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# Eco-Biology of CIRRHINUS REBA (HAMILTON) with Special Reference to Its Fishery at Rajshahi

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University of Rajshahi

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A
THESIS SUBMITTED TO
THE UNIVERSITY OF RAJSHAHI, RAJSHAHI, BANGLADESH
FOR THE DEGREE OF
**DOCTOR OF PHILOSOPHY (Ph. D)**

By
**MST. SHAHANAJ FERDOUS**
B. Sc. (Hons.), M. Sc.

**JUNE, 2017**

**DEPARTMENT OF FISHERIES**
FACULTY OF AGRICULTURE
UNIVERSITY OF RAJSHAHI
RAJSHAHI-6205, BANGLADESH

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## *DEDICATION*

**To my**

**Beloved Parents**

&

**My Husband and Daughter**

whose love and inspiration encouraged me to
complete the research work

## *DECLARATION*

I do hereby declare that, the research work submitted as a thesis entitled "ECO-BIOLOGY OF *CIRRHINUS REBA* (HAMILTON) WITH SPECIAL REFERENCE TO ITS FISHERY AT RAJSHAHI" in the Department of Fisheries, University of Rajshahi, Bangladesh for the Degree of Doctor of Philosophy is the result of my own investigation. The thesis or part of it has not been submitted to any other University or Institution for any degree.

Dated: June, 2017

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Ph.D Researcher

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# CERTIFICATE OF RESEARCH

This is to certify that

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Ph. D. Fellow, Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi-6205, Bangladesh carried out the investigation on "ECO-BIOLOGY OF *CIRRHINUS REBA* (HAMILTON) WITH SPECIAL REFERENCE TO ITS FISHERY AT RAJSHAHI" under my supervision. She fulfilled all the requirements and regulations relating to the nature and period of research. It is further certified that the entire work presented as a thesis for the degree of **Doctor of Philosophy** is based on the results of author's own investigation.

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**The Author**

# ABSTRACT

The eco-biology and fishery of *Cirrhinus reba* in Padma river were studied for a period of 3 years (January 2014 to December 2016) in 5 different sampling stations (Godagari, Bullanpara, Padma garden, Yusufpur and Charghat). **In experiment 1**, the study focused on physico-chemical parameters and their relation with occurrence and abundance of plankton population in Padma river. The physico-chemical condition and plankton population of Padma river exhibited more or less variations according to the change of months and season. The study revealed that monsoon rain and land drainage seems to play an important role in changing the physico-chemical parameters of the Padma river. During the study period, a total of 130 species of phytoplankton and 30 species of zooplankton were recorded. The findings of the present study indicate that the ecology of Padma river are still in good condition for *C. reba*. **In experiment 2**, Length-weight frequency distribution of *C. reba* ranged between 6.60 to 23.80 cm in total length and 2.63 to 136.00 g in total body weight during the sampling period. The 'b' value for male, female and combined sex was 3.020, 3.215 and 3.116 respectively, that indicates isometric growth type in male and positive allometric growth type in female and combined sexes. The minimum and maximum value of $K_F$ during the study period was 0.39 and 1.65 for male and 0.48 and 1.83 in females with mean value of 0.94 and 0.97 for combined sex. Spearman rank correlation showed that $K_F$ was significantly correlated with both total length ($p = 0.125$) and body weight ($p = 0.324$) of *C. reba*. **In experiment 3,** based on the finding of the study, *C. reba* is considered to have herbivorous feeding habits. The major food items of analyzed gut content of *C. reba* was detritus and plant materials. Small fishes are exclusively zooplankton feeders subsisting mainly on small rotifer, cladocera, copepoda and crustacean, whereas the adult ones are plankton and detritus feeder. The feeding activity of this fish species fluctuated between seasons and length groups. The conducting the relationship between total length and alimentary canal of this species an equation of $ACL = - 0.923+1.8023(TL)$ was found and the ratio obtained was 1:3.07, which indicates herbivorous nature of *C. reba*. **In experiment 4**, during the study period, reproductive activity of *C. reba* was analyzed in terms of sex ratio, spawning season and fecundity. In the present study, 600 species were collected among them 317 was male and 283 was female, with a sex ratio of 1:0.89. There were differences in the monthly male, female number and sex ratio, which indicates unequal distribution of male and female fishes with number of female fishes increases during spawning season. However, the overall sex ratio was also did not differ significantly from the expected value of 1:1 ($df = 1$, $\chi 2 = 3.84$, $p<0.05$). Values of GSI and GLI also fluctuated with months and number of gravid females was highest (70 %) in the month of August, which indicates peak breeding season of this fish species is August. The total number of mature eggs varied from 11542.10 to 265042.23 with mean value 11542.10 ± 53602.28. The results of the linear relationship depicted that fecundity increased at the rate of 5.892, 1.492 and 1.316 times of the total length, weight of fish and weight of ovary, respectively. **In experiment 5,** although the fishery of *C. reba* constitute a minor portion of Padma river's total catch, it forms a economically important role in fishery status of Padma river. The major fishing gears operated for capturing of *C. reba* were cast net (Jhaki jal), Gill net (Current jal), Square lift net (Tar jal), Seine net (Ber jal). The average yearly landings of *C. reba* was 3618 kg, which was low but contributes significantly in fishery of Padma river. The highest landing of this fish was in the month of November. During monsoon months, the catch was low due to the high water level of river that decreases the catching capacity of fishing gears. But after July, the quantity of landing gradually increased since the juveniles attained the adulthood and started gaining the maximum size and the water level of river gradually becomes low, which make the fishes available in fishing gears. Study of different aspects of the ecology, biology and fishery of *C. reba* indicates the suitability of this species for culture in both the ponds and other aquaculture systems.

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# Chapter One

# General Introduction

Bangladesh is enriched with a vast water bodies which are considered as the gold mines fisheries sector as well as national economy. Situated in the largest deltaic plain (the Ganga, the Brahmaputra and the Meghna) the country is criss-crossed with large number of rivers and rivulets. There are also huge number of other types of water bodies like ponds, canals, haors, baors, beels, estuaries, ox-bow lakes, Kaptai lake and vast coastal belt. These water bodies play a vital role in aquaculture in regarding animal protein supply, employment generation, foreign currency earning, poverty alleviation and economic development. Bangladesh is a developing country in the third world. It lies in the North-Eastern part of the South Asia, between 20°34′ and 26°38′ north latitude and 88°01′ and 92°41′ east longitude. The country is surrounded by India, on the west, the north and the north-west and Myanmar on the south-east and the Bay of Bengal on the south. Except a few part of hilly regions in the north-east and the southeast, some areas of high lands in the north and north-west parts, the basic characteristics of the land of the country are low, flat and fertile. The total area of the country is 147,570 sq km (56977.09 sq mile) (BBS, 2008).

## 1.1 Fisheries Resources of Bangladesh

Fisheries is one of the rich potential sector of agriculture and over the last three decades aquaculture has developed to become the fastest growing food producing sector in the world as well as in Bangladesh. About 4708193 ha. of inland waters and 16600 ha. (68480 sq. nautical miles) of marine waters are available in Bangladesh (FRSS, 2016). Bangladesh is fortunate enough in having an extensive and huge water resources scattered all over the country in the form of rivers and estuaries (853863 km.), beels (114161 ha.), baor (5488 ha.), pond-dighi (377968 ha.), Kaptai lake (68800 ha.) Sundarban (177700 ha.) and floodplain (2692964 ha.). Water areas of marine fisheries including terrestrial water 2,640 sq. n. miles, exclusive economic zone (EEZ) 41040 sq. n. miles, continental shelf 24,800 sq. n. miles and coast line 710 km (FRSS, 2016). Bangladesh is resourceful of fish biodiversity. The country abounds in large varieties of fish species that is 260 indigenous freshwater fish species, 24 species of prawns in inland water bodies and 486 species of marine fish, 36 species of marine shrimps and 12 species of exotic fish (FRSS, 2016).

Bangladesh is ranked 3rd in aquatic biodiversity in Asia behind China and India, with approximately 300 species of fresh and brackish water species (Hussain and Mazid, 2001). These vast and varied aquatic resources support artisanal and commercial fisheries as well as offer opportunities for agriculture development.

## 1.2 Importance of fisheries sector in Bangladesh

Bangladesh classified by the United Nations as a low income (per capita income 407 US$) food deficit (caloric consumption 80% requirement) country, has one of the highest population densities of any country (904 inhabitants per kilometer square) (ADB, 1997). So, in Bangladesh malnutrition is a serious problem which is caused mainly due to animal protein deficit diet. In Bangladesh annual total fish demand is 25.90 lakh MT. per capita annual fish needed is 18.0 kg whereas per capita annual fish intake is 17.23 kg (DoF, 2009).

Fishes have a great significance role in the life of mankind being a most important and cheapest source of protein. About 50 species SIS (Small Indigenous Species) are available in our country. SIS (maximum 25 cm in adult stage) of Bangladesh alone could supply more nutrients (like protein, essential fatty acids, vitamins and minerals in human diets to meet up the demand of nutrition (DoF, 2007). Protein deficiency is a main nutritional problem of rural people of Bangladesh and aquaculture is the most only cheapest way of supply protein in the diet of rural people. Only the fish protein contents all the essential amino acid such as lysine, arginine, histidine, leusine, iso-leusine, valline, fenyl alanine and tryptophan. The important omega-three fatty acid is also found in fishes with almost proper proportion and thus the fish is called as "Complete diet" (DoF, 2007). According to FAO report (1991) proximate composition of fish are shown in Table 1.1.

**Table 1.1 Proximate composition of fish**

| Water | Protein | Fat | Calcium | Phosphorous | Vitamins A,B,C,D |
|---|---|---|---|---|---|
| 72% | 19% | 8% | 0.5% | 0.25% | 0.10% |

Fisheries sector is also contributing 2.01% of the total export earnings and 3.69% to the GDP (FRSS, 2016). About 12.8 million people are directly or indirectly involved in this sector, among them 90% are engaged in inland and 40% are marine fishing.

## 1.3 Status of fisheries sector in the economy of Bangladesh

Bangladesh ranks at the top for production of freshwater fish (4076 kg per sq. km). In terms of total production Bangladesh stands fifth after China, India, Vietnam and Indonesia as the world largest inland fish producing country (FAO, 2015).

Total fish production from inland water area in the year 2014-2015 was 3085048 MT (inland capture 1023991 MT and inland culture 2061057 MT) which is 83.72%of the total catch. From marine fisheries, production in the year 2014-2015 was 599846 MT, which is 16.78% of the total catch (Figure 1.1) (FRSS, 2016).

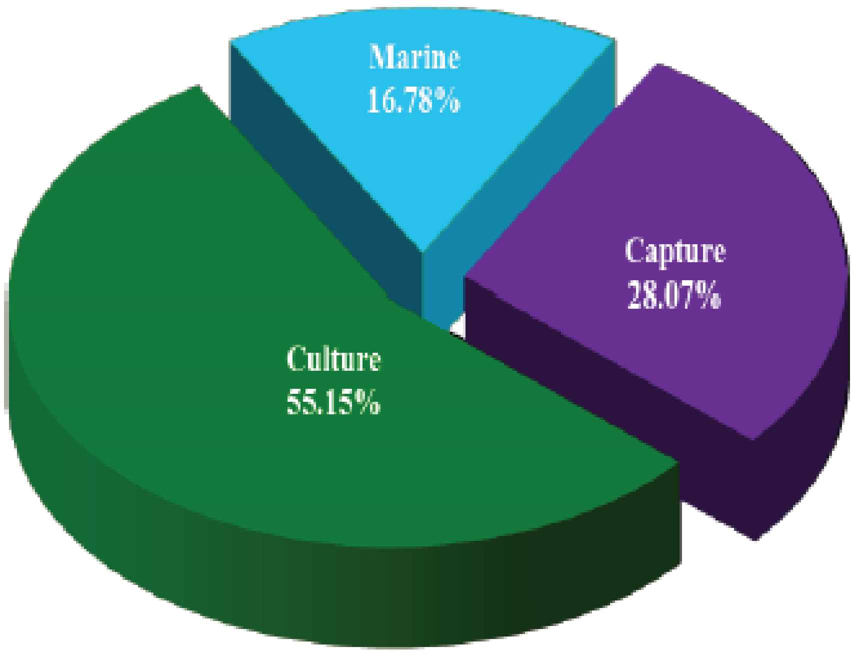



**Figure 1.1. Fish production (2013-2014) (Source: Department of Fisheries FRSS Report, 2015)**

Fish production is decreasing from the rivers day by day due to both manmade and natural causes. Inland fisheries contributed 51.5% of the total fish production in 1987-1988, whereas in 1997-1998 inland capture fisheries contributed 42.09% of the total production. In addition, inland capture fisheries contributed 39.23% of the total production in the year 2007-2008, whereas this production further decreased in the year 2014-2015 as 28.07% (FRSS, 2016) which shows gradual declination of capture fish production in Bangladesh. A year wise percent production from capture fishery is shown in Figure 1.2.

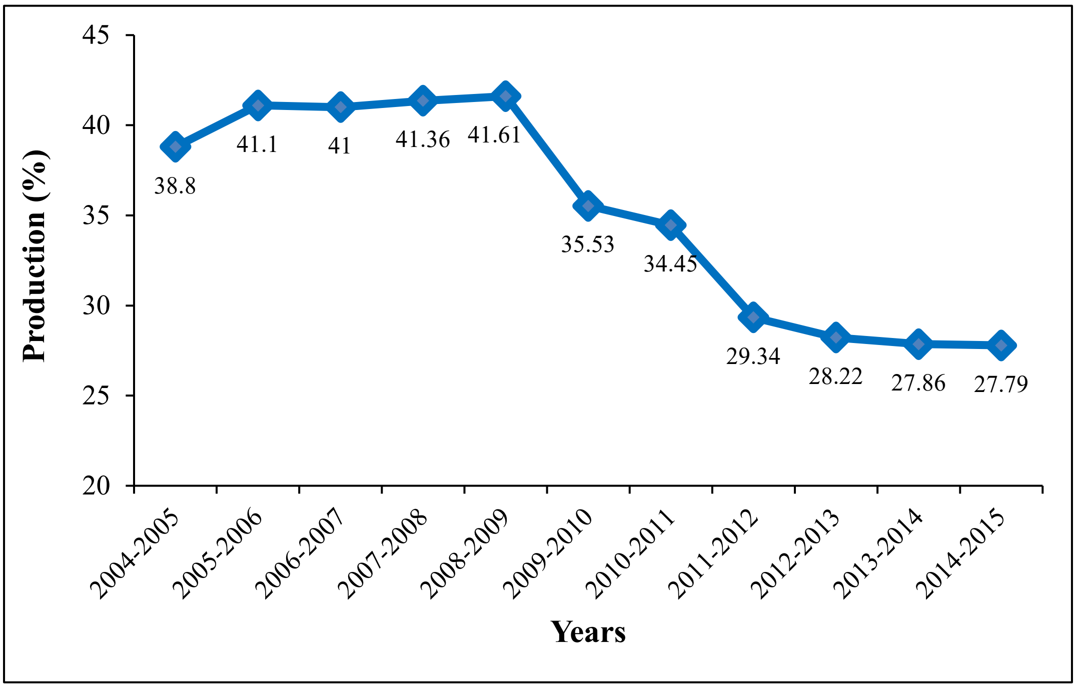



**Figure 1.2. Year wise fish production (%) of capture fisheries from year 2004-2005 to 2014-2015**

The North-West region of Bangladesh covers about 3.5 million ha. Rajshahi district is one of the greater districts of North-West region covers 2407.01 sq. km of area and landing a population of 19,88,000. Open water capture fisheries in this district comprise the major river the Padma and its tributaries. Annual fish catch from Padma river in Rajshahi district is shown in Figure 1.3.

In Bangladesh inspite of its tremendous potential for development, fish production has failed to keep pace with its demand due to increase in population which can be tackled by proper utilization of all the water bodies for the culture of fishes by using scientific method. Among them *Cirrhina reba* (Hamilton, 1822) commonly known as 'Rikhor' or 'Raik' is a remarkable one. Although the fish is rarely available in the eastern part of the country, but it is abundantly available in the western and north western part of Bangladesh (ADB, 1997). It is one of the most popular food fishes of Bangladesh. This is an important target species for small and large-scale fishers of

Bangladesh (Hossain *et al*., 2013). It is a good source of protein, calcium and low fatty acid, as well as an ideal dietetic food for human consumption (Afroz and Begum, 2014). Reba carp was abundant in the rivers, streams, canals, reservoirs, lakes, swampland (beels, haors and baors) and ponds in the western and north-western part of Bangladesh (ADB, 1997). During the last 14 years, the population of reba carp has declined considerably due to increased fishing pressure, and various anthropogenic activities leading to siltation, aquatic pollution, and loss of natural habitat for spawning and growth (Akhteruzzaman *et al.*, 1998; Hussain and Mazid, 2001). These factors not only destroyed the breeding grounds but also caused havoc to the availability of brood fish including fry and fingerlings (Hussain and Mazid, 2001). As a result IUCN (2015) declared this fish as nearly threatened (NT) in Bangladesh. To maintain this fish population as well as its conservation and rehabilitation, development of a suitable technology for breeding, and rearing of fry and fingerlings in nursery ponds is urgently needed. At present, *C. reba* can be a potential candidate for artificial culture in ponds and rivers. Therefore a detailed study on ecology and biology of *C. reba* in Padma river is required. Study of the size structure in this riverine fish can also reveal several ecological health conditions improvement aspects.

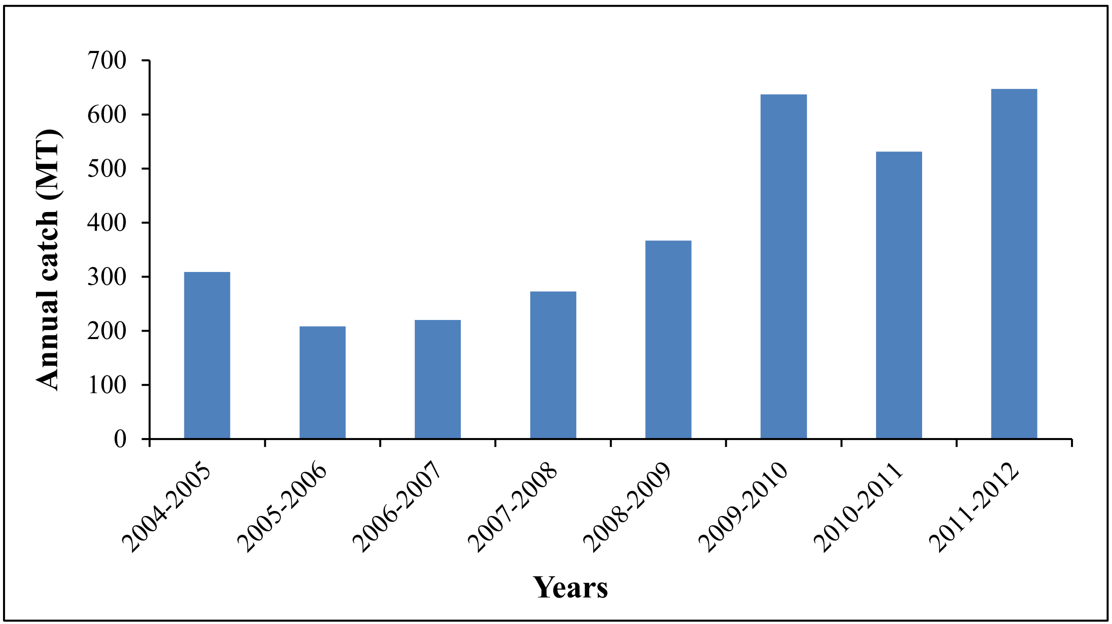



**Figure 1.3. Annual fish catch from Padma river in Rajshahi district from 2004-2005 to 2011-2012**

## 1.4 A few words about *Cirrhina reba*

*Cirrhina reba* is a freshwater fish. It is locally known as "Aikhor or Raikhor" (western part of Bangladesh), "Bangna" (Eastern part of Bangladesh), "Bhangan" (North Western Part of Bangladesh). In the past, it was abundantly available throughout the water body but at present it is rarely available.

### 1.4.1 Systematic position

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Super Class: Pisces
Class: Osteichthyes
Sub Class: Actinopterygii
Super Order: Teleostei
Order: Cypriniformes
Sub Order: Cyprinoidei
Family: Cyprinidae
Genus: *Cirrhina*
Species: *Cirrhina reba* (Hamilton, 1822)

### 1.4.2 Synonyms

1822. *Cyprinus reba*, Ham-Buch. Fish Ganges. 180, 386.

1877. *Cirrhina reba*, Day, Fish. India. III 280.

1943. *Cirrhina reba*, Ahmed, N. Fish. Lahore. 278.

1958. *Cirrhina reba*, Day, F. Fishes of India. Vol. I. London, William Dawson of Sons of Ltd. 778.

1964. *Cirrhina reba*, Bhuiyan, A.L. Fishes of Dacca, Asiatic Soc. Pakistan, Dacca, 148.

1968. *Cirrhina reba*, Srivastava, G.J. Fishes of Eastern Uttar Prodesh. 1st Edn. Varanasi (India). 163.

1973. *Cirrhina reba*, Doha, S. Fishes of the district Mymensingh and Tangail, *Bangladesh J. Zool.* 1(1): 1-10.

1975. *Cirrhina reba*, Jhingran, V.G. Fish and Fisheries of India. 954.

1982. *Cirrhina reba,* Shafi and Quddus, Bangladesher Matshaw Shampad. Fishery Resources of Bangladesh (text in Bengali), Bangla Academy, Dhaka.

### 1.4.3 Red List Category & Criteria

Near Threatened (NT) ver 3.1 (Date Assessed: 21 October 2014, IUCN, 2015).

### 1.4.4 Geographic Range

1. **Global**

*C. reba* occurs in Bangladesh, India, Myanmar, Nepal and Pakistan (Menon 1999) (Figure 1.4).

2. **Bangladesh**

*C. reba* is found in rivers, streams, canals, ponds, beels and inundated fields throughout Bangladesh. The fish has been reported from the Ganges-Brahmaputra Basin, Karnaphuli and adjacent basins of the Chittagong Hill Tracts, in the Bookbhara Boar in Jessore, Chalan Beel in Rajshahi, Halti Beel in Natore, Choto Jamuna River and Turag River (Alam 2007, Hossain *et al.* 2013).

### 1.4.5 Morphological Characteristics

**1.4.5.1 Body**- tapering anteriorly, mouth inferior, lips thin, upper lips fringed in the young, sometimes entire in the adult. Snout slightly projecting, more distinctly in the immature. Eyes are located nearer to the end of the snout than the hind edge of operculum. Dorsal profile slightly more convex than that of the abdomen. The greatest wide of the head equals its length excluding the snout. Snout slightly projecting and quite distinctly in the immature. Inter orbital space slightly convex. Two pairs of nostrils at the anterior angle of the orbit. A thin cartilaginous layer covering inside of lower jaw (Plate 1.1).

**1.4.5.2 Mouth** – Mouth inferior.

**1.4.5.3 Head** – Head 4.5-4.8 in standard, 5.8-6.3 in total length. In immature specimens (80-90 mm) head larger, being 4.0 in standard and 5.2 in total length.

**1.4.5.4 Barbels -** a pair of short rostral which is sometimes absent, none on the maxilla.

**1.4.5.5 Teeth-** pharyngeal

**1.4.5.6 Fins-** dorsal commences slightly nearer the snout than the base of the caudal, upper margin concave. Pectoral nearly as long as head, the pectoral does not reach the pelvic. The anal is much apart from the pelvic. Caudal large, deeply forked, sharp lobes. Gill opening large, gill rackers arranged at short intervals.

**Plate 1.1** ***Cirrhinus reba***

**1.4.5.7 Lateral line-** five to seven rows of scales between it and the base of the ventral fin.

**1.4.5.8 Scales -** hexagonal.

**1.4.5.9 Colour -** silvery yellowish, scales darkest at the upper and lower edges forming bluish longitudinal bands above and 2 or 3 rows below the lateral line. Ventral side white, dorsal and caudal grey or yellowish. Tip of the pelvic and anal orange. The young's sometimes with a leaden coloured band along the sides.

**1.4.5.10 Habitat and Ecology**

*C. reba* inhabits freshwaters and occurs in a wide variety of habitats, such as rivers, streams, canals, ponds, beels and inundated fields throughout Bangladesh (Hossain and Haq 2005, Alam 2007). The fish is bentho-pelagic and feeds mainly on plankton and detritus. It is a potamodromous and prolific breeder (Alam 2007).

### 1.4.6 Food and feeding habit

Generally it feeds on vegetables and smaller animals. Feed contents algae 20%, bits of higher plants 35%, protozoa 15%, crustacea 20%, mud and sand 10% (Shafi and Quddus, 2001). It usually does not take worms, insects, molluscs and fishes.

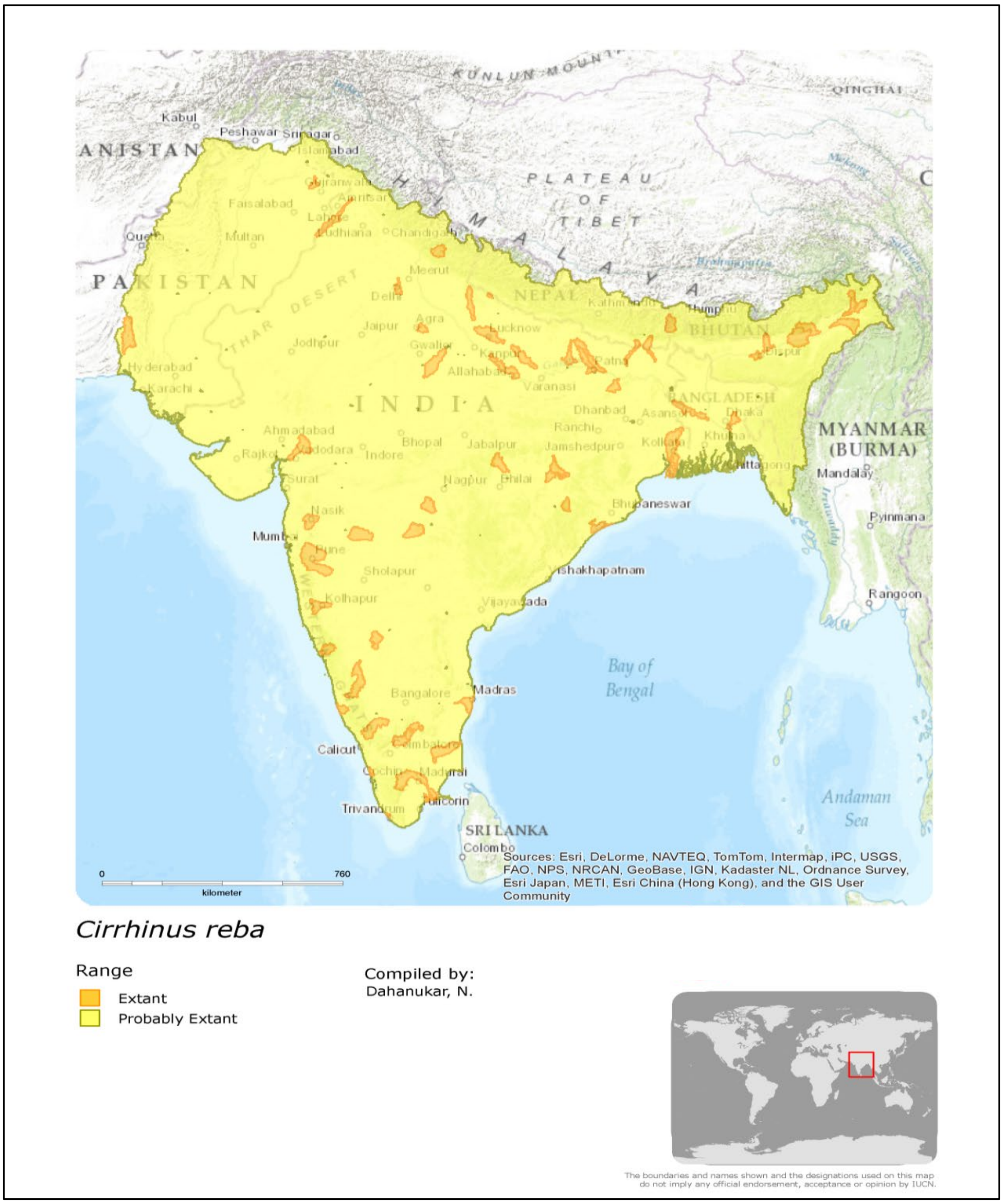



**Figure 1.4. Geographical distribution of *Cirrhinus reba***

## 1.5 Rationale and aim of the present study

To the best of our knowledge, no detailed research work has been performed on *C. reba* (Hamilton, 1822) in Bangladesh but Hossain *et al*. (2013), who studied the life-history traits of this fish species in the Ganges River, Northwestern Bangladesh. So, as an important fish species with IUCN (2015) standard of nearly threatened (NT) this species need detailed study on ecology, biology and fishery aspects. Therefore, the present investigation was performed to know the ecology, biology and fishery of *C. reba* in Padma river, Northwestern Bangladesh. This work has been divided into five parts.

**The first part deals with the following aspects**

- ✓ Physico-chemical parameters of water of Padma river
- ✓ Biological parameters in terms of phytoplankton and zooplankton population and
- ✓ Interaction among physic chemical and biological parameters to find out suitability of Padma river as habitat of *C. reba*.

**The second part deals with the following aspects**

- ✓ Population structure of *C. reba* in Padma river
- ✓ Length-weight relationships and
- ✓ Condition factors

**The third part deals with the following aspects**

- ✓ Seasonal feeding intensity
- ✓ Seasonal pattern of feeding based on percentage occurrence of food items
- ✓ Relationship between total length and alimentary canal length

**The fourth part deals with the following aspects**

- ✓ Male and female reproductive system
- ✓ Reproductive periodicity
- ✓ Sex ratio
- ✓ Fecundity

- ✓ Relationship between fecundity and others parameter

**The fifth part deals with the following aspects**

- ✓ Fishing methods
- ✓ Fish landings and prices
- ✓ Marketing channel

## 1.6 Objectives of the study

The present study on *C. reba* is a step in the direction of the effort to get much information as-

- To have an overall ideas about the ecological condition and productivity status of Padma river
- To know relationship between length and weight and condition factors of c. reba
- To evaluate the food and feeding behavior
- To know the reproductive biology
- To know the fishery status.

## 1.7 Hypothesis of the study

Bangladesh is an over populated country and faced by serious malnutrition problem. To meet up protein deficiency of people, greater emphasis should be given to boost up fish production in this country through proper management of open water fishery and Aquaculture. Bangladesh is rich with diversified freshwater fish species. Among them *C. reba* which was found abundantly in river, stream pond are rarely available at present. It's induced breeding technique as well as culture technique is well developed in India. Though this species are cultured in this sub continental climate but unfortunately culture technique of *C. reba* had never been successfully done in Bangladesh due to lack of sufficient biological information available in literature. It is declared as 'nearly threatened' by IUCN in their 'Red book of threatened fishes of Bangladesh' in the year 2015.

It is virtually impossible to gather sufficient information on this without knowing its biological aspects. The present research aims to study some major aspects of biology and marketing system of *C. reba* that may provide important clue for its conservation in natural waters as well as culturing this species commercially in confined waters. That is why the researcher gets on interest to conduct a research on the above mentioned topic to test the hypothesis.

# Chapter Two

# Review of literature

A large number of literatures are available on the ecological and biological works of fishes. Some of the allied references are mentioned below-

## 2.1 Ecological studies

Ahmed and Alfasane (2004) conducted a study on ecological studies of river Padma at Mawa Ghat, Munshiganj, II. Primary productivity, Phytoplankton standing crops and diversity and reported 29 genera of phytoplankton belonging to 6 families. They recorded dominant species of *Melosira* sp., *Synedra* sp., and *Fragilaria* sp., with cell density of $897.9\times10^3$, $129.1\times10^3$, $117.1\times10^3$ individual/L respectively of Chlorophyceae. The found Shannon-Wiener index of diversity was minimum (0.81) in the month of June and highest (5.1) in the month of February. Here species diversity increased with higher net production.

Ahsan *et al*. (2012) studied plankton composition, abundance and diversity in Hilsa (*Tenualosa ilisha*) migratory rivers of Bangladesh during spawning season and reported total of 58 taxa of plankton were present. Of which, 19 taxa (32.76%) were of phytoplankton and 39 taxa (67.24%) of zooplankton. 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). The average abundance of plankton was recorded as 194.05 ± 82.58 indiv/l. The highest abundance of total plankton (692 indiv/l) was observed in Godagari, Rajshahi (Station 3) and was lowest (4.00 indiv/l) in Charghat, Rajshahi (Station 2). The highest abundance (49 indiv/l) of total zooplankton was observed in Godagari and lowest (1 indiv/l) in Charghat with mean value of 19.46 ± 4.12 indiv/l. The highest species richness (SR = 45) was observed in Daulotkhan, Vhola (Station 9) and the lowest (SR = 3) in Charghat (Station 2), with mean value of 17.10±4.408. Shannon-Weiner species diversity index (H′) ranged from 3.334 in Daulotkhan (Station 9) to 1.5 in Charghat, (Station 2) with mean value of 2.717 ± 0.147. Based on the plankton profile it may be concluded that the biological quality of hilsa migratory river was not alike throughout the route which may restrict the migration up to up steam and spontaneous spawning of hilsa.

Kshirsagar *et al*. (2012) studied phytoplankton diversity related to pollution from Mula river at Pune city and reported A total of 162 algal species belonging to 75 genera were recorded at selected sampling stations at Mula river throughout the study period. Among the different groups, Chlorophyceae was the most abundant followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. The greatest algal population was recorded at station III followed by stations II and I. Maximum abundance of *Scenedesmus quadricauda*, *Chlorella vulgaris*, *Oscillatoria limosa* and *Melosira granulata* at stations II and III throughout the year showed that these algal species could be considered as bioindicators of organic pollution. Algal monitors showed that water at stations II and III are highly polluted with organic pollutants in the Mula river. Highest algal populations were observed in April, May and June, i.e., summer, and fewest in winter and the monsoon season.

Jasmine *et al*. (2013) studied Plankton production in relation to water quality parameters in lentic and lotic water bodies during postmonsoon season in the northwestern Bangladesh and reported that in the Padma river, among Zoophamkton Nauplius was the most dominant genus followed by *Cyclops*, *Daphnia*. They also found that among phytoplankton *Spirogyra*, *Chlorella*, *Microcystis*, *Navicula* and *Euglena* was the dominat geneus. They also reported that although plankton production was not strongly correlated with temperature, transparency, pH and alkalinity in both Padma river and small pond but significant correlation was calculated among plankton production and dissolved oxygen and free carbon dioxide in these water bodies.

Alam *et al*. (2014) studied the Diversity and Taxonomic Enumeration of Phytoplankton of river Jamuna near Bangabandhu Multi-Purpose Bridge, Bangladesh. They taxonomically illustrated 54 taxa and among these 15 belonged to Chlorophyceae, 16 to Euglenophyceae, 13 to Bacillariophyceae and 10 to Cyanophyceae indicating mesotrophic nature of the river Jamuna.

## 2.2 Population structure, Length-weight relationships and Condition factors

Narejo (2006) studied the length-weight relationship and relative condition factor (Kn) of a carp, *Cirrhinus reba* (Hamilton) from Manchar Lake Distt. Dadu, Sindh, by examining 265 specimens collected during October, 2003 to February, 2004. These fishes ranged from 1 0.0 - 22.5 cm in length (TL) and 7.6 - 102.5 g in weight. The relation between the total length and weight of male, female and sexes combined of *C. reba* is described as Log W= - 2.53 + 3.40 x Log L for males, Log W= -2.91 + 3.74 x Log L for females and Log W= - 2.43 + 3.32 x Log L for sexes combined. The mean relative condition factor (Kn) values ranged from 0.96 to 1.10 (Mean 1.02 ±0.20) for males, 0.99 to 1.07 (Mean 1.03±0.18) for females and 0.96 to 1.05 (Mean 1.04 ±0.20) for combined sexes. The length-weight relationship and relative condition factor show that the growth of *C. reba* from Manchar Lake District Dadu, Sindh was found to be isometric.

Afroz (2001) studied the length-weight relationships and condition factor of 'Chapila', *Gudusia chapra* are estimated based on 2336 specimens ranging from 50 mm to 190 mm (TL) sampled from Jahangirnagar University ponds, Jahangirnagar Bangladesh. The length-weight relationships of fish are an important piece of information in fisheries biology, but often not available when needed.

Afroze (2003) published a paper on biology and feeding experiment of *Heteropneustes fossilis* (Bloch) and observed the relationship between total length (TL) and standard length (SL), total length and dorsal length (DL), total length and pectoral length (PL), total length and pelvic length (PvL), total length and anal length (AL), total length and caudal length respectively.

Rahman *et al.* (2004) observed the length-weight relationship and condition factor of silver pomfret *(Pampus argenteus)*, collected from the southwestern region of Bangladesh (Khulna, Bagerhat and Pirojpur) for a period of twelve months. A total of 317 fish was collected monthly. Standard length-weight relation of this species was obtained to be logW = - 1.004 + 2.7931 logTL. The co-efficient correlation (r) was found to be 0.989. The mean value of condition factor was found to be 44.27.

$$SL = 5.7768 + 0.861089TL, r = 0.964798$$

Akter (2005) published a paper on biology of freshwater fish *Cirrhina reba* and observed the length weight relationships in males, females and combined sexes respectively. The values of the exponent 'n' in males, females and combined sexes were 1.0792, 1.194 and 1.1782. The mean values of $K_0$ were obtained as 0.844, 0.891 and 0.853 for the males, females and combined sexes. The mean values of Kc were obtained as 0.981, 0.994 and 0.997 for the males, females and combined sexes. The mean values of Kn were obtained as 1.173, 1.171 and 1.136 for the males, females and combined sexes.

Amin *et al.* (2005) published an article on the estimation of the size frequency distribution, sex-ratio and length-weight relationship of Hilsa *(Tenualosa ilisha)* by SPSS programme from length-weight data collected from Bangladesh water. Annual mean length of male and female *T. ilisha* was estimated as 29.30 cm and 34.23 cm. The annual mean weight was 265.89 g and 520.38 g respectively. Standard deviation for length was 3.45 cm and 5.15 cm for male and female. Standard deviation for weight was 88.65 g and 276.28 g respectively. Females were on an average about 4.98 cm taller than males ($P<0.05$). The 95% confidence interval of the difference between two means was 5.35 to 4.60. The bigger size of female hilsa was observed during the month of June to November and mean length was between 33.36 cm and 34.81 cm whereas mean weight was between 564.57 g and 521.87 g. A marked decline was observed in mean length and weight of male during the month of September. In case of female, mean length and as well as mean weight decreased from the month of October and it continued up to the month January and subsequent recovery after this month. This may be the cause of peak spawning period of hilsa in the month of September. The value of regression coefficient and constant was 49.58 and -1173.091 respectively. The logarithmic form of length-weight relationship of *T. ilisha* was $LogW = -2.516 + 3.381*Log TL$. The exponential form of equation obtained for the length-weight relation was $W = 0.00305 TL$. The value of co-efficient of correlation (r) estimated for the species was 0.93 ($P<0.01$), *3.381 which indicated that the relationship between length and weight of the fish was highly significant.

$$DL = 3.4568 + 0.266728TL, r = 0.966 196$$

Jha *et al.* (2005) reported the length weight relation of *Garua gotyla*, a very common fish in 9 rivers f Nepal including all the seasons of 2003 by using electro fishing gears. The length weight relationship was found to vary both spatially and temporarily among rivers and seasons respectively indicating different conditions in different rivers. The length weight relationship also showed some interesting facts about the seasonal cycle of the species indicating the period of growth and stress in different rivers. The monsoon event was found to be highly influenced in this relationship.

Hossain *et al.* (2006) made a study on the length-weight relationships and length-length relationships for eight important small indigenous fish species from the Mathabhanga River Southwestern Bangladesh *viz. Amblypharyngodon mola* (Hamilton, 1822), *Channa punctata* (Bloch, 1793), *Hyporhamphus quo* (Valenciennes, 1847), *Macrognathus aculeatus* (Bloch, 1786), *Nandus nandus* (Hamilton, 1822), *Puntius sophore* (Hamilton, 1822) and *Setipinna phasa* (Hamilton, 1822). A total of 2543 specimens used for this study were caught by traditional fishing gears from January to December 2005. The calculated allometric co-efficient 'b' ranged from a minimum of 2.864 for *M. aculeatus*, to a maximum of 3.397 for *A. mola*, with an average value of 3.098. The LWRs indicated a negative allometric growth in *M. aculeatus* and a positive allometric growth for the remaining species. All LLRs represented in this study were highly significant ($p < 0.001$), with most of the coefficient of determination values being > 0.9; one exception was *A mola* ($r^2 = 0.868$ for SL vs FL).

Pervin (2007) published a paper on biology of freshwater fish *Labeo boga* (Hamilton) and observed the sizes of the fishes were ranged from 92 mm to 290 mm. In meristic analysis, *L. boga* is a soft-rayed fish. Relationship between total length and other lengths were positively linear. The mean values of $K_0$ were males, females and combined sexes. The mean values K were found as 2.7223, 1.44358 and 1.48013 for males, females and combined sexes. The mean values of K were obtained as 1.0502, 0.58268 and 0.886523 for the males, females and combined sexes respectively.

Soomro *et al.* (2007) reported the length-weight and length-length relationships of a freshwater catfish *Eutropiichthys vacha* (Hamilton, 1822) from Indus River, Sindh, Pakistan. A total of 281 specimen of *E. vacha* were collected from fishermen's catch from February 2005 to January 2006 are used for this study. The parameters 'a' and 'b' of the length-weight relationships were calculated as W= $aL^b$ are presented. The values for allowmetric coefficient 'b' of the LWR were close to isometric value for male (b=3.159) and combined values for both sexes (b=3.053). However, it suggested negative allometric growth for females (b=2.973). Results for LLRs indicated that these are highly correlated ($r^2 > 0.9$, $p < 0.0001$).

Hossain *et al.* (2009a) studied the length-weight (LWR) and length- length (LLR) relationships for ten small indigenous fish species from the lower part of the Ganges, Bangladesh, namely *Ailia coila, Amblypharyngodon mola, Aspidoparia morar, Clupisoma atherinoides, Eutropiichthyes vacha, Glossogobius giuris, Gudusia chapra, Lepidocephalus guntea, Mystus vittatus,* and *Puntius ticto.* A total of 2142 specimens, representing 10 species of 5 families used for this study were caught by traditional fishing gear from March 2006 to February 2007. Standard length (SL), total length (TL) and fork length (FL) for each specimen were measured by digital slide calipers and each body weight (BW) was taken by a digital balance. The allometric coefficient b of the LWR was close to the isometric value *(b* = 3.001) in *G. giuris,* although it suggested negative allometric growth in *A. coila, A. morar, C. atherinoides, E. vacha, and P. ticto,* whilst positive allometric growth in rest of the species. The results further indicated that the LLRs were highly correlated ($r^2 >0.890$; $P<0.01$).

Hossain *et al.* (2009b) illustrated the length-weight (LWR) and morphometric relationships of the tank goby *Glossogobius giuris* (Hamilton 1822) (Perciformes: Gobiidae), an important small indigenous fish species in the Ganges, northwestern Bangladesh. A total of 266 specimens, 11.30-23.60 cm total length (TL), were caught with traditional fishing gear from March 2006 to February 2007. The allometric coefficient *b* of the LWR for the combined sexes was close to the isometric value *(b* = 3.068 for TL and *b* = 3.089 for SL, standard length), but with a slight negative allometric growth for males *(b* = 2.954 for TL, *b* = 2.953 for SL) and a slight positive allometric growth for females *(b* = 3.293 for TL, *b* = 3.166 for SL). The results further indicated that morphometric relationships were highly correlated ($r^2 > 0.712$; $P < 0.001$). To the best of our knowledge, this study presented the first reference on LWR and morphometric relationships for *G. giuris* from Bangladeshi waters. These results will be useful for fishery managers to impose adequate regulations for sustainable *G. giuris* fishery management not only in the Ganges of Bangladesh but also in neighboring countries.

Hossain *et al.* (2008) described some biological parameters, including sex ratio, length-frequency distributions, size at sexual maturity, fecundity as well as length-weight (LWR) and length-length (LLR) relationship of the Ganges River sprat *Corica soborna* (Pisces: Clupeidae), an important target species for small scale fisheries in the Mathabhanga River in Bangladesh. A total of 135 specimens ranging from 30.6-48.9 mm TL (total length) and 0.22-1.20 g BW (body weight) were analyzed in the present study. Sampling was done using traditional basket traps and funnel bag nets between January and December 2004. The sex ratio showed no significant differences from expected value of 1:1 ($x^{2=}$ 0.07, $p > 0.05$). The size at sexual maturity *(TL^o)* for *C. soborna* females was estimated to be 44.4 mm TL and the mean fecundity of the sampled population was 1,280±870 eggs, ranging from 420 to 3,240. The allometric coefficient *b* values of the LWR indicated isometric growth (-3.0) for both males and females (2.946 and 2.968, respectively). The LLR analysis between TL and fork length (FL) showed a highly significant correlation in both sexes ($r^2 > 0.911$, $p <$ 0.001). The data presented in this study would be useful for the sustainable management of the Ganges River sprat fishery in the Mathabhanga River in Bangladesh and neighboring countries.

Lashari *et al.* (2007) conducted study from fishpond to determine the fecundity and gonadosomatic index of a carp, *Cirrhinus reba,* during the period March 2004 to February 2005. It was observed that both males and females mature simultaneously. The gonads attain the maximum weight 5.05±0.88 and 12.5±1.55 for males andfemales respectively in July and minimum in November. The fish has only one spawning season of short duration, running from June to August as indicated by the peaks of gonadosomatic index and ova diameter. The fecundity of *C. reba* varied from 20,722 eggs in fish of 150 mm (TL) to 211,200 in fish of 290 mm total length. The fecundity increased with increasing total length, gonad length, gonad weight and body weight. The relationship of fecundity was curvilinear with total length and gonad length and linear with body weight and gonad weight.

Hossain (2010a) described the length-weight (LWR) and length-length (LLR) relationships, as well as the condition factors of the three important Schibid catfishes from the Padma river, northwestern Bangladesh, namely *Ailia coila* (Hamilton 1822), *Eutropiichthys vacha* (Hamilton 1822), and *Neotropius atherinoides* (Bloch 1794). A total of 347 specimens were caught by traditional fishing gear from March 2006 to February 2007. For each individual, the total (TL), fork (FL) and standard (SL) lengths were measured by digital slide calipers. Individual body weight (BW) was also taken by a digital balance. The coefficient *b* of the LWR was close to the isometric value *(b* 3.000) in *A. coila,* although it suggested negative allometric growth in *E. vacha* (b 2.980) and *N. atherinoides* (b 2.900). The results also indicated that the LLRs were highly correlated ($r^2$ > 0.914; P < 0.01). The equations of the condition factors for each species were best expressed by $K— 100 x (BW/ (TL^{3.000})$ for *A. coila,* $K= 100$ x $(BW/(TL^{3.000})$ for *E. vacha,* and $Kn= BW/[(0.095xTL^{2.899}]$ and $K= 100 x(BW/(TL^{3.000})$ for *N. atherinoides.* This study presents for the first time results on the total length-body weight relationships and on the condition factors of these catfish from the Padma river.

Hossain *et al.* (2012c) describe the five at first sexual maturity, fecundity, length-weight (LWRs) and length-length relationships (LLRs) of the pool barb, *Puntius sophore,* using data obtained from different geographical locations in Bangladesh. A total of 905 specimens were caught by traditional fishing gear from March 2010 to February 2011. Additionally, a total of 121 females were collected from a commercial catch of the Padma River during June-July 2011 to estimate size at first maturity and to determine fecundity. Total length (TL), fork length (FL) and standard length (SL) were measured with digital slide calipers. Individual body weights (BW) were determined for all specimens, and gonad weights (GW) from 121 females were weighed to an accuracy of 0.001 g. The female gonadosomatic index (GSI) was calculated as [GSI (%) = (GW / BW) • 100]. Female size at first maturity was estimated using GSI and TL as indicators, and estimated as 5.00 cm TL in the Padma River. Specimens larger than 5.00 cm TL were used to determine fecundity. Mean total fecundity was 5300 ± 2700, ranging from 1580 to 16590. A positive exponential correlation was recorded between total fecundity and total length ($r^2$ = 0.421). Relative fecundity ranged from 466 to 4036 (mean 1100 ± 580) in the Padma River. The LWR of pooled data for sexes combined was estimated as BW = 0.0155 TL2.98 as ANCOVA revealed no significant differences in LWRs between rivers (P > 0.05). All LLRs were highly correlated ($r^2$ > 0.983; P < 0.001), and ANCOVA analyses further indicated that LLRs did not differ between rivers ($P > 0.05$). These results will help in further studies on the population assessment of the species.

Hossain *et at.* (2012d) described the relationships between body size, weight, condition (Fulton's, $K_F$; relative, $K_R$, and relative weight, $W_R$) and fecundity of the threatened species *P. ticto* from the Ganges River, northwestern Bangladesh. A total of 24 mature female specimens were collected by the traditional fishing gears from March to August 2006. For each individual, total (TL), fork (FL), standard length (SL), and ovary length (OL) were measured by digital slide calipers, while body (BW) and ovary weight (OW) were taken by a digital balance. Total fecundity (FT) of each female was calculated as the number of eggs found in each ovary, whereas relative fecundity *($F_R$)* was the number of eggs per gram of fish weight. The results showed that TL of P. *ticto* varied from 9.10 to 10.80 cm, with calculated mean ± SD as 9.77±0.57 cm. Body weights extended from 14.00 to 24.00 g, with calculated mean ± SD as 17.83±3.39 g. The mean FT was 2586±700 and ranged from 1611 to 4130. BW was more significantly correlated with total fecundity (r^O.633; p<0.001) than various other body metrics. The results also indicated significant correlation between length-weight (df=22, t-test>8.86, p<0.001); FT -KF (rs=0.473; p=0.019), FT-KA (rs=0.502; p=0.012), and FT-WR (rs=0.483; p=0.016), but insignificant correlations were found between FT-GSI (rs=0.309; p=0.141) and FR-with various other body metrics. The knowledge of fecundity would be useful to impose adequate regulations for the conservation of this threatened species in the Ganges river and nearby areas of Bangladesh.

Rahman *et at.* (2012) described the length-frequency distributions, length-weight (LWR), length-length relationship (LWR), condition- and form-factor of *Puntius sophore* wild populations from the Chalan *beel,* northcentral Bangladesh. Sampling was done using traditional fishing gears during March 2010 to February 2011. For each individual, the total length (TL), fork length (FL) and standard length (SL) were measured by digital slide calipers. Individual body weight (BW) was also taken by a digital balance. A total of 185 specimens ranging from 3.62-9.02 cm TL (total length) and 0.70-13.20 g BW (body weight) were analyzed in this study. The length-frequency distribution showed that the 6-7 cm TL size group was numerically dominant and constituted 43% of the total population. The coefficient *b* of the LWR indicated positive allometric growth (6<3.00) for *P. sophore* in the Chalan *beel.* The results also indicated that the LWRs were highly correlated ($r^2$ > 0.945). The calculated Fulton's condition factor *(K)* values ranged from 0.69-2.35, with a mean value 1.64±0.30. The relative weight ($W_r$) was not significantly different from 100 for (p=0.074), indicating the balance habitat with food availability relative to the presence of predators for *P. sophore.* The estimated values of form factor (03.0) were as 0.0138, 0.0345 and 0.0435 for TL, FL and SL of P. *sophore.* These results will be useful for fishery biologists and conservationists to suggest adequate regulations for sustainable fishery management and conservation its numerous stocks in the region.

## 2.3 Food and Feeding habit

Bhuiyan and Islam (1991) recorded that smaller fishes, crustaceans, protozoans and insects were the most important food items of *Ompok pabda*.

Alam *et al.* (1994) reported that the stomach contents of Ailia coila include crustaceans (17.89%), insects (12.42%), fishes (15.95%), annelids (4.54%), algae (8.37%), plant parts (10.05%), debris and detritus (8.94% and sand and mud (17.29%).

Bhuiyan *et al.* (1997) observed that *Clupiosoma atherinoides* is a carnivorous fish and the most important food items are the crustaceans, insects, protozoans and rotifers.

Bhuiyan *et al.* (1998) studied the food and feeding habit of *Puntius gonionotus* (Bleeker). They observed that *P. gonionotus* is a planktivorous fish.

Bhuiyan *et al.* (1999) studied the seasonal pattern of the feeding of grey mullet, *Mugil cephalus*. Among the major food items, the fish was found to prefer crustaceans in winter, algae in summer and protozoans in autumn.

Bhuiyan *et al.* (2001) reported that the *Puntius ticto* (Hamilton) is a herbivorous fish. The fish is feeding mainly on algae (36.46%), protozoans (20.69%), plant parts (13.98%), insects (10.18%), sand and mud (6.03%), crustaceans (3.73%) and rotifers (3.06%). Relationship between total length (TL) and alimentary canal length is positively correlated. The regression equation is ACL = 12.698 + 2.808 TL (r = 0.992). The total length and alimentary canal length ration are 1:3.

Hussain *et al.* (2002) studied that the *Tor putitora* (Hamilton) was found to be an omnivorous fish with higher feeding preference for plant material than for animal material. The dominant food groups recorded in the gut contents were Cyanophyceac (35.34%), Bacillariophyceae (26.07%) and Chlorophyceae (12.97%).

Mahamood *et al.* (2004) conducted an experiment to assess the suitability of different larval feeds (artemia, naupli, tubified worms, rotifera and zooplankton) for fry of climbing perch *(Anabas testudineus)* for a period of 28 days. They reported that fry fed tubified worms had significantly higher growth and survival followed by artemia naupli, zooplankton and rotifera powder. They concluded that tubified worms might be a good source for feeding climbing perch fry up to stocking size.

Bhuiyan *et al*. (2006) observed that *Channa punctatus* is mainly a carnivorous fish. Its food consists mainly of crustaceans, insects, molluss, fishes, plant and semi-digesed materials. The juvenile and adult *C. punctatus* are surface feedersThe fish changed its food and feeding habit seasonally. The feeding intensity was very poor in mature fishes during the spawning period. The juvenile fishes fed actively throughout the year. The ratio of the total length and alimentary canal length of juvenile and adult stages is 1:0.36 and 1:0.28 respectively.

Manon and Hossain (2011) conducted a study on food and feeding habit of *Cyprinus carpio* var. *specularis* and found that the highest percentage of empty stomach was in the month of April 2011 (56.67%) and the lowest percentage of empty stomach was in the month of August 2011 (26.32%). The highest percentage of full stomachs was found in the month of August 2011 (73.68%) and the lowest percentage of full stomachs was found in April 2011 (43.33%). The analysis of stomach contents of *C. carpio* var. *specularis* revealed that the food of the fish consists of aquatic plant parts (20.12%), phytoplankton (16.46%), zooplankton (19.69%), debris and detritus (22.00%), insects (6.78%) and semi-digested materials (14.83%). The highest percentage (33.26%) of aquatic plant parts were observed in June 2011 and the lowest percentage (8.80%) in December 2010. The average total length was 37.83±6.96 cm and the average alimentary canal length was 100.63±7.89 cm.

Agbabiaka *et al*. (2012) studied the food and feeding habits of Tilapia zilli (pisces: cichlidae) in river Otamiri south-eastern Nigeria. He found that Tilapia zilli is an Omnivorous fish with dietary preference for Algae (71.05% and 59.52%), vegetative matter (10.52% and 50.00%), detritus (0% and 11.90%) and aquatic invertebrates larvae such as Chaoborus larvae (52.63% and 47.61%) and Chironomid larvae (31.58% and 21.43%) for juveniles and adult Tilapia respectively.

Kumar *et al*. (2012) conducted a study on analysis of diet composition, feeding dynamics and proximate composition of Bombayduck, *harpodonnehereus* along Sunderban area of west Bengal, India and reported that Non- penaeid prawns are the main food item, contributing maximum percentage were noticed during the November (54.80%) and lowest during the August (20.90%). Juveniles of Bombay duck formed the second important gut content of Harpodonnehereus, which indicates the cannibalistic feeding behavior. Plant matter,zooplankton, sand and mud and miscellaneous items are also noticed in guts, but they are less quantities when compare to previous food items. Non penaeid prawns are the major diet for the Bombayduck fisheries.

Mushahida-Al-Noor *et al*. (2013) studied the Food and feeding habit of the critically endangered catfish *Rita rita* (Hamilton) from the Padda river in the north-western region of Bangladesh. He reported that the diet of *Rita rita* consisted of a broad spectrum of food types but crustaceans were dominant, with copepodes constituting 20.73%, other non-copepode crustaceans constituted 12.01%. The next major food group was insect (15.97%), followed by mollusks (14.76%), teleosts (12.98%) and fish eggs (8.608%). Food items like Teleosts, mollusks, insects and shrimps tended to occur in the stomachs in higher frequencies with an increase in *R. rita* size (up to 30.5 - 40.5cm), while fish eggs, copepods and non-copepode crustaceans tended to increase in stomachs at sizes between 10.5-20.5cm. Analysis of monthly variations in stomach fullness indicated that feeding intensity fluctuated throughout the year with a low during June and August corresponding to the spawning period.

Hossain *et al*. (2015) studied the food and feeding habit of *Aspidoparia morar* in Padma river and found that *Aspidoparia morar* was omnivorous due to the presence of both phytoplankton (Chlorophyceae, Euglenophyceae, Bacillariophyceae, Cyanophyceae) and zooplankton (Rotifera, Crustacea) in the gut content. Based on the point method, the average percentage of phytoplankton and zooplankton was 80.71% and 19.29%, respectively. The highest average percentage of fullness was 72.62% in October whereas the lowest was 56.55% in December. The highest average percentage of emptiness recorded was 43.45% in December and the lowest was 27.38% in October. Total length was found statistically positively significant ($P<0.01$) with the alimentary canal length.

Shinkafi and Ajoku (2015) studied the food and feeding habits of African carp (*Labeo senegalensis,* valenciennes 1842) in river Rima, North-Western Nigeria. They reported that *Labeo senegalensis* was an herbivorous detritivore, feeding mainly on plant materials such as *Lymnaea*, *Potamonautes,* worms and algae.

## 2.4 Reproductive biology

Afroz *et al.* (1990) observed the fecundity of *Gudusia chapra* which varied from 1,105 to 26, 532 with standard length from 1.4 to 1.90 m and body weight 13.47 to 50.47 g. They calculated the relationship between fecundity and body parameters.

Islam and Hussain (1990) made an observation on the fecundity and sex ratio of the common punti, *Puntius stigma*. They recorded the fecundity of this fish as 2,475 to 14,461 eggs in specimens varying in length from 74 mm to 98 mm. The mean fecundity was 8635. Per gram body weight of fecundity was 849. The male and female ratio was 1:2.09.

Hoque and Ahmed (1993) observed that the fecundity of the fresh water cat fish *Cirrhinus mrigala* ranged from 2,534 to 60,746 ova in specimens varying in length from 92 mm to 116 mm.

Parween *et al.* (1993) observed that *Esomus danricus* bred from March to July, with a peak in the months from April and May.

Bhuiyan *et al.* (1995) worked on the fecundity of the fresh water fish *Colisha fasciatas* (Bloch) and they observed that the fecundity of the fish ranged from 45,265 to 31,527.

Bhuiyan and Afrose (1996) studied the fecundity and sex ratio of *Oreochromis nilotica.* The fecundity of the matured fish varied from 290 to 1,265 for a fish of total length and body weight 131-230 mm and 50-232 g. The mean fecundity was 575.01±296.75. The male and female sex ratio was 1:1.31.

Latifa *et al.* (1996) published a paper on the fecundity of Kachki fish, *Corica soborna* and observed the fecundity from 1,309 to 8,919 with the standard length ranging from 2.85 to 3.75 cm respectively.

Alam *et al.* (1997) published a paper on sex-ratio and reproductive cycle of *Ailia coila*. The male and female sex-ratio was 1:1.287. *A. coila* breeds once a year from May to September with the peak in the month of August and September.

Sultana *et al.* (1998) made an observation on the fecundity and breeding periodicity at *Pangasius pangasius*. They observed the number of eggs varied from 1,02,600 eggs (for a fish at total length and total weight 92 cm and 8.5 kg) to 27,50,000 eggs (for a fish total length and total weight of female was 1,192 cm 18.7 kg). The mean fecundity was estimated as 1,06,9473 eggs. The gravid females were obtained during the periods from January to March and June to November with peak October and June respectively. The fish bred twice a year.

Bhuiyan and Perveen (1998) worked on the fecundity of *Puntius sophore* and observed that the fecundity of this fish ranged from 1,221 to 3,432 eggs per fish of total length and total weight were 103 mm and 16.58 g respectively. The mean fecundity was 1824.6 egg for a fish with a mean total length 86.773 mm. Some sized fish had different number of eggs in their ovaries.

Das (1998) worked on the maturity and spawning of *Mugil cephalus* in Goa waters. He observed that the males of this species matured earlier

Bhuiyan *et al.* (2000) published a paper on the fecundity and sex ratio of *Barbodes gonionotus*. They observed that the matured fish had 18,001 to 42,035 eggs in varying weight of 42 to 15-9 g and male, female ratio was1: 0.90. It was observed that males were predominant during the months of February, April to June, October, December while the females were predominant and rest of the months.

Bhuiyan and Akter (2002) studied the number of eggs of *Cyprinus carpio* varying from 2, 22,222 of total length 16.2 cm to 2, 55,942 at total length 30.8 cm. The total male and female sex ratio was 1: 1.241.

Latifa *et al.* (2002) studied the fecundity and sexual maturity of the gonad of *Channa striatus*. They observed the fecundity which ranged between 3,454 for a fish of length at 21.9 cm and weight of 122g and 20,568 eggs for a fish of length of 38.3 cm and weight of 42g. The average number of eggs was 11,720.

Sarker *et al.* (2002) carried out investigation on the fecundity and gonadosomatic index (GSI) of *Mystus gulio* in brackish water. They cited that the minimum number of eggs observed (11,436-12,712) was in a fish length ranging 10-12 cm having 4.8-6.2 g at ovary weight. The maximum number at fecundity was 19,394-2348 1 in a fish measuring 20-22 cm with 14.8-21.2 g of fish increased with the size, weight and gonad weight as well.

Kiran and Puttaiah (2003) studied the total number of mature eggs ranging between 6,729 and 26,952 in *Chela untrahi*. The average fecundity was 2,475 eggs. There was variation in the number of ripe ova present in the ovaries of fish having some length.

Islam *et al.* (2006) published a paper on the reproductive biology spawning of *Labeo rohita* (Hamilton) and *Puntius gonionotus* (Bleeker) and observed the fecundity of *L. rohita* ranged from 103534 to 881103 eggs and that of *P. gonionotus* ranged from 14321 to 42034. The relationship between the fecundity and the total length, gonadal weight was established, the sex- ratio of *L. rohita* and *P. gonionotus* has been determined. The male and female ratio was 1: 1.03 for *L. rohita* and 1: 1.06 for *P. gonionotus i.e.* the female number was more than male for both the species.

## 2.5 Marketing System

Biswas (1990) noted that fishermen usually brought their fish to Netrokona Mechua Bazar, and sold them to aratdars, a small number of fishermen sold fishes to retailers directly. Study shows that fishermen sold 60.3% fish to aratdars, 29.16% fish to retailers and only 10.49% fish directly to consumers. Aratdars sold 88.38% fish to retailers and only 11.62% fish to consumers directly. Retailers collected 75.20% fish from aratdars 24.80% fish from fishermen for selling to consumers.

Khan (1995) identified two marketing channel in Netrokona and Mymensingh town, one was fishermen-aratdars (commission agents) paikers (wholesalers)-retailers-consumers and the other was fishermen-paikers - consumers.

Shrivastava and Ranadhir (1995) observed that there are three marketing channel Bhubaneshwar city of Orissa, India. The first, local producers sell fishes the retail marketing points; the second, local producer to retailers than consumers; the third, non-local producers cum wholesalers to commission agent then to retailers and finally to consumers.

Mia (1996) identified three marketing channel in Mymensingh district, the first one was fish farmer-bapary-aratdar-retailer-consumer, the second one was fish farmer-bapary- retailer consumer and the third one was bapary-aratdar- retailer-consumer.

Parween *et al.* (1996) found in a study in Natore and Nawabganj district that fishes are packed with ice and aquatic vegetation and covered with banana leaves or gunnysacks. The catch is dumped in large bamboo baskets, covered with aquatic vegetation and carried to the nearest center for transportation to big towns and cities. From the fishing area rickshaw vans bull-carts or even “the lagari” carried the fishes then transported either by rail, truck, bus or boat in Natore and Nawabganj districts.

Rokeya *et al.*, (1997) found that there are five other people involved in the distribution network from producer to consumer in Rajshahi markets. Local agents (dalal) collect and purchase fish on a commission basis. Mahajans then transport the fish to local market and sell the catch to local retailers (nicary) wholesalers (paiker) and distributors (bapery) through commission agents (aratdar). For carrying fishes the fishers were mainly used wooden box, bamboo basket, earthen pot, aluminum can, drum etc. Fish transportation in Rajshahi includes boat, head load, shoulder load, bullock cart, pull cart, rickshaw and motor vehicle and often used train, bus, truck etc.

Ahmad (1997) proposed that intensification of marketing activities should incorporate in fish handling, training of fish market operators, fish quality control after examining existing fish marketing practices, channels of distribution, price pattern and marketing margin of three beels of western Bangladesh.

According to Lofvall (1999) the middlemen usually buy the fish directly from the farmers or fishermen but do not seem to have formal agreements with particular producers. Traders complaining that earlier market had been a buyer's market, but farmers now had become tougher in negotiating prices and played traders out against each other. Practically all wholesalers also operate as retailers and have shops in Katmandu, Nepal. Sales per trader amounts to some 200-300 kg/day and their respective market shares appear equal. The fish is usually packed in bamboo using ice for chilling and large leaves or jute for protection. The ice fish ratio varies between 1:2 and 1:1 depending on the season.

Huq and Husain (1999) indicated that the baparies purchase dry fish from producers. Whereas wholesalers purchase dry fish form baparies through aratders and sale to retailers in Mymensingh. Dry fish marketing system in Mymensingh district is inefficient as there is less number of fish traders having good understanding among them lead to imperfect competition. The dry fish producer's share was 31% to 49% on consumer's price.

Olalo, (2000) noted that, fish traders buy and sell all kinds of fish - freshwater, brackish water and marine. A majority or 70% of the traders directly obtain their supply from fish producers, while the rest (30%) buy from wholesalers.

Rahman (2003) conducted a study on fish marketing in Gazipur district. He found that the market chain from farmers to consumers passes through a number of intermediaries: local fish traders, agents, wholesalers and retailers. With a few exceptions, farmers never directly communicate with consumers, market communication normally being made through middlemen. The middlemen usually buy the fish from the farmers but do not seem to have agreements with particular producers.

Musa and Bhuiyan (2007) reported that the landing facilities of the wholesale fish markets are not well developed specially in this region because of by the .private sector. There are four possible channels of flow of fish from producers to consumers and five other people (intermediaries) involved in the distribution network. Transportation is mainly done by train, bus, truck, boat and so on, which is convenient or available. The packing materials used for mentioned markets were mostly earthen pot, aluminum can, drum etc.

The nature of marketing channel or distribution channel of *L. calcarifer* is found to depend on the distance between producing areas and the market, and on the condition of transportation system. The channel becomes more complex in the greater distance and undeveloped communication system.

Galib *et al.* (2009a and 2009b) reported that 27 fishing gears and 2 FADs were used in the Chalan Beel of north-west Bangladesh for catching fishes. Jewel (2006) indentified 6 types of net, 4 types of traps and 1 types of wounding gear in the Padma river adjacent to Boalia Thana under the district of Rajshahi, Bangladesh.

Flowra *et al.* (2010) identified five different marketing channels in the marketing system of dry fish in Rajshahi and Thakurgaon district of Bangladesh. Galib *et al.* (2010) figured out three types of marketing channels in their study with small indigenous species of fishes in the Chalan Beel. Samad *et al.* (2010) found the highest retail price of 400BDT/kg of *Clarias batrachus*.

# Chapter Three

# Ecological studies of Padma River, North-western Bangladesh

## 3.1 Introduction

Hydrographical studies play an important role in understanding the various biological processes (growth, physiology, reproduction, etc.) and the general productivity of aquatic ecosystem. Water maintains an ecological balance between various group of living organism and their environment (Khanna *et al.,* 2012). The productivity of freshwater community that controls the fish growth is regulated by the dynamics of its physico-chemical and biotic environment (Wetzel, 1983). The physical and chemical characteristics of water bodies affect the species composition, abundance, productivity and physiological conditions of aquatic organisms, which in turn regulate the growth rate and development of fish.

Biological potentiality of an aquatic ecosystem depends on the biomass of the plankton. Both the qualitative and quantitative abundance of plankton in a water body are of great importance for imposing sustainable management policies, as they vary from location to location and aquatic systems within the same location even within similar ecological conditions (Boyd, 1982). The knowledge on the abundance, composition and seasonal succession of the same is a prerequisite for the successful management of an aquatic ecosystem (Ahmed *et al.,* 2003). Both phytoplankton and zooplankton supports the economically important fish populations. Phytoplankton is the primary producers for the entire aquatic body and comprises the major portion in the ecological pyramids (Odum, 1971). In the consumer food chain of aquatic ecosystems zooplankton play an important role in the transfer of energy from the primary producer to fish. They play an important role in the natural food chain which constitute important food item of omnivorous and carnivorous fishes. Different species of plankton vary in different seasons due to the changes in physico-chemical nature of water.

The Padma is the major trans-boundary river of Bangladesh. It is the main distributary of Ganges, which originates in the Himalaya. This river plays a vital role as the important freshwater resources of Bangladesh. Among the different fish items, *C. reba* is a natural inhabitant of Padma river. The population of this natural fish species has declined from Padma river considerably due to increased fishing pressure and various anthropogenic activities that leading to siltation, aquatic pollution and loss of natural habitat for spawning and growth (Akhteruzzaman *et al*., 1998; Hussain and Mazid, 2001). As a result, recently the fish is considered as one of the most threatened species in Bangladesh (Hossain *et al*., 2013). The quality of aquatic environment generally depends on four kinds of factors, such as physical, chemical, biological and meteorological factors (Stanitski *et al*., 2003). Just by assessing the physical, chemical and biological characteristics of water, one can conclude about its quality. An assessment of plankton community and abundance will enhance our understanding of biological productivity and fish population dynamics (Onyema, 2007). It is also believed that the morphology of fish is determined by genetic and environmental factors, with these being particularly important during the early developmental stages when individuals are influenced by the environment (lhssen *et al*., 1981). Therefore, in eco-biological point of view it is necessary to understand the prevailing ecological condition of the natural habitat of this vulnerable fish species.

In the present investigation we tried to understand the physico-chemical and biological constituents of the environment of Padma river in a sense of present status of this aquatic habitat for living condition of *C. reba*.

**The present investigation is aimed on the following objectives**

- To know the physico-chemical nature of this aquatic ecosystem
- To understand the interrelationship among the physico-chemical parameters
- To determine the planktonic diversity and evenness
- To revealed the relationship between physico-chemical and planktonic population of Padma river.

## 3.2 Materials and methods

### 3.2.1 Study site and duration

The present study was conducted along the Padma river from Godgari to Charghat Rajshahi. Five distinct stations were selected for collection of environmental data during the two years (From January 2014 to December 2015) of study period. Name of the sampling station with GPS point are shown in Table 3.1 and Figure 3.1.

**Table 3.1. Sampling station with GPS points**

| Name of the river | Sampling station | GPS points (Latitute, Longitute) |
|---|---|---|
| Padma | 1. Godagari | N-24º27´34.79´´ E-88º20´09.54´´ |
| | 2. Bullanpara | N-24º22´13.96´´ E-88º33´27.78´´ |
| | 3. Padma garden | N-24º21´42.30´´ E-88º35´52.44´´ |
| | 4. Yusufpur | N-24º20´08.77´´ E-88º42´44.41´´ |
| | 5. Charghat | N-24º16´43.25´´ E-88º45´06.75´´ |


**Figure 3.1 Map of Rajshahi district with studied sampling station (★)**

### 3.2.2 Sampling procedures

#### 3.2.2.1 Sampling and analysis of physic-chemical parameters of water

Surface water samples were collected once in a month between 10:00 and 11:00 hours for analysis of various physico-chemical parameters using dark bottles. The water samples were chilled in ice and transferred to the laboratory at 4°C. Surface water temperature and transparency were measured using a Celsius thermometer and a using a black and white standard colour coded Secchi disc. Water pH was measured using an electronic pH meter (Jenwary, 3020). Nitrate-nitrogen ($NO_3$-N), phosphate-phosphorus ($PO_4$-P) concentrations were measured using the Hach Kit (DR/2010, a direct-reading spectrophotometer) with high range chemicals (Nitra Ver. 5 Nitrate Reagent Powder Pillows for 25 ml sample for $NO_3$-N and Phos. Ver. 3 Phosphate Reagent Powder Pillows for 25 ml sample for $PO_4$-P analysis). Dissolved oxygen (DO), total hardness and total alkalinity were measured by using a portable aquaculture kit (Model FF2, HACH, USA). EC and TDS were measured with an EC, TDS tester (Adwa AD31 waterproof EC/TDS Testers). The meteorological data during the study period was collected from BRRI, Regional Station, Shaympur, Rajshahi.

#### 3.2.2.2 Plankton study

Plankton samples were collected using plankton net (25 µm mesh size) and fixed in 5% formalin on site. Identification of the plankton species were conducted under a phase contrast light microscope (Olympus CX21, Tokyo, Japan) with bright field and phase contrast illumination (Anagnostidis and Komarek 1985; Skulberg *et al.,* 1993). Quantitative estimation of plankton was done on Sedgewick-Rafter counting chamber (S-R cell) by following the method described by Stirling (1985). The quantitative abundance of plankton was expressed as units/1 of water using the formula given by Stirling (1985), N = (A*100*C)/V*F*L, where, N is the number plankton cells or unit per liter of original water, A is the total number of plankton counted, C is the volume of final concentrate of the sample in ml, V is the volume of a field, F is the number of the field counted, L is the volume of original water in liter. Identification of plankton (phytoplankton and zooplankton) up to generic level was made according to Prescott (1964).

Shannon-Weiner diversity index (H`) and evenness (J`) were also estimated. Diversity index of plankton during each month was calculated by using the formula (Shannon and Wiener, 1949):

$$H' = -\sum_{i=1}^{s}(pi)(log2pi)$$

Where,

S= number of species, *p*i = the proportion of individuals belonging to $i^{th}$ species.

Species evenness (J`) was calculated from the observed species diversity and from the equation of Hmax (Tian *et al.,* 2012). Index of species evenness was measured by using the following formula:

$$J' = \frac{H'}{Hmax}$$

Where,

H` = Observed species diversity, H max = Maximum species diversity = $Log_2$ S

**3.2.3 Statistical analysis**

For the statistical analysis of data collected, one-way analysis of variance (ANOVA) and Pearson correlation were performed using the SPSS (Statistical Package for Social Science, evaluation version-20.0, IBM Corporation, Armonk, NY, USA). The mean values were also compared to see the significant difference through DMRT (Duncan Multiple Range Test) at 5% level of significance (Gomez and Gomez, 1984). The percentages and ratio data were analyzed using arcsine transformed data.

## 3.3 Results

### 3.3.1 Physico-chemical variables

#### 3.3.1.1 Air and water temperature

The highest average air temperature was 33.93±1.85 $^0$C recorded in the month of May (2014) and lowest was 15.21±0.21 $^0$C recorded in the month of January (2014). In case of water temperature, the highest value (32.34±1.00 $^0$C) was also recorded in the month of May (2014); whereas, the lowest water temperature (13.75±0.25 $^0$C) was in the month of January (2014). The mean air and water temperature of Padma river was 26.48±5.98 $^0$C and 24.35±5.57 $^0$C, respectively. Variation in the mean values of air and water temperature of Padma river during two years (2014 and 2015) of study period are shown in Figure 3.2.

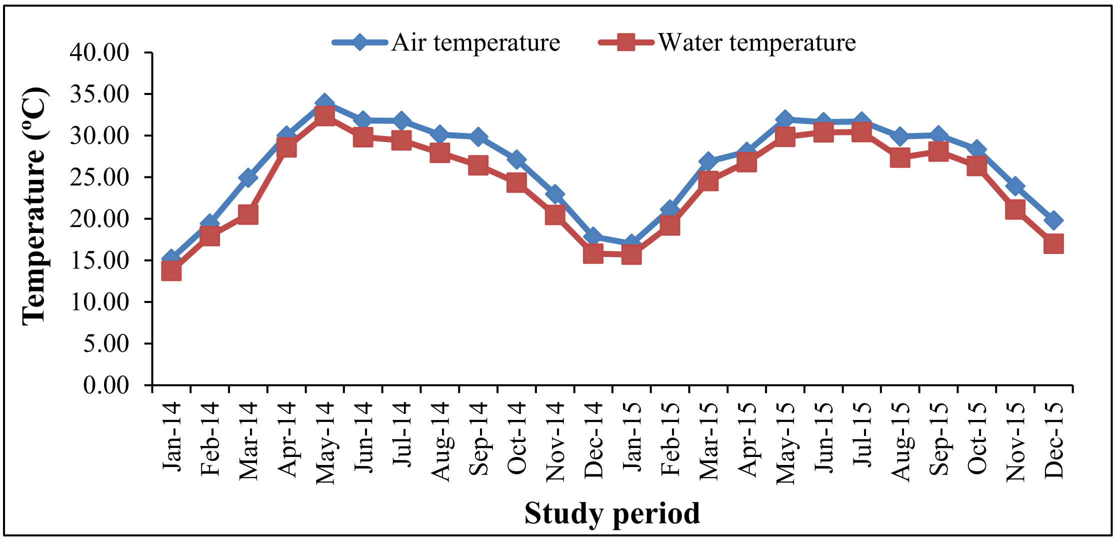



**Figure 3.2.** Monthly variation of air and water temperature of Padma river during January 2014 to December 2015

#### 3.3.1.2 Water transparency and rainfall

The mean values of water transparency in the Padma river during the study period was 29.07±3.59 cm, with the highest value observed in the month of April 2014 (34.49±0.89 cm) and lowest value was recorded as 23.33±0.99 cm in the month of August 2014. The highest monthly average rainfall was measured 246.62 mm (August 2014) and the lowest was 0.00 mm (April, November and December 2014; and February and December 2015). Monthly variation in the mean values of water transparence and rainfall is shown in Figure 3.3.

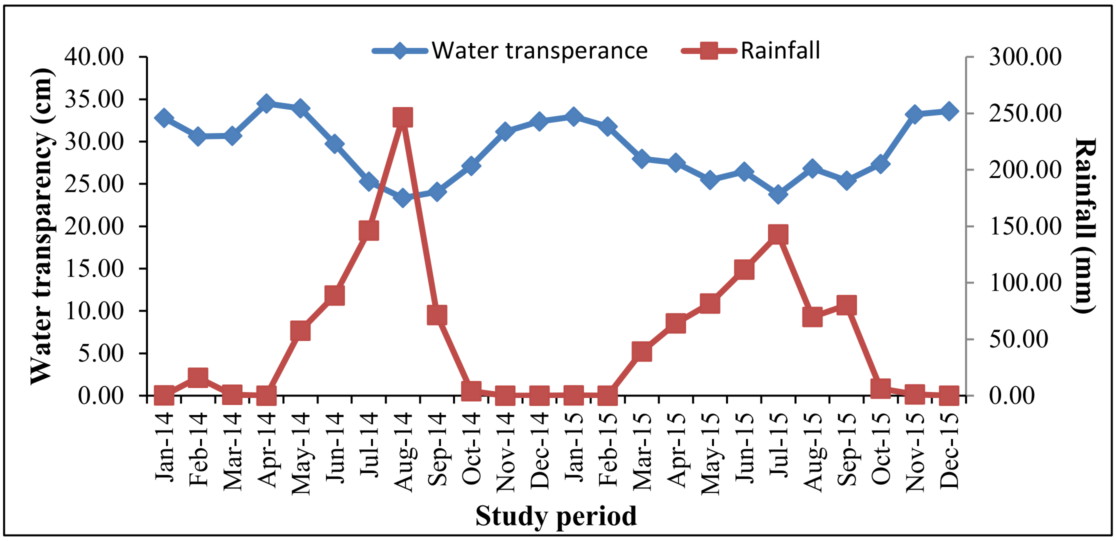



**Figure 3.3.** Monthly variation in water transparence and rainfall of Padma river during January 2014 to December 2015

### 3.3.1.3 pH and dissolved oxygen (DO)

The highest value of pH (8.74±0.11) was observed in January 2014 and lowest (6.86±0.27) was in May of the same year. The mean value of pH in Padma river during the study period was 7.61±0.56. The mean value of dissolved oxygen during the study period was 7.29±1.02 mg/l with highest value (9.44±0.58 mg/l) observed in the month of January 2014 and the lowest was 5.40±0.15 mg/l in the month of May 2014. Monthly variation in the mean values of pH is shown in Figure 3.4.

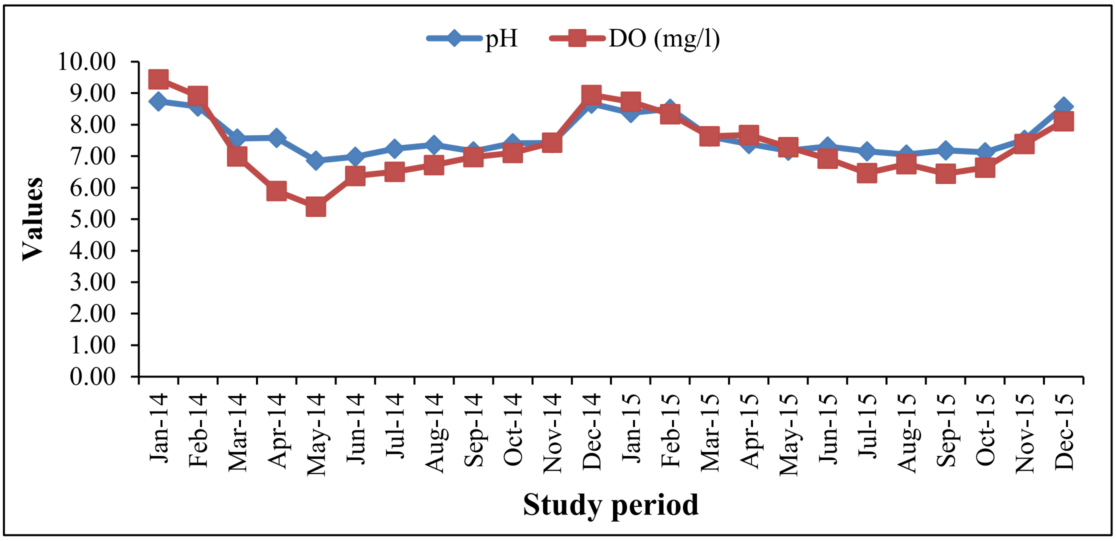



**Figure 3.4.** Monthly variation in dissolved oxygen of Padma river water during January 2014 to December 2015

### 3.3.1.4 Electrical conductivity (EC) and total dissolved solids (TDS)

The highest value of EC was recorded 262.48±15.97 µs/l in the month of December 2015 and lowest value (94.10±3.74 µs/l) was observed in the month of June 2014. The mean values of EC of Padma river during the study period was 189.77±53.55 µs/l. The mean value of TDS of Padma river during the study period was 112.71±36.85 ppm, whereas the highest value (186.61±8.72 ppm) was recorded in the month of July 2014 and lowest value was 78.83±2.90 ppm in the month of February 2015. Monthly variation in the mean values of EC and TDS is shown in Figure 3.5.

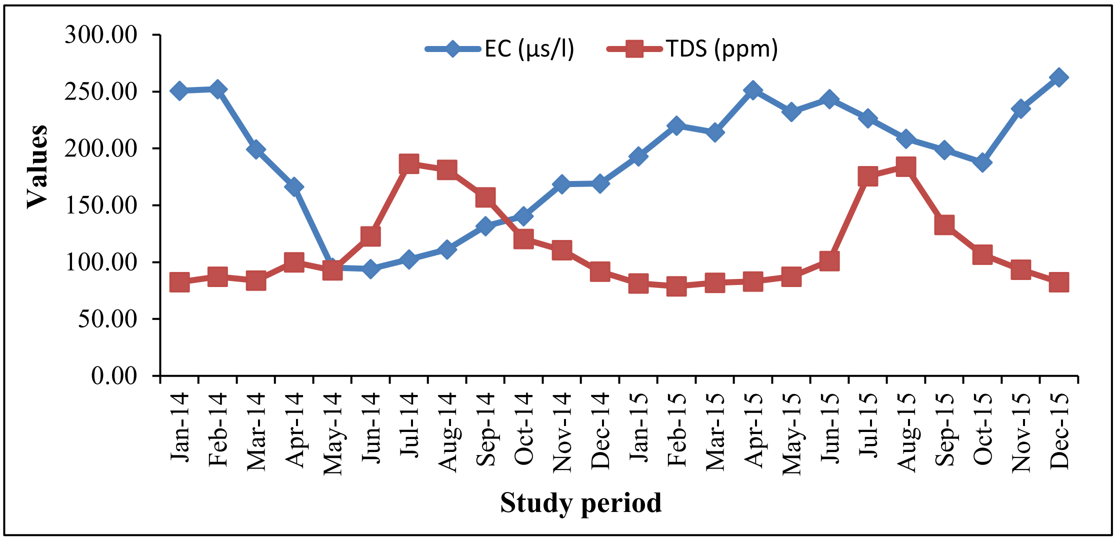



**Figure 3.5.** Monthly variation in EC and TDS of Padma river water during January 2014 to December 2015

### 3.3.1.5 Total hardness and total alkalinity

The highest value of total hardness was found 134.41±9.68 mg/l in the month of May 2015, while the lowest value was 78.39±8.53 mg/l in the month of October 2015. The mean value of total hardness of the Padma river was recorded 99.62±15.65 mg/l. The highest value of total alkalinity was 129.81±2.21 mg/l recorded in the month of January 2015 and the lowest value was 80.46±0.68 observed in the month of October 2015. Mean total alkalinity recorded during the study period (January 2014 to December 2015) was 103.25±19.96 mg/l. Monthly variation in the mean values of total hardness and total alkalinity is shown in Figure 3.6.

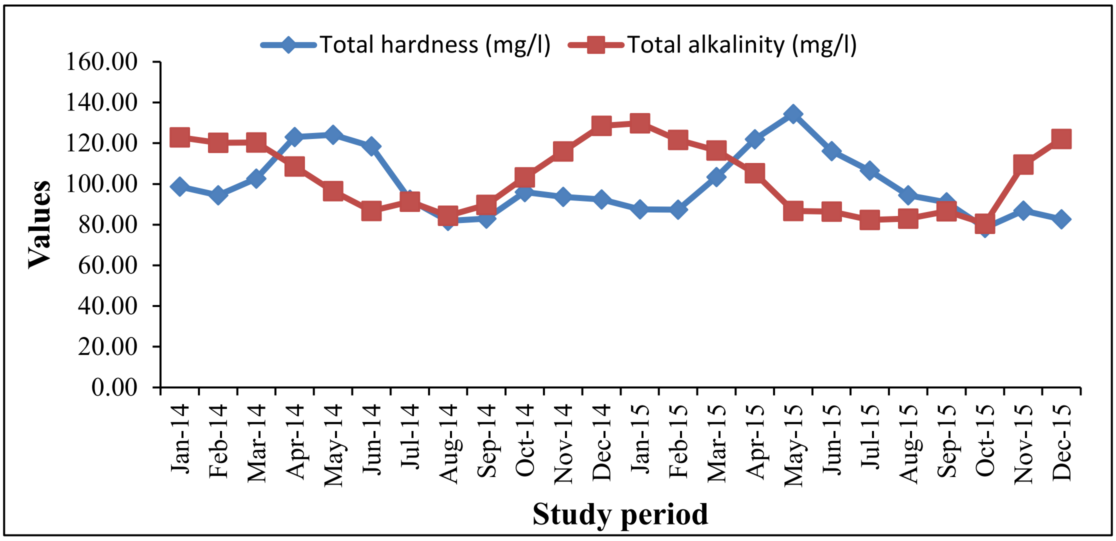



**Figure 3.6.** Monthly variation in total hardness and total alkalinity of Padma river water during January 2014 to December 2015

### 3.3.1.6 Nitrate- nitrogen ($NO_3$-N) and phosphate-phosphorus ($PO_4$-P)

The mean values of $NO_3$-N and $PO_4$-P were 0.25±0.11 mg/l and 0.18±0.07 mg/l during the study period. The highest value of $NO_3$-N and $PO_4$-P was found 0.49±0.04 and 0.26±0.02 mg/l which was recorded in the same month of April 2014 and lowest value (0.05±0.02 and 0.04±0.02 mg/l) of these two parameters was also recorded in the month of in the month of July 2015. Monthly variation in the mean values of $NO_3$-N and $PO_4$-P is shown in Figure 3.7.

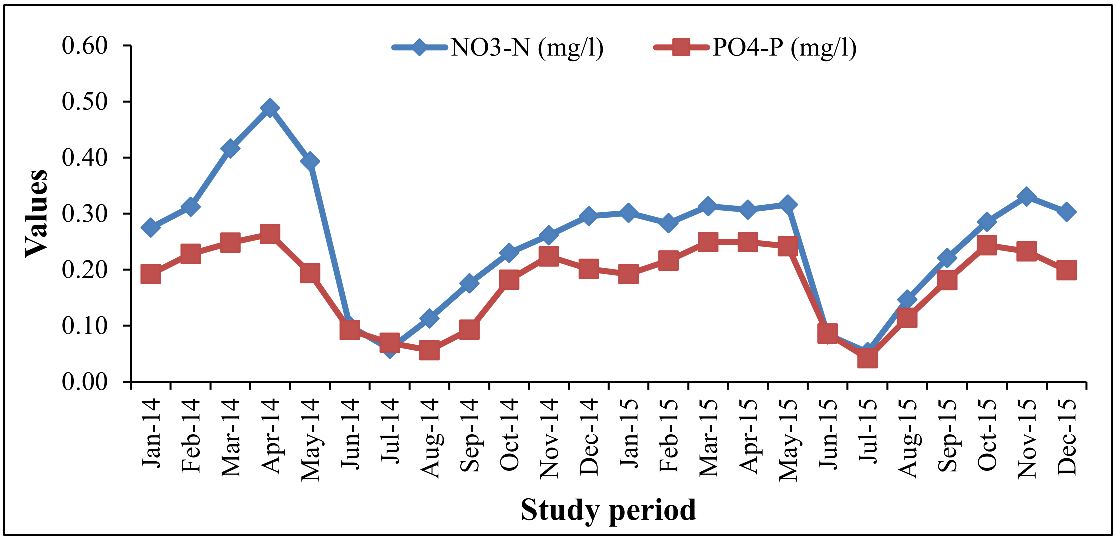



**Figure 3.7.** Monthly variation in $NO_3$-N and $PO_4$-P of Padma river water during January 2014 to December 2015

### 3.3.1.7 Correlation among physico-chemical variables of water

The correlation among different physico-chemical parameters of water is shown in Table 3.2. Air temperature had positive correlation with water temperature, rainfall, TDS and total hardness, while negative correlation with water transparence, pH, DO, EC, total alkalinity, $NO_3$-N and $PO_4$-P. Water temperature had positive correlation with rainfall, TDS and total hardness; and negative correlation with water transparence, pH, DO, EC, total alkalinity, $NO_3$-N and $PO_4$-P. Water transparence had positive correlation with pH, DO, EC, total hardness, total alkalinity, $NO_3$-N and $PO_4$-P; and negative correlation with rainfall and TDS. Rainfall was positively correlated with TDS and total hardness and negative correlation with pH, DO, EC, total alkalinity, $NO_3$-N and $PO_4$-P. pH was positively correlated with DO, EC, total alkalinity, $NO_3$-N and $PO_4$-P and negatively with TDS and total hardness. DO have positive correlation with EC, total alkalinity, $NO_3$-N and $PO_4$-P and negative with TDS and total hardness. EC was positively correlated with total hardness, total alkalinity, $NO_3$-N and $PO_4$-P and negatively with TDS. TDS was negatively correlated with total hardness, total alkalinity, $NO_3$-N and $PO_4$-P. Total hardness was positively correlated with $NO_3$-N and $PO_4$-P; and negatively with total alkalinity. Total alkalinity was positively correlated with both $NO_3$-N and $PO_4$-P, while $NO_3$-N has positive correlation with $PO_4$-P.

**Table 3.2. Correlation among physic-chemical variables of water**

| | Air temperature | Water temperature | Transparence | Rainfall | pH | DO | EC | TDS | TH | TA | $NO_3$-N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Water temperature | 0.964** | | | | | | | | | | |
| Transparence | -0.560** | -0.546** | | | | | | | | | |
| Rainfall | 0.631** | 0.641** | -0.727** | | | | | | | | |
| pH | -0.898** | -0.866** | 0.537** | -0.501** | | | | | | | |
| DO | -0.890** | -0.864** | 0.330** | -0.450** | 0.861** | | | | | | |
| EC | -0.436** | -0.411** | 0.155 | -0.350** | 0.448** | 0.550** | | | | | |
| TDS | 0.529** | 0.501** | -0.666** | 0.719** | -0.512** | -0.479** | -0.462** | | | | |
| TH | 0.432** | 0.482** | 0.037 | 0.100 | -0.325** | -0.312** | 0.013 | -0.225 | | | |
| TA | -0.837** | -0.827** | 0.713** | -0.689** | 0.809** | 0.718** | 0.322** | -0.671** | -0.172 | | |
| $NO_3$-N | -0.343** | -0.352** | 0.689** | -0.705** | 0.314** | 0.164 | 0.223 | -0.724** | 0.193 | 0.572** | |
| $PO_4$-P | -0.398** | -0.397** | 0.569** | -0.761** | 0.319** | 0.297* | 0.386** | -0.783** | 0.143 | 0.561** | .875** |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Note: DO = Dissolved oxygen, EC = Electrical conductivity, TDS = Total dissolved solids, TH = Total hardness, TA = Total alkalinity, $NO_3$-N = Nitrate-nitrogen and $PO_4$-P = Phosphate-phosphorus.

### 3.3.2 Phytoplankton

#### 3.3.2.1 Plankton community composition

A total of 4 classes, 59 genera and 130 species which belongs to Chlorophyceae (51 species), Bacillariophyceae (39 species), Cyanophyceae (26 species) and Euglenophyceae (14 species) were recorded during two years (January 2014 to December 2015) of study period from Padma river (Table 3.3). The percent composition based on species number was Chlorophyceae 39.77 %, Bacillariophyceae 42.42 %, Cyanophyceae 13.72 % and Euglenophyceae 4.09 % respectively (Figure 3.8).

**Table 3.3.** List of phytoplankton species in Padma rive during January 2014 to December 2015

| **Chlorophyceae** | |
|---|---|
| 1. *Actinastrum hantzschii* Lagerheim | 27. *Oedogonium hirnii* Gutw. |
| 2. *Actinastrum* sp. | 28. *Oedogonium* sp. |
| 3. *Ankistrodesmus* sp. | 29. *Pandorina cylindricum* Iyengar |
| 4. *Ankistrodesmus falcatus* (Corda) Ralfs. | 30. *Pediastrum boryanum* (Turpin) Meneghini |
| 5. *Ankistrodesmus spiralis* | 31. *Pediastrum duplex* Meyen |
| 6. *Botryococcus* sp. | 32. *Pediastrum simplex* var. deodenarium Bailey |
| 7. *Chlamydomonas angulosa* Dill | 33. *Pediastrum* sp. |
| 8. *Chlorella* sp. | 34. *Scenedesmus arcuatus* (Lemm.) |
| 9. *Chlorella vulgaris* Beijerinck | 35. *Scenedesmus hystrix* Lagerheim |
| 10. *Chlorococcum infusionum* (Schrank) Meneghini | 36. *Scnedesmus acuminatus* var. acuminatus nach Philipose |
| 11. *Cladophora* sp. | 37. *Scnedesmus quadricauda* (Turp.) de Brebisson |
| 12. *Closteriopsis longissima* Lemm. | 38. *Scnedesmus* sp. |
| 13. *Closterium moniliferum* (Bory) Ehr. | 39. *Schroederia* sp. |
| 14. *Closterium* sp. | 40. *Selenestrum* sp. |
| 15. *Coleochaete scutata* Bréb | 41. *Spirogyra elliptica* Jao |
| 16. *Cosmarium* sp. | 42. *Spirogyra hyalina* Cleve |
| 17. *Cosmarium constractum* Kirchn. | 43. *Spirogyra* sp. |
| 18. *Cosmarium formosulum* Hoffman. | 44. *Spirogyra verrucosa* (Rao) Krieger var. minor Islam var. nov. |
| 19. *Cosmarium granatum* Breb. | 45. *Staurastrum* sp. |
| 20. *Crucigenia crucifera* (Wolle) Collins | 46. *Tetraedron minimum* (A. Braun) Hansgirg |

| | |
|---|---|
| 21. *Crucigenia lauterbornii* Schmidle | 47. *Ulothrix* sp. |
| 22. *Cylindrocystis brebissonii* Menegh. | 48. *Ulothrix zonata* Weber et Mohr.Kuetzing |
| 23. *Microspora* sp. | 49. *Volvox* sp. |
| 24. *Oedogonium borisianum* (Le Cl.) Wittr. var. crassa | 50. *Zygnema* sp. |
| 25. *Oedogonium elegans* West & West var. elegans | 51. *Zygnema pectinatum* (Vauch.) C. A. Agardh |
| 26. *Oedogonium formosum* Kam. | |
| **Bacillariophyceae** | |
| 1. *Amphora* sp. | 21. *Melosira* sp. |
| 2. *Amphora acutiuscula* Kuetz. | 22. *Melosira granulata* (Ehr.) Ralf. |
| 3. *Asterionella* sp. | 23. *Navicula* sp. |
| 4. *Asterionella formosa* Hass. | 24. *Navicula grimmi* Krasske |
| 5. *Bacillaria* sp. | 25. *Navicula placentula* (Ehr) Grun. |
| 6. *Coscinodiscus* sp. | 26. *Navicula rhynchocephala* Kutzing |
| 7. *Cyclotella* sp. | 27. *Navicula viridula* Kuetz. |
| 8. *Cyclotella glomerata* Bachmann | 28. *Nitzschia* sp. |
| 9. *Cyclotella meneghiniana* Kuetz. | 29. *Nitzschia sublinearis* Hustedt. |
| 10. *Cymbella* sp. | 30. *Nitzschia thermalis* Kuetz. |
| 11. *Cymbella affinis* Kuetzing | 31. *Rhizosolenia* sp. |
| 12. *Cymbella delicutala* | 32. *Surirella* sp. |
| 13. *Diatom* sp. | 33. *Surirella robusta* Ehrenb. |
| 14. *Fragilaria brevistriata* Grun | 34. *Synedra* sp. |
| 15. *Fragilaria intermedia* Grun | 35. *Synedra affinis* Kuetz. var. fasciculata |
| 16. *Fragillaria* sp. | 36. *Synedra ulna* (Nitzch) Ehrenb. |
| 17. *Gomphonema* sp. | 37. *Tabellaria* sp. |
| 18. *Gomphonema angustatum* Kuetz | 38. *Tabellaria fenestrate* |
| 19. *Gomphonema intricatum* Kuetz. | 39. *Triceratium* sp. |
| 20. *Grysosigma kuetzingii* (Grun) Cleve | |
| **Cyanophyceae** | |
| 1. *Anabaena circinalis* | 14. *Merismopedia punctata* Meyen |
| 2. *Anabaena spiroides* Klebahn | 15. *Microcystis robusta* (Clark) Nygaard |
| 3. *Anabaena ballyganglii* Banerjii | 16. *Microcystis holsatica* Lemm. |
| 4. *Anabaenopsis elenkinii* (?) Miller | 17. *Microcystis aeruginosa* Kutzing |
| 5. *Anabaenopsis raciborskii* Wolosz. fa. | 18. *Nostoc* sp |
| 6. *Aphanocapsa* sp. | 19. *Oscillatoria amphibia* Ag. ex Gomont |
| 7. *Chroococcus* sp. | 20. *Oscillatoria subbrevis* Schmidle |
| 8. *Chroococcus turgidus* (Kuetz.) Nag | 21. *Oscillatoria limosa* Ag. ex. Gomont |
| 9. *Chroococcus minor* (Kutz.) Nag. | 22. *Oscillatoria agardhii* Gomont |
| 10. *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju | 23. *Polycistis* sp. |

| | |
|---|---|
| 11. *Merismopedia glauca* (Ehrenberg) Kuetz | 24. *Phormidium calcicola* Gardner |
| 12. *Merismopedium* sp. | 25. *Spirulina* sp. |
| 13. *Merismopedia elegans* A. Br | 26. *Spirulina major* Kuetz |
| **Euglenophyceae** | |
| 1. *Euglena acus* Ehr. | 8. *Phacus acuminatus* Stoccker |
| 2. *Euglena caudata* Huebener | 9. *Phacus wettzteinii* |
| 3. *Euglena fusca* (Klebs) Lemm. | 10. *Strombomonas* sp. |
| 4. *Euglena* sp. | 11. *Trachelomonas globularis* (Awerinzew) Lemm. |
| 5. *Euglena viridis* Ehrb. | 12. *Trachelomonas hystrix* Teiling |
| 6. *Lepocinclis* sp. | 13. *Trachelomonas raciborskii* Wolosz. |
| 7. *Phacus* sp. | 14. *Trachelomonas* sp. |

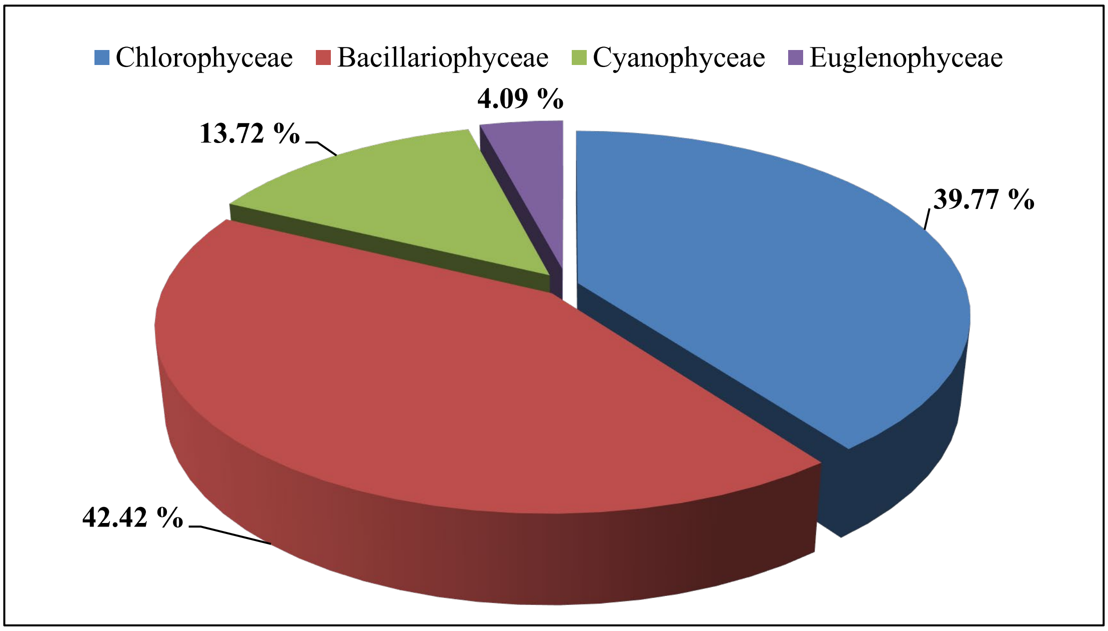



**Figure 3.8.** Percent composition of different groups of phytoplankton of Padma river during January 2014 to December 2015

### 3.3.2.2 Phytoplankton abundance

The phytoplankton population of Padma river showed distinct spatial and temporal distribution pattern (Figure 3.9 and 3.10). The highest abundance (with an average of $31.00\times10^3$ units/l) was found in the month of November 2014 and lowest (with an average of $0.29\times10^3$ units/l) in August 2014. The average phytoplankton abundance recorded during the study period was $18.90\times10^3$ units/l. During the present study, it was found that phytoplankton abundance of different groups showed different trend than that of total phytoplankton abundance. The dominant group of phytoplankton was Bacillariophyceae with an average highest abundance of 13.49×10$^3$ units/l in the month of December 2015, followed by Chlorophyceae with an average highest abundance of 12.58×10$^3$ units/l in the month of November 2014. The abundance of Cyanophyceae was highest (with an average of 7.47×10$^3$ units/l) in the month of April 2015 and the abundance of Euglenophyceae was highest (with an average of 4.48×10$^3$ units/l) in the month of December 2014 (Figure 3.9). The highest average phytoplankton abundance was recorded in station 3 (21.36×10$^3$ units/l) followed by station 1 (19.97×10$^3$ units/l), while the lowest average abundance was found in station 5 with an average abundance of 16.63×10$^3$ units/l (Figure 3.10).

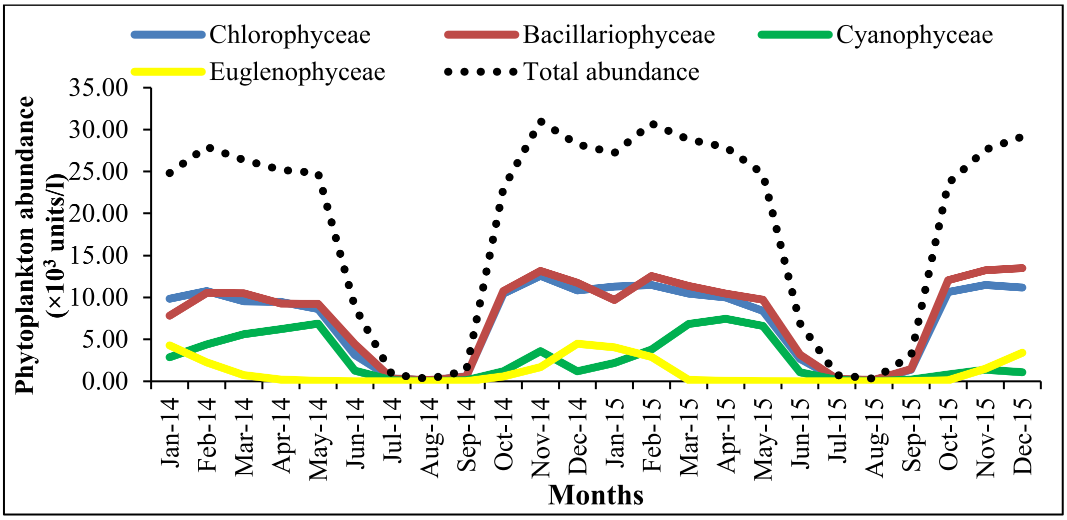



**Figure 3.9.** Temporal variation of phytoplankton abundance of Padma river during January 2014 to December 2015

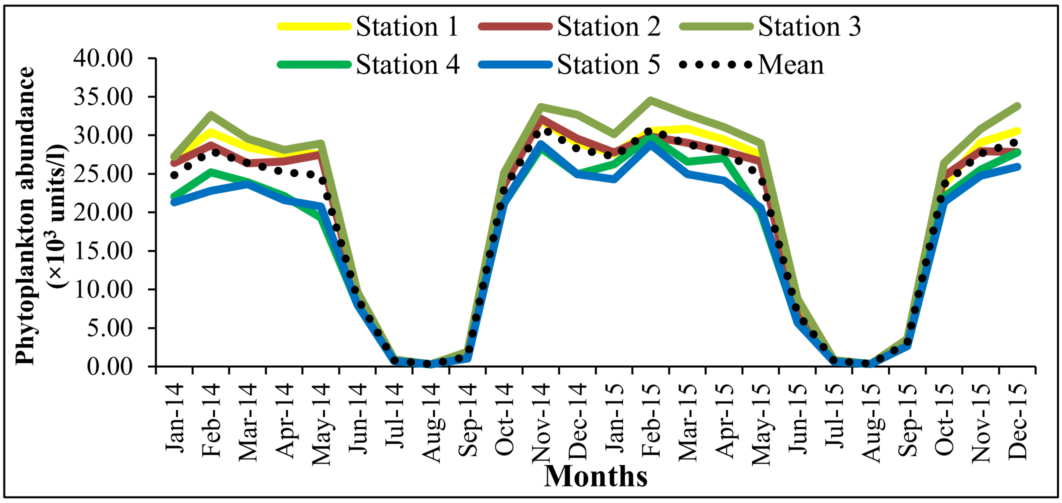



**Figure 3.10.** Spatial variation of phytoplankton abundance of Padma river during January 2014 to December 2015

### 3.3.2.3 Phytoplankton diversity index and evenness

Diversity index and evenness calculated from total abundance of phytoplankton of Padma river are shown in Figure 3.11 and 3.12 respectively. The highest (3.88) diversity index was recorded in the month of April 2015 at station 5 and lowest (0.53) at station 3 in August 2014. The average diversity index of phytoplankton of Padma river was 2.6. The highest (0.97) evenness of phytoplankton was observed at station 5 in April 2014 and lowest (0.10) was in August 2014 and 2015, with average mean evenness of 0.62 during the study period (Figure 3.11 and 3.12).

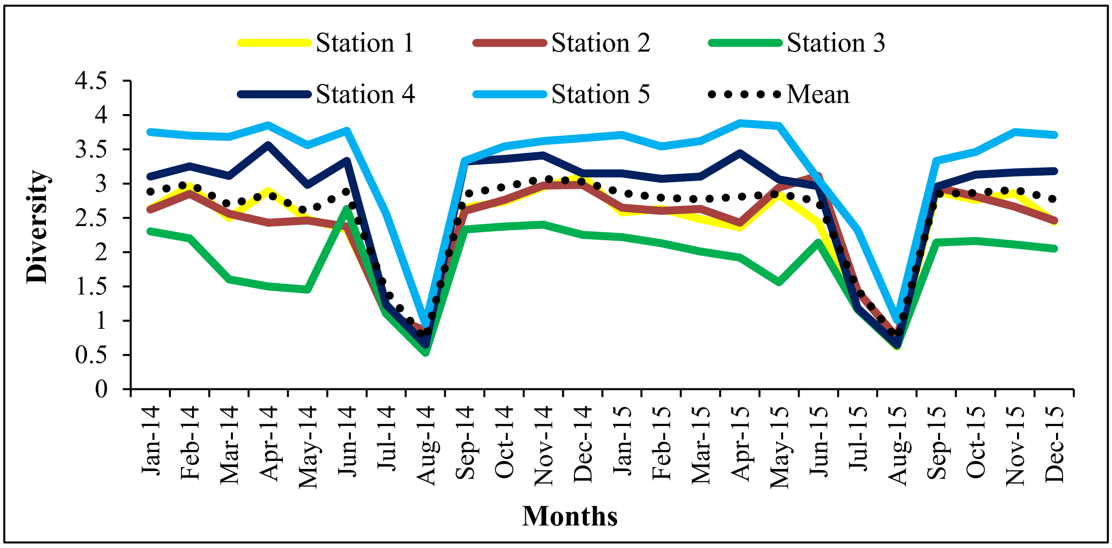



**Figure 3.11.** Spatial and temporal variation of phytoplankton diversity index of Padma river during January 2014 to December 2015

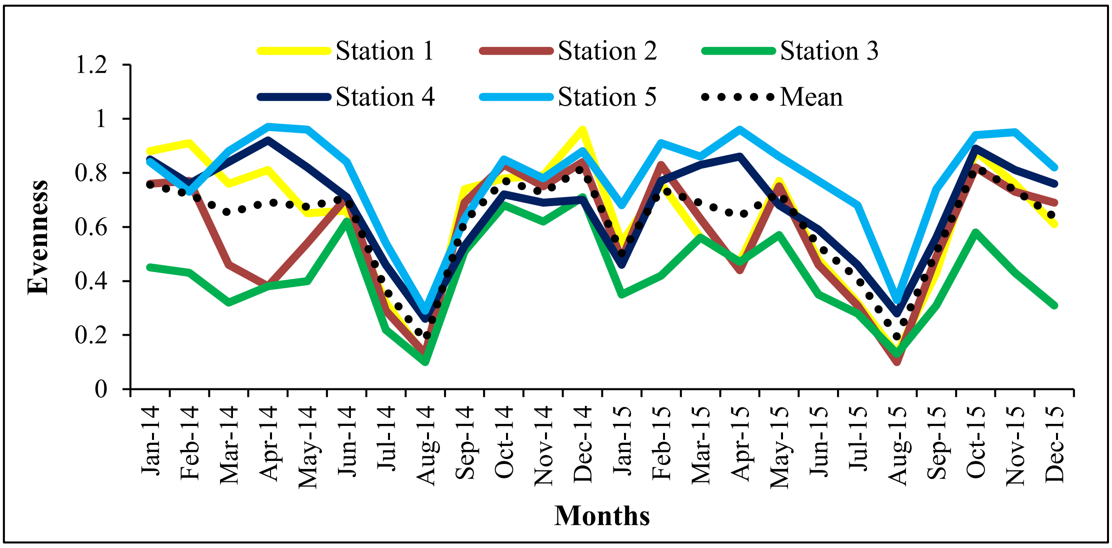



**Figure 3.12.** Spatial and temporal variation of phytoplankton evenness of Padma river during January 2014 to December 2015

### 3.3.2.4 Interaction between total phytoplankton and physico-chemical parameters of water of Padma river

Correlation of total phytoplankton abundance and physico-chemical parameters of water are shown in Table 3.4. Phytoplankton was positively correlated with water transparence, pH, dissolved oxygen, EC, total hardness, total alkalinity, $NO_3$-N and $PO_4$-P, while it was negatively correlated with air temperature, water temperature, rainfall and TDS.

**Table 3.4.** Pearson correlation coefficient between phytoplankton and physic-chemical parameters of water during the study period.

| Parameters | Correlation |
|---|---|
| Phytoplankton vs. air temperature | -0.604** |
| Phytoplankton vs. water temperature | -0.593** |
| Phytoplankton vs. water transparence | 0.724** |
| Phytoplankton vs. rainfall | -0.798** |
| Phytoplankton vs. pH | 0.538** |
| Phytoplankton vs. dissolved oxygen | 0.498** |
| Phytoplankton vs. EC | 0.363** |
| Phytoplankton vs. TDS | -0.880** |
| Phytoplankton vs. total hardness | 0.089 |
| Phytoplankton vs. total alkalinity | 0.757** |
| Phytoplankton vs. $NO_3$-N | 0.798** |
| Phytoplankton vs. $PO_4$-P | 0.866** |

**. Correlation is significant at the 0.01 level (2-tailed).

### 3.3.3 Zooplankton

A total of 4 groups, 26 genera and 40 species belonging to the group Rotifera (20 species), Cladocera (9 species), Copepoda (9 species) and Ostracoda (2 species) were recorded during the study period from January 2014 to December 2015) (Table 3.5). Percent composition of zooplankton followed the order of Rotifera > Copepoda > Cladocera > Ostracoda with the composition of 50.26 %, 29.21 %, 20.02 % and 0.50 % respectively (Figure 3.13).

**Table 3.5.** List of zooplankton of Padma river recorded during January 2014 to December 2015

| | |
|---|---|
| **Rotifera** | |
| 1. *Ascomorpha* sp. | 11 *Hexarthra* sp. |
| 2. *Asplanchna* sp. | 12 *Kellicottia* sp. |
| 3. *Brachionus angularis* | 13 *Keratella* sp. |
| 4. *Brachionus calyciflorus* | 14 *Keratella quadrata* |
| 5. *Brachionus capsuliflorus* | 15 *Keratella quadrata* |
| 6. *Branchionus falcatus* | 16 *Keratella vulga* |
| 7. *Filinia* sp. | 17 *Lecane* sp. |
| 8. *Filinia brachiata* | 18 *Polyarthra* sp. |
| 9. *Filinia longiseta* | 19 *Polyarthra vulgaris* |
| 10. *Gastropus* sp. | 20 *Trichocerca* sp. |
| **Cladocera** | |
| 1. *Alona* sp. | 6. *Diaphanosoma brachyurum* |
| 2. *Bosmina* sp. | 7. *Moina* sp. |
| 3. *Ceriodaphnia quadrangula* | 8. *Moina reticulate* |
| 4. *Daphnia* sp. | 9. *Sida* sp. |
| 5. *Diaphanosoma* sp. | |
| **Copepoda** | |
| 1. *Calanoid* sp. | 6. *Mesocyclops* sp. |
| 2. *Cyclops* sp. | 7. *Mesocyclops edax* |
| 3. *Cyclops strenus* | 8. *Mesocyclops leukarti* |
| 4. *Diaptomus* sp. | 9. Nauplius larvae |
| 5. *Laptodora* sp. | |
| **Ostracoda** | |
| 1. *Cypris* sp. | 2. *Stenocypris* sp. |

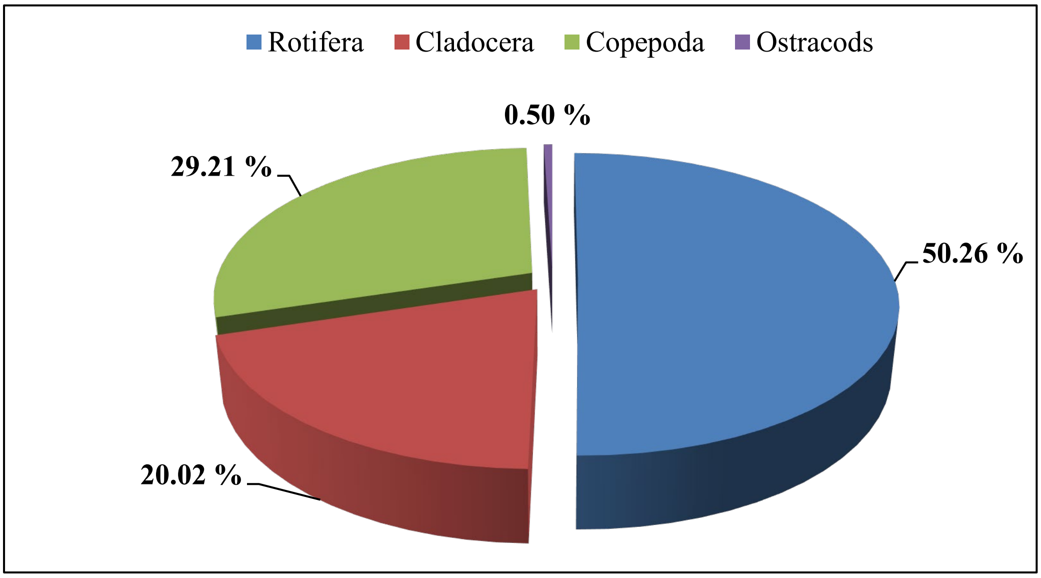



**Figure 3.13.** Percent composition of different groups of zooplankton of Padma river during January 2014 to December 2015

### 3.3.3.1 Zooplankton abundance

The average zooplankton abundance recorded was $0.32\times10^3$ units/l with a range of $0.01\times10^3$ units/l to $0.55\times10^3$ units/l. The highest ($0.55\times10^3$ units/l) zooplankton abundance was recorded in the month of February 2015 and lowest ($0.01\times10^3$ units/l) in September 2014. The dominant group of zooplankton during the study period was Rotifera with average highest abundance of $1.09\times10^3$ units/l in December 2015 and lowest was $0.03\times10^3$ units/l in September 2014. The average abundance of Cladocera, Copepoda and Ostracoda ranged between $0.01\times10^3$ to $0.50\times10^3$ units/l, $0.02\times10^3$ to $0.69\times10^3$ units/l and $0.00\times10^3$ to $0.04\times10^3$ units/l respectively (Figure 3.14). The abundance of zooplankton was also varied with station to stations. The maximum abundance was found at station 1 in January 2015 and minimum abundance was recorded in the month of October of both years at station 4 and 5 respectively (Figure 3.15).

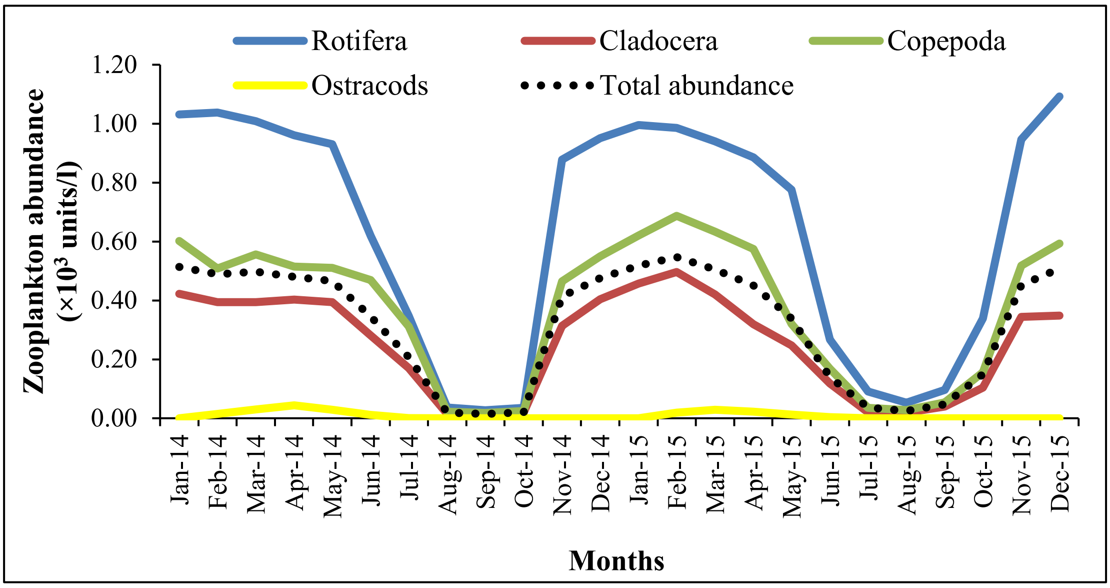



**Figure 3.14.** Temporal variation of zooplankton abundance of Padma river during January 2014 to December 2015

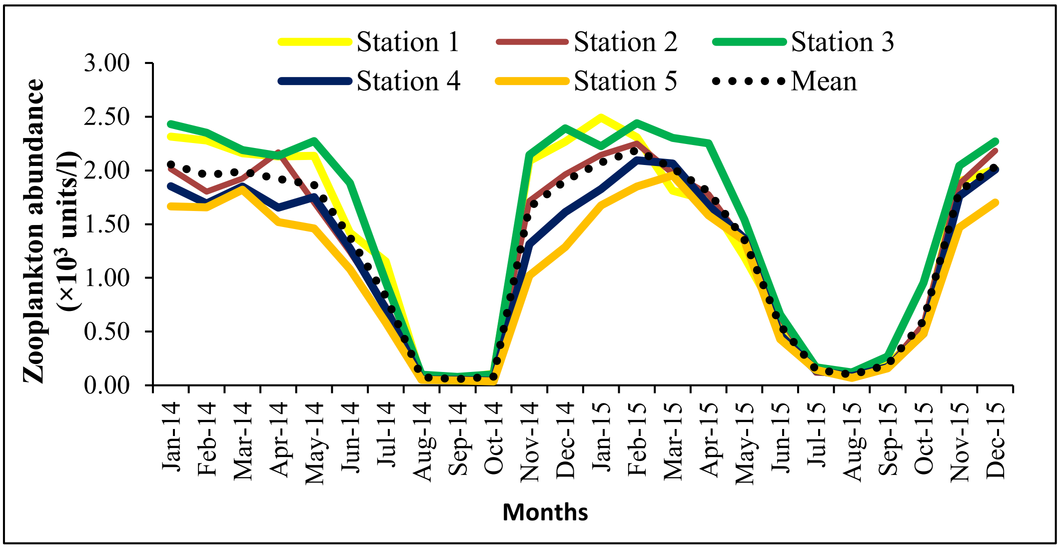



**Figure 3.15.** Spatial variation of zooplankton abundance of Padma river during January 2014 to December 2015

### 3.3.3.2 Zooplankton diversity index and evenness

The diversity index and evenness of zooplankton of Padma river calculated during the study period are shown in Figure 3.16 and 3.17. The zooplankton diversity index of Padma river varied from 0.22 to 3.46, and the average diversity index was 2.46. The highest diversity index was found 3.81 at station 5 in of February 2014 and the lowest was 0.20 which was found at station 3 in of September 2014 (Figure 3.16). The average evenness value recorded during the study period was 0.45 with range of 0.21 to 0.67. The highest (0.88) evenness was found at station 5 in February 2014 and the lowest (0.19) was in September 2015 at station 1 (Figure 3.17).

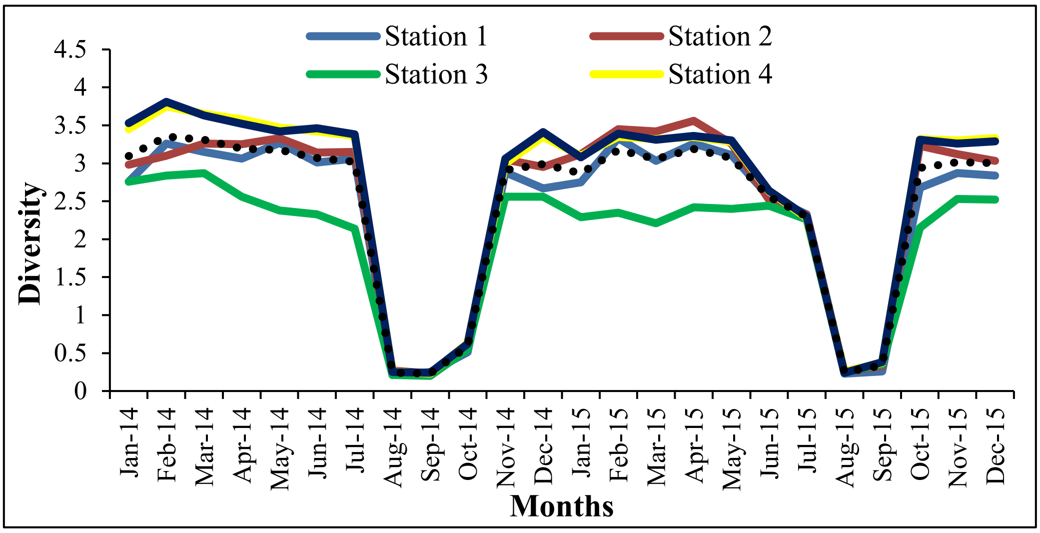



**Figure 3.16.** Spatial and temporal variation of zooplankton diversity index of Padma river during January 2014 to December 2015

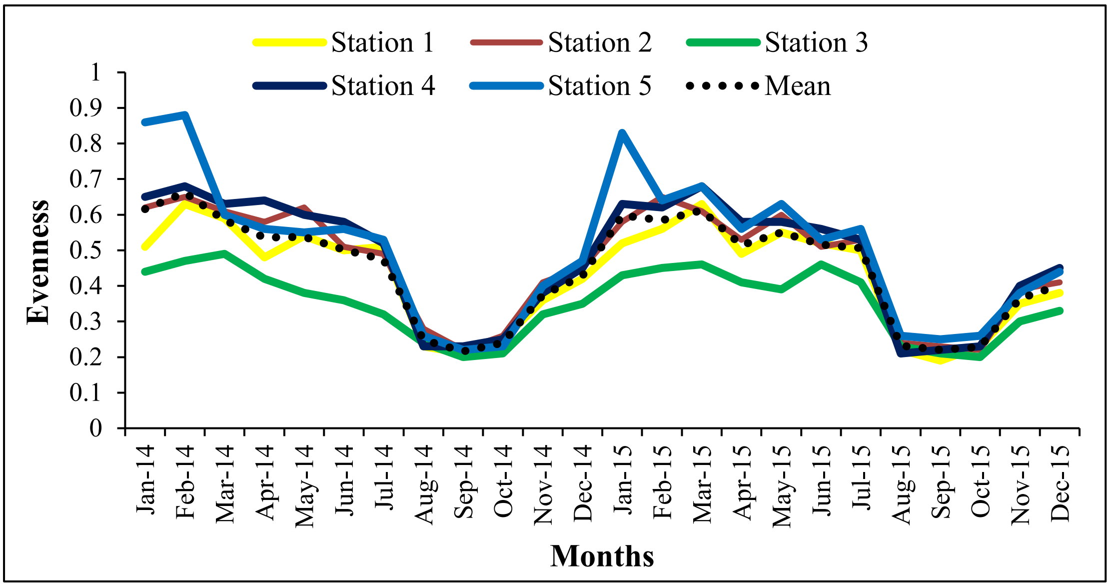



**Figure 3.17.** Spatial and temporal variation of zooplankton evenness of Padma river during January 2014 to December 2015

### 3.3.3.3 Correlation of zooplankton with phytoplankton and physico-chemical parameters of water

The correlation of zooplankton with phytoplankton and physico-chemical parameters of water are shown in Table 3.6. Zooplankton abundance of Padma river was positively correlated with total phytoplankton, water transparence, pH, dissolved oxygen, EC, total hardness, total alkalinity, $NO_3$-N and $PO_4$-P, while zooplankton was negatively correlated with air temperature, water temperature, rainfall and TDS of the water body.

**Table 3.6** Pearson correlation coefficient among zooplankton, phytoplankton and physic-chemical parameters of water during the study period.

| Parameters | Correlation |
|---|---|
| Zooplankton vs. phytoplankton | 0.834** |
| Zooplankton vs. air temperature | -0.591** |
| Zooplankton vs. water temperature | -0.567** |
| Zooplankton vs. water transparence | 0.808** |
| Zooplankton vs. rainfall | -0.624** |
| Zooplankton vs. pH | 0.600** |
| Zooplankton vs. dissolved oxygen | 0.494** |
| Zooplankton vs. EC | 0.304** |
| Zooplankton vs. TDS | -0.804** |
| Zooplankton vs. total hardness | 0.192 |
| Zooplankton vs. total alkalinity | 0.797** |
| Zooplankton vs. $NO_3$-N | 0.693** |
| Zooplankton vs. $PO_4$-P | 0.673** |

**. Correlation is significant at the 0.01 level (2-tailed)

### 3.4 Discussion

Hydrographical parameters of Padma river system revealed that the physical, chemical and biological features are adapted to a seasonal rhythm, and the changes are dependent upon the monsoon cycle. The fluctuation in river water temperature usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream (ADB, 1994). The highest (32.04 ºC) mean temperature during the two years of study period was recorded in the month of April 2014 and lowest (13.75 ºC) in the month of January 2014. The highest and lowest water temperature in the present study was coincided with the highest and lowest air temperature, as there was positive relation between air temperature and water temperature. Similar findings was also reported by Rahman and Huda (2012), who stated that higher temperature in the summer is due to the excess heat of the sun and lowest in the winter because on that time air temperature was low. The mean water temperature of Padma river recorded during the two year of study period was 24.35 ºC, which was lower than the average temperature (27.5 ± 3.36 ºC) reported by Rahman and Huda (2012) at Pathuria Ghat of Padma River, Manikganj and Ahmed (2004) at Mawa ghat of Padma river, Munshiganj (29.4 ºC).

The transparency of productive water bodies should be 40 cm or less (Stepenuck *et al.,* 2002). The transparency water during the study period ranged between 23.33 to 34.49 cm, with a mean value of 29.07 ± 3.59 cm. So, the Padma river water was within productive range. There was inverse relationship between transparency and rainfall during the study period. With increase in rainfall, transparency of water decreases, which may due to excess load of silt particle in the river water during rainy months. Highest (246.62 mm) rainfall was recorded in the month of August 2014 and lowest (23.33 cm) water transparency was also found in this months.

The mean pH found during the study period was 7.61 ± 0.06 with highest (8.54) value observed in the month of January 2014 and lowest (6.86) in April 2014. The pH of the water under study was within the WHO standard of 6.50 to 8.50. Ahmed (2004), observed the pH of the Padma river as 7.5 at Mawa ghat, Munshiganj, which was more or less similar to the present study. The mean DO was found 7.29 ± 1.02 mg/, with highest (9.44 mg/l) in the month of January 2014 and lowest (5.40 mg/l) in May 2014. It was reported that dissolved oxygen concentration of at least 5 mg/L is required for maintaining a healthy aquatic life and concentration of DO less than 5 mg/L indicates pollution (Khanderkar, 1986). There was a negative correlation between temperature and pH and temperature with DO. But there was positive correlation between pH and DO. The lowest DO and pH during the summer month was due to higher water temperature and higher sewage disposal into the river system that cannot carry out due to low river flow. Similar results also reported by Saxena *et al*., (1966), who stated that sewage disposal into the river is responsible for depletion of DO in water.

Total dissolve solids (TDS) are a measure of the amount of particulate solids that are in solution. This is an indicator of nonpoint source pollution problems associated with various land use practices. They are the direct measurement of particle concentration that quantifies the diffraction of light caused by particles in the water (Collins *et al.,* 2008). Mean TDS concentration was found 112.71 ± 36.85 ppm, with highest (186.61 ppm) in July 2014 and lowest (78.83 ppm) in February 2015. TDS concentrations have been recommended by the USEPA (up to 500 mg/l) as useful indicators of water quality and are important measurements for a number of reasons (Sawyer *et al.,* 1994). The TDS value in this study period increases during monsoon season due to higher flow of water and lowest in May due to lower flow of water, which is similar to the findings of Rahman and Huda (2012). There was negative correlation with EC and TDS and with increase with TDS, EC becomes decreased. Water transparency, pH, DO also have negative correlation with TDS.

The hardness value during the study period ranged bewteen 78.39 to 134.41 mg/l with mean value 99.62 ± 15.65 mg/l. Total hardness was positively correlated with water temperature, transperancy, rainfall, EC and negetively with pH, DO, and TDS. Total alkalinity of rivers is mainly carbonates and bicarbonates in any the samples which may be resulted due to the weathering of rocks, waste discharge and microbial decomposition of organic matter in the water body. The mean value of total alkalinity during the study period was 103.25 ± 16.96 mg/l, with the highest value (129.81 mg/l) observed in the month of January 2015 and lowest (80.46 mg/l) in October 2015.

Hasan and Islam (2010), reported alkalinity of Padma river as 75-100mg/l. The higher values in the present study might be due to changes in rainfall pattern and other anthropogenic activities that reside along the bank of the river during low flood reason.

Nitrates and phosphates are the main nutrients parameters of a water body. The productivity of natural water body are largely depends on these two important parameters. The concentration of nitrates is used as indication of level of micronutrients in water bodies and has ability to support plant growth. High concentration of nitrate sometimes favored growth of phytoplankton. Phosphate is also a vital nutrient for all living things but, introduction of excessive phosphorus in form of phosphates in aquatic environment can cause eutrophication. The mean values of nitrate and phosphate during the study period were $0.25 \pm 0.11$ and $0.18 \pm 0.07$ mg/l. The mean concentration of nitrate and phosphate was highest in dry months and lowest in monsoon months during the study period. Uddin *et al*. (2014) also found higher nitrate concentration in dry season and lower in wet season. The fluctuation of nitrate and phosphate between dry and wet months might be due to flow of river water, which causes dilution of these nutrients in river water. Similar observation was also made by Khan *et al*. (2007) and Hasan *et al*. (2013), who reported that during monsoon months, the reduction in phosphates could be due to dilution of nutrients by the flow of the river system. Other causes might be the biochemical mechanisms cause by ionization and increased solubility or precipitation of bottom sediment deposits, which ultimately lead to rapid decomposition of excessive oxidizable organic matter soon after the cessation of rains, leading to high nutrient levels (Dart and Stretton, 1980).

A total of 4 classes, 59 genera and 130 species of phytoplankton were recorded during the study period (January 2014 to December 2015). The most abundant group of phytoplankton was Bacillariophyceae with a percent composition of 42.42 %. Similar findings were also found by Rahman and Huda (2012), who reported that dominant group of phytoplankton in Padma river at Paturia Ghat, Manikganj was Bacillariophyceae. The highest abundance of total phytoplankton was observed in the month of November 2014 and lowest in the month of August 2014. The lower abundance of phytoplankton in August might be due to higher water flow in the river. Rahman and Huda (2012) was also reported lower abundance of phytoplankton in August in their study. Kshirsagar *et al*. (2012) reported that fast water flow and turbid water were responsible for lower phytoplankton cell density in his study period. The highest average abundance of phytoplankton was found at station 3 ($21.36 \times 10^3$ units/l), which are polluted with organic pollutants coming from the city drains. Although the cell abundance was highest at station 3, diversity and evenness index were lowest in this station, which might be due to presence of higher amount of pollution tolerant species that increases the cell density but decreased the diversity and evenness index. Kshirsagar *et al*. (2012) also reported higher abundance of phytoplankton in areas where anthropogenic activities were intensively performed. Positive correlation of phytoplankton with nitrate and phosphate was also found during the study period, which indicates more nutrient enrichment at station 3. Pollution tolerant species such as *Ankistodesmus, Pediastrum, Scenedesmus, Chlorella, Cosmarium, Melosira, Nitzschia, Oscillatoria, Microsystis, Euglena, Phacus* etc were more abundant at station 3 than other station during the study period, which also indicate organically pollutant nature of station 3. A similar finding was also reported by Kshirsagar *et al*. (2012).

A total of 4 groups, 26 genera and 40 species belonging to the group Rotifera (20 species), Cladocera (9 species), Copepoda (9 species) and Ostracoda (2 species) were recorded during the study period from January 2014 to December 2015). Rotifera was the most dominant groups during the study period, which was similar to the findings of Rahman and Huda (2012). There was positive correlation with phytoplankton and zooplankton, which might be due to increased number of zooplankton species during the months when the abundance of phytoplankton was also highest. The gradual decrease of zooplankton diversity and evenness index during the month of August and September of the both studied years were due to higher water flow and turbidity, which also support the findings of Rahman and Huda (2012).

### 3.5 Conclusion

Based on the findings of the present study it can be concluded that water quality and plankton productivity of Padma river are still in good condition of *C. reba*. But due to several natural catastrophes like siltation, pollution and other many causes the water quality of this river becomes deteriorate day by day. Therefore, it is necessary to take initiatives for better management of water resources of Padma river.

# Chapter Four

# Population structure, Length-weight relationships and Condition factors of *Cirrhinus reba* (Hamilton, 1822) of Padma River

## 4.1 Introduction

The morphometric relationships between length and weight can be used to assess the well-being of individuals and to determine possible differences between separate unit stocks of the same species (King, 2007). The size structure of a fish population at any point in time can be considered a 'snapshot' that reflects the interactions of the dynamic rates of recruitment, growth and mortality (Neumann and Allen, 2001). Study of the size structure in the riverine fishes revealed several ecological and life-history traits, such as river health, stock conditions and breeding periods of the fishes (Beyer, 1987). Knowledge of fish stock structure is also essential for effective fishery management (Grimes *et al.,* 1987; Carvaiho and Hauser, 1994; Begg et *al.,* 1999).

Morphometric relationships including length frequency distribution, length-weight relationships (LWRs), relative condition factor ($K_R$) and Fulton's condition factor ($K_F$) are important biological parameters for fishes, from which the condition of stocks' health of fish populations can be deduced (Bagenal and Tesch 1978). Length frequency distribution provides an idea about the maximum length and weight of a species which is necessary to estimate the population parameters including asymptotic length and growth coefficient of fishes that are essential for fisheries resource planning and management (Hossain, 2010). From length frequency distributions of fish there are methods to determine the ages (Bagenal and Tesch, 1978), which together with the weight and abundance give details of the different distribution regime of the rivers, breeding ground and breeding seasons, the general health of the stock, density and the status of the species. Therefore, the size structure analysis is one of the most commonly used fisheries assessment tools (Ranjan *et al.* 2005). Length frequency distribution is also a first step to evaluate gear selectivity of catches made by different kinds of gear fished in the same water (Bagenal, 1978). The LWR plays a vital role in fisheries biology, population dynamics and also important for comparative growth studies in fish population (Fulton, 1904). As length and weight of fish are among the important morphometric characters, they can also be used for the purpose of taxonomy and ultimately in fish stock assessment models to estimate stocks, standing crop biomass and seasonal variations in fish growth can be tracked by this way (Morey *et al.,* 2003). This relationship is also very important for proper exploitation and management of fish population (Anene, 2005; Moutopoulos and Stergiou, 2002). Moreover, length-weight relationships (LWR) are an important tool in fishery management (Bagenal and Tesch, 1978; Gonzalez Acosta *et al*., 2004) as they provide additional information about body condition of specimens in stocks or populations (Gerritsen and McGrathb, 2007).

In addition, the condition factor is a quantitative parameter that is very helpful to estimate present and future population success (Richter, 2007). Moreover, concerning the condition factor, it is used for fishery biology in order to compare the 'condition', 'fatness' or wellbeing of fish in such environment. Condition factor is an index of the degree of wellbeing of a species. Furthermore, the Fulton's condition factor ($K_F$) which provides some information regarding physiological state of the fishes, based on the assumption that individuals of a given body length are in better condition when their biomass is greater (Anene, 2005). Study of relative condition factor ($K_R$) provides necessary assumptions of the overall health of fish stocks that is an alternative to the expensive *in-vitro* proximate analyses of tissues (Sutton *et al.,* 2000). The study of condition factor is also important to understand the life cycle of fish species and it also contributes to adequate management ecosystem equilibrium (Haruna and Bichi, 2005).

Relative weight ($W_R$) is also one of the most popular indexes for assessing condition of fishes in the USA since last two decades (Rypel and Richter 2008). However, based on the importance of morphometrics study of fishes, this present experiment was designed to study length-frequency distributions, length-weight relationship and condition factor of threatened fish, reba carp (*cirrhinus reba*) of Padma river in Northwestern Bangladesh.

**The present investigation was made based on the following objectives**

- To assessing the length-frequency distribution
- To study length-weight relationship
- To calculate the condition factors ($K_F$ and $K_R$)
- To determine the relative weight ($W_R$).

## 4.2 Materials and methods

### 4.2.1 Study Site

The present study was conducted in the lower parts of the Ganges River, North-Western (NW) Bangladesh also known as the Padma River. Five distinct stations were selected for collection of experimental fishes during the one year (From January 2015 to December 2015) of study period. Name of the sampling station with GPS point are shown in Table 3.1 and Figure 3.1.

### 4.2.2 Sampling

Samples of *C. reba* were collected during daytime (8:00-17:00) on a monthly basis (from January 2015 to December 2015) from fisherman's catch landed at nearby fish landing centers, from Godagari to Charghat Upazila of Rajshahi district. Fish were usually caught using the traditional fishing gears for example cast net (*jhaki jal*), square lift net (*tar jal*), conical trap (*dughair*) and monofilament fixed gill net (*Current jal*). Samples were instantly preserved with ice in the fish landing area and fixed with 10% formalin on arrival in the laboratory. For each individual, Total length (TL) and body weight (BW) of each specimen were measured to 0.1 cm and 0.1 g accuracy with digital slide calipers and electronic balance, respectively.

### 4.2.3 Length- weight frequency distribution (LFD)

The collected individuals were categorized on the basis of the total length-weight recorded from different size groups. Length-frequency distribution methods for each sex and combined sex were conducted by histograms with normal curve. The LFD and descriptive statistics were conducted by SPSS, ver. 20.0. (IBM Corporation, Armonk, NY, USA).

### 4.2.4 Length-Weight and Length-Length Relationships

The length-weight relationship (LWR) was estimated using the equations: $W = a \times L^b$ and its logarithmic form,

$$ln\ (W) = ln\ (a) + b\ ln\ (L)$$

Where

W = Weight (in g)

L = Length (in mm)

'a' and 'b' are = Regression co – efficient

### 4.2.5 Condition factors

The Fulton's Condition factor ($K_F$) was calculated employing the formula (Fulton, 1904).

$$K_F = 100\ W/\ L^3$$

Where,

$K_F$ = Fulton's condition factor

W = Weight of fish (in g)

L = Length of fish (in cm)

The relative condition factor ($K_R$) for each individual was calculated by the following formula (Le Cren, 1951):

$$K_R = W/\ a \times L^b$$

Where,

$K_R$ = Relative condition factors

W = Weight of fish (in g)

L = Length of fish (in cm)

'a' and 'b' are = Regression co – efficient

Furthermore, relative weight was calculated as Froese (2006):

$$W_R = (W/\ W_S) \times 100$$

Where,

$W_R$ = Relative weight

W = Weight of fish (in g)

Ws = $a \times L^b$ (a and b values were obtained from the relationships between TL and BW)

### 4.2.6 Statistical analyses

Statistical analyses were performed using Microsoft® Excel-2010 and SPSS, ver. 20.0. (IBM Corporation, Armonk, NY, USA). All data were checked for homogeneity of variance. Tests for normality was conducted by visual assessment of histograms and box plots, and confirmed using the Kolmogorov-Smirnov test. Where test for normality assumption was not met, then the non-parametric Wilcoxon rank test was used to compare the mean relative weight of a population with 100 (Anderson and Neumann 1996), whereas Spearman rank test was used to correlate total length and body weight with Fulton's condition factor ($K_F$), relative condition factor ($K_R$) and relative weight ($W_R$). Pearson Correlation were analyzed by at $P < 0.05$ % level of the significant. In addition non-parametric correlation like, Kendall's tau-b and Spearman's rho test was used to support statistically between length and weight. Regression analysis and line parameters, a (intercept) and b (slope) was made with log-transformed measurement and growth plots were performed by scatter diagram being included in regression analyses. The Mann-Whitney U test was used to compare the LFD between the sexes. All statistical analyses were considered significant at 5 % ($p < 0.05$).

## 4.3 Results

### 4.3.1 Length-weight frequency distribution

A total of 600 (male = 317 and female = 283) specimens of *C. reba* were analyzed for this study. Sample size, minimum and maximum length and body weight, and 95% confidence limit (CL) are shown in Table 4.1. The total length ranged from 6.70 to 19.70 cm (mean ± SD: 12.02 ± 2.72 cm and 95% CL of mean: 13.08 – 13.81 cm) for male and 6.60 to 23.80 cm for female (mean ± SD: 13.44 ± 3.08 cm and 95% CL of mean: 11.71 – 12.32 cm). While the total body weight ranged from 2.63 to 106.25 g (mean ± SD: 19.01 ± 13.72 g and 95% CL of mean: 25.82 – 32.09 g) for male and 4.10 to 136.00 g (mean ± SD: 28.23 ± 16.08 g and 95% CL of mean: 17.49 – 20.52 g) for female. In case of combined sex, the total length ranged between 6.60 to 23.80 cm (mean ± SD: 12.69 ± 2.98 cm and 95% CL of mean: 12.45 – 12.93 cm) and total weight ranged from 2.63 to 136.00 g (mean ± SD: 23.69 ± 21.49 g and 95% CL of mean: 21.97 – 25.42 g). To illustrate length-weight frequency distribution (LFD), histograms with normal curve of male, female and combined sex are shown in Figure 4.1, 4.2 and 4.3 respectively. The LFD of illustrated the smallest and the largest specimens as 6.70 and 19.70 cm total length for males, 6.60 to 23.80 cm total length for females and 6.60 to 23.80 cm for combined sex, respectively. However, the LFD for males and females pass the normality test (Kolmogorov-Smirnov test; $P < 0.05$) with a skewness of 0.087 (SE 0.137) and a kurtosis of -0.466 (SE 0.273) for the males and a skewness of 0.594 (SE 0.145) and a kurtosis of 0.481 (SE 0.289) for the females.

**Table 4.1. Descriptive statistics on length and weight measurements of *Cirrhinus reba***

| Measurements | n | Min | Max | Mean±SD | $CL_{95\%}$ |
|---|---|---|---|---|---|
| Male | 317 | | | | |
| TL | | 6.70 | 19.70 | 12.02 ± 2.72 | 13.08 – 13.81 |
| BW | | 2.63 | 106.25 | 19.01 ± 13.72 | 25.82 – 32.09 |
| Female | 283 | | | | |
| TL | | 6.60 | 23.80 | 13.44 ± 3.08 | 11.71 – 12.32 |
| BW | | 4.10 | 136.00 | 28.23 ± 16.08 | 17.49 – 20.52 |
| Combined sex | 600 | | | | |
| TL | | 6.60 | 23.80 | 12.69 ± 2.98 | 12.45 – 12.93 |
| BW | | 2.63 | 136.00 | 23.69 ± 21.49 | 21.97 – 25.42 |

TL, total length; BW, body weight; *n*, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values.

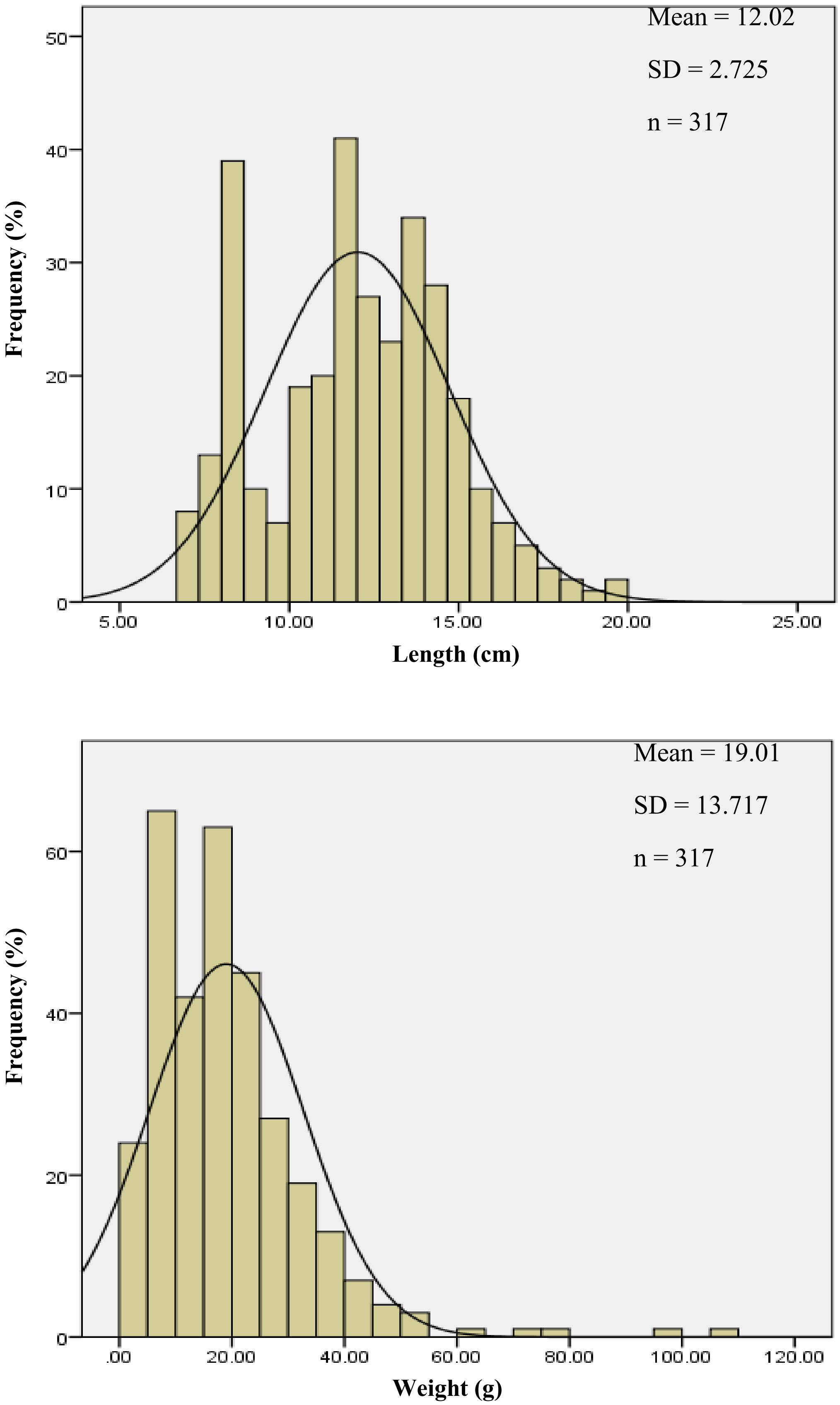



**Figure 4.1.** Length-weight frequency distribution of male *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period

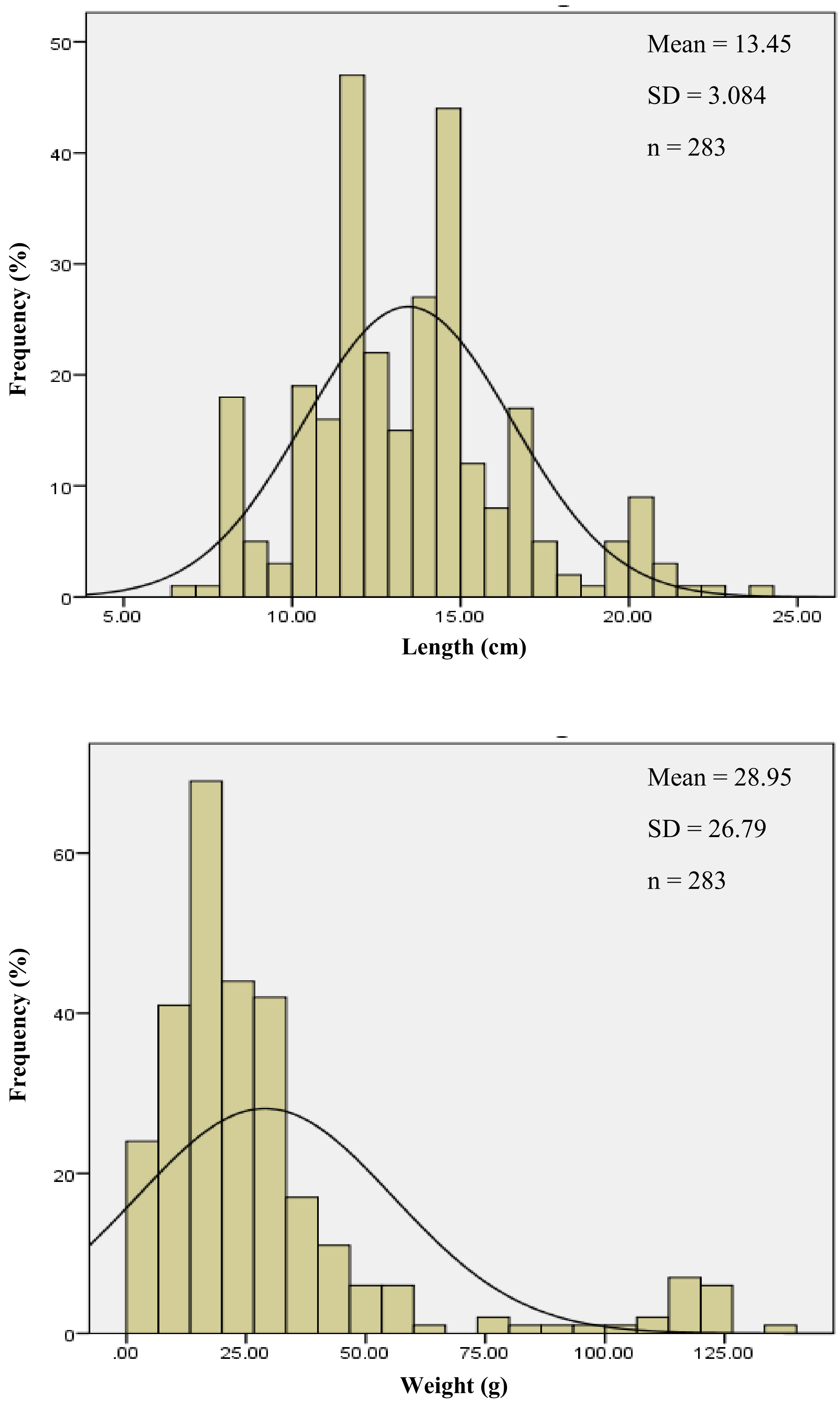



**Figure 4.2**. Length-weight frequency distribution of female *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period

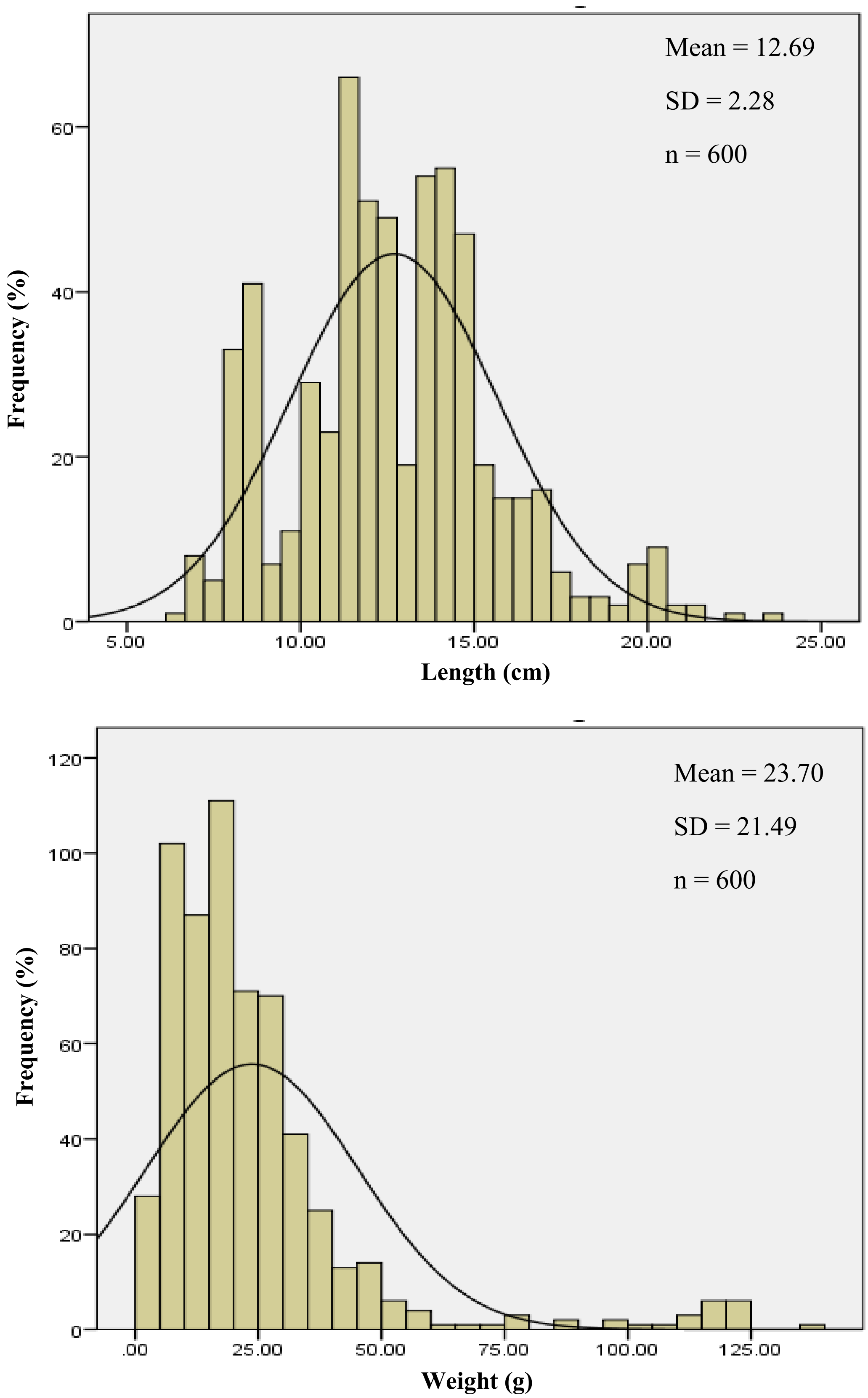
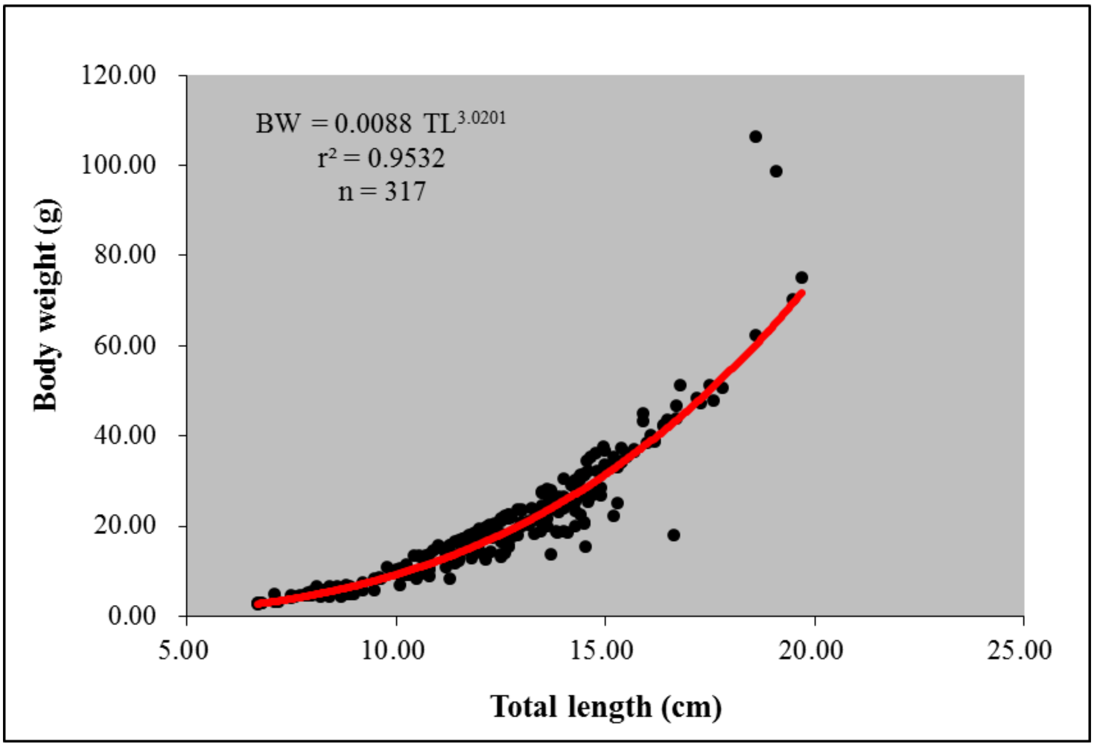



**Figure 4.3.** Length-weight frequency distribution of combined sexes *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period

### 4.3.2 Length-weight relationships (LWR)

The scatter diagrams of length weight relationship for male, female and combine sexes are shown in Figure 4.4, 4.5 and 4.6 respectively. While, logarithmic transformation of LWR parameters, a-intercept, b-slope, correlation co-efficient 'r' (Pearson correlation), nonparametric correlation co-efficient (Kendall's tau-b and Spearman's rho), regression co-efficient '$r^2$' and growth pattern are also shown in Table 4.2. The regression parameter b of the LWRs ranged from 2.149 ($r^2$ = 0.9267) in November to 3.797 ($r^2$ = 0.8921) in July. However, the slope (b) value was more than 3 in the month of June to September, which indicate positive allowmetric growth of *C. reba* in these months. The slope was equal to 3 only in the month of May and it indicates isometric growth in this month. Besides this, during the rest of the month of the year *C. reba* shows negative allowmetric ($b < 3$) growth during the study period. Pearson correlation co-efficient ranging from $0.922^{**}$ (January) to $0.992^{**}$ (April) in different months are found to be highly significant ($p < 0.01$). The non-parametric correlation KC was ranged between $0.697^{**}$ (July) to $0.937^{**}$ (May) and SC was ranged from $0.821^{**}$ (July) to $0.992^{**}$ (September) which were also found to be highly significant ($p < 0.05$). The regression co-efficient '$r^2$' was high for all the months and ranged from 0.8508 (January) to 0.9654 (September) indicating good linear regression close to 1 ($r < 1$). It also suggests good adjustment between length and weight among months (Table 4.2). Length weight equation was also calculated based on sexes in this experiment. The slope (b) of regression line for male was equal to 3, which indicate isometric growth of male population of *C. reba* in Padma river during the present study period. Where, the slope value were greater than 3 for female and combined sex indicating positive allometric growth of *C. reba* of Padma river. All LWRs were highly significant ($P < 0.01$), with all $r^2$ values exceeding 0.950, that also indicating good linear regression close to 1 ($r < 1$) with good adjustment between length and weight among sexes (Table 4.3).



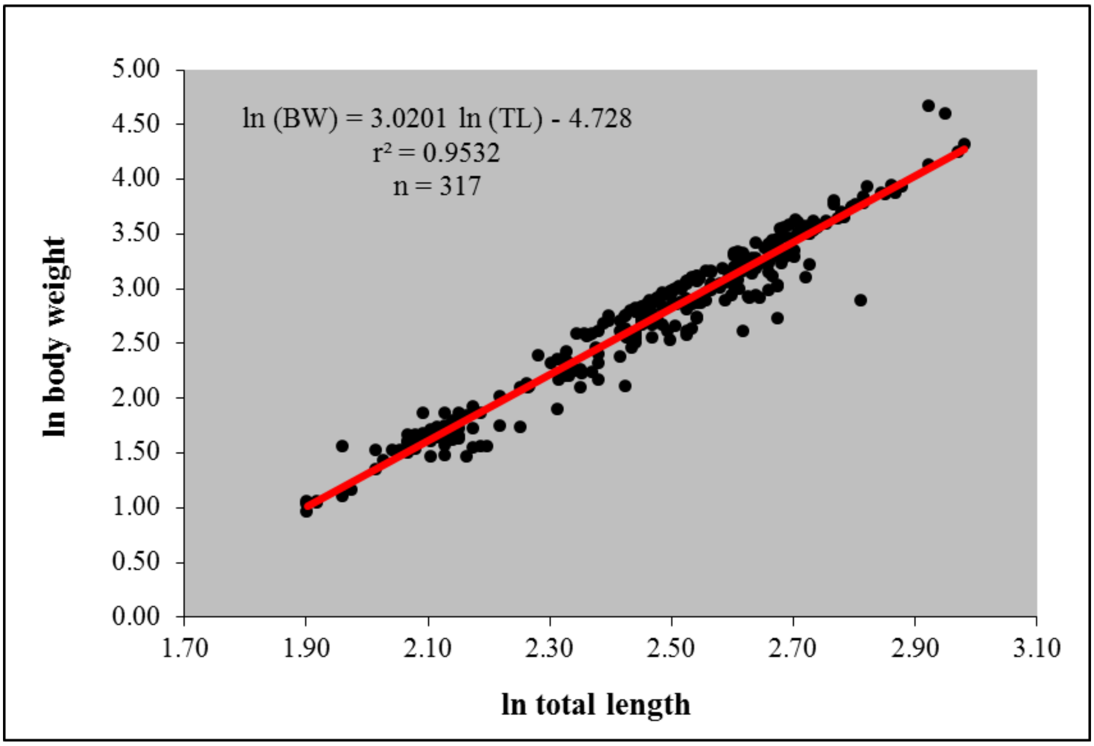
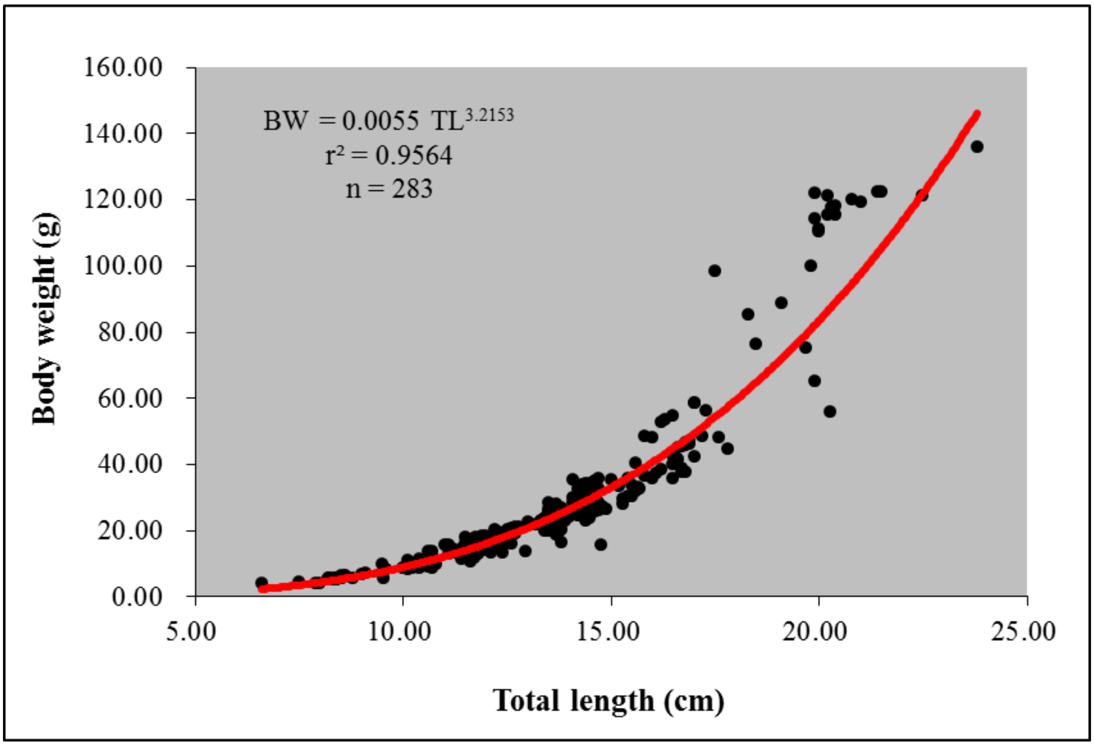




**Figure 4.4.** Length-weight relationships ($W = a \times L^b$ and $ln\ W = ln\ a + b\ ln\ L$) of male *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period



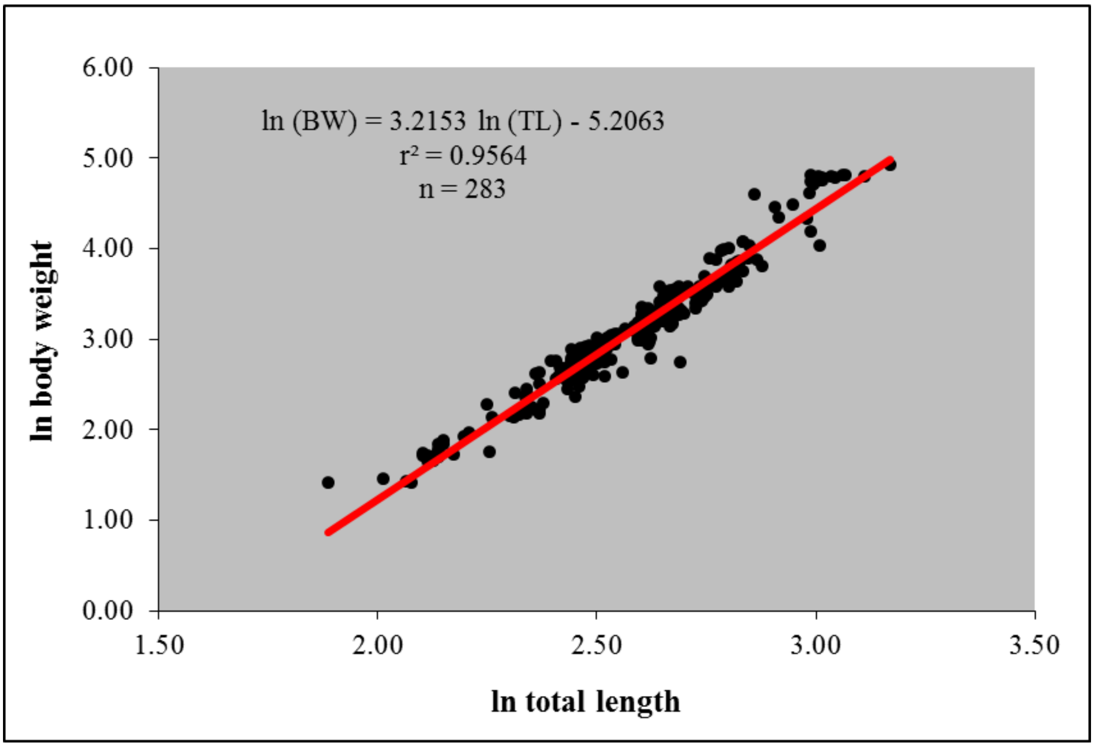
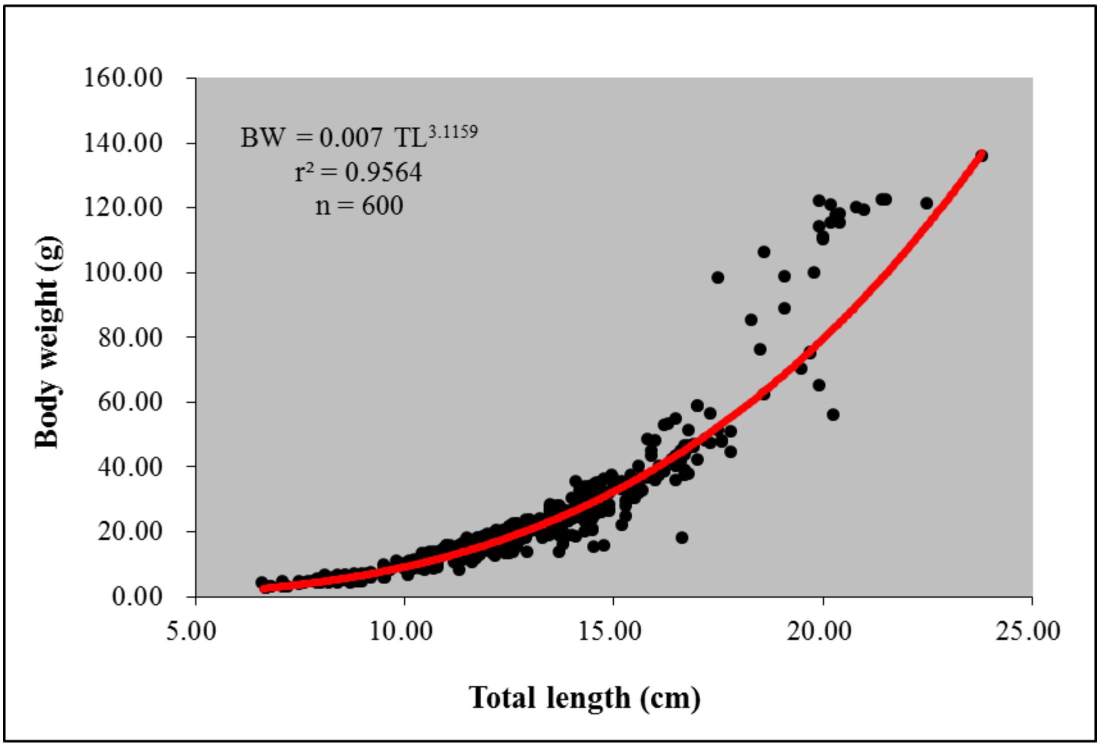




**Figure 4.5.** Length-weight relationships ($W = a \times L^b$ and $ln\ W = ln\ a + b\ ln\ L$) of female *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period



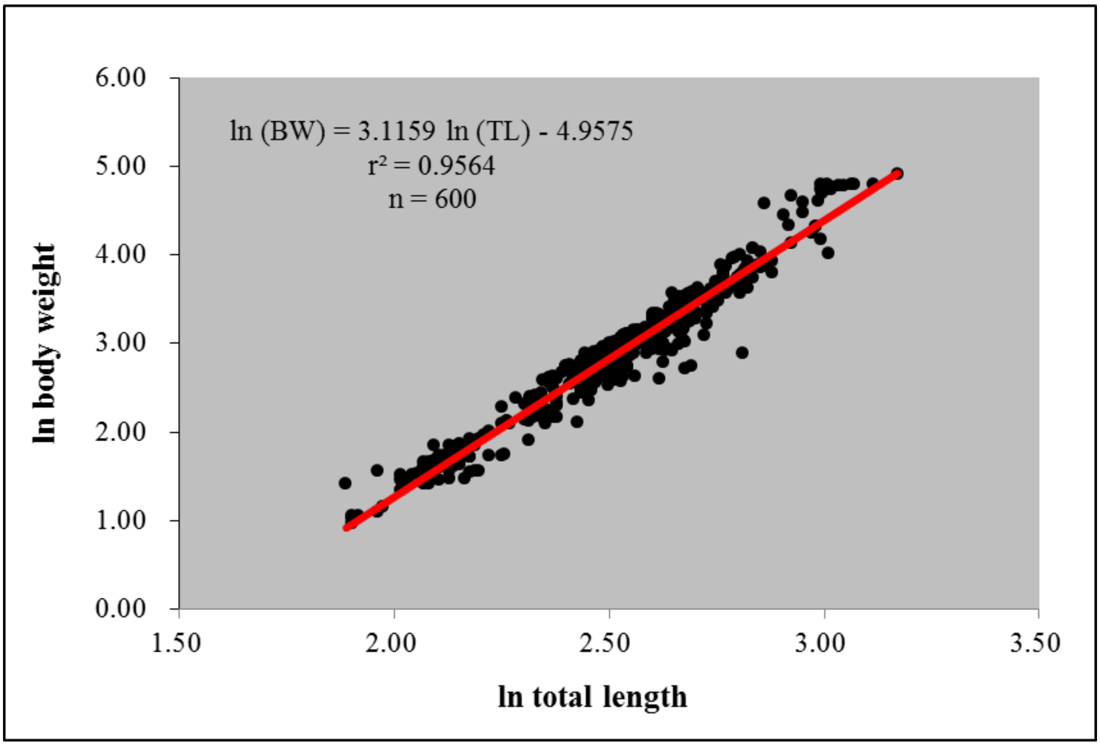




**Figure 4.6.** Length-weight relationships ($W = a \times L^b$ and $ln\ W = ln\ a + b\ ln\ L$) of combined sexes *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period

### 4.3.3 Condition factors

The sample size (n), minimum and maximum values, mean ± SD, 95% confidence levels of each of the condition factors ($K_F$ and $K_R$) and relative weight ($W_R$) of *C. reba* are shown in Table 4.4. All the condition factors of this fish in the Padma River passed normality test (Kolmogorov-Smirnov test; $P > 0.10$). The $K_F$ ranged from 0.39 to 1.65 (mean ± SD: 0.94 ± 0.14 and 95% confidence level: 0.92 - 0.96) and 0.48 to 1.83 (mean ± SD: 0.97 ± 0.17 and 95% confidence level: 0.95 - 0.99) for males and females, respectively. The unpaired *t-test* showed significant difference in $K_F$ between males and females ($P = 0.033$) during the present study. In addition, $K_R$ varied from 0.42 to 1.76 (mean ± SD: 1.01 ± 0.15 and 95% confidence level: 1.00 - 1.03) for males and 0.56 to 1.32 (0.83±0.17) for females. The unpaired *t-test* showed no significant difference in $K_R$ between males and females ($P = 0.994$) during the study. Furthermore, the one sample *t-test* showed that the mean $W_R$ of *C. reba* showed significant differences from 100 for males ($P = 0.046$) but showed no significant differences for females ($P = 0.183$) in the Padma River. While the mean value of $W_R$ of combined sexes of *C. reba* showed significant differences from 100 ($p = 0.019$). Monthly mean Fulton's condition factor and relative condition factor are shown in Figure 7 and relative weight is in Figure 8 of *C. reba* of Padma river. The primary axis indicates $K_F$ values and secondary axis indicate $K_R$ values. The $K_F$ value was observed in low during January (0.84) and highest was 1.06 in the month of March. The $K_R$ value was highest (1.03) in the month of January and lowest (1.00) in the month of March and April (Figure 4.7). The $W_R$ was highest (101.75) in the month of January and lowest (100.14) in August (Figure 4.8). Furthermore, Spearman rank correlation showed that $K_F$ was significantly correlated with both TL ($p = 0.125$) and BW ($p = 0.324$. While $K_R$ and $W_R$ are both significantly correlated with BW ($p = 0.142$ and 0.143) (Table 4.5).

**Table 4.2. Month-wise length-weight and growth type of *Cirrhinus reba* during January to December 2015**

| Months | Logarithmic transformation | Intercept 'a' | Slope 'b' | Correlation co-efficient 'r' | Non-parametric correlation 'r' | | Regression co-efficient '$r^2$' | Growth type |
|---|---|---|---|---|---|---|---|---|
| | | | | PC | KC | SC | | |
| January | ln (BW) = 2.366 ln (TL) - 3.255 | - 3.255 | 2.366 | $0.922^{**}$ | $0.741^{**}$ | $0.910^{**}$ | 0.8508 | $A^-$ |
| February | ln (BW) = 2.784 ln (TL) - 4.029 | - 4.029 | 2.784 | $0.952^{**}$ | $0.817^{**}$ | $0.922^{**}$ | 0.9055 | $A^-$ |
| March | ln (BW) = 2.711 ln (TL) - 3.818 | - 3.818 | 2.711 | $0.980^{**}$ | $0.907^{**}$ | $0.982^{**}$ | 0.9606 | $A^-$ |
| April | ln (BW) = 2.810 ln (TL) - 4.260 | - 4.260 | 2.810 | $0.992^{**}$ | $0.922^{**}$ | $0.986^{**}$ | 0.9842 | $A^-$ |
| May | ln (BW) = 3.008 ln (TL) - 4.674 | - 4.674 | 3.008 | $0.986^{**}$ | $0.937^{**}$ | $0.987^{**}$ | 0.9715 | I |
| June | ln (BW) = 3.168 ln (TL) - 5.098 | - 5.098 | 3.168 | $0.978^{**}$ | $0.902^{**}$ | $0.974^{**}$ | 0.9562 | $A^+$ |
| July | ln (BW) = 3.797 ln (TL) - 6.747 | - 6.747 | 3.797 | $0.944^{**}$ | $0.697^{**}$ | $0.821^{**}$ | 0.8921 | $A^+$ |
| August | ln (BW) = 3.499 ln (TL) - 5.904 | - 5.904 | 3.499 | $0.981^{**}$ | $0.896^{**}$ | $0.977^{**}$ | 0.9621 | $A^+$ |
| September | ln (BW) = 3.391 ln (TL) - 5.644 | - 5.644 | 3.391 | $0.983^{**}$ | $0.939^{**}$ | $0.992^{**}$ | 0.9654 | $A^+$ |
| October | ln (BW) = 2.879 ln (TL) - 4.444 | - 4.444 | 2.879 | $0.983^{**}$ | $0.887^{**}$ | $0.976^{**}$ | 0.9655 | $A^-$ |
| November | ln (BW) = 2.149 ln (TL) - 2.839 | - 2.839 | 2.149 | $0.963^{**}$ | $0.806^{**}$ | $0.918^{**}$ | 0.9267 | $A^-$ |
| December | ln (BW) = 2.748 ln (TL) - 4.210 | - 4.210 | 2.748 | $0.969^{**}$ | $0.768^{**}$ | $0.895^{**}$ | 0.9389 | $A^-$ |

**** P < 0.01.**

**Table 4.3. Sex wise length-weight and growth type of *Cirrhinus reba* during January to December 2015**

| Sexes | Logarithmic transformation | Intercept 'a' | Slope 'b' | Correlation co-efficient 'r' | Non-parametric correlation 'r' | | Regression co-efficient '$r^2$' | Growth type |
|---|---|---|---|---|---|---|---|---|
| | | | | PC | KC | SC | | |
| Male | ln (BW) = 3.020 ln (TL) - 4.728 | - 4.728 | 3.020 | $0.897^{**}$ | $0.857^{**}$ | $.963^{**}$ | 0.9532 | I |
| Female | ln (BW) = 3.215 ln (TL) - 5.206 | - 5.206 | 3.215 | $0.894^{**}$ | $0.867^{**}$ | $.969^{**}$ | 0.9564 | $A^+$ |
| Combined sex | ln (BW) = 3.116 ln (TL) - 4.958 | - 4.968 | 3.116 | $0.873^{**}$ | $0.865^{**}$ | $.969^{**}$ | 0.9564 | $A^+$ |

**** P < 0.01.**

**Table 4.4. Condition factors of the *C. reba* (Hamilton 1822) in the Padma River, during the study period**

| Condition factor | n | Min | Max | Mean ± SD | $CL_{95\%}$ |
|---|---|---|---|---|---|
| Male | 317 | | | | |
| $K_F$ | | 0.39 | 1.65 | 0.94 ± 0.14 | 0.92 - 0.96 |
| $K_R$ | | 0.42 | 1.76 | 1.01 ± 0.15 | 1.00 - 1.03 |
| $W_R$ | | 41.91 | 176.91 | 101.70 ± 15.09 | 100.03 - 103.37 |
| Female | 283 | | | | |
| $K_F$ | | 0.48 | 1.83 | 0.97 ± 0.17 | 0.95 - 0.99 |
| $K_R$ | | 0.49 | 1.81 | 1.01 ± 0.16 | 0.99 - 1.03 |
| $W_R$ | | 49.27 | 180.66 | 101.28 ± 16.17 | 99.39 - 103.18 |
| Combined sex | 600 | | | | |
| $K_F$ | | 0.39 | 1.83 | 0.95 ± 0.15 | 0.94 - 0.97 |
| $K_R$ | | 0.40 | 1.87 | 1.01 ± 0.15 | 1.00 - 1.03 |
| $W_R$ | | 40.08 | 187.17 | 101.26 ± 15.80 | 100.00 - 102.53 |

**Table 4.5. Spearman rank correlation coefficient for total length (TL), body weight (BW), Fulton's condition factor ($K_F$), Relative condition factor ($K_R$) and Relative weight ($W_R$) of *C. reba* (Hamilton 1822) in the Padma River, during the study period**

| Parameters | BW | $K_F$ | $K_R$ | $W_R$ |
|---|---|---|---|---|
| TL | 0.969** | 0.125** | -0.057 | -0.056 |
| BW | | 0.324** | 0.142** | 0.143** |
| $K_F$ | | | 0.976** | 0.976** |
| $K_R$ | | | | 1.000** |

**. Correlation is significant at the 0.01 level (2-tailed).

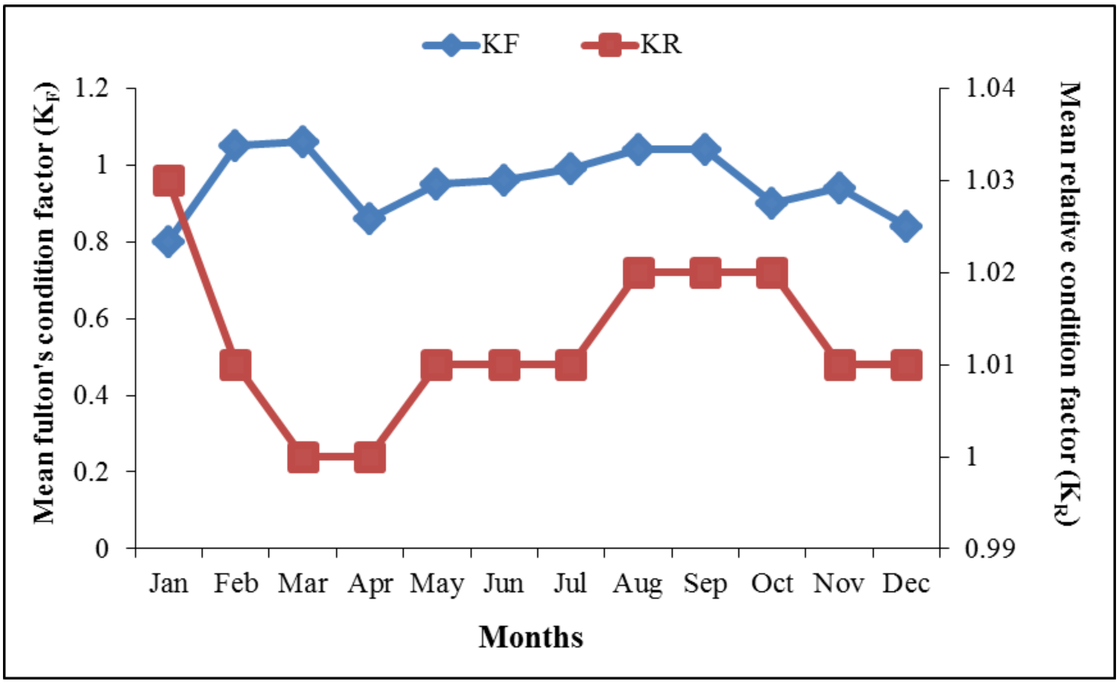



**Figure 4.7.** Monthly mean fulton's condition factor and relative condition factor of *C. reba* (Hamilton 1822) in the Padma River, during the study period

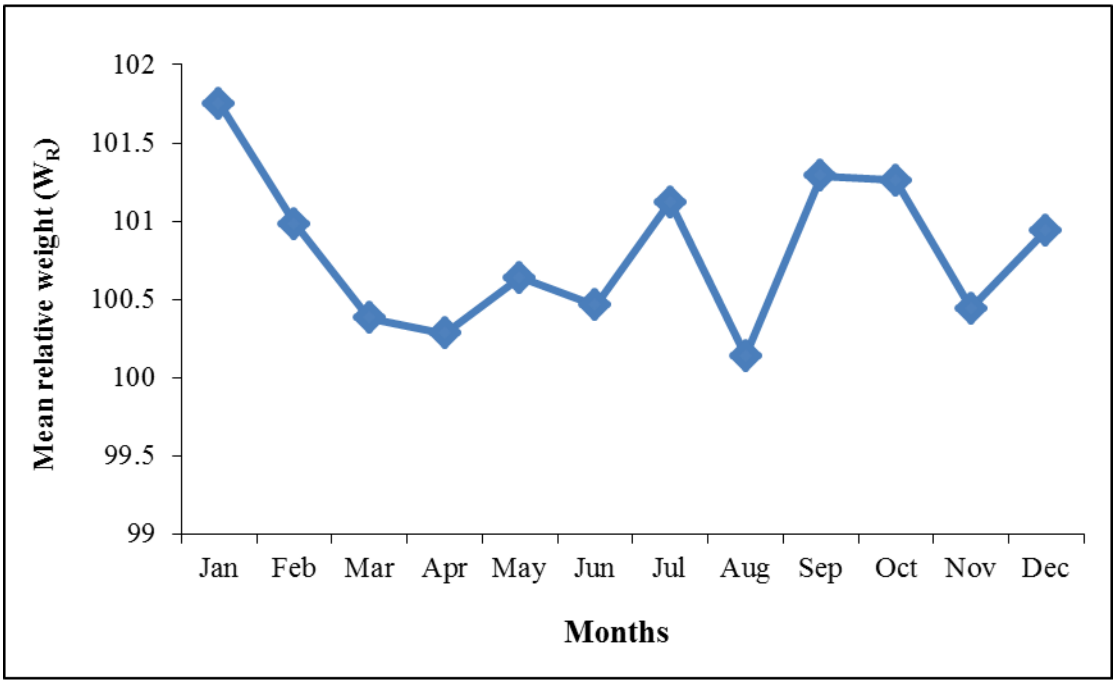



**Figure 4.8.** Monthly mean relative weight of *C. reba* (Hamilton 1822) in the Padma River, during the study period

## 4.4 Discussion

A total of 600 specimens of *C. reba* were used for the present study. These fish specimens were collected using different types of fishing gears. Therefore, variations in size class might be a common phenomenon. During the study, length-frequency distribution with various length ranges between 6.60 to 23.80 cm in total length and 2.63 to 136.00 in total body weight during the sampling period. However, some authors have reported the maximum size (length-frequency) of this species as 60.0 cm (Hamilton, 1822); 22.00 cm (Bhuiyan, 1964); 32.00 cm (Khan, 1986); 32.50 cm (Rahman, 1989); 30.00 cm (Talwar and Jhingran, 1991); 29.30 cm (Hussain, 1999); 22.50 cm (Narejo, 2006); 30.00 cm (Lashari *et al.,* 2007); 23.50 cm (Galib *et al.,* 2009); 18.40 cm (Muralidharan *et al.,* 2011); 23.40 cm (Hossain *et al*. 2013) and 23.50 cm reported by Bathialagan *et al*. (2014). These regional differences in total length perhaps depend on the ecological conditions in the areas of study and food availability (Weatherley and Gill, 1987).

During the present study, the maximum weight recorded was 106.25 g and 136.00 g for male and female respectively. In case of combined sex, minimum and maximum weight was 2.63g and 136.00 g. The maximum weight recorded in the present experiment was lower than the maximum weight recorded by Hossain *et al*. (2013) as 200 g in the same studied river (Padma river) and Muralidharan *et al*. (2011) as 147.00 g in Cauvery River, south India. However, it was higher than the findings of Narejo (2006), who found maximum weight of *C. reba* was 102.50 g in Manchar Lake, Pakistan. The results of length-weight frequency distribution also revealed that females were larger than males, which are in agreement of the findings of Hossain *et al.* (2013), who also reported larger female size compared to males and described the causes might be either to the absence of larger-sized individuals in the populations in fishing grounds (Hossain *et al*. 2012a) and/or shrinkage in body size of the formalin-preserved specimens. He also added that the variations in the fishing gear used and the selectivity on the target species might also be responsible for this bias (Hossain *et al.* 2012b). The differences in length-weight frequency distribution between male and female in the present study might also be due the prevailing causes reported by the earlier scientist.

The month-wise LWR study in the present study depicted that different growth types were observed in different months. The calculated values of 'b' for length and weight were lower than 3 in the month of January to April and October to December. In these months the growth type was negative allometric. While positive allometric growth was observed in the months of June to September. However, in the month of May the growth type was isometric, where the 'b' value was 3.008. The 'b' value for male, female and combined sex was 3.020, 3.215 and 3.116 respectively, that indicates isometric growth type in male and positive allometric growth type in female and combined sexes. The findings of the growth type at different month and sex-wise showed some dissimilarity with the findings of Hossain *et al*. 2013 and Mathialagan *et al.* 2014. That might be due to environmental effects on growth pattern of fishes. Similar statement was also made by Frosese (2006), who stated that, the reasons for this month and sex-wise variation in growth types are said to be due to seasonal fluctuations of the environmental parameters, physiological conditions of the fish at the time of collection, sex, gonad development and nutritive conditions. Tesch (1971) also added some other causes including habitat, degree of stomach fullness, preservation techniques and differences in the observed length ranges of the specimen caught might also affect the length-weight relationship in fishes. Behaviour (active or passive swimmer) and water flow might also be other causes of differences in length-weight relationships (Muchlisin *et al*. 2010). While all of these above mentioned causes were not considered for the present study.

Three types of condition factors were used to assess the overall health and productivity of *C. reba* of Padma river during the study period. The condition factor is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fishes (Lizama and Ambrosio, 2002). The minimum and maximum value of $K_F$ during the study period was 0.39 and 1.65 for male and 0.48 and 1.83 in females with mean value 0.94 ± 0.14 and 0.97 ± 0.17. For combined sex the minimum, maximum and mean of $K_F$ was 0.39, 1.83 and 0.95 ± 0.15, which are slightly lower than the findings of Hossain *et al*. (2013). Seasonal differences in $K_F$ were also observed during the study period with lowest (0.80) values were observed during the month of January and highest (1.06) value during the month of March. The fluctuation in $K_F$ might be attributed to seasonal changes in feeding intensity and gonadal development, which was early mentioned by Mathialagan *et al*. (2014) for the same species from lower Anicut, Tamil Nadu, India. Relative condition factor ($K_R$) also did not follow any rule of thumb and fluctuated with different season and size groups. It also influenced by feeding intensity and highest value was observed in the month coincided with higher availability of food during the study period. Similar to Hossain *et al*. (2013) and Froese (2006) the most popular index (relative weight, $W_R$) was used to focus the present status of the threatened Reba carp in the Padma River. In the present study, the mean value of $W_R$ of combined sexes of *C. reba* showed significant differences from 100 ($p = 0.019$). The relative weight showed no significant differences from 100 for male and female in this study, indicating the habitat was still in good condition for *C. reba*. But Hossain *et al* (2013) have found that relative weight showed no significant differences from 100 for male and female in their study and indicated that the habitat was still in good condition for *C. reba*. While as the present study found significant differences of $W_R$ from 100, it is clear that the habitat of *C. reba* in the Padma river becomes degraded day by day and during the course of time, as recently reported by Flura *et al*. (2016), who mentioned that the water quality of Padma river was decreasing day by day. Month-wise fluctuation in $W_R$ might also be seasonal fluctuation in food content of nature, which is also in agreement with the findings of Offem *et al*. (2007), who reported that the seasonal variation in food supply may change this condition factor.

## 4.5 Conclusion

*C. reba* is categorized as nearly threatened in Bangladeshi waters by IUCN Bangladesh (2015). However, the wild population of the species could be declining due to heavy harvest, habitat loss and other ecological changes to their habitat. Therefore, one of the most important steps towards safe the population of this species is commercial aquaculture practice in ponds and rivers. Study of population structure, length-weight relationship and condition factors are very important to achieve necessary information for better management and conservation of this species. Thus, this present study will be an effective tool for fishery biologists, managers and conservationists towards providing management strategies of this species in aquaculture system and for initiate better regulation option for the sustainable conservation of the remaining stocks of this species in the Padma River ecosystem.

# Chapter Five

# Food and feeding habits of *C. reba* (Hamilton, 1822) from Padma river, North-western Bangladesh

## 5.1 Introduction

Food and feeding habits of carps have been a field of interest to fisheries researchers since very long. Feeding is the dominant activity of the entire life cycle of fish (Royce, 1972) and food is the main source of energy which plays an important role in determining the population levels, rate of growth and condition of fishes (Begum *et al.*, 2009). The growth of the fish is optimum when the environmental conditions are in optimum quantity. Naturally growth of the fish is governed by the parameter such as availability of sufficient food resources. The food and feeding habits of fish vary with the time of the day, season, size of fish, various ecological factors, and different food substances present in the water body (Hynes, 1950). The success on good scientific planning and management of fish species largely depends on the knowledge of their biological aspects, in which food and feeding habits include a valuable portion (Sarkar and Deepak, 2009). Study of food and feeding habits of fishes have manifold importance in fishery biology and in fisheries management programme (Khan and Fatima, 1994; Sarkar and Deepak, 2009). The gut content analysis gives an idea about the actual diet of the fish species. The knowledge of food and feeding habit helps to select species that produce maximum yield by utilizing all the available potential food of the water bodies without competition (Dewan *et al.*, 1985).

The food habit of different fishes vary from month to month. This variation is due to changes in the composition of food organisms occurring at different seasons of the year. Jhingran (1983) stated that the natural food of fishes are classified under four groups- (a) Main or basic food, which is natural food consumed by fish under fovourable conditions. (b) Occasional or secondary food which is eaten by the fish in small quantities when available. (c) Incidental food, which is rarely enters the gut along with others items. (d) Emergency food or obligatory food which is ingested in the absence of basic food and on which the fish is able to survive. Various factors affect the feeding habit of fish such as season, time of day, light intensity, temperature an internal rhythm of fish. In aquaculture practice, to increase the yield of cultured fish the accurate knowledge of food and feeding is essential. The food studies may also show details of the ecological relationships among organisms. The food relationships determine population levels, rates of growth and conditions of fish.

Studies on the food and feeding habit of different fishes have been made by many workers like Karim and Hossain, (1972), Doha, (1974), Dewan and Saha, (1979), Jhingran, (1983), Bhuiyan and Haque, (1984), Bhuiyan and Islam, (1990, 1991), Hossain *et al.* (1991) and others. But there is no sufficient information about food and feeding habit of *C. reba.*

The present study deals with the food and feeding habit of *C. reba* that helps to select such species of fish for culture and produce an optimum yield by utilizing all the available potential food of the waterbodies without any competition.

**The present investigation was made on based on the following objectives**

- To know the various food items preferred by *C. reba*
- To know the monthly and size wise variation of food items in the stomach of *C. reba*
- To determine the feeding intensity at different months and size groups
- To know the selectivity of different food items of *C. reba*.

## 5.2 Materials and methods

### 5.2.1 Sampling site and study duration

Fishes are procured for the present study, diet composition and feeding dynamics from the commercial catch of fishermen from five different locations of Padma river from Godagati to Chargat, Rajshahi for a period of one year (From January 2015 to December 2015). Name of the sampling station with GPS point are shown in Table 3.1 and Figure 3.1.

### 5.2.2 Collection, preservation and analysis of stomach content

In each sampling station 10 fishes were collected for the study and a total of 50 fishes were studied in each month during the study period. The fishes were collected from the sampling site and dissect out full digestive tract. Then preserve the dissected gut in 10% alcohol for further study of gut content analysis. Before preceding the analysis the weight of gut was recorded by electronic balance. Gut contents were analyzed by both quantitative and qualitative method. The food items were identified by referring the standard literature. The unidentified materials were grouped under the miscellaneous group. For qualitative and quantitative analysis, gut contents were washed in petridish and the food items were identified by naked eye (for macro organisms) and by microscope (for micro/small organisms). For quantitative analysis of different food items were done by using Sedgwick Rafter Counting Cell.
After that gut fullness has been assessed according to the subjective scale described by Lebedev (1946) as empty, ¼ full, ½ full, ¾ full and full. Food in relation to size of the fish was also studied by tabulating percentage composition of varying food items against the size groups.

### 5.2.3 Food Selectivity Study

The composition of the phytoplankton community in the stomach was then compared with that of nature to evaluate grazing selectivity, which was calculated according to Ivlev (1961) by fish: Ei = Sti - Pi/Sti + Pi. Where, Ei = electivity index for species I, Sti = relative proportion of species i in the diet, Pi = relative proportion of species i in the environment. E values vary from -1 to +1, values around 0 indicate no selection, a value of +1.0 indicates strong positive selection, and -1.0 indicates strong avoidance.

**5.2.4 Relation between total length and alimentary canal**

Length of alimentary canal was taken with the help of measuring board fitted with a meter scale and recorded in record book. The relation between total length and alimentary canal length of the fish were computed by regression analysis after logarithmic transformation of the respective X and Y values

,

$$\ln Y = \ln a + b \ln X$$

where, Y = Alimentary canal length (ACL)
X = Total length (TL)
a = Intercepts on the ordinate
b = Regression co-efficient

**5.2.5 Statistical analysis**

Statistical analyses were performed using SPSS (Statistical Package for Social Science) version 20.0 (IBM Corporation, Armonk, NY, USA).

## 5.3 Results

### 5.3.1 Food items in the gut of *C. reba*

The various food items recorded from the stomach of *C. reba* during the study period are presented in Figure 5.1. The food items found in the examined stomachs were grouped into eleven categories namely debris, Cyanophyceae, Chlorophyceae, Bacillariophyceae, Euglenophyceae, higher plants, rotifer, cladocera, copepod, ostracoda and others food items. The major food items by percentage were debris, which constitute 37.643 % of the total food items. However, other unidentified matter was also found in large quantities (21.728 %). Among the phytoplankton group, Chlorophyceae (19.023 %) constitute major portion and among zooplankton percent composition of rotifer (3.208 %) was highest (Figure 5.1). Among other food items higher plants get the higher position with percent composition (6.731 %). The various food items found in the different months are stated below:

**Debris:** It mainly consists of sand mud and other undigested materials.

**Cayanophyceae:** It includes *Microcystis, Merismopedia, Aphanocapsa, Chroococcus, Oscillatoria, Anabaenopsis, Anabaena* and *Nostoc.*

**Chlorophyceae:** *Actinastrum, Pediastrum, Chlorella, Cosmarium, Pandorina, Scenedesmus, Ulothrix, Volvox* and *Zygnema.*

**Bacillariophyceae:** *Cyclotella, Melosira, Navicula* and *Synedra.*

**Euglenophyceae:** *Euglena, Phacus* and *Trachelomonas.*

**Rotifera:** *Brachionus, Keratella, Polyarthra* and *Filinia.*

**Cladocera:** *Bosmina, Daphnia* and *Moina.*

**Copepoda:** *Cyclops, Diaptomus* and Nauplius larvae

**Ostracoda:** *Cypris*

**Aquatic higher plants:** The aquatic plants parts food item consisted of mainly grass plant root, leaves and parts of aquatic plants.

**Others:** Semidigested unidentified parts of plants and animals.

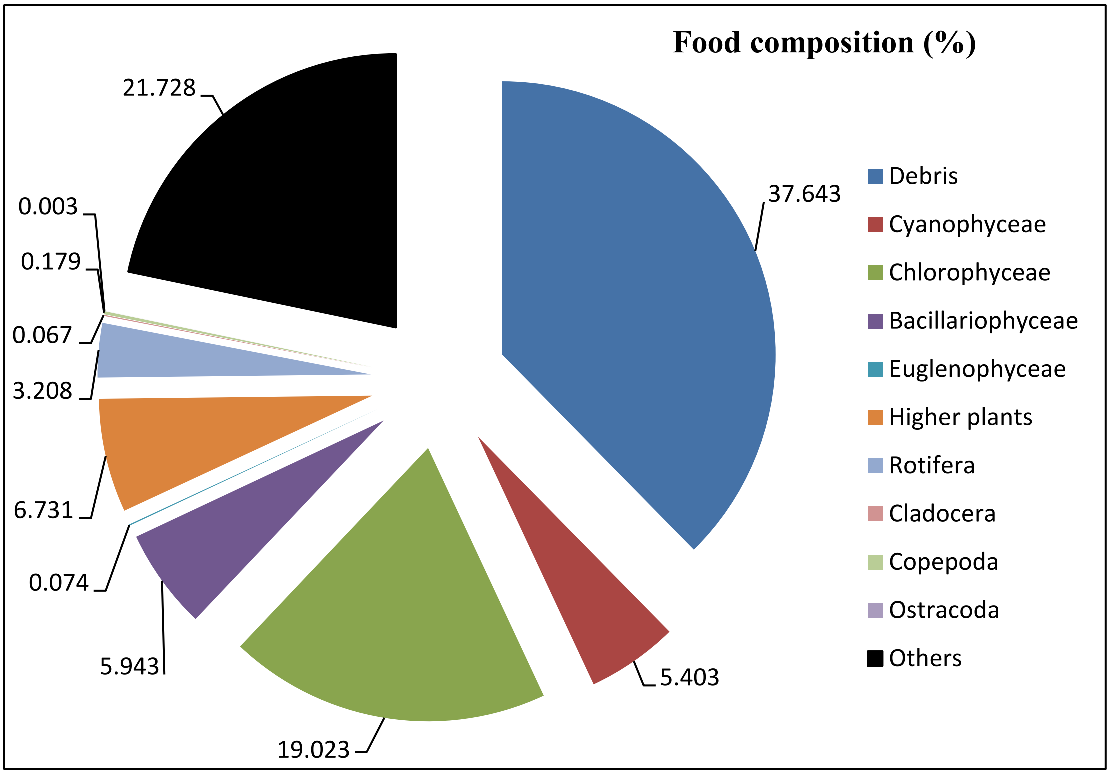



**Figure 5.1.** The average percentage of main food items in the stomach of *C. reba*

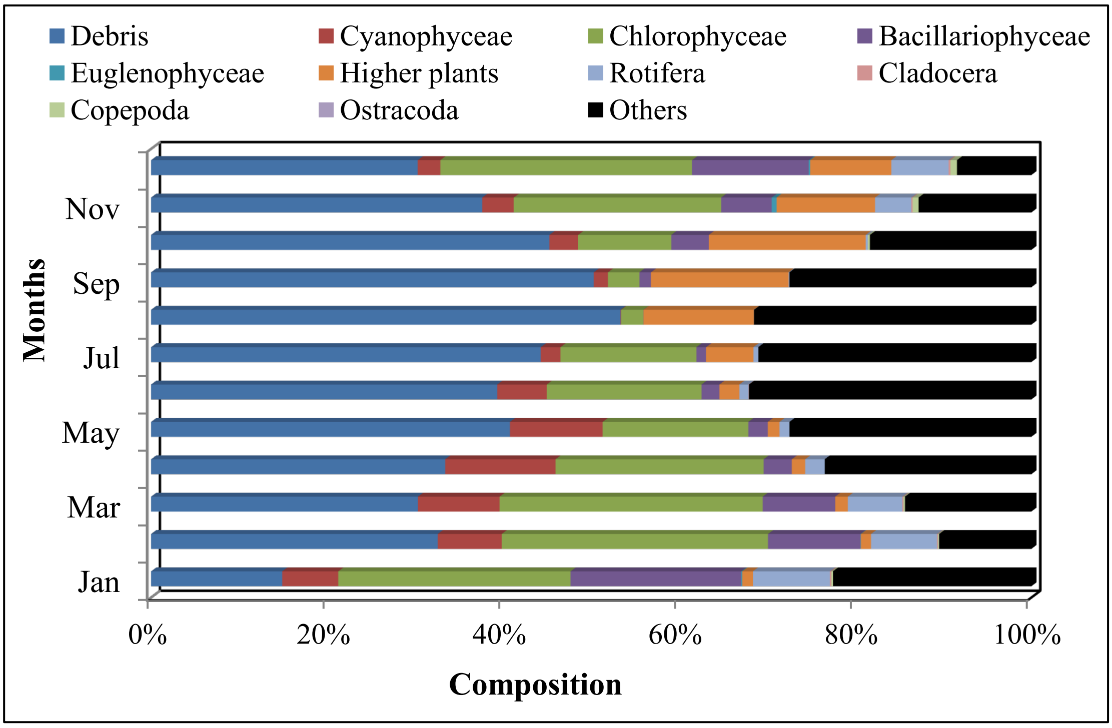



**Figure 5.2.** Monthly variation of food items composition in the gut of *C. reba* of Padma River during January 2015-December 2015

### 5.3.2 Monthly analysis of the stomach contents

Table 5.1 shows the twelve months categorization of the stomach content of *C. reba* from River Padma. The variations in percentage composition and percentage occurrence of food items revealed that percentage composition of different food items varied in different months according to their availability and preference of fish. The highest percentage (20.89 %) of empty stomach was found in the month of August and the lowest percentage (0.00 %) of empty stomach was in the month of January and February.

**Table 5.1. Monthly analysis of stomach content of *C. reba* of Padma river**

| Months | No. of samples | No. of stomach with food | % of stomach with food | No. of empty stomach | % of empty stomach |
|---|---|---|---|---|---|
| January | 50 | 50 | 13.33 | 0 | 0.00 |
| February | 50 | 50 | 13.33 | 0 | 0.00 |
| March | 50 | 46 | 12.27 | 4 | 1.78 |
| April | 50 | 36 | 9.60 | 14 | 6.22 |
| May | 50 | 35 | 9.33 | 15 | 6.67 |
| June | 50 | 33 | 8.80 | 17 | 7.56 |
| July | 50 | 5 | 1.33 | 45 | 20.00 |
| August | 50 | 3 | 0.80 | 47 | 20.89 |
| September | 50 | 6 | 1.60 | 44 | 19.56 |
| October | 50 | 28 | 7.47 | 22 | 9.78 |
| November | 50 | 39 | 10.40 | 11 | 4.89 |
| December | 50 | 44 | 11.73 | 6 | 2.67 |

Monthly variation of food items composition in the gut of *C. reba* is shown in Figure 5.2. Except the month of January, higher percentage of food items was occupied by debris in the gut of *C. reba* in all the months. Higher percentage of debris (52.36 %) was recorded in the month of August. Cyanophyceae was highest (12.52 %) in the month of April and Chlorophyceae (30.22 %) and Bacillariophyceae (19.36 %) was dominant in the month of February and January respectively. Percentage of Euglenophyceae was highest (0.55 %) in the month of November. Amount of higher plant materials was highest (17.85 %) in the month of October. Among the zooplankton group rotifer was the most dominant and its highest (8.77 %) abundance was observed in the month of January. Other zooplankton groups such as cladocera, copepoda and ostracoda were found in minor amount.

### 5.3.3 Food composition in relation to size group

The percentage composition of various food items in the stomach of *C. reba* belonging to various size groups are presented in Figure 5.3. Rotifera was dominating group between the sizes 2.63 to 22.66 cm. From that point, the percentage of zooplankton group becomes decreased and amount of plant materials increased with increased the size of fishes. Among the phytoplankton group Chlorophyceae occupied the highest position followed by Bacillariophyceae and Cyanophyceae. While Euglenophyceae constituted little contribution to the overall gut content of *C. reba*. With increase in size of fish, percent contribution of Chlorophyceae in total ingested food was increased. This finding clearly indicated that *C. reba* changes their feeding habits with differences in size.

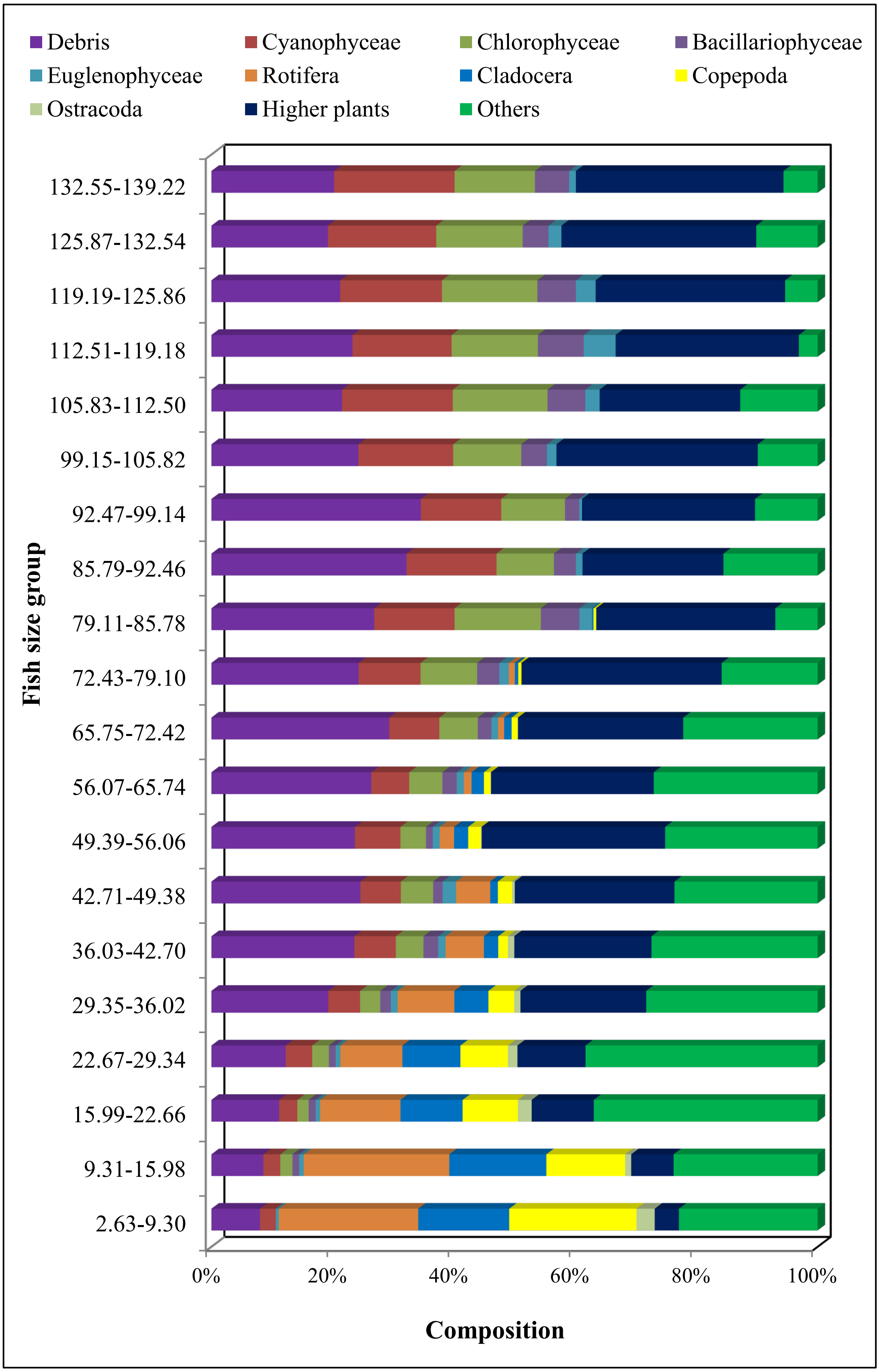



**Figure 5.3.** Food items composition in the gut of *C. reba* with different sizes of Padma River during January 2015-December 2015

### 5.3.4 Feeding intensity

Monthly fluctuation in the percentage occurrence of stomachs in different degrees of fullness and feeding condition are given in Figure 5.4. Highest percentage of full stomach was observed in the month of February (42.13 %) and lowest in the month of July (2.16 %), while highest percentage of empty stomach was recorded in the month of August (48.86 %) and lowest or nil in the month of February and March (0.00 %). The fullness and emptiness of stomach of fish was varied with food availability in the nature and breeding season of the fish. The fluctuation in fullness of stomach of fish with different size groups are also shown in Figure 5.5. Both highest percentage of gorged and full stomach was found in the size group of 72.43-79.10 cm. While highest percentage of ¾ full, ½ full, ¼ full and empty stomach was found in 92.47-99.14, 105.83-112.50, 119.19-125.86, 2.63-9.30 cm fish size groups. No empty stomach was observed in the size groups of 42.71-92.46 and 119.19-139.22 cm and no gorged stomach was found in the size groups of 2.63-15.98, 42.71-56.06, 105.83-112.50 and 119.19-139.22 cm.

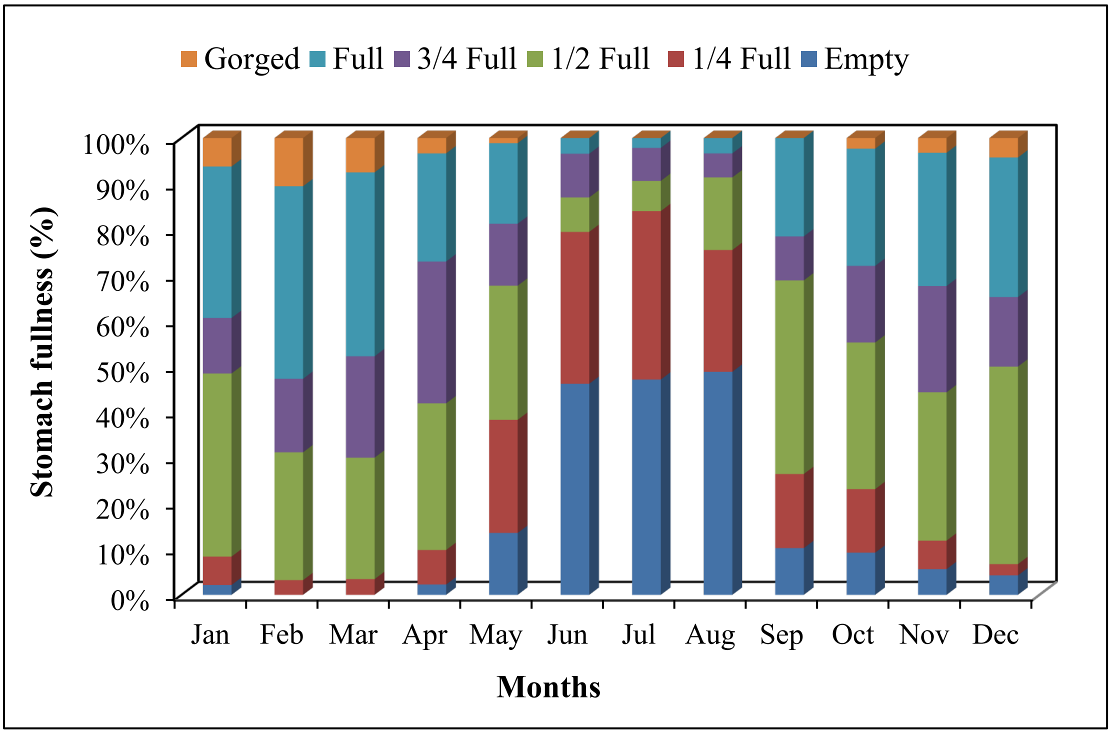



**Figure 5.4.** Monthly variations in stomach fullness degree of *C. reba* of Padma River during January 2015-December 2015

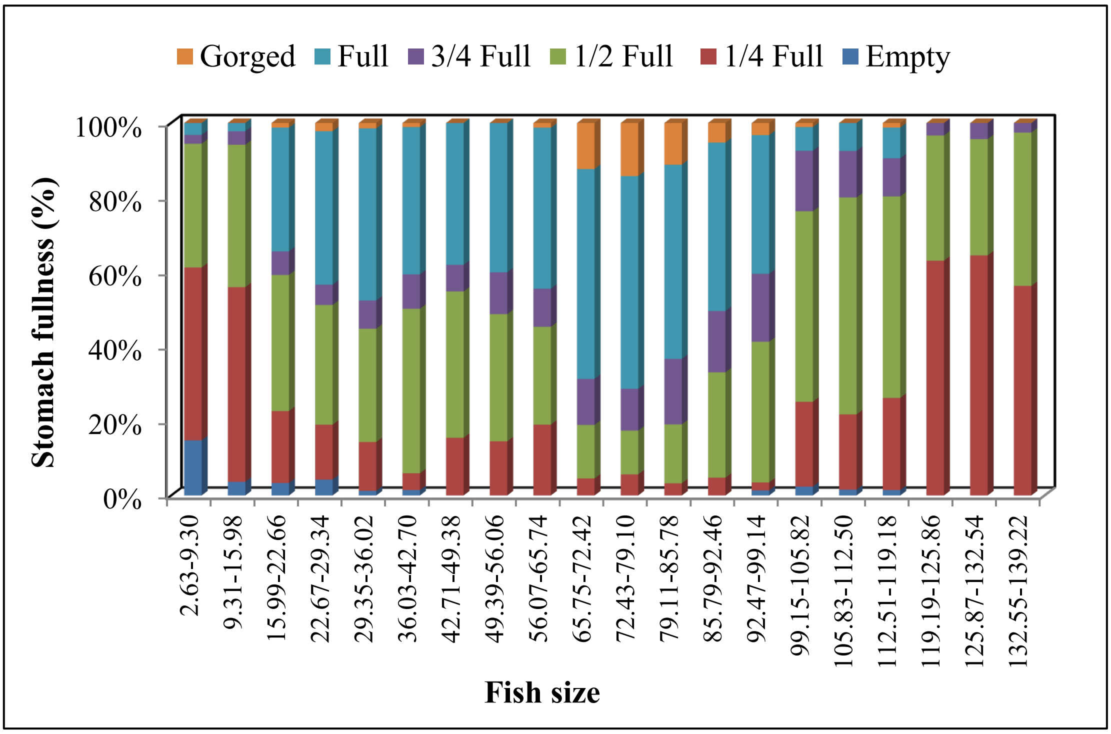



**Figure 5.5.** Variations in stomach fullness degree of *C. reba* at different size groups of Padma River during January 2015-December 2015

### 5.3.5 Electivity index

Electivity indices were calculated for each food organism recovered from gut contents of *C. reba* (Figure 5.6). The fingerlings and adults of *C. reba* showed sharp difference in selection of food items through electivity index. In fingerling stages it showed negative electivity for most of the phytoplanktonic organisms but showed slightly positive electivity for Chlorophyceae like *Scenedesmus*, *Closterium*, *Pediastrum*, Bacillariophyceae like *Cyclotella*, *Navicula*, Euglenophyceae like *Euglena* and all other zooplankton groups. But in case of adults it showed positive electivity for most of the phytoplanktonic organisms like *Actinastrum, Ceratium, Pediastrum, Chlorella, Cosmarium, Pandorina, Scenedesmus, Ulothrix, Volvox* and *Zygnema* from Chlorophyceae, *Microcystis, Merismopedia, Aphanocapsa, Chroococcus, Oscillatoria, Anabaenopsis, Anabaena* and *Nostoc,* from Cyanophyceae, *Cyclotella, Melosira, Navicula* and *Synedra* from Bacillariophyceae and *Euglena, Phacus* and *Trachelomonas* from Euglenophyceae but negative selection for all zooplanktonic organisms. While some unintentional positive selection of some minor zooplankton species was also occurred in adult groups.

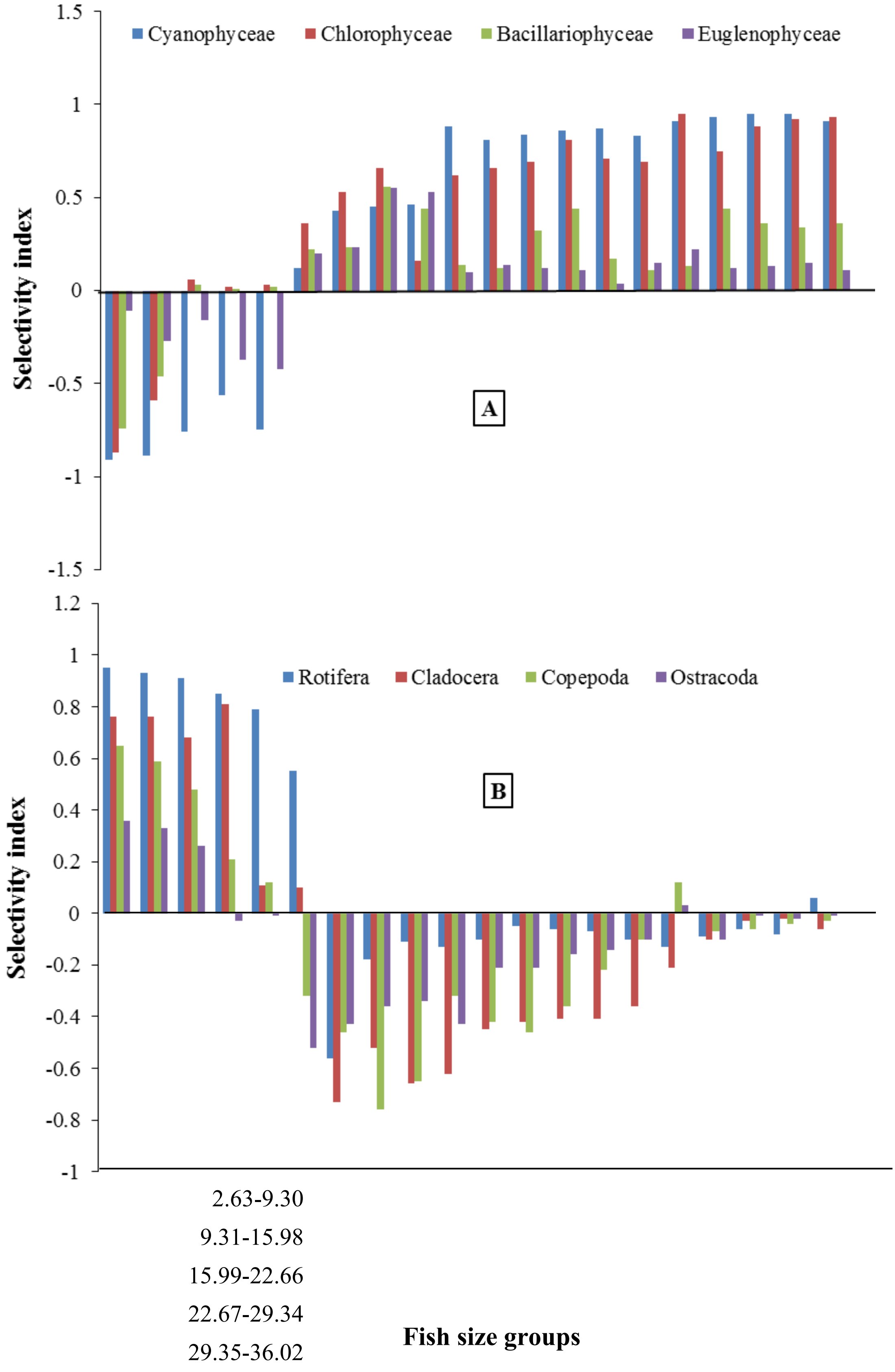



**Figure 5.6.** Selectivity index of *C. reba* with different sizes for phytoplankton (A) and zooplankton (B) of Padma River during January 2015-December 2015

### 5.3.7 Relationship between total length (TL) and alimentary canal length (ACL)

Relationship between total length and alimentary canal length was shown in Figure 5.7. The equation of the relationship between total length and alimentary canal length and their logarithmic transformation with the values of regressions, correlation-efficient, point of intercepts and standard deviation were computed (Table 5.3) using statistical formula according to Simpson (1951). The result showed that total length was positive and significant ($p < 0.05$) with the alimentary canal length.

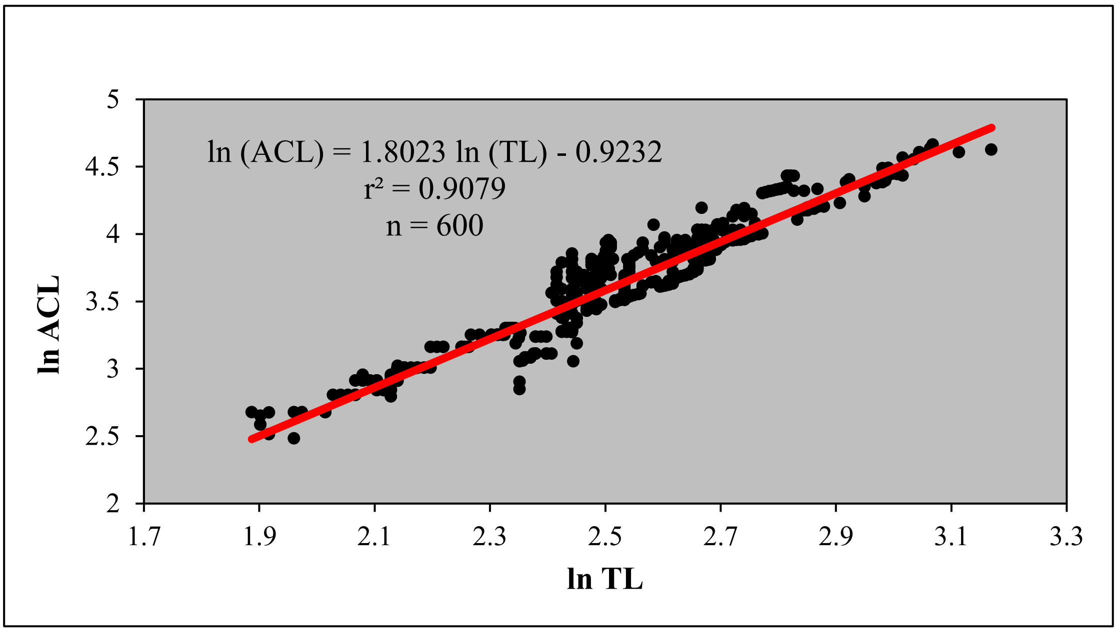



**Figure 5.7.** Relation between total length (TL) and alimentary canal length (ACL)

**Table 5.3.** Relation between total length and alimentary canal length of *C. reba*

| **Total length (TL)** | **Alimentary canal length (ACL)** | **Regression equation** | **Intercept 'a'** | **Slope 'b'** | **Regression co-efficient '$r^2$'** | **Level of significance** | **Ratio of TL:ACL** |
|---|---|---|---|---|---|---|---|
| 12.69±2.98 | 40.71±18.54 | ACL = - 0.923+1.8023(TL) | - 0.923 | 1.8023 | 0.9079 | $P < 0.05$ | 1:3.07 |

## 5.4 Discussion

In the present study food groups recorded in the gut content of *C. reba* constitute 11 feed groups. Among the 11 fish group debris constitute the major portion both in case of total percentage composition, month wise percentage and size wise percentage composition followed by higher aquatic plants. Similar finding also reported by Lashari *et al*., (2010), who found debris to be the most dominant food items followed by higher plants in the gut content of *C. reba*. The phytoplankton group recorded in the gut content was divided into 4 groups. Among the phytoplankton groups Chlorophyceae were dominant both in percent composition and month's wise percent composition. But the percentages of debris were decreased with increase in size groups, and subsequently replaced by plant materials especially higher plants. The dominant phytoplanktonic group Chlorophyceae was also replaced by Cyanophyceae groups at larger sized fishes. Animal food items occupied a small portion of total gut content of *C. reba*. Among animal food items rotifers accounted for larger position in gut contents. The ingestion rate of animal food items was highest in small size fishes; however this rate was decreased with increasing fish total length and the turning point from zooplankton to phytoplankton in *C. reba* during the present study was 29.35 to 36.02 cm total length. This result is in agreement with Yada, (1982), who found that the ingestion ratio of zooplankton decreased with increasing fish total length. However, higher percentages of debris in the gut content indicate bottom feeding nature of this fish species. Similar observation was also made by Menon and Chacko (1955), Dewan *et al*., (1985) and Lashari *et al*., (2010), who also reported *C. reba* as bottom feeder fish. The large portion of empty stomach of *C. reba* was found during the month of July, August and September, when the river was characterized by high water flow and low abundance of available food items. While large portion of empty stomach of *C. reba* during monsoon might also be attributed to the peak breeding season. Naik *et al*., (2015) also reported that during spawning season the size of ovaries increases and most of the abdominal cavity is occupied by it; as a result number of fish with empty stomach increases. The fishes with highest full stomach were found in the month of January to March and later on October to December, which might be due to higher food abundance in nature during these seasons. Similar findings also reported by Olele, (2011) in his study on diet composition, length/weight relationship and condition factor of *Hyperopisus bebe occidentalis* (Lacepede, 1803) caught in Warri River, Nigeria. However, no marked variation was found in feeding intensity of fish based on size groups during the study period. The result of regression analysis between total length and alimentary canal length showed that total length was positive and significant ($p < 0.05$) with the alimentary canal length. Which indicates that alimentary canal length of *C. reba* increased with increase in total length. Positively significant correlation between total length and alimentary canal length was also reported by Hossain *et al*., (2015) in their study on food and feeding habit of *Aspidoparia morar* in Padma river, Northwestern Bangladesh. The total length and alimentary canal length ratio (1:3.07) obtained in the present study indicates herbivorous feeding nature of *C. reba* that was previously reported by many researchers (Das and Moitra, 1956 and 1963; Jhingran, 1983; Mookerjee *et al*., 1946; Chacko and Kurian, 1949; Alikunhi, 1957 and Das and Srivastava , 1979).

## 5.5 Conclusion

The above findings indicated that *C. reba* was an omnivorous fish with highest feeding intensity in summer followed by winter and lowest in monsoon, which was also breeding season of this fish species. This study also finds that young's of *C. reba* prefer zooplankton up to a certain length group and intended to consume plant materials in their adult stage.

# Chapter Six

# Reproductive biology of *Cirrhinus reba* (Hamilton, 1822) of Padma river

## 6.1 Introduction

Reproduction is the process by which species are perpetuated. The success of any fish species is ultimately determined by the ability of its members to reproduce successfully in a fluctuating environment (Moyle and Czech, 2000). Therefore the reproductive strategy as reflected in anatomical, behavioral, physiological, and energetic adaptations is an essential commitment to future generation. Study on reproductive biology of any fish species is essential for assessing commercial potentialities of its stock, life history, culture practice and actual management of its fishery (Doha and Hye, 1970). Reproduction in fishes is the process by which species are perpetuated and by which in combination with genetic change, characteristics for new species first appear (Lagler, 1967). Continuity of the biological race is maintained by the process of reproduction. Information on fish reproduction is also important in aquaculture. The availability of quality seeds and the ability to control fish reproduction are limiting factors in the farming of any commercial species. This became an important factor to fulfill the demand of continuity in supply of table fish and fish seeds throughout the year. Sufficient information related to reproductive parameters and developmental biology can only meet this requirements. The successful adoption of induced breeding technique, using pituitary hormone, for a number of important species may play an important role in improving the fish seed supply in aquaculture. Study of sex-ratio, length at first sexual maturity, cycle of maturation and spawning periodicity etc. are important aspects of reproductive biology study of any fish species (Reddy, 1979; Vazzoler, 1996). Sustainable fisheries management relies on understanding the regenerative ability of fish populations and having an accurate assessment of biological parameters, including reproductive traits such as size and age at maturity and fecundity (Tracey *et al*., 2007). In order to make success in fish culture, it is important to assess the yearly breeding cycle of culturable fishes (Stoumboudi *et al*., 1993). The time or season when species breeds is normally termed as the breeding or spawning season of the species. The breeding or spawning season repeats in cyclic orders in which the organism undergoes maturation change and thereby gets ready to breed again. This repeated phenomenon is known as reproductive cycle or sexual periodicity. Knowledge of gonadal development and the spawning season of a species allow subsequent studies on spawning frequency of its population, which is important for its management. Moreover, the size at first maturity can be used to set minimum permissible capture size and for stock assessment (Lucifora *et al.,* 1999). Besides, assessment of fecundity is having paramount importance in fisheries management as it provides knowledge about the number of offspring produced in a season and the reproductive capacity of the species (Qasim and Qayyum, 1963). A thorough knowledge of the fecundity of fish is essential for evaluating the commercial potentialities of its stock, for studying of its life history, practical culture and actual management of the fishery (Doha and Hye, 1970). The study of fecundity is also undertaken to determine the index of density affecting the population size (Soomro, 2007; Das, 1977). Fecundity is more or less inversely related to size of eggs. The number of eggs contained in the ovary of a fish is called as fecundity (Nikolsky, 1983). Total fecundity is the number of egg laid down during the life time of the female. The fecundity of an individual female varies according to many factors including her egg size, types of species, age and condition such as food availability, water temperature and season etc. (Lagler, 1967).

*Cirrhina reba* is regarded as mostly freshwater capture fishery and it has declared as vulnerable by IUCN but it has failed to attract the attention of the fishery biologist. It should be mentioned that no fruitful work on the breeding biology of this species has been done till now in Bangladesh. Although some aspects of the biology of this species have been studied by some workers, it has received little importance regarding the reproductive process either to protect them from vulnerability or to explain the cause of great fluctuation in abundance. Study of reproductive biology of *Cirrhina reba* is found to be essential in the sense that it may provide information and clues for a tactful and skillful management and exploitation of this fish. The present study is aimed at providing a comprehensive account of the reproductive organ, reproductive cycle, sex ratio and fecundity of *C. reba* of Padma river of Bangladesh.

**The present investigation was made on based on the following objectives**

- To determine the sex ratio of *C. reba*
- To know the breeding and spawning season of *C. reba*
- To estimate the fecundity of *C. reba* of Padma river.

## 6.2 Materials and methods

### 6.2.1 Study sites

The present study was conducted in the lower parts of the Ganges River, North-Western (NW) Bangladesh also known as the Padma River. Five distinct stations were selected for collection of experimental fishes during the one year (From January 2015 to December 2015) of study period. Name of the sampling station with GPS point are shown in Table 3.1 and Figure 3.1.

### 6.2.2 Specimen collection

A total number of 600 specimens were collected during study period (January 2015 to December 2015) among which 317 species were male and 283 were female. Among 283 female specimens, a total of 50 gravid females (10 for each month from May to September) were taken for calculation of reproductive periodicity and fecundity. Eye observation and common experience were used in identifying the gravid female.

### 6.2.3 Preservation

After collection, specimens were preserved in 10% formalin solution. Gonads were preserved in 5% formalin solution after dissection in separate vials and plastic containers.

### 6.2.4 Measurements

During preservation, gonads were properly labeled for subsequent studies. Excess moisture was removed as consistently as possible by blotting paper before taking the weight. Different lengths of the fishes were measured in mm and their weight in gram. The ovary length and ovary weight was taken by a measuring board and electronic balance respectively.

### 6.2.5 Sex ratio

The sex ratio was tested by the Chi-Square test to know whether the observed ratios of sexes are significant or not. Statistical methods used for formula as-

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where, O = Observed value

E = Expected value

### 6.2.6 Reproductive cycle determination

Various methods are used to determine the reproductive periodicity of *Cirrhina reba*. Among them three methods were applied as percentage of gravid female against time, Gonado Somatic Index (G.S.I.) and Gonadal Length Index (G.L.I.).

For studying the Gonado Somatic Index (GSI), the following formula was used-

$$G.S.I. = \frac{OW}{TL} \times 100$$

Where, OW = Weight of the ovary

TW = Total weight of the specimen

Gonadal Length Index of *Cirrhina reba* was calculated by the following formula-

$$G.L.I. = \frac{OL}{TL} \times 100$$

Where, OL = Length of the ovary

TL = Total length of the specimen

### 6.2.7 Fecundity estimation

For fecundity estimation only mature and ripe ovaries eggs were considered. To estimate the fecundity from the ovaries eggs, gravimetric method was applied by using the following equation-

$$\text{Fecundity} = \frac{\text{Total weight of ovary} \times \text{No. of eggs in the fraction}}{\text{Weight of the fraction}}$$

### 6.2.8 Relationship between fecundity and others parameter

The relation between fecundity and total length, total weight and ovary weight of the fish were computed by regression analysis after logarithmic transformation of the respective X and Y values

$$\ln Y = \ln a + b \ln X$$

### 6.2.9 Statistical analysis

Statistical analyses were performed using SPSS (Statistical Package for Social Science) version 20.0 (IBM Corporation, Armonk, NY, USA).

## 6.3 Results

### 6.3.1 Measurement and sex ratio

Different measurements with minimum, maximum, mean ± SD and 95 % CL of male, female and combined sexes is shown in Table 6.1. During the present study, among the 317 male *C. reba* examined, the mean total length, gonad length, body weight, and gonad weight were recorded as 12.02 ± 2.72 cm, 3.39±1.10 cm, 19.01 ± 13.72 g and 0.22 ± 0.23 g respectively. In case of females (283 females), the mean total length, gonad length, body weight and gonad weight were 13.44 ± 3.08 cm, 4.22 ± 1.56 cm, 28.23 ± 16.08 g and 4.91 ± 6.62 g. While in case of combined sex, these values were 12.69 ± 2.98 and 2.43 ± 5.11 cm and 23.69 ± 21.49 and 2.43 ± 5.11 g respectively. Monthly number of total male, female, sex ratio, chi-square value and significance level are shown in Table 6.2. From the 600 species collected during the study period 317 was male and 283 was female, with a sex ratio of 1:0.89. There were differences in the monthly male, female number and sex ratio and the highest sex ratio was obtained in the month of August (1:3.17) and lowest in January (1:0.32). The sex ratio was significantly different from the expected value of 1:1 in the month of January (df = 1, $\chi 2$ = 6.63, p<0.01), June (df = 1, $\chi 2$ = 3.84, p<0.05), July (df = 1, $\chi 2$ = 6.63, p<0.01), August (df = 1, $\chi 2$ = 3.84, p<0.05) and October (df = 1, $\chi 2$ = 3.84, p<0.05). The sex ratio was not differ significantly from the expected value of 1:1 (df = 1, $\chi 2$ = 3.84, p<0.05) in the month of February, March, April, May, September, November, and December respectively. However, the overall sex ratio was also did not differ significantly from the expected value of 1:1 (df = 1, $\chi 2$ = 3.84, p<0.05).

**Table 6.1. Descriptive statistics on length and weight measurements of *Cirrhinus reba***

| Measurements | n | Min | Max | Mean±SD | $CL_{95\%}$ |
|---|---|---|---|---|---|
| Male | 317 | | | | |
| TL | | 6.70 | 19.70 | 12.02 ± 2.72 | 13.08 – 13.81 |
| BW | | 2.63 | 106.25 | 19.01 ± 13.72 | 25.82 – 32.09 |
| GW | | 0.02 | 1.77 | 0.22 ± 0.23 | 0.20 - 0.25 |
| GL | | 0.10 | 7.20 | 3.39±1.10 | 3.26-3.51 |
| Female | 283 | | | | |
| TL | | 6.60 | 23.80 | 13.44 ± 3.08 | 11.71 – 12.32 |
| BW | | 4.10 | 136.00 | 28.23 ± 16.08 | 17.49 – 20.52 |
| GW | | 0.04 | 45.00 | 4.91 ± 6.62 | 4.13 - 5.68 |
| GL | | 1.18 | 10.39 | 4.22 ± 1.56 | 4.04 - 4.40 |
| Combined sex | 600 | | | | |
| TL | | 6.60 | 23.80 | 12.69 ± 2.98 | 12.45 – 12.93 |
| BW | | 2.63 | 136.00 | 23.69 ± 21.49 | 21.97 – 25.42 |
| GW | | 0.02 | 45.00 | 2.43 ± 5.11 | 2.02 - 2.84 |
| GL | | 0.10 | 10.39 | 3.78 ± 1.40 | 3.67 - 3.89 |

**Table 6.2. Monthly number of male, female, sex ratio, $\chi^2$ value and significance level of *C. reba***

| Sampling months | Number of specimens | | | Sex ratio (male:female) | $\chi^2$ df (1) | Significance |
|---|---|---|---|---|---|---|
| | Male | Female | Total | | | |
| January | 38 | 12 | 50 | 1:0.32 | 13.43 | ** |
| February | 31 | 19 | 50 | 1:0.61 | 2.88 | ns |
| March | 30 | 20 | 50 | 1:0.67 | 2.00 | ns |
| April | 28 | 22 | 50 | 1:0.79 | 0.72 | ns |
| May | 24 | 26 | 50 | 1:1.08 | 0.08 | ns |
| June | 18 | 32 | 50 | 1:1.78 | 3.92 | * |
| July | 15 | 35 | 50 | 1:2.33 | 8.00 | ** |
| August | 12 | 38 | 50 | 1:3.17 | 13.52 | ** |
| September | 27 | 23 | 50 | 1:0.85 | 0.32 | ns |
| October | 33 | 17 | 50 | 1:0.52 | 5.12 | * |
| November | 30 | 20 | 50 | 1:0.67 | 2.00 | ns |
| December | 31 | 19 | 50 | 1:0.61 | 2.88 | ns |
| Overall | 317 | 283 | 600 | 1:0.89 | 1.93 | ns |

NS, not significant; significant at 5% level ($\chi^2_{t\,1}$, 0.05 = 3.84) and 1% level ($\chi^2_{t\,1}$, 0.01 = 6.63)

*P < 0.05, **P < 0.01, ns = not significant.

### 6.3.2 Monthly GSI and GLI value

Monthly minimum, maximum, mean ± SD and 95% CL of GSI and GLI for male and female are shown in Table 6.3, 6.4, 6.5, 6.6 and Figure 6.1, 6.2, 6.3 and 6.4 respectively. The highest peak of GSI for male and female was observed in August (2.66 ± 0.50 and 35.28 ± 7.88) and lowest in October (0.65 ± 0.07 and 0.84 ± 0.25). The highest peak of GLI (34.63 ± 3.72) was observed in September for male and in August (37.94 ± 8.01) for female. While, the lowest values were 24.05 ± 7.68 and 25.83 ± 5.71 in December for male and female respectively.

**Table 6.3. Monthly values of GSI of male *C. reba***

| Sampling months | Gonadosomatic index (GSI) | | | |
|---|---|---|---|---|
| | Min | Max | Mean±SD | $CL_{95\%}$ |
| January | 0.66 | 0.92 | 0.77 ± 0.08 | 0.74 - 0.80 |
| February | 0.71 | 1.16 | 0.84 ± 0.08 | 0.81 - 0.87 |
| March | 0.86 | 1.13 | 0.96 ± 0.07 | 0.94 - 0.99 |
| April | 0.94 | 1.23 | 1.07 ± 0.09 | 1.02 - 1.13 |
| May | 0.98 | 1.51 | 1.18 ± 0.12 | 1.13 - 1.23 |
| June | 1.23 | 1.72 | 1.40 ± 0.12 | 1.35 - 1.44 |
| July | 0.75 | 1.74 | 1.42 ± 0.22 | 1.33 - 1.50 |
| August | 2.18 | 4.12 | 2.66 ± 0.50 | 2.41 - 2.91 |
| September | 0.89 | 1.25 | 1.14 ± 0.12 | 1.06 - 1.21 |
| October | 0.51 | 0.76 | 0.65 ± 0.07 | 0.62 - 0.67 |
| November | 0.53 | 1.03 | 0.66 ± 0.11 | 0.62 - 0.70 |
| December | 0.47 | 0.92 | 0.71 ± 0.11 | 0.66 - 0.76 |

**Table 6.4. Monthly values of GSI of female *C. reba***

| Sampling months | Gonadosomatic index (GSI) | | | |
|---|---|---|---|---|
| | Min | Max | Mean ± SD | $CL_{95\%}$ |
| January | 3.53 | 7.61 | 4.89 ± 1.05 | 4.40 - 5.38 |
| February | 6.39 | 7.82 | 7.10 ± 0.35 | 6.88 - 7.32 |
| March | 6.91 | 9.15 | 7.77 ± 0.71 | 7.43 - 8.11 |
| April | 9.45 | 11.67 | 10.37 ± 0.59 | 10.18 - 10.57 |
| May | 11.42 | 13.71 | 12.86 ± 0.61 | 12.59 - 13.13 |
| June | 9.62 | 19.20 | 17.59 ± 2.06 | 16.59 - 18.58 |
| July | 20.37 | 28.88 | 23.15 ± 2.01 | 22.21 - 24.09 |
| August | 20.48 | 55.36 | 35.28 ± 7.88 | 32.44 - 38.11 |
| September | 13.33 | 30.02 | 22.64 ± 4.60 | 21.13 - 24.15 |
| October | 0.20 | 1.40 | 0.84 ± 0.25 | 0.72 - 0.97 |
| November | 1.01 | 1.60 | 1.23 ± 0.14 | 1.16 - 1.30 |
| December | 1.04 | 1.49 | 1.19 ± 0.10 | 1.15 - 1.23 |

**Table 6.5. Monthly values of GLI of male *C. reba***

| Sampling months | Gonadal length index (GLI) | | | |
|---|---|---|---|---|
| | Min | Max | Mean±SD | $CL_{95\%}$ |
| January | 16.12 | 36.57 | 26.00 ± 5.53 | 23.93 - 28.07 |
| February | 15.09 | 51.43 | 29.74 ± 7.37 | 27.32 - 32.17 |
| March | 25.21 | 36.87 | 31.41 ± 3.54 | 30.11 - 32.71 |
| April | 22.16 | 35.65 | 29.57 ± 3.63 | 27.27 - 31.88 |
| May | 18.69 | 39.17 | 28.86 ± 4.62 | 27.07 - 30.65 |
| June | 17.32 | 38.39 | 28.23 ± 4.48 | 26.58 - 29.87 |
| July | 19.44 | 38.04 | 28.53 ± 4.91 | 26.70 - 30.36 |
| August | 21.68 | 36.94 | 27.64 ± 5.25 | 25.03 - 30.25 |
| September | 26.79 | 40.44 | 34.63 ± 3.72 | 32.26 - 36.99 |
| October | 12.40 | 43.98 | 24.68 ± 6.89 | 22.24 - 27.13 |
| November | 21.33 | 35.18 | 26.58 ± 3.95 | 25.10 - 28.05 |
| December | 1.19 | 40.22 | 24.05 ± 7.68 | 20.80 - 27.29 |

**Table 6.6. Monthly values of GLI of female *C. reba***

| Sampling months | Gonadal length index (GLI) | | | |
|---|---|---|---|---|
| | Min | Max | Mean±SD | $CL_{95\%}$ |
| January | 17.07 | 42.49 | 27.53 ± 5.96 | 24.75 - 30.32 |
| February | 17.50 | 38.73 | 29.28 ± 6.72 | 25.01 - 33.55 |
| March | 25.93 | 41.57 | 31.69 ± 4.02 | 29.75 - 33.62 |
| April | 21.35 | 40.17 | 30.14 ± 5.06 | 28. 48 - 31.80 |
| May | 17.52 | 35.85 | 26.55 ± 6.03 | 23.88 - 29.23 |
| June | 20.22 | 45.39 | 32.74 ± 7.75 | 29.01 - 36.47 |
| July | 26.41 | 45.45 | 37.93 ± 5.03 | 35.58 - 40.28 |
| August | 5.49 | 51.72 | 37.94 ± 8.01 | 35.06 - 40.83 |
| September | 18.93 | 47.21 | 33.62 ± 7.87 | 31.03 - 36.21 |
| October | 20.07 | 47.29 | 30.39 ± 6.41 | 27.10 - 33.69 |
| November | 18.94 | 33.50 | 25.95 ± 4.21 | 23.98 - 27.92 |
| December | 15.05 | 34.72 | 25.83 ± 5.71 | 23.52 - 28.14 |

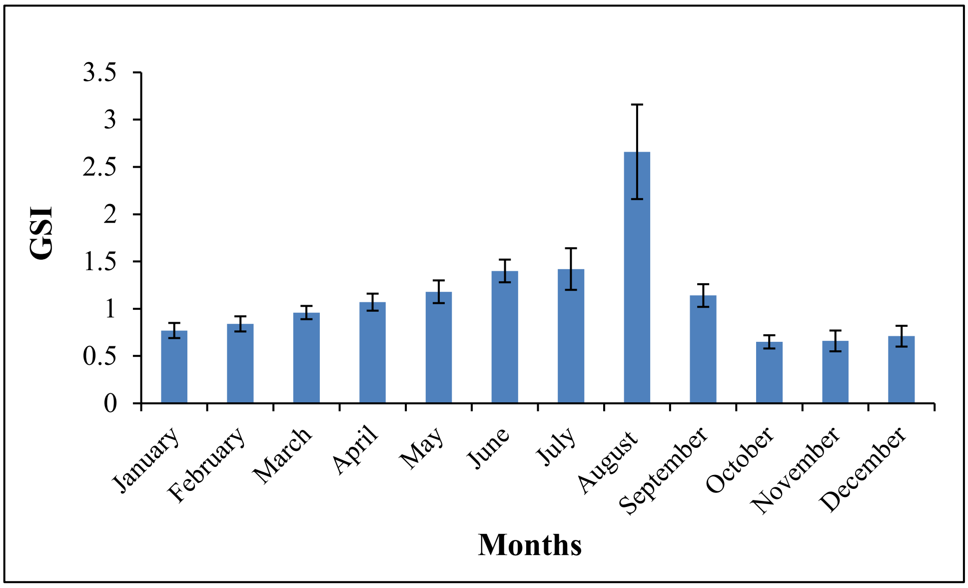



**Figure 6.1. Monthly GSI of male *C. reba***

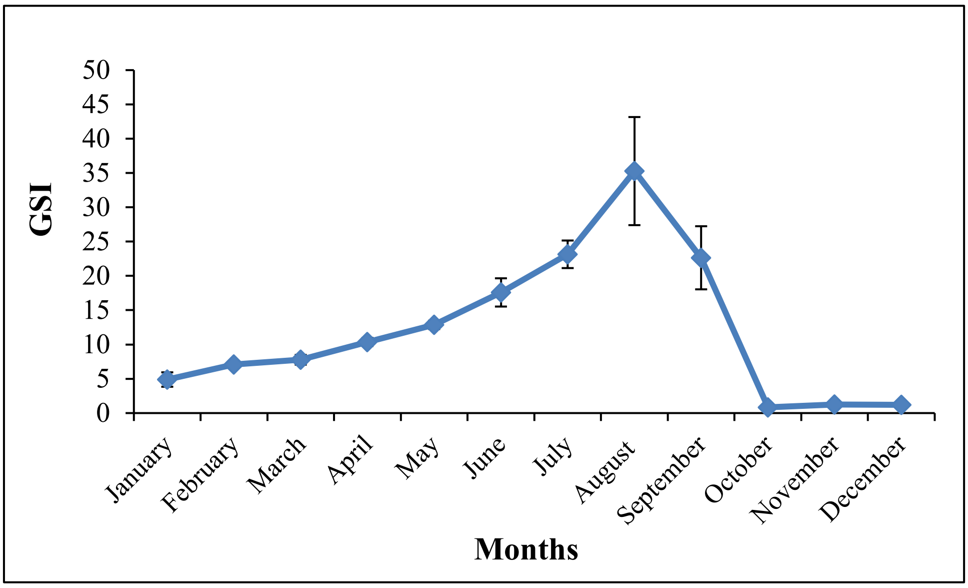



**Figure 6.2. Monthly GSI of female *C. reba***

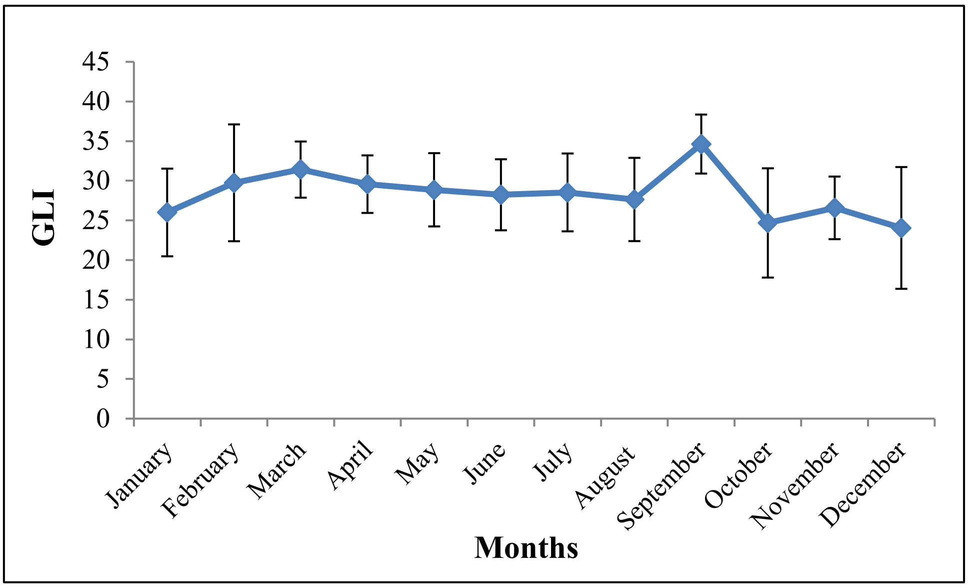



**Figure 6.3. Monthly GLI of male *C. reba***

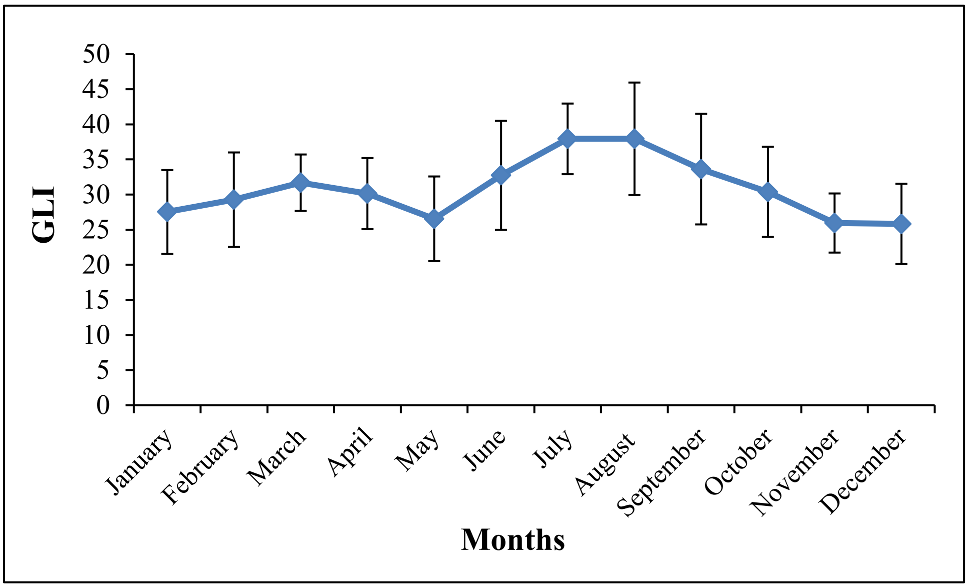



**Figure 6.4. Monthly GLI of female *C. reba***

### 6.3.3 Percentage of gravid female

No gravid females were obtained in the months of October, November, December, January and February. Only in the month of July to September and March to June gravid females were obtained. However, maximum percentage of gravid female were found in the month of August (70%) followed by July 55.17%, September 29.63%, June 20%, May 12.50%, April 6.67% and march (2.23%) (Figure 6.5).

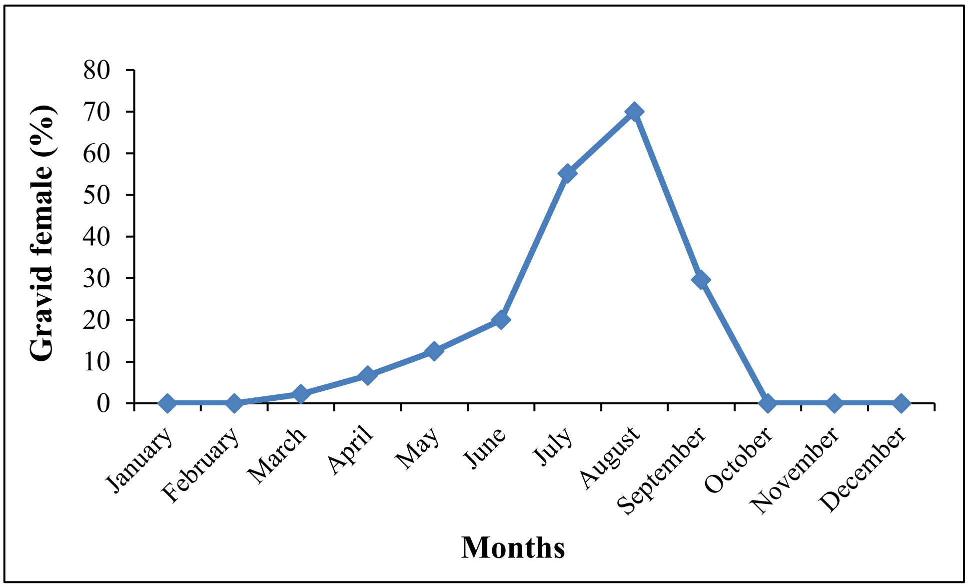



**Figure 6.5. Monthly percentage of no. of gravid female**

### 6.3.4 Fecundity

Data on total length (TL), body weight (BW), gonad weight (GW) and fecundity of 50 mature species of *C. reba* were recorded during the month of June to September for estimation of fecundity are shown in Table 6.7. The total number of mature eggs varied from 11542.10 to 265042.23 with mean value 11542.10 ± 53602.28. The relationships between fecundity, total length and gonad weight are shown in Table 6.8 and Figure 6.6. From the scattered diagrams of relationship between fecundity and total length, weight of fish and weight of ovary, it can be seen that there was linear relationship between fecundity and the three variables. Fecundity increased at the rate of 5.892, 1.492 and 1.316 times of the total length, weight of fish and weight of ovary, respectively.

**Table 6.7. Descriptive statistics on length, weight and fecundity measurements of *Cirrhinus reba***

| No. | TL (cm) | TW (cm) | GW (g) | Fecundity | No. | TL (cm) | TW (g) | GW (g) | Fecundity |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 14.56 | 35.70 | 4.80 | 12362.20 | **26** | 22.36 | 122.23 | 31.00 | 204525.11 |
| **2** | 14.55 | 38.50 | 5.15 | 13251.21 | **27** | 23.80 | 136.00 | 45.00 | 265042.23 |
| **3** | 15.63 | 40.15 | 5.30 | 11542.10 | **28** | 15.63 | 37.24 | 9.21 | 18562.11 |
| **4** | 16.70 | 45.50 | 5.45 | 17562.20 | **29** | 16.88 | 35.70 | 9.90 | 24362.10 |
| **5** | 16.60 | 45.11 | 5.50 | 15462.01 | **30** | 16.50 | 42.68 | 9.88 | 20154.25 |
| **6** | 16.80 | 46.50 | 5.50 | 16121.10 | **31** | 17.56 | 41.70 | 10.02 | 25343.26 |
| **7** | 17.50 | 48.23 | 6.15 | 17562.12 | **32** | 16.80 | 37.63 | 10.37 | 26451.26 |
| **8** | 15.60 | 32.00 | 5.90 | 13141.10 | **33** | 18.62 | 47.05 | 10.42 | 30215.22 |
| **9** | 19.88 | 85.25 | 8.20 | 32157.15 | **34** | 16.90 | 46.28 | 10.50 | 24162.36 |
| **10** | 14.63 | 34.02 | 8.21 | 27563.22 | **35** | 18.52 | 48.50 | 10.98 | 29456.15 |
| **11** | 16.85 | 40.23 | 8.50 | 26751.26 | **36** | 17.56 | 56.36 | 11.12 | 49254.26 |
| **12** | 14.30 | 33.90 | 14.00 | 36451.25 | **37** | 18.45 | 76.36 | 13.70 | 56852.00 |
| **13** | 16.85 | 48.50 | 20.00 | 47132.25 | **38** | 20.46 | 88.63 | 14.32 | 95641.26 |
| **14** | 17.56 | 48.27 | 18.00 | 44132.25 | **39** | 19.70 | 75.25 | 15.60 | 89652.10 |
| **15** | 18.44 | 52.66 | 19.00 | 49056.12 | **40** | 17.89 | 65.25 | 15.90 | 74154.26 |
| **16** | 16.30 | 53.40 | 20.00 | 23522.10 | **41** | 18.52 | 114.12 | 16.00 | 45123.20 |
| **17** | 17.42 | 54.62 | 22.00 | 26432.12 | **42** | 18.99 | 121.01 | 16.13 | 54210.30 |
| **18** | 17.00 | 58.63 | 22.00 | 60152.25 | **43** | 18.75 | 111.01 | 16.92 | 66754.20 |
| **19** | 18.96 | 58.68 | 22.00 | 56421.36 | **44** | 19.56 | 115.24 | 17.00 | 86754.10 |
| **20** | 19.56 | 98.26 | 23.00 | 86542.22 | **45** | 20.52 | 116.23 | 20.00 | 110432.10 |
| **21** | 20.86 | 100.01 | 24.00 | 105120.20 | **46** | 19.86 | 117.52 | 22.24 | 103454.26 |
| **22** | 19.90 | 122.10 | 25.00 | 126245.12 | **47** | 22.16 | 118.10 | 22.00 | 96451.20 |
| **23** | 20.00 | 110.21 | 26.00 | 130264.25 | **48** | 20.55 | 120.10 | 23.00 | 88566.26 |
| **24** | 22.15 | 115.24 | 25.00 | 156421.20 | **49** | 20.18 | 122.25 | 22.21 | 87152.10 |
| **25** | 21.00 | 119.21 | 25.00 | 150456.20 | **50** | 21.23 | 121.10 | 26.00 | 133211.02 |

**Table 6.8. Relationship of fecundity with total length (TL), body weight (BW) and gonad weight (GW) of *C. reba***

| Parameters | Logarithmic transformation | Intercept 'a' | Slope 'b' | Correlation co-efficient 'r' | Regression co-efficient '$r^2$' |
|---|---|---|---|---|---|
| F vs. TL | ln (F) = 5.892 ln (TL) – 6.354 | - 6.354 | 5.892 | 0.871** | 0.7617 |
| F vs. BW | ln (F) = 1.492 ln (BW) + 4.495 | 4.495 | 1.492 | 0.872** | 0.7604 |
| F vs. GW | ln (F) = 1.316 ln (GW) + 7.282 | 7.282 | 1.316 | 0.897** | 0.8043 |

**P < 0.01, ns = not significant.

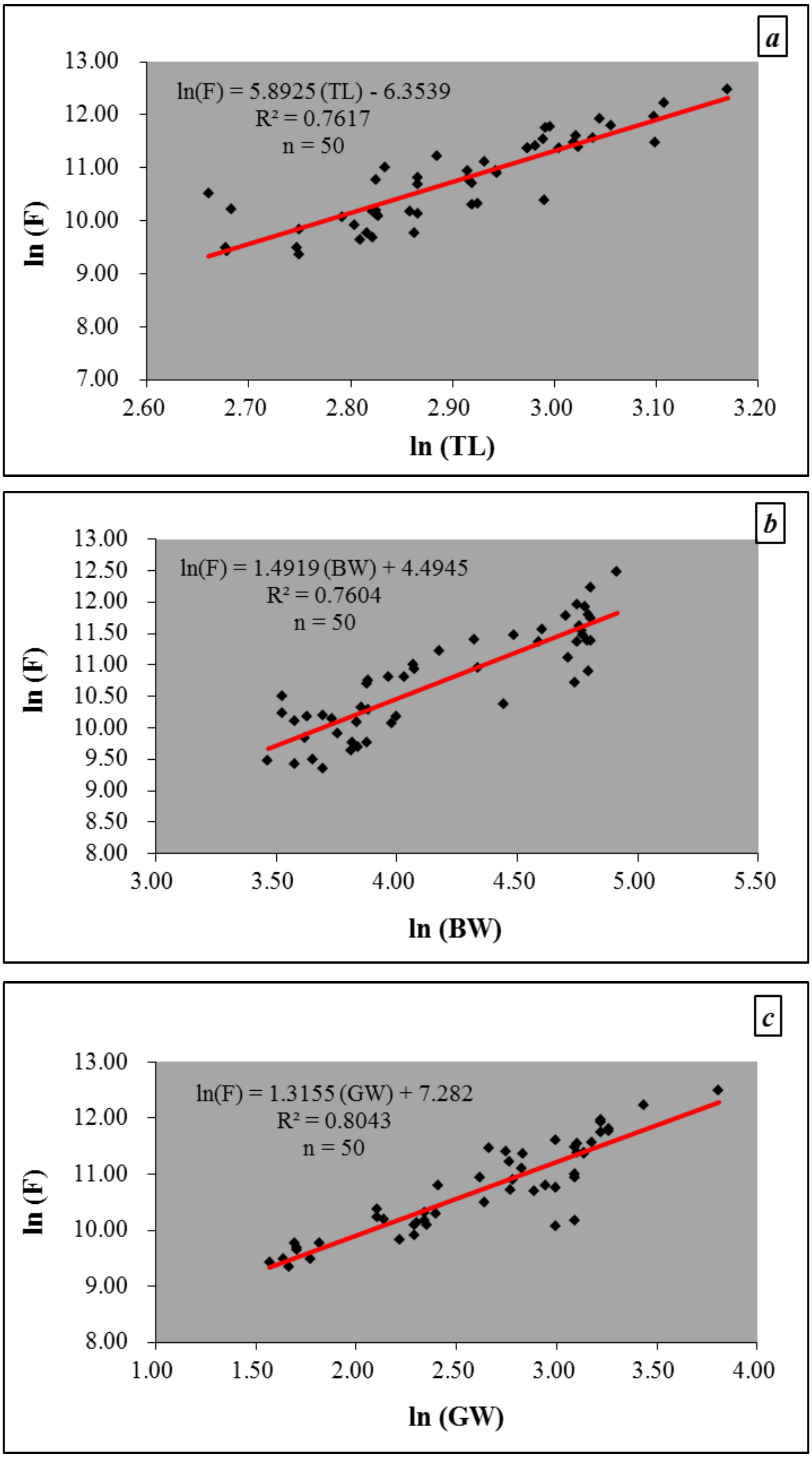



**Figure 6.6. Relationship of fecundity of *C. reba* with total length *(a),* body weight (b) and gonad weight (c).**

## 6.4 Discussion

### 6.4.1 Sex ratio

Sex ratio indicates the proportion of male and female in the population and is expected to be 1:1 in nature. Any deviation from this ratio may indicate the dominance of one sex over the other. This is happens because of differential behaviour of sexes, environmental conditions, fishing, etc. (Bal and Rao, 1984). During the study period, the male dominated in the months of January to April and September to December. But the female were dominated during the month of May to August, which were actually the breeding and spawning period. The sex ratio was also tending to increases from May to August. Monthly fluctuation in sex ratio of *C. reba* was also reported by Akhter and Akhter, (2011) in their study on reproductive biology and sex ratio of *C. reba*. They also reported an increase in sex ratio during the breeding season (April to October). However, overall sex ratio of *C. reba* for 600 specimens was 1:0.89 (317 male and 283 female). Here the Chi-square test did not show any significant difference between the sex ratio indicating equal distribution of both sexes. Similar observation was also made by Hossain et al. (2013), who recorded a sex ratio of 1:0.79 and did not reported any significant differences in Chi-square test in their study on life history traits of *C. reba* of Padma river.

### 6.4.2 GSI and GLI of *C. reba*

Gonado Somatic Index is a well-known relationship and frequently used to determine the reproductive periodicity of fishes (Doha, 1974). The theme of this method is that the weight of the gonad particularly the ovary varies greatly due to presence or absence of ripe gametes. The month wise variation is helpful to estimate the reproductive periodicity. Variation in monthly GSI value was found during the present study period. The highest values of GSI of male and female *C. reba* was found in the month of August (55.36 and 20.48) and lowest value was in October (0.20). The mature males and females bear mature and ripe ovaries which increase the value of GSI during this study, which was similar to the findings of Akhter and Akhter (2011), who also reported highest GSI during breeding season. The highest GSI value in August during the present study indicates that peak breeding period of *C. reba* was during this months. Highest percentage (70. 00%) of gravid female was also recorded during this month. Although, the peak breeding month of *C. reba* during the present study was in August, the breeding and spawning extended from the month of June to September. This may be due to the presence of higher level of flowing flood water in the river during these months. Similar results was also reported by Akhteruzzaman *et al.* (1998); Hussain and Mazid, (2001), who stated that the spawning season of reba carp stars in April and ends in August with peak spawning occurring during the rainy months in flowing flood waters. Although several scientist (Rao *et al.,* 1972; Gupta, 1975; Qazi, 2001; Lashari *et al.,* 2007; Akhter and Akhter, 2011) reported the peak breeding season of *C. reba* was in the month of July, the breeding season recorded in the present study was within their recommended range of breeding season (June to August). The GLI of male and female of *C. reba* during the study period fluctuated among the months, while the highest mean GLI was in September (34.63 ± 3.72) for male and in August (37.94 ± 8.01) for female.

### 6.4.3 Fecundity

During the study period, the total number of mature eggs varied from 11542.10 to 265042.23 with mean value 11542.10 ± 53602.28, which was within the range reported by Lashari *et al.,* (2007), who reported a fecundity of 20,722 to 211,200 eggs in his study on the Gonadosomatic Index and Fecundity of *C. reba* from Fishponds of District Jacobabad, Sindh, Pakistan. Although higher fecundity of C. reba have been reported by Khan (1986) as 22,356 to 437,400 eggs from Baigul reservoir (U.P) India. The causes of lower fecundity during the present study might be due to conditions of female and several environmental factors that can affect fecundity of fishes (Simpson, 1951).

During the present investigation, the regression analysis revealed that fecundity increased with the increase in total length, body weight and gonad weight in *C. reba.* Similar observations have been reported by various workers in different fish species like Siddiqui *et al.* (1976) in *Labeo bata,* Narejo *et al.* (2006) in Mastacembelus armatus and Lashari *et al.* (2007) in *C. reba*.

## 6.5 Conclusion

The study will provide an important baseline study on reproductive biology of the *C. reba* in the Padma river, north western Bangladesh with respect to sex ratio, spawning and peak spawning season, gonadosomatic index (GSI) and fecundity indices. The result of the study would be an effective tool for fishery biologists, managers and conservationists to initiate early management strategies and regulation for. The sustainable conservation of the remaining stocks of this species in the Padma river ecosystem. Moreover information on over all biology indices clearly lacking from literature and data bases including fish base. Therefore, the data of the study will provide invaluable information for the online fish base database, as well as providing an important baseline for future studies with in the Padma river and surrounding ecosystem.

# Chapter Seven

## Fishery of *Cirrhinus reba* in Padma river, North-western Bangladesh

### 7.1 Introduction

Fishing and fisheries contribute more than any other animal production activity to protein intake in most of the developing regions of the world. In the agro-based economy of Bangladesh, fisheries and aquaculture are important as source to supplement animal protein, employment generation and earning foreign exchange. Fisheries sector is contributing 2.01% to the total export earning, 3.69% to GDP (FRSS, 2016). Approximately 14 million people are directly or indirectly involved in the fisheries sector for their livelihood (Khan, 2011). The pride of Bangladesh is its rivers with one of the largest network in the world with a total number of about 800 rivers which have a total length of about 24,140 km (Wazed, 1991).

The Padma is a major trans-boundary river in Bangladesh. It is the main distributaries of the Ganges, which originates in the Himalaya. It is high in biodiversity. There are over 140 fish species, the richest freshwater fish fauna in Bangladesh (Jones *et al.,* 2003). Fishing in Padma river is an ancient practice. Different types of fishing gears and crafts have been used for fishing in Padma river from time to time. Fishing gear is any form of equipment, implement, tool or mechanical device used to catch, collect or harvest fish (Banglapedia, 2006). The principal categories of fishing gears that are traditionally used in Bangladesh can be enumerated as the following: fishing nets, fishing traps, hooks and lines, wounding gears and fish aggregation device (Chakraborty *et al.*, 1995).

Besides fishing gears and crafts, the successful fishery development of Bangladesh depends upon adequate consideration of biological, technical and economic information along with socio economic and cultural information for making an overall decision. Making fish available to consumers at reasonable prices at right time and place in fresh condition requires an effective marketing system. According to Olukosi *et al.* (2007), marketing channel is the path of a commodity from its raw to finished form. Marketing is of high importance to fisheries and marketing of fish makes significant contributions to economic growth through generating employment, providing livelihood support and poverty alleviation. Fisheries development depends on improved production and processing technology and also on effective marketing system. In Bangladesh about 97 percent of the fish production is marketed internally for domestic consumption, while the remaining part is exported (Rahman, 1997). Fish marketing in Bangladesh is almost exclusively maintained by the private sector. Four distinct tires viz. primary, secondary, higher secondary and consumer market of marketing systems are observed in the process of distribution of fishes in Bangladesh (Ahmed, 1983). As fish is highly perishable with unpredictable supply, analysis of fish marketing system is essential considering the fact that fish is the main protein source in the diet of Bangladeshi people, which supplements 60% of total animal protein (DoF, 2012).

The Reba carp *C. reba* is a freshwater fish of the family Cyprinidae. It is an important fish species in the overall catch of Padma River. The flesh of this fish is oily and tasty and preferred by the consumers (Rahman, 1989). Now this species is considered as nearly threatened by IUCN Bangladesh (2015). Recently there are no any information on fishing method and marketing system of this important fish species of Padma River in Bangladesh. In the view of its importance in the fishery and absence of any published information on the fishery of this species from this area, the present study was undertaken to study the fishing method and marketing system of *C. reba* in selected landing centers around Padma river.

**The present investigation is aimed on the following objectives**

- To know the fishing gears and crafts used for capture of *C. reba* in Padma river
- To determine the landing and pricing strategy of *C. reba* in Padma river
- To evaluate the marketing channel of *C. reba* in Padma river
- To determine the culture possibilities of *C. reba* in Padma river.

## 7.2 Materials and methods

### 7.2.1 Study site and duration

The present study was conducted along the Padma river from Godgari to Charghat Rajshahi. Five distinct landing centers namely Godagari, Bulanpur, Shaheb Bazer, Katakhali fish market and Charghat were selected for collection of fishery information during one year from January 2016 to December 2016.

### 7.2.2 Data collection

Information on fishery of *C. reba* has been collected by visiting the landing center of the studied locations. Three visits were made in each month and necessary data were recorded according to necessity. The information on marketing system of *C. reba* was collected from the selected landing center on the basis of interview taken from the fish traders engaged with the business of the studied species.

### 7.2.3 Data processing and analysis

The collected data were coded, summarized and processed for analysis. These data were verified to eliminate all possible errors and inconsistence. Any kinds of inconsistence in the data were searched and avoided out from the relevant data. Data entry was made in computers and analysis was done using the concerned software MS Excel. Finally, tabulated data were analyzed and condensed by using averages, percentages etc. to obtain the results.

## 7.3 Results

### 7.3.1 Fishing methods

The fishes of tropical and subtropical rivers are particularly diverse, most of which differ to some degree in their selection of habitat, diet and migration pattern. Many fisheries exploit all species that are catchable and so a great number of fishing methods have evolved. The term fishing means to capture of fish by any process. Capture of fish from a certain water body largely depends on the availability and performance of fishing gears and crafts. The fishing gears and crafts used for harvesting of *C. reba* in Padma river are mentioned below.

### 7.3.2 Fishing gears

During the period of study, several types of fishing gear were found to operate in the study area. During the study period, 4 types of nets and 1 type of traps were recorded that were used for harvesting of *C. reba*.

**7.3.2.1 Cast net (Jhaki jal):** Jhaki jal is made up of made of nylon or cotton twine. It is a conical shaped circular net. A long string about 5-7 m is attached to the apex of the cone. Iron weight in cylindrical form is attached at a regular interval around the peripheral end with the help of strong string. The string with weight is attached to some upper meshes directly about 10-20 cm above the bottom forming pocket all along the circular end inside the net. It is locally known as "Jhaki jal". It needs single fisherman for operation. When the net is casted it spreads out over the water surface circularly and when lifted it comes out in conical form.

**7.3.2.2 Gill net (Current jal):** It is rectangular in shape and made up of synthetic or cotton twine (Plate 7.1). The head line has a series of floats at regular interval while the lower portion has a series of sinker at regular interval. Light wood or sponge or plastic bottle are used as float and substances made by metal or burned soil used as sinker. Its mesh size varies with size and types of target fish and season. It has fixed multifilament.

**Plate 7.1: Gill net (current jal)**

**7.3.2.3 Square lift net (Tar jal):** The shape of this net is square and it is fitted with two bamboo strips arranged in cross-bars and connected at the four corners of the net. The arranged crossbars with the net are then attached with another lever for lifting the net from out of the water. This can be operated by one or two men at a time.

**7.3.2.4 Seine net (Ber jal):** This net was very long with wings and a towing rope. The shape of the net is rectangular. The length ranged from 70-150 m and depth from 5-8.5 m. The head rope contents floats and bottom rope contains sinkers. The mesh size of the net is 0.7-1.7 cm. All type of fishes are caught by this net. The nets are of various lengths and come with or without bags for catching and are locally called Ber Jal.

**7.3.3 Traps**

Conical trap (Dughair): It is a tubular shaped basket like trap. The bamboo sticks are arranged in parallel one after another and them with cane materials to make the structure of this gear. There is a unidirectional valve at the mouth and single opening at the upper side. It is mainly operated in shallow running water and set against the water current. Fish once entered through the valve cannot escape. Trapped fish are gathered at the back side. After certain period of time fish are collected through the opening. Here requires single fishermen to operate.

### 7.3.4 Fishing crafts

Fishing crafts are specialized boats, ships or other vessels used for fishing. Two types of fishing crafts were recorded during the study period.

**7.3.4.1 Small motorized boat (Chandi nauka):** Chandi has a flat wooden bottom. Side wall is constructed by wood pieces or iron sheet. Stern or bow pointed. Bottom flat. Length, width and depth of this fishing crafts ranged between 5.31 m to 7.66 m, 1.40 m to 1.65 m and 0.45 m to 1 m. Constructed by valuable wood pieces (amm, jam, koroi, kathal, mehogoni etc.). Besides these iron sheet is also used. This boat is operated by 1-3 persons (Plate 7.2).

**Plate 7.2. Chandi Nauka**

**7.3.4.2 Donga:** It is made of tin and wood. Some pieces of bamboo are also used. It is rectangular in shape one end is tapered and another end is slightly wide. The bottom of the donga is slightly rounded. Stern or bow blunt. Length, width and depth of donga is 3.42 m, 0.64 m and 0.4 m. Only one man is needed to operate this craft (Plate 7.3).

**Plate 7.3. Donga**

### 7.3.5 Fish landing and price analysis

The landing indicates unloaded fishes by commercial fishermen either in number on in poundage of fish. The survey on the studied year (January 2016 to December 2016) indicates that the total landing of *C. reba* at five fish landing center was Total 3618 kg. The highest landing of the fish was in the month of November (Godagari 95 kg, Bulanpur 93 kg, Shaheb Bazer 115 kg, Katakhali fish market 96 kg and Chargat 86 kg) and the lowest landing was in the month of July (Godagari 32 kg, Bulanpur 30 kg, Shaheb Bazer 40 kg, Katakhali fish market 20 kg and Charghat 23 kg) (Table 7.1). The percentage of total landings at different landing centers is shown in Figure 7.1.

The highest landing was found at Padma garden landing center (23.24 %) and the lowest at Charghat landing center (16.94 %).

The price level reached its high in the month of July and August at Shaheb Bazer landing center (270.00 BDT/kg). Monthly average price (BDT/kg) of *Cirrhina reba* at studied landing centers is shown in (Table 7.2). Lowest price of the fish was observed in the month of November at Charghat landing center (150 BDT/kg). The mean price of *C. reba* at different landing centers are shown in Figure 7.2.

**Table 7.1. Monthly average landing (kg) of *Cirrhina reba* at studied landing centers**

| Month | Landing (kg) | | | | |
|---|---|---|---|---|---|
| | Godagari | Bulanpur | Shaheb Bazer | Katakhali fish market | Charghat |
| January | 65 | 68 | 78 | 66 | 53 |
| February | 56 | 53 | 56 | 50 | 43 |
| March | 64 | 60 | 86 | 74 | 65 |
| April | 59 | 53 | 67 | 36 | 36 |
| May | 62 | 65 | 43 | 43 | 32 |
| June | 35 | 43 | 33 | 23 | 21 |
| July | 32 | 30 | 40 | 20 | 23 |
| August | 36 | 31 | 45 | 26 | 44 |
| September | 85 | 88 | 92 | 59 | 65 |
| October | 97 | 92 | 118 | 76 | 75 |
| November | 95 | 93 | 115 | 96 | 86 |
| December | 86 | 75 | 68 | 72 | 70 |
| Total | 64.33 | 62.58 | 70.08 | 53.42 | 51.08 |
| Mean±SD | 64.33±22.80 | 62.58±21.87 | 70.08±28.55 | 53.42±24.31 | 51.08±21.19 |

**Table 7.2. Monthly average price (BDT/kg) of *Cirrhina reba* at studied landing centers**

| Month | Landing (BDT/kg) | | | | |
|---|---|---|---|---|---|
| | Godagari | Bulanpur | Shaheb Bazer | Katakhali fish market | Charghat |
| January | 230 | 230 | 240 | 205 | 200 |
| February | 236 | 230 | 246 | 210 | 210 |
| March | 240 | 235 | 250 | 215 | 200 |
| April | 245 | 245 | 250 | 210 | 210 |
| May | 250 | 250 | 260 | 220 | 220 |
| June | 250 | 250 | 260 | 220 | 235 |
| July | 250 | 250 | 270 | 235 | 230 |
| August | 250 | 250 | 270 | 240 | 230 |
| September | 235 | 235 | 260 | 230 | 200 |
| October | 200 | 215 | 235 | 200 | 180 |
| November | 175 | 165 | 186 | 174 | 150 |
| December | 210 | 210 | 220 | 200 | 200 |
| Mean±SD | 230.92±23.93 | 230.42±24.72 | 245.58±23.75 | 213.25±17.95 | 205.42±23.69 |

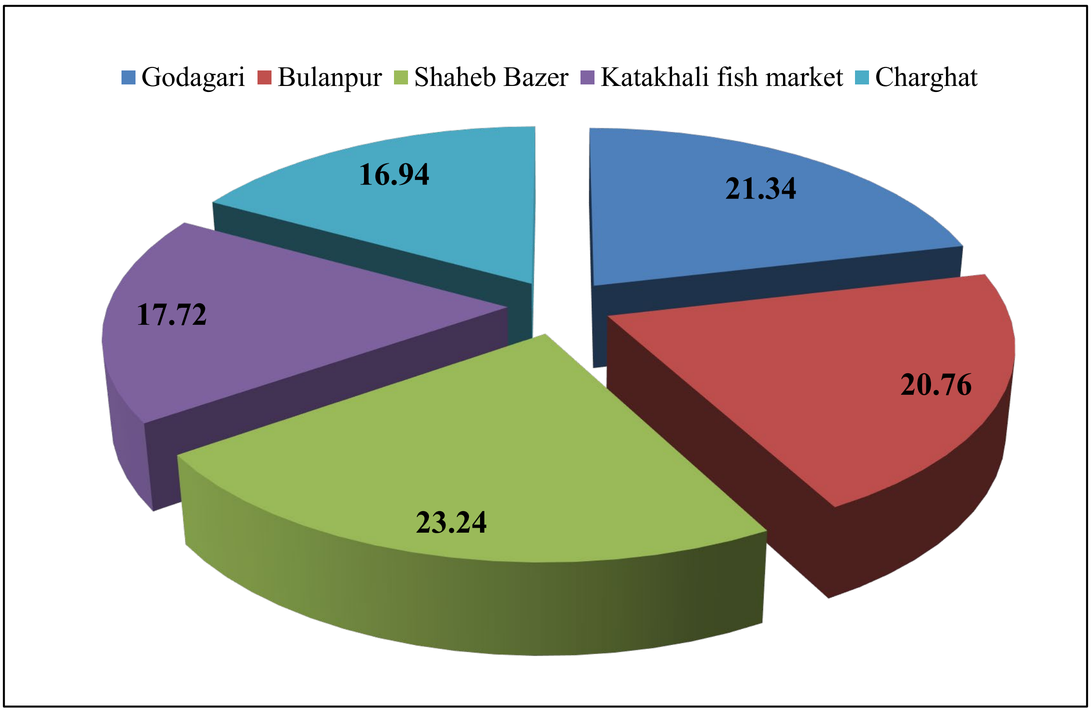



**Figure 7.1. The percentage of total landings of *C. reba* at different landing centers**

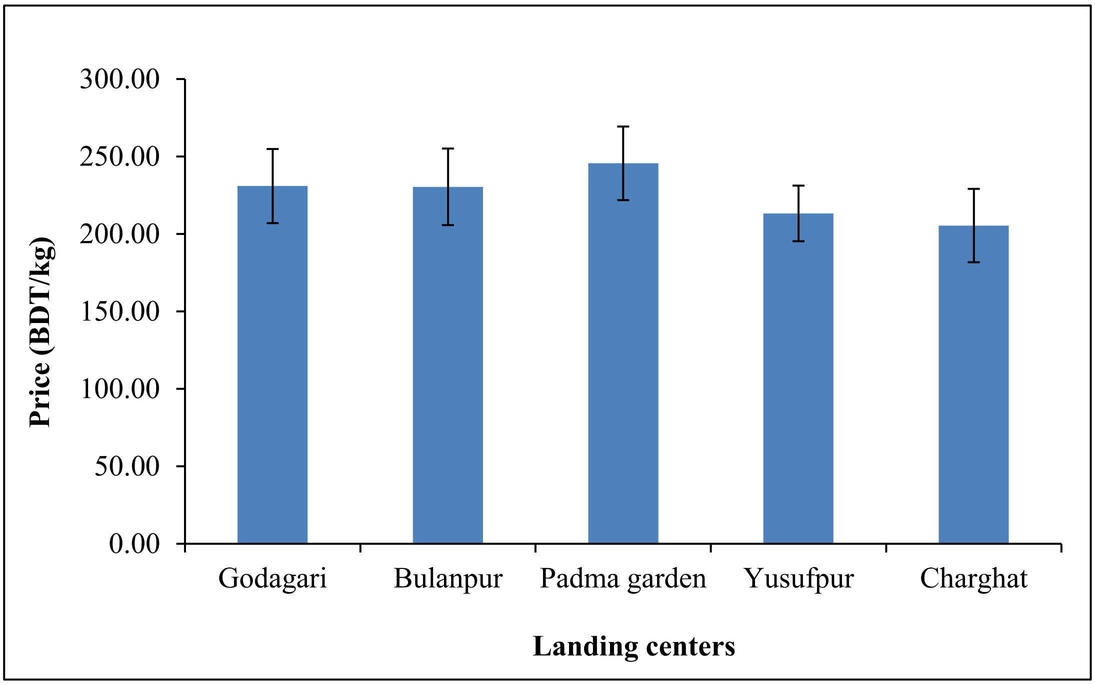



**Figure 7.2. The mean market price of *C. reba* at different landing centers**

### 7.3.6 Marketing Channel of *Cirrhina reba*

The marketing channel can be defined as the pathway taken the commodities as they flow from the point of production to the point of intermediate and final use of the consumer level. Each level contains a set of middlemen who perform the functions with the intention to bring the product closer to the point of consumption. Each channel system creates a different level of sales and costs. Once a distribution channel has been chosen, the firm usually must stick to it for a long term. The chosen channel strongly affects, and is affected by the other elements in the marketing mix.

Marketing channel found in the observed fish markets composed of fishermen or fish growers, several middleman and consumers (Figure 7.3). Following categories of personnel are engaged in the marketing channel of *C. reba* of the studied fish markets-

**Wholesalers and Beparies**

They usually assemble fish from different fishing grounds of Rajshahi and purchase straight way from the fisherman. Sometime they purchase the commodity from fishermen coming to the market from different areas or sometimes procure it from the local arat and then they sell it to the retailers either on cash or credit.

**Artdar/Commission agent**

They deal various kinds of fish of fresh origin which includes usually native and exotic major carps and other small indigenous fishes. Aratdars are the most influential having sufficient money. Usually this category performs their business on partnership basis.

**Aratdars-Cum-Wholesaler**

They combine in themselves in the functions and duties of both wholesaler and aratdars in the visited shahed bazar, Shalbagan and Horhgram (court) fish market.

**Brokers**

In the visited fish markets, the wholesalers and aratdars of the market perform this function. Few brokers are engaged in the marketing channel by following instructions of their principal closely and the aided in transactions of the seller and buyer.

**Retailer-cum-wholesalers**

They combine with the functions of the wholesalers and retailers. Their number is greater than the pure type of wholesalers.

**Retailers**

Retailers act on last link of marketing channel. They purchase fish mostly from aratdars on credit and sell this to the consumers on cash basis.

**Consumers**

Consumers are the last link of marketing channel and they are the general people found in every types of fish market where they used to buy fish for consumption. The consumers of fish markets found mostly in higher class and middle class.

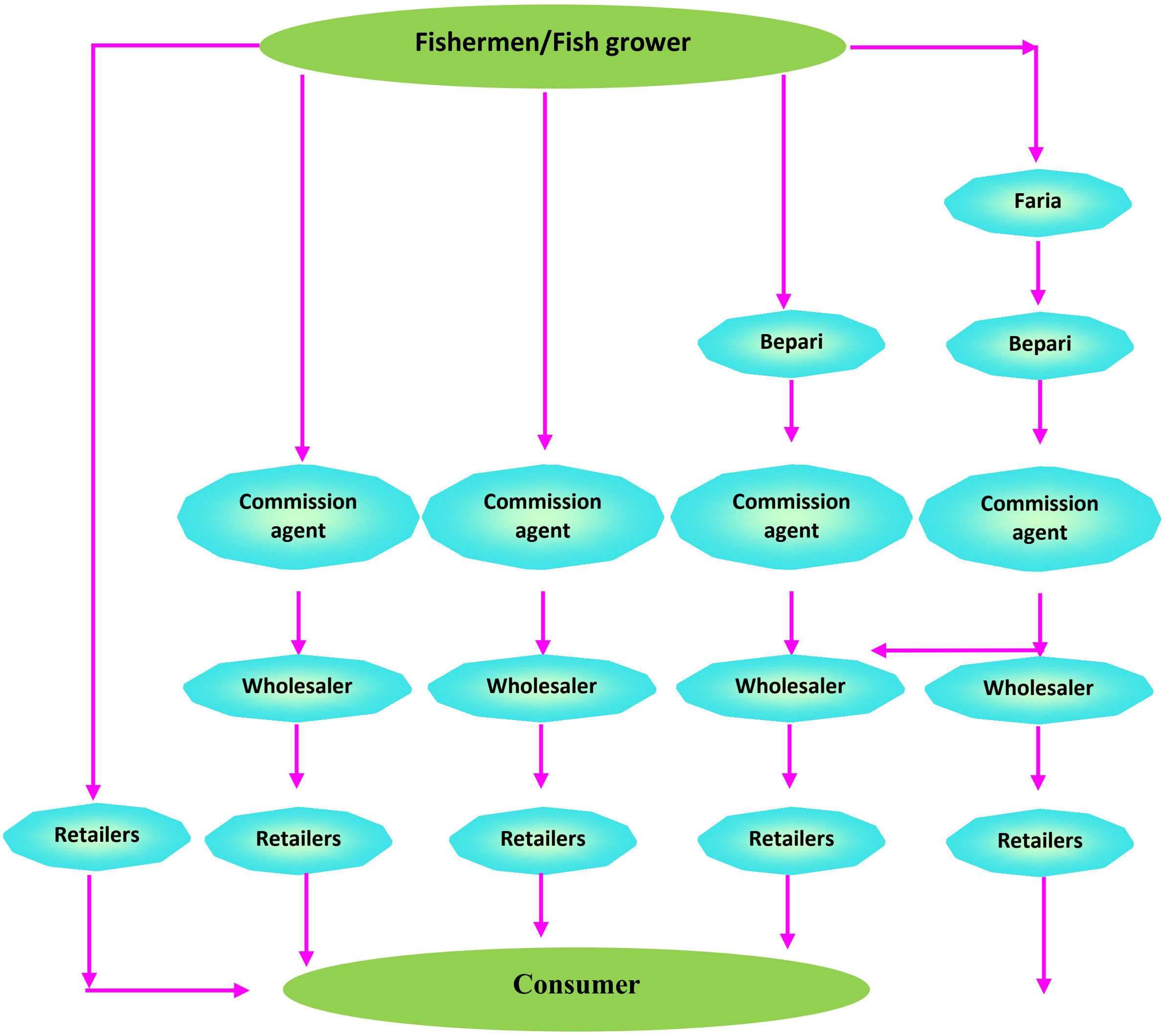



**Figure 7.3. The marketing channel of *Cirrhina reba* at different fish markets.**

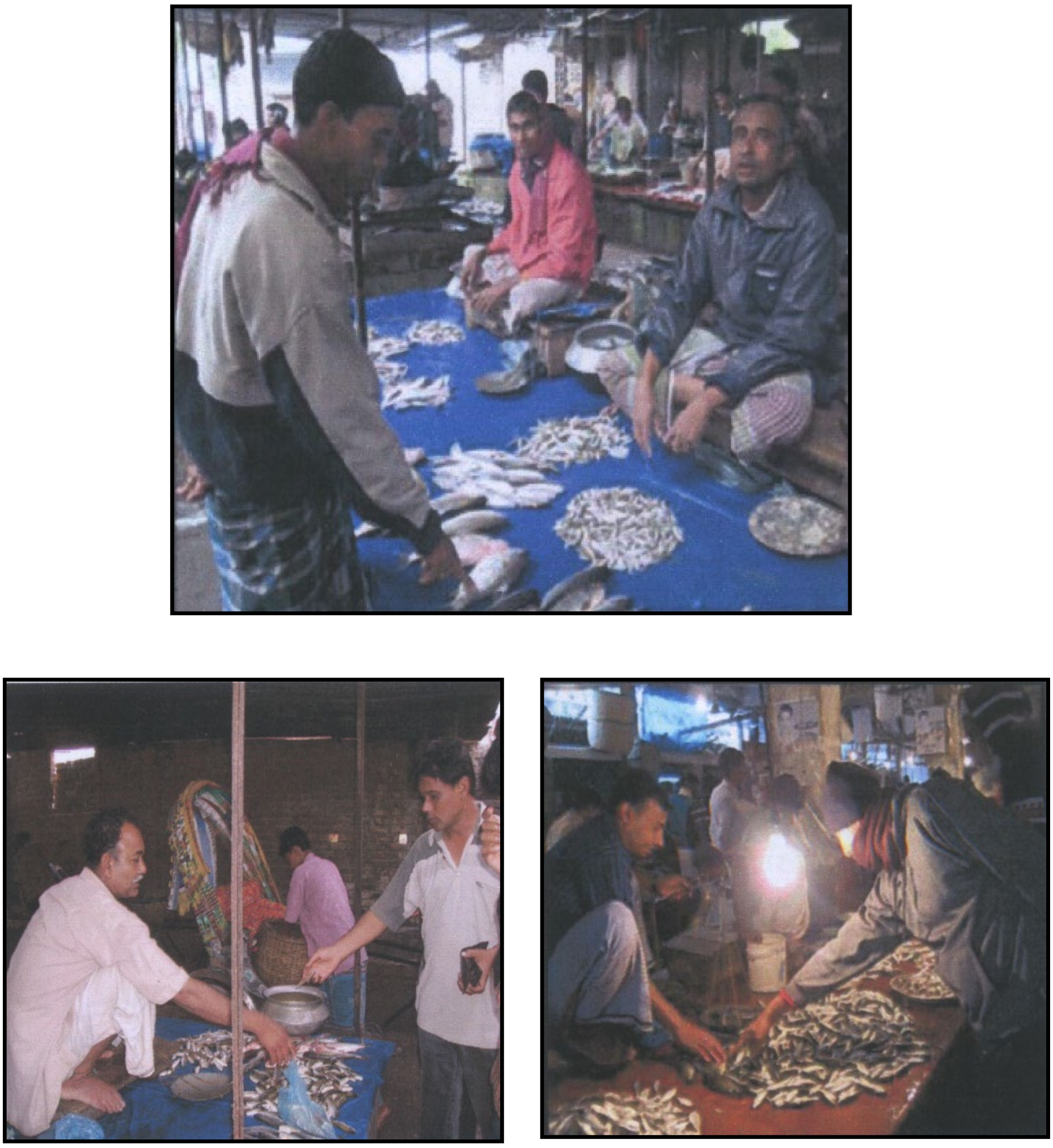


**Plate 7.4. Interaction between retailers and consumers**

## 7.4 Discussion

The fishery of Padma River is multispecies and multigears in nature. Different fishing methods are employed in different season for fishing. The fishing gears used for catching *C. reba* were Cast net (Jhaki jal), Gill net (Current jal), Square lift net (Tar jal), Seine net (Ber jal) and one trap (Conical trap) recorded during the study period. Hossain *et al.* (2013) also reported similar types of gears for catching of *C. reba* from Padma river. Two types of fishing craft, chandi nauka and donga that reported in this study were also early reported by CIDA (1993) in the North-East region of Bangladesh.

The landing of *C. reba* in different markets varied in different months of the year. From the survey, it is observed that the highest landing of fish in the month of November since the adult specimens are captured and sold in the market. Although adult fishes were also present in the monsoon months, the catch was low due to the high water level of river that decreases the catching capacity of fishing gears. After July, the quantity of landing gradually increased since the juveniles attained the adulthood and started gaining the maximum size and the water level of river gradually becomes low, which make the fishes available in fishing gears. Musa and Bhuiyan (2007) also reported the monthly fluctuation of landing of fish in Naogaon, Atrai and Abadpukur fish market respectively.

The price of *Cirrhina reba* also varied. Since the size of the fish the largest in July, the price per kg also the highest in this month. In November, since the landing of fishes was high and most of the fishes comprised mainly of the juveniles, the price was also the lowest in this month. The demand of this fish is high against its supply. Musa and Bhuiyan (2007) reported similar seasonality for the prices of fish in Naogaon, Atrae and Abadpukur fish market. Rahman (2003) also mentioned price variability with the season during summer and winter in Gazipur, Bangladesh.

Seven different marketing channels were identified during the study period. Five different marketing channels was identified Flowra *et al.* (2010) in the marketing system of dry fish in Rajshahi and Thakurgaon district of Bangladesh. Galib *et al.*

(2010) figured out three types of marketing channels in their study with small indigenous species of fishes in the Chalan Beel.

## 7.5 Conclusion

The findings of the present study revealed that price of *C. reba* did not varied with different landing centers. Fishing methods were also common in studied locations. Variation in total catch also varied from on to another landing center. Information gathered in the present study will plays important role in regulating proper management and conservation strategy of *C. reba* in Padma river.

# Chapter Eight

# Summary and Conclusion

*Cirrhinus reba* (Hamilton, 1822) is one of the popular food fishes in Bangladesh. Wild population of this species is now being declined due to heavily harvested from rivers. As a result, recently the fish is considered as one of the most nearly threatened species in Bangladesh (IUCN, 2015). To maintain this fish population as well as its conservation and rehabilitation, development of a suitable technology for breeding, and rearing of fry and fingerlings in nursery ponds is urgently needed. Since commercial aquaculture of this species are most possible (Dewan *et al.,* 1985), information regarding its ecology, population structure, food and feeding habits and biology are scanty. In view of its importance in the fishery and absence of any published information on its eco-biology and fisheries from Padma river, the present study was undertaken for a period of three years (January 2014 to December 2016).

Monthly variation of the major hydrographical parameters such as air temperature, water temperature, water transparency, rainfall, pH, dissolved oxygen, electrical conductivity, total dissolved solids, total hardness, total alkalinity, nitrate-nitrogen and phosphate-phosphorus were recorded during the study period. The study revealed that monsoon rain and land drainage seems to play an important role in changing the physico-chemical parameters of the Padma river. The temperature values were low during winter and higher in summer months. During monsoon seasons the transparency of the water was low due to heavy silt particles than other months of the year. Rainfall has a direct effect on the temperature and transparency. Dissolved oxygen values increased during winter months and shows fluctuation during the other months of the year. Higher values of pH were recorded in January and lowest in May. EC also shows fluctuation during the years and highest value was found in the month of December and lowest in the month of June. In case of TDS higher value was found in the month of July and lowest in the month of February. Highest alkalinity was found in May and lowest in January. Total alkalinity was highest in the month of January and lowest in the month of October. Values of $NO_3$-N and $PO_4$-P were highest in April and lowest in July.

A total of 130 species under 4 classes, 59 genera which belongs to Chlorophyceae (51 species), Bacillariophyceae (39 species), Cyanophyceae (26 species) and Euglenophyceae (14 species) were recorded during two years (January 2014 to December 2015) of study period from Padma river. The percent composition based on species number was Chlorophyceae 39.77%, Bacillariophyceae 42.42%, Cyanophyceae 13.72% and Euglenophyceae 4.09% respectively. The highest abundance (with an average of $31.00\times10^3$ units/l) was found in the month of November 2014 and lowest (with an average of $0.29\times10^3$ units/l) in August 2014. The average phytoplankton abundance recorded during the study period was $18.90\times10^3$ units/l.

A total of 40 species of zooplankton under 4 groups, 26 genera and belonging to the group Rotifera (20 species), Cladocera (9 species), Copepoda (9 species) and Ostracoda (2 species) were recorded during the study period from January 2014 to December 2015). Percent composition of zooplankton followed the order of Rotifera > Copepoda > Cladocera > Ostracoda with the composition of 50.26 %, 29.21 %, 20.02 % and 0.50 % respectively. The average zooplankton abundance recorded was $0.32\times10^3$ units/l with a range of $0.01\times10^3$ units/l to $0.55\times10^3$ units/l. The highest ($0.55\times10^3$ units/l) zooplankton abundance was recorded in the month of February 2015 and lowest ($0.01\times10^3$ units/l) in September 2014. The findings of the present study indicate that the ecology of Padma river are still in good condition for *C. reba*, but it is in risk of deterioration in future.

Length-weight frequency distribution of *C. reba* ranges between 6.60 to 23.80 cm in total length and 2.63 to 136.00 g in total body weight during the sampling period. The month-wise LWR study in the present study depicted that different growth types were observed in different months. The calculated values of ‘b’ for length and weight were lower than 3 in the month of January to April and October to December. In these months the growth type was negative allometric. While positive allometric growth was observed in the months of June to September. However, in the month of May the growth type was isometric, where the ‘b’ value was 3.008. The ‘b’ value for male, female and combined sex was 3.020, 3.215 and 3.116 respectively, that indicates isometric growth type in male and positive allometric growth type in female and combined sexes. The LWR of relationship of C. reba produced the following equation for male, female and combined sex.

ln (BW) = 3.020 ln (TL) - 4.728 (Male)
ln (BW) = 3.215 ln (TL) - 5.206 (Female)
ln (BW) = 3.116 ln (TL) - 4.958 (Combined sex)

The minimum and maximum value of $K_F$ during the study period was 0.39 and 1.65 for male and 0.48 and 1.83 in females with mean value 0.94 ± 0.14 and 0.97 ± 0.17. Seasonal differences in $K_F$ were also observed during the study period with lowest (0.80) values were observed during the month of January and highest (1.06) value during the month of March. The unpaired *t-test* showed significant difference in $K_F$ between males and females (P = 0.033) during the present study. $K_R$ varied from 0.42 to 1.76 (mean ± SD: 1.01 ± 0.15 and 95% confidence level: 1.00 - 1.03) for males and 0.56 to 1.32 (0.83±0.17) for females. The unpaired *t-test* showed no significant difference in $K_R$ between males and females (P = 0.994) during the study. The $W_R$ was highest (101.75) in the month of January and lowest (100.14) in August. Spearman rank correlation showed that $K_F$ was significantly correlated with both TL (p = 0.125) and BW (p = 0.324. While $K_R$ and $W_R$ are both significantly correlated with BW (p = 0.142 and 0.143). The present study will be an effective tool for fishery biologists, managers and conservationists towards providing management strategies of this species in aquaculture system and for initiate better regulation option for the sustainable conservation of the remaining stocks of this species in the Padma River ecosystem.

Based on the finding of the study, *C. reba* is considered to have herbivorous feeding habits. The major food items of analyzed gut content of *C. reba* was detritus and other plant materials. Small fishes are exclusively zooplankton feeders subsisting mainly on small rotifer, Cladocera, Copepoda and crustacean, whereas the adult ones are plankton and detritus feeder and the major food items are the phytoplanktonic groups Chlorophyceae, Bacillariophyceae, Cyanophyceae and a little amount of Euglenophyceae. Higher plants also constitute major portion of gut content of *C. reab* during the study period. The feeding activity of this fish species fluctuated between seasons and length groups. The conducting the relationship between total length and alimentary canal of this species an equation of ACL = - 0.923+1.8023(TL) was found and the ratio obtained was 1:3.07, which indicates herbivorous nature of *C. reba*.

During the study period, reproductive activity of *C. reba* was analyzed in terms of sex ratio, spawning season and fecundity. From the 600 species collected during the study period 317 was male and 283 was female, with a sex ratio of 1:0.89. There were differences in the monthly male, female number and sex ratio. Which indicates unequal distribution of male and female fishes with number of female fishes increases during spawning season. However, the overall sex ratio was also did not differ significantly from the expected value of 1:1 (df = 1, $\chi 2$ = 3.84, p<0.05). Values of GSI and GLI also fluctuated with months and number of gravid females was highest (70 %) in the month of August, which indicates peak breeding season of this fish species. The total number of mature eggs varied from 11542.10 to 265042.23 with mean value 11542.10 ± 53602.28. Linear relationship of fecundity with total length, total weight and ovary weight of fishes were formed with the equations of-

$$\ln (F) = 5.892 \ln (TL) - 6.354$$

$$\ln (F) = 1.492 \ln (BW) + 4.495$$

$$\ln (F) = 1.316 \ln (GW) + 7.282$$

The results of the linear relationship depicted that fecundity increased at the rate of 5.892, 1.492 and 1.316 times of the total length, weight of fish and weight of ovary, respectively. Increase in fecundity with increase in total length, total weight and ovary weight was also revealed by the positive correlation between fecundity and total length, weight of fish and weight of ovary. The Pearson correlation coefficient values obtained were r = 0.871, (P < 0.01); r = 0.872, (P < 0.01); r = 0.897, (P < 0.01), respectively.

Although the fishery of *C. reba* constitute a minor portion of Padma river's total catch, it forms a economically important role in fishery status of Padma river. The major fishing gears operated for capturing of *C. reba* were Cast net (Jhaki Jal), Gill net (Current jal), Square lift net (Tar jal), Seine net (Ber jal) and one types of trap namely Conical trap (Dughair). The major crafts operated were small motorized and non-motorized boats and Donga. The average yearly landings of *C. reba* was 3618 kg, which was low but contributes significantly in fishery of Padma river. The highest landing of fish in the month of November. During monsoon months, the catch was low due to the high water level of river that decreases the catching capacity of fishing gears. But after July, the quantity of landing gradually increased since the juveniles attained the adulthood and started gaining the maximum size and the water level of river gradually becomes low, which make the fishes available in fishing gears.

Study of different aspects of the ecology, biology and fishery of *C. reba* indicates the suitability of this species for culture in both the ponds and other aquaculture systems.

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