
</table>

Table 4.8: Plankton abundance (Ind. /l) in 50-liter volume of water sample during the study period

Availability of planktonic groups (ind./L)	Phytoplankton	Months							Mean ± St. Deviation	Group (%)
		Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.		
	Chlorophyceae	538	600	487	313	363	437	538	468±102.95	45.35
	Bacillariophyceae	225	163	213	100	0	137	87	132±78.18	12.80
	Cyanophyaceae	337	425	312	375	188	113	275	289±108.08	28.03
	Euglenophyceae	38	0	25	87	0	37	0	27 ±31.65	2.59
	Zooplankton									
	Rotifer	0	87	63	37	50	0	75	45±34.46	4.32
	Cladocera	87	37	0	13	37	63	25	37±29.61	3.63
	Copepods	0	25	37	25	25	13	0	18±14.02	1.73
	Protozoans	13	0	25	37	0	0	37	16±17.03	1.55
	Total	1238	1337	1162	987	663	800	1037	1032±293.6	100

4.3.1 Phytoplankton

A total of 22 taxa of phytoplankton were identified belonging to Chlorophyceae (10 taxa), Bacillariophyceae (4 taxa), Cyanophyaceae (6 taxa) and Euglenophyceae (2 taxa) which agreed with the findings of Wahab *et al.* (1994) who observed the phytoplankton population consisted of chlorophyceae, cyanophyceae and euglenophyceae in the ponds of BAU campus. Hossain *et al.* (1998) recorded the phytoplankton of bacillariophyceae, chlorophyceae, cyanophyceae and Euglenophyceae. Hossain *et al.* (2013) recorded 23 taxa of phytoplankton belonging to four groups such as bacillariophyceae (4), chlorophyceae (11), cyanophyceae (6) and euglenophyceae (2). Ahmed *et al.* (1993) recorded 27 genera of phytoplankton composed of bacillariophyceae (4), Chlorophyceae (15), Cyanophyceae (6) and euglenophyceae (2). Kohinoor *et al.* (1998) recorded 31 genera of phytoplankton belonging to bacillariophyceae (4), chlorophyceae (15), cyanophyceae (8) and euglcnophyccae (3) in the research ponds of BAU campus Mymensingh. Ahsan *et al*. (2012) identified 19 taxa of phytoplankton comprising Cyanophyceae (6 taxa), Chlorophyceae (7 taxa) and Bacillariophyceae (6 taxa). Ferdous *et al.* (2012**)** identified 27 taxa of phytoplankton belonging to the families Cyanophyceae, Bacillariophyceae, Chlorophyceae, Euglenophyceae and Cryptophyceae.These findings supports the present findings.

4.3.1.1 Chlorophyceae

Chlorophyceae was the most dominant group which constituted 45.35% of total plankton and 51.04% of total phytoplankton this was represented by ten species. Chowdhury *et al.* (2008) documented that Chlorophyceae was the most dominated group contributing 46% of total plankton abundance which is congruent with the present findings. The occurrence of Chlorophyceae was highest i.e. 600 Ind/l in May, 2015 and lowest i.e. 313 Ind/l in July, 2015. In all the month combinrd average chlorophyceae abundance was found to occur 468±102.95 Ind./l. The commonly occurring taxa of chlorophyceae were *Chlorella, Microspora, Scenedesmus, Pediastrum, Spirogyra, Tetraedron, Ulothrix* which were found all over the study period.

4.3.1.2 Bacillariophyceae

Bacillariophyceae constituted 12.80% of total plankton and 14.42% of total phytoplankton which was represented by four species named *Navicula, Cymbella, Cyclotella* and *Synedra.* Choudhury *et al.* (2007**)** reported Bacillariophyceae contributed 19% of total phytoplankton population which is almost similar to the present findings. The occurrence of Bacillariophyceae was highest i.e. 225 Ind. /l. in April, 2015 and lowest i.e. 0 Ind. /l in August, 2015.The average abundance of Bacillariophyceae over the study period was 132± 78.18 Ind/l.

4.3.1.3 Cyanophyaceae

Cyanophyaceae placed second in position among plankton abundance and contributed 28.03% of total plankton and 31.58% of total phytoplankton which was represented by six taxa like *Gleocapsa ,Microcystis, Spirulina,Oscillatoria, Anabaena, Gomphospheria* which agreed with the findings of Hossain *et al*. (2013**)** who observed Cyanophyceae was dominated by six genera *such as Microcystis, Anabaena, Gomphoshaeria, Agmenellum, Oscillatoria* and *Nostoc.*The occurrence of cyanophyceae was highest i.e. 425 Ind/l in May, 2015 and lowest i.e. 113 Ind. /l in September, 2015. In all the month combined average cyanophyceae was found to occur 289± 108.08 Ind. /l.

4.3.1.4 Euglenophyceae

Euglenophyceae was the least dominant group among phytoplankton and constituted 2.59% of total plankton and 2.92% of total phytoplankton. This group represented by two taxa named *Euglena* and *Phacus*. The occurrence of Euglenophyceae was highest i.e. 87 Ind/l in July, 2015 and lowest i.e. 0 Ind/l found in May, August and October, 2015. The average abundance of Euglenophyceae over the study period was 45 ± 34.46 Ind. /l. Siddika *et al*. (2012**)** reported *Euglena* and *Phacus* were the contributing species under the group Euglenophyceae.

4.3.2 Zooplankton

In the present study, a total of 12 taxa of zooplankton were identified belonging to Rotifer (4 taxa), Cladocera (5 taxa), Copepods (2 taxa) and Protozoans (2 taxa). Azher *et al.* (2006)

conducted a research on beels of haor region of Bangladesh and identified 15 major taxa of zooplankton under Rotifer, Cladocera and Copepod. Rahi and Sabbir (2010**)** identified 24 different taxa of zooplankton under the group Rotifer, Cladocera, Copepod and ostracoda. In the present study, zooplankton contributing 11% of total plankton abundance which is almost similar to the study of Ahsan *et al.* (2012). They reported zooplankton contributing 10% of total plankton population.

4.3.2.1 Rotifer

Rotifera was the dominant group out of total zooplankton population and represented by four major taxa named *Asplanchna, Brachionus, Keratella, Filinia which concurred* by Choudhury *et al.* (2007) who documented five species namely *Asplanchna, Brachionus, Filinia, Keratella, Polyarthra* under Rotifer.They contributed 4.32% of total plankton and 38.47% of total zooplankton. In the entire study period combined average rotifer was found to occur 27± 31.65 Ind. /l.

4.3.2.2 Cladocera

Cladocera placed second in position among zooplankton abundance and represented by five major taxa named *Sida, Moina, Daphnia, Diaphanosoma* and *Bosmina.*They contributed 3.63% of total plankton and 32.3% of total zooplankton which agreed by Ahsan *et al.* (2012) who observed Rotifer contributed 32% of total zooplankton abundance. The average abundance of cladocera over the study period was 37 ± 29.61 Ind. /l.

4.3.2.3 Copepoda

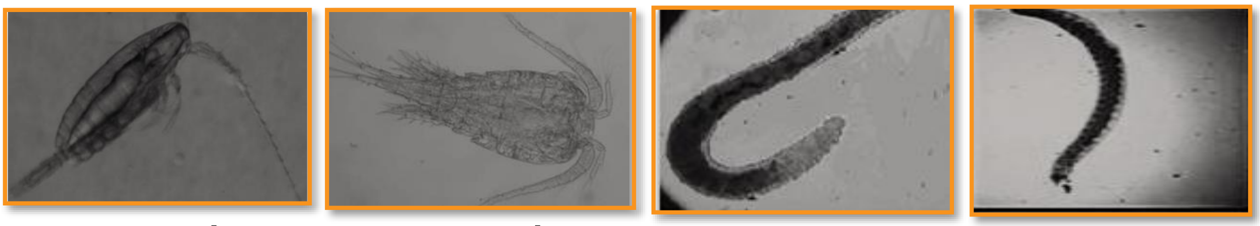
Cyclops and *Diaptomus* were the major taxa under the group copepod which represented by 1.73% of total plankton and 15.41% of total zooplankton. Azher *et al.* (2006) conducted a research on beels of haor region of Bangladesh and reported *Cyclops* and *Diaptomus* under copepod which is similar to the present findings. The average abundance of copepod over the study period was 18 ± 14.02 Ind. /l.

4.3.2.4 Protozoans

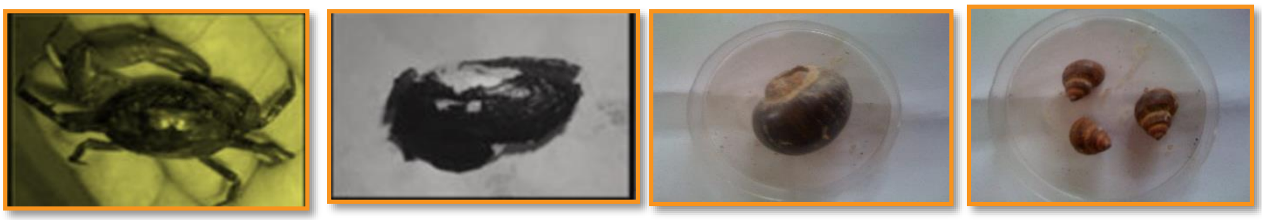
Protozoans was the least dominant group among the plankton abundance and contributed 1.55% of total plankton and 13.81% of total zooplankton. *Difflugia* and *Arcella* were the observed species under protozoa which concurred by Bera *et al.* (2014) who observed four species under protozoa in which *Difflugia* and *Arcella* frequently found. The average abundance of protozoans over the study period was 16 ± 17.03 Ind. /l.

4.4 Macro benthic diversity

The macro benthic fauna is important for enhancing of aquatic resources and also play an important role in food chain and biological purification of water. A total eight major groups of macro benthic organisms were identified namely Oligichaetes, Polychaetes, Gastropods, Bivalvia, Copepods, Isopods, Crab and prawn larvae. Among them oligochaetes, polychaetes and gastropods found throughout the entire study period. The present finding is congruent with the findings of Chakma *et al.* (2015)**,** Asadujjaman *et al.* (2012) and Biswas (2015). Chakma *et al.* (2015) identified ten major groups of macro benthic organisms comprising Polychaetes, Oligochaetes, Gastropods, Amphipods, Bivalvia, Diptera, Crab, Isopods, Prawn larvae and Copepods. Asadujjaman *et al* (2012) conducted a research on Hatiya and Nijhum Dweep Islands, Bangladesh and reported ten major groups of macrobenthic organisms including polychaetes, oligochaetes, shrimp larvae, crab, gastropods, isopods, bivalves, copepods, annelids, amphipods. Biswas (2015) recorded eight major groups comprising Oligiochaeta, Hirudinea, Crustacea, Odonata, Coleptera, Diptera, Gastrpoda and Bivalvia in a rural pond near Naihati, West Bengal, India



Copepod Copepod Oligochaetes Oligochaetes



Crab Bivalve Gastropod Gastropod

Shrimp larvae Polychates Polychates

Figure 4.16: Macro benthos found in Ratargul swamp forest during the study period

4. 5 Diversity of aquatic weeds

A total of 20 species of aquatic weeds were identified. Among them 15 species were emergent, 3 species were floating and 2 species were submerged species. Basak *et al.* (2014) recorded 10 species of aquatic weed in haor area of Kishoregonj District of which 4 species were floating, 4 species were emergent and 2 species were submerged. This finding is lesser than the present findings. This may be due to the nature of swamp forest and its geographical location.

A list of aquatic weeds with their details were presented in the table 4.9.

Table 4.9: Aquatic weeds/Herbs diversity of Ratargul Swamp Forest

Sl. No.	Scientific Name	Local Name	Family	Types	Present Status
1.	*Sagittaria sp.*	Arrowhead	Onagraceae	Emergent	common
2.	*Pistia stratiotes*	Topapana	Araceae	Floating	Less common
3.	*Colocasia esculenta*	Kochu	Araceae	Emergent	Less common
4.	*Eicchornia crassipes*	Kachuripana	Pontederiaceae	Floating	common
5.	*Eleusine indica*	Notey Shak	Poaceae	Emergent	Less common
6.	*Glinus lotoides*	Alughas	Molluginaceae	Emergent	Less common
7.	*Jussicea repens*	Keshordam	Alismataceae	Emergent	common
8	*Heliotropium indicum*	Hatisur	Boraginaceae	Emergent	common
9	*Higrophyla salicifolia*	Bontil	Acanthaceae	Emergent	Less common
10	*Hydrilla spp*	Hydrila	Hydrocharitaceae	Submerged	Less common
11	*Alternanthera philoxerodies*	Malancha	Convolvulaceae	Emergent	Less common
12	*Ipomoea fistulosa*	Dulkolmi	Convolvulaceae	Emergent	Less common
13	*Lemna minor*	Khudipana	Araceae	floating	common
14	*Najas spp*	Najas	Hydrocharitaceae	Submerged	common
15	*Polygonum sp.*	Bish Katali	Polygonaceae	Emergent	Very common
16	*Scleria levis*	Kasum	Cyperaceae	Emergent	Less common
17	*Schoenoplectus juncoides*	Jayna	Cyperaceae	Emergent	Less common
18	*Scoparia dulcis*	Bondoni	Scophuariaceae	Emergent	common
19	*Typha spp*	Hogla	Thypaceae	Emergent	common
20	*Vetiveria zizanioides*	Binna	Poaceae	Emergent	Very common

4.6 Present status of Ratargul swamp forest

Ratargul is the evergreen swamp forest known as "Amazon of Bangladesh" which is situated at Gowainghat upazilla under Sylhet district by the river Goyain and linked with the cannel Changer khal. This forest is flooded by the water coming from Indian hills only in the monsoon period and made the swamp. This swamp forest chunk is surrounded by nine villages namely Ratargul, Bagh Bari, Dewaner Goan, Ram Nagar, Maheshkher, Julurpar, Chailtha Bari, Kucharkandi and Erertuk under Fatehpur union. This villagers are the main beneficiary of this forest. Presently, the area of the forest is approximately 504 acres. The forest goes under 20-30 feet water at rainy season. Rest of the year the water level is about 10 feet deep or less. The forest is silted by the river goyain and made it swallow and remain dried almost half of the year. Few years ago, it was dredged into many dishes so that water remains throughout the year. The name of this dishes are Rangaputi, Atalow, Shiri Kuri, Kutor Khal, Garur Ghat, Nal Khuri, Chari Kuri, Motor Fishery and Uglamazor Kuri. Most of the dishes remain inundated throughout the year. The forest is flooded from April or May and remain fully inundated up to late October or early November. Fishing is mainly done at that time span. Fishers use different types of fishing gears for catching fish. They use different types of net, fish trap and hooks for catching fish. This swamp forest act as a feeding, breeding and nursing ground of lots of indigenous fishes. During sampling, a total 62 species of fishes belonging to 9 orders under 27 families were recorded. A total of 28 threatened fish species were found in the study area of which 6 were critically endangered (CR), 11 were endangered (EN), 11 were Vulnerable (VU) according to IUCN status 2000.Fishers and local people said that a large number of fishes were available few years ago. They said that chela, kachki, karish, and numerous exotic species of fishes were available few years ago and some of the fishers claimed that sometimes this species are found in a small number still however those were absent during sampling.

Present study revealed that hydrological parameters i.e. temperature, dissolved oxygen, free pH, ammonia, transparency etc. of the study area are more or less vicinity to optimum and permissible limits at which aquatic animals lead their normal life. The composition of plankton, benthos and aquatic weed remain in acceptable limits. These findings indicate that the study area is productive for aquatic animals. Presences of vulnerable, endangered and critically endangered species illuminate that the area is still preferable for various species of fishes

4.7 Major threats to Ratargul swamp forest

Major threats to ecosystem that reduces overall diversity and availability of fishes are-

- Use of fertilizers, insecticides and pesticides in the adjacent agricultural lands;
- Frequent movement of tourist;
- Use of ban monofilament net (current jal);
- Use of poison for fishing;
- Conflicts among the villagers;
- Priority to tourism;
- Priority to floral sector; and
- Indifference of forest division etc.

CHAPTER FIVE

SUMMARY

The present study was conducted to assess the existing diversity of indigenous fish species with water quality parameters, plankton assemblage, benthic composition and aquatic weeds diversity of Ratargul Swamp Forest, Sylhet, Bangladesh for a period of seven months from April, 2015 to October, 2015. A total 62 species of fishes were identified belonging to 9 orders under 27 families in which 28 species of fishes were threatened. The most dominant order, family and species were cypriniformes (37.46%), cyprinidae (33.96%) and *Puntius sophore* (19.32%), respectively. The Mean Shannon-Wiener diversity index, Margalef richness index, Pielou'sevenness index and Simpson dominance index were found to be 3.690±0.191, 9.497± 1.314, 0.971±0.003 and 0.982±0.003, respectively. In case of SIMPER analysis highest number of similar species was found between July and August and lowest between April and October. In case of cluster analysis, at the similarity of 76.9%, four groups were attained where June, July, August and September showed in a cluster while April, October and May showed separate cluster respectively. Non-metric Multidimensional scaling shows 60% similarity for all months. On the other hand, 70% similarity observed among all the months except April. The CCA ordination indicates p^H and ammonia were two most dominant environmental variables affecting species composition of the studied area than the other variables. In case of environmental parameter water temperature ranged from 26.3-29.4°C, air temperature 27.7-31.3°C, Transparency 18.7-41.7 cm, P^H 7.2-8.1, Dissolved oxygen 7.3-10.7 (Mg/l), NH_3 0.008-0.027 (Mg/l), NH^4+ 0.38-0.73 (Mg/l), Nitrite 0.007-0.02 (Mg/l), Photoperiod 2.83-6.7 hrs./day, Rainfall 30.12-1.82 mm and Relative Humidity 2.33-2.73%. In case of planktonic study, a total of 34 planktonic taxa (88.77%) were identified of which 22 taxa (11.23%) were of phytoplankton and 12 taxa of zooplankton. Phytoplankton belonging to Chlorophyceae (10 taxa), Bacillariophyceae (4 taxa), Cyanophyaceae (6 taxa) and Euglenophyceae (2 taxa) while zooplankton including Rotifer (4 taxa), Cladocera (5 taxa), Copepods (2 taxa) and Protozoans (2 taxa). On the contrary, a total eight major groups of macro benthic organisms were identified namely Oligichaetes, Polychaetes, Gastropods, Bivalvia, Copepods, Isopods, Crab and Prawn Larvae. Among them Oligochaetes, Polychaetes and Gastropods found throughout the entire study period. During the study period, a total of 20 species of aquatic weeds were identified in which 15 species of emergent, 3 species of floating and 2 species of submerged species were recorded from the study area

CHAPTER SIX
CONCLUSION AND RECOMMENDATION

Ratrgul swamp forest is a typical wetland ecosystem having high potentials of biodiversity especially diversity of indigenous species of freshwater fishes. Total sixty two species of fishes were identified including tweenty eight threatened species. On the contrary water quality, plankton assemblage, benthos composition and aquatic weeds also existed in satisfactory level. But fish catch is declining day by day due to various reason such as use of destructive fishing, tourism, siltation etc. However a major portion of the total fish species recorded from Ratargul swamp forest was found threatened in Bangladesh. Abundance of threatened fish species among the total catch strongly reflect its potentiality to be an excellent site for natural fish conservation. An ecosystem management approach is necessary for the sustainable use of these potentials of this unique forest.

Some suggestion and recommendation for better management of this ecosystem are as follows:

- ❖ Destructive fishing by poisioning should be stopped.
- ❖ Movement of tourist should be restricted.
- ❖ Fisheries laws and regulations should be implemented properly.
- ❖ Establishment of fish sanctuary for sustainable fisheries production.
- ❖ Declaration of the swamp forest as an ecological critical area.
- ❖ Awareness should be build up among the local community.

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APPENDICES

Appendix-1: Photographic plate of collected fish species of the Ratargul swamp forest during the study period

Mastacembelus pancalus

Tetraodon cutcutia

Notopterus notopterus

Lepidocephalus guntea

Bagarius yarrellii

Catla catla

Wallago attu

Labeo rohita

Colisha chuna

Gudusia chapra

Plate -1

Channa striatus

Cirrhinus reba

Puntius sarana

Chanda nama

Nandus nandus

Botia dario

Aorichthys aor

Glossogobius giuris

Pisodonophis boro

Cirrhinus cirrhosus

Plate - 2

Amblypharyngodon mola

Mystus tengara

Puntius ticto

Puntius sophore

Channa barca

Channa marulius

Hyporamphus limbatus

Arious gagora

Chitala chitala

Conta conta

Plate - 3

Mystus bleekeri

Eutropiichthys vacha

Parambasis ranga

Ailia coila

Xenentodon cancila

Mystus vittatus

Rita rita

Channa punctatus

Clupisoma garua

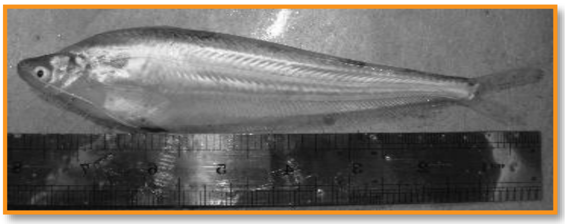
Heteropneustes fossilis

Plate - 4

Osteobrama cotio

Rhinomugil corsula

Channa orientalis



Ompok pabda

Labeo gonius

Tenualosa ilish

Nemachilus botia

Somileptes gongota

Pseudeutropius atherinoides

Ailia puctata

Chaca chaca

Aorichthys seenghala

Plate - 5

Anabas testudineus

Macrognathus aculeatus

Clarias batrachus

Colisa fasciata

Mastacembelus armatus

Monopterus cuchia

Johnius coitor

Labeo calbasu

Ompok bimaculatus

Esomus danricus

Plate - 6

Appendix-2: Aquatic weeds/herbs of Ratargul Swamp Forest

Colocasia esculenta

Eicchornia crassipes

Polygonum sp.

Alternanthera philoxerodies

Pistia stratiotes

Sagittaria sp.

Jussicea repens

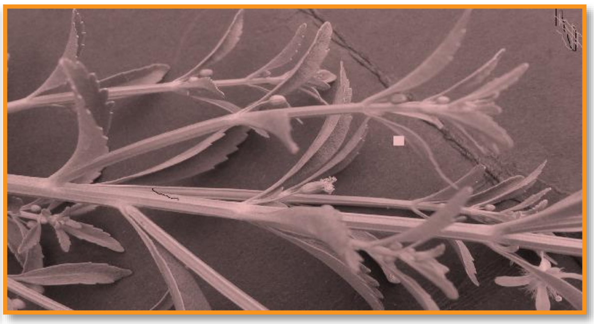
Schoenoplectus sp

Plate - 1

Lemna minor

Lemna minor

Najas spp



Scoparia dulcis

Hydrilla spp

Glinus lotoides

Eleusine indica

Polygonum sp.

Plate - 2