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Eco-Biology and Biochemical Composition of Lates Calcarifer (Bloch, 1790) In Coastal Water of Bangladesh

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ECO-BIOLOGY AND BIOCHEMICAL COMPOSITION OF *LATES CALCARIFER* (BLOCH, 1790) IN COASTAL WATER OF BANGLADESH

Ph.D. Thesis

A Thesis submitted for the degree of Doctor of Philosophy at the Department of Fisheries in the Faculty of Agriculture of the University of Rajshahi, Bangladesh

By

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I OWE TO ALL MY TEACHERS WHO CONTRIBUTED A LOT TO MY ACHIEVEMENT

DEDICATION

DECLARATION

I hereby declare that the entire work entitled

"ECO-BIOLOGY AND BIOCHEMICAL COMPOSITION OF *LATES CALCARIFER* (BLOCH, 1790) IN COASTAL WATER OF BANGLADESH"

submitted as a thesis towards by me of the requirements for the degree of **Doctor of Philosophy** in the Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Bangladesh is the record of work carried out by me during the period from July 2013 to June 2016 under the guidance of Dr. Md. Delwer Hossain, Professor, Department of Fisheries, University of Rajshahi, Rajshahi-6205, Bangladesh that this has not the thesis contains no material which has been accepted for the award of any other degree or diploma elsewhere, and to the best of my knowledge, the thesis contains no material previously written or published for the award of any degree for this University or any other University or any other similar institution of higher learning or prize.

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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 AND BIOCHEMICAL COMPOSITION OF *LATES CALCARIFER* (BLOCH, 1790) IN COASTAL WATER OF BANGLADESH”** under my supervision. He 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 present study was conducted for a period of two years from July 2013 to June 2015 to assess the ecology, food and feeding habits, body composition and fishery of *Lates calcarifer* in Khulna district of Bangladesh. Among the water quality and hydrological parameters, air and water temperature, water transparency, salinity, rainfall, pH, dissolved oxygen and free carbon dioxide were recorded on monthly basis in different types of habitats including coastal rivers and ghers (polder area). For the analysis of food and feeding habits of the studied fish, a total of 300 specimens including 180 adults and 120 juvenile were dissected and studied under the microscope. Monthly variation in the degree of feeding was also studied. In case of juvenile *L. calcarifer* maximum 26.67% stomachs were found as ½ full followed by full (25%), ¾ full (17.50%), 1/3 full (15%), ¼ full (8.33%), empty (4.17%) and 1/8 full (3.33%) stomachs. Whereas for adults, maximum 28.89% stomachs were found as full followed by ¾ full (22.78%), ½ full (20%), empty (11.67%), 1/3 full (9.44%), ¼ full (5%) and 1/8 full (2.22%) stomachs. Following categories of food items were recorded from gut analysis of both juvenile and adult specimens: algae or phytoplankton, zooplankton (protozoans and small crustaceans), large crustaceans, insects, teleosts and unidentified food materials. For the analysis of body composition moisture, protein, fat, ash and minerals (phosphorus, iron, calcium and magnesium) were measured in both male and female at different phases, *i.e.* juvenile, adult and spent. In male, the highest moisture was found in spent (71.230±0.843%) and the lowest amount was found in adult fish (69.633±0.464%). In female the highest moisture was recorded in spent (72.453±0.552%) and the lowest moisture was found (70.190±0.877%) in adults. For protein, the highest amount was found in male adult (22.940±0.255%) and the lowest amount was found in female spent fish (16.207±0.342%). In case of fat, the highest amount of fat was found in adult male (6.017±0.235%) whereas, the lowest amount was found in female spent fish (3.117±0.440%). This study revealed the variation in body composition that helps stakeholders to manage the species appropriately. Information regarding the fishery of *L. calcarifer* has been collected by visiting various fishing and landing centres of southern region of Bangladesh. Three visits were made in each month and necessary data were recorded. A range of fishing gears and methods including nets (veshal jal, khepla jal, ber jal and punti jal) and katha fishing were recorded. Restriction should be made against the use of harmful fishing gears and methods used in capturing studied species. Status of fish landing, marketing channel, profit analysis were also studied in this study. The present study showed the ecology, food and feeding habits, biochemical compositions and fishery of *L. calcarifer*, these findings would be helpful for the future researchers who will conduct further research on this fish species.

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Chapter One

General Introduction

GENERAL INTRODUCTION

1.1 Development Potentials and Challenges

Bangladesh has a land area of 147,570 km^2 and a population of about 160 million, making it the most densely populated country in the world (i.e. other than city state such as Singapore). The Bangladesh coastline extends 710 km along the northern edge of the Bay of Bengal, from the mouth of the Naaf river in the Southeast, to the mouth of the Raimongal river in the Southeast. At the same time, the country is located in one of the world's major river delta systems, with the rivers meeting the Bay of Bengal in the South of the Country. A wide range of salinity levels are encountered in the rivers up to a considerable distance upstream from the shoreline of the Bay of Bengal (Habib, 1999). Bangladesh has achieved remarkable progress in the fisheries sector since its independence in 1971. Fisheries have been playing a very significant role and deserve potential for future development in the agrarian economy of Bangladesh. This sector contributes 3.69% to the national GDP and almost one-fourth (22.60%) to the agricultural GDP (DoF, 2015). In recent years, this sector performs the highest GDP growth rate in comparison to other agricultural sectors (crop, livestock and forestry). The growth rate of this sector over the last 10 years is almost steady and encouraging, varying from 4.55 to 7.32 percent with an average 5.49 percent. Whereas last five years average growth rate of this sector is 5.88 percent. The country's export earnings from this sector is 2.01 in 2012-13. The fisheries sector provides about 60% of the animal protein intake and more than 11% of the total population of the country is directly or indirectly involved this sector for their livelihoods. Bangladesh is one of the world's leading fish producing countries with a total production of 35.48 lakh MT in the last fiscal 2013-14 (DoF, 2015). According to available statistics, it is found that the total fish production of the country shows a consistently increasing trend during the last 30 years. Over the stipulated period the fish production is increased almost five times (7.54 lakh MT in 1983-84 to 35.48 lakh MT in 2013-14). The overall growth performance from inland aquaculture shows a credible increasing trend (1.17 lakh MT in 1983-84 to 18.60 lakh MT in 2012-13) due to dissemination of improved technology packages and supportive/need-based extension services at farmer's level. A slight growth in the production from both inland and marine fisheries was also noticed during the last two and half decades with some exceptions. Bangladesh is the drainage outlet for a vast basin Meghna complex made up of the Ganges- Bramhmaputra-Meghna river system. The inland water areas of the country comprise 853,863 hectares of rivers, canals and estuaries; 177,700 of Sundarbans; 114,161 hectares of beels (wetlands); 371,309 hectares of ponds and ditches; 5,488 hectares of baors (oxbow lakes); 68,800 hectares of Kaptai Lake; 27,02,308 hectares of open floodplains; 22,382 hectares of semi-open floodplains; and 275,274 hectares of shrimp and prawn farms (DoF, 2015).

Food is the most important basic need for survival of the living beings on the earth. Whenever it is not available in sufficient quantities, there arises the problem of competition. It is a well-known that the population of the world is increasing day by day. The population of Bangladesh is also increasing very rapidly. As a result, Bangladesh government has taken up the green revolution project through which they are exploiting most of the terrestrial and aquatic resources to the maximum possible and improving the gross agriculture production to a remarkable extent. Nowadays, the greatest challenge to Bangladesh is to combat the prevalent malnutrition.

Micronutrients deficiencies are wide spread in Bangladesh, particularly among children and women. Among other serious deficiencies Vitamin A deficiency is a declared public health problem currently being targeted, through a national supplementation program of vitamin A capsules (Ahmed, 1999). Almost 90% of her people have been suffering from this malady. To overcome this problem it is necessary to supply protein rich diet to the people. Fish is a major animal protein source in the diet of our people because more than 80% of animal protein comes from fish alone (Rubbi *et al*., 1978). Among fish protein 85% - 95% is digestible part which contains all dietary essential amino acids (Nikolsky, 1963). Fish plays a major role in the Bangladeshi diet, constituting the only animal food source among rural poor households (Ahmed and Hasan, 1983; Hels *et al*., 2002). Fish is also a good source of fat, vitamins (both fat and water soluble) and some important minerals. To fill up the protein gap UN Advisory Committee emphasized the following:

- To improve the efficiency and broaden the scope of inland and marine fisheries including fish farming; and
- To improve protein intake and to take necessary measures to prevent the protein deficiency.

About 12 million people are directly involved in fisheries sector. Bangladesh, being an agricultural country and rich in many fishery potential, water bodies are remaining neglected in the country even up to these days. Only by the proper culture of these water bodies' resources the country can overcome this problem. Due to the high population growth there is an even increasing gap between supply and demand of fish and fisheries products in Bangladesh. For narrowing of the gap it not only requires increasing production but also improvements at all aspects of marketing and distribution system (ICLARM, 1991; SAARC, 1994).

Despite this vital importance of fish in the diet of the people it is to note that the per capita consumption has shown a drastic decline over the years 1975-1976 to 1984-1985 as 22.2 g/person/day to 20.1 g/person/day. A recent study made by the DoF, Ministry of Fisheries and Livestock (2013-14) indicates that the situation has developed and the per capita consumption increased (52.88 g/person/day) due to increase of culture and capture fisheries in Bangladesh (DoF, 2015). Even this was found to be not sufficient enough to satisfy the present day demand.

From the nutrition survey of 1963-1964 published in 1965 it was evident that total protein intake in Bangladesh per capita per day was about 57g of which 7.8g was of animal origin out of which 6.38g *i.e.* about 80 percent came from fish alone (Rabbani and Hossain, 1970; Mannan, 1977; Ali, 1982).

Fisheries is the second crop in the overall agro-based economy of Bangladesh. This sector is playing a very vital role regarding employment generation, animal protein supply, foreign currency earning and poverty alleviation. According to the report of BBS (2003-2004), Fisheries sector is contributing 5.71% of the total export earning and 4.92% to the GDP. About 12 million people are directly and indirectly involved in this sector. Labor employment in this sector has been increasing approximately by 3.5% annually. Fish production in estuarine, ponds, lakes, borrow pits, flood plains, ox-bow lakes and semi-closed water bodies are increasing day by day through transfer of modern technology. Fish production has been increased to 25.64 lakhs MT in 2007-2008 which was 17.81 lakhs MT in 2000-2001 (DoF, 2009). Fish production in some floodplains increased from 150 kg/ha to 2000-3000 kg/ha in resent year. In 2004-2005, the highest over export earning of Tk. 2572 core was earned through export of 6,33,378 MT shrimp and fish products (Ahmed, 2005) Fisheries contributing to GDP in 2007-2008 was 3.74% and the fiscal year (2008-2009) more than 3,396.28 core Tk. of foreign currencies had been earned by exporting fish and fisheries products (DoF,2009). So on the basis of contribution towards national economy fish is rightly regarded as the “silver crop” of Bangladesh. About 7% of total population is involved in fish transport, processing and marketing. Unfortunately fish production in the country is very low as compared to other developing countries of the world. The low level of the fish production is the result of which socio-economic and technical problems are the most important ones (Rahman *et al*., 1989).

Fish protein is said to be more healthier and cholesterol free and also contains fatty acids which help in absorption in the body tissues. The people are advised to take much fish than meat. Mannan (1977) demonstrated the especially of the fish protein. Fish diet mainly provides proteins, fats, vitamins A and D and phosphorous. According to the FAO (1991), fish contains 72% water, 19% protein, 8% fat, 0.15% calcium, 0.25% phosphorus and 0.10% vitamin A, B, C and D. Generally, the body composition of fish seems to depend on age, sex, season and diet (FAO, 1995; Love, 1970a). National Household Expenditure Survey (NHES) shows that annual fish consumption in Bangladesh peaked in 1985 at 13.2 kg/person by 1992.

Development study (NWADS) which shows that overall fish supply has stagnated resulting in price increases in real terms of over 2.8% per annum in the North-west region (Intrem Report Vol. 5, ADB Dhaka, February, 1997).

The important of marine fisheries in relation to the economy of Bangladesh cannot be overlooked. We have a large number of species which can be exploited from the Bay of Bengal on commercial scale.

The Centropomidae probably has the brightest future of all the marine and brackish water finfish in the developing technology of the most widely distributed commercial fishery in the worlds coastal water and they are of significant importance, meeting the subsistence protein requirements of the people of the Pacific basin, Southeast Asia, India, the Mediterranean and Eastern European countries and in many parts of central and south America. Mullet and mullet products also contribute to valuable fishery economics in Japan and Australia (Nash and Shehadeh, 1980).

The major species of Latinae are desirable fish with good flesh texture and taste, particularly when capture or taken from water of high salinity. They have capacity for tolerating extreme condition of temperature, salinity and dissolved oxygen content. They are naturally hardly animals which thrive on good husbandry but are also capable of with-standing poor farming practices.

Though the fish is very familiar and popular in that area but still it is not properly exploited in large scale for the local people. If this fish is properly exploited it can be fulfill the local consumption and moreover the surplus can be exported to the foreign countries.

The farming of *Lates calcarifer* has been practiced for centuries. Experimental activities in intensive *L. calcarifer* farming aimed at finding ways to optimize production, which is necessary forerunner of any large scale operation, are more recent. Approaches of this increased efforts to develop intensive culture differ from region to region because traditional needs and practices.

According to D`Aneona (1955) and Angelis (1969), in Italy traditional "Valliculture" method is employed in farming *L. calcarifer*, which is now advanced. In Egypt, successful stocking experiment was carried out at lake (Faouzi, 1936). According to Nash and Shehadeh (1980) in Southeast Asia and the Far East efforts to intensify mullet culture were centered in Taiwan, India and Hong Kong.

In India with its extensive estuarine waters in Kerala, West Bengal and Madras, mullets have been farmed from very ancient time (Campbell, 1921; Hornell, 1922). Though *L. calcarifer* species constitute one of the most important commercial fisheries of the Bay of Bengal, a very little information is yet available on the various aspects of its biology.

L. calcarifer (Bloch, 1790), locally called "Bhetki" belonging to the family Centropomidae of the order Perciformes, is an euryhaline species and in Bangladesh *L. calcarifer* occurs along the coastal regions of the Bay of Bengal. They are also found in coastal rivers including Andharmanik river of Patuakhali district (Mohsin *et al.*, 2014.) principal areas where it is available, are the ghers (polder area), the estuaries of the rivers Shibsa, Rupsha and the coastal regions of the Bay of Bengal.

L. calcarifer with its tasty and rich flesh is valued commercially. About 35% to 45% of total *L. calcarifer* are found in coastal regions of the Bay of Bengal. *L. calcarifer* is adapted for cultivation with shrimps and milk fish and this species is preferred by people as food fish.

1.2 A Few Words about *Lates calcarifer* (Bloch, 1790)

Lates calcarifer, locally known as Bhetki is a commercial important euryhaline fish of Indian sub-continent and it grows to comparatively large size with delicate, flovoured flesh and commands high price in the markets (Das, 2000).

1.2.1 Identification

The valid scientific name	:	*Lates calcarifer* (Bloch, 1790)
Local names	:	Bhetki and Coral
English names	:	Barramundi, White Seabass, Silver Sea perch, Giant sea perch, Palmer and Cock-up Sea perch
Synonyms	:	*Coius vacti* Hamilton, 1822 *Holocentrus calcarifer* Bloch, 1790 *Lates darwiniensis* Macleay, 1878 *Pseudolates cavifrons* Alleyne & Macleay, 1877

1.2.2 Taxonomic Hierarchy of *Lates calcarifer*

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Superclass: Osteichthyes
Class: Actinopterygii
Subclass: Neopterygii
Infraclass: Teleostei
Superorder: Acanthopterygii
Order: Perciformes
Suborder: Percoidei
Superfamily: Percoidea
Family: Centropomidae
Subfamily: Latinae
Genus: *Lates*
Species: ***L. calcarifer***

1.2.3 Distinguishing Characters

Shape-size: *Lates calcarifer* has an oblong, laterally compressed body, thick in the middle and tapering at both ends. It consists of three ill-defined regions- the head, trunk and tail. The head extends from the snout to the posterior end of the operculum, the trunk from the posterior end of the head to the anus and the tail from the anus to the posterior caudal end of the fish.

Teeth: Teeth are not preeminent. They are a series of small sharp, villiform teeth borne on both the upper and lower jaw and also on vomer and palatine bones.

Eyes: On each side of the head dares-laterally, there is a envied slightly bulging eye, divide of eyelids. The depth of the head over this region varies from 2/5 to 1/3 of the head length of the fish.

Fins: The fins are flattened outgrowths of the body. The base of the each fin is attached with the body of the fish and the other and remains free. The fins are provided with bony rays and are of two types namely (i) median fins and (ii) paired fins.

Scales: Externally, the soft, slimy surface of the body of skin of the fish is covered with ctenoid scales of moderate size. The scale number varies from 6 to 7 in transverse above the lateral line and from 13 to 16 below the lateral line and from 48 to 60 on the lateral line in the longitudinal series.

Colour: The colour of the fish is variable and in live fishes ranges from dark gray to olive brown or bluish above and silvery on abdomen and sides, The two dorsal fins, the anal fin and the caudal fin, all are grayish in colour. While the pectoral and pelvics are whitish to pale yellowish in colour. The immature fishes are darker than the adults.

Fin Formula: D_1 7, D_2 1/11-12, P_1 17, P_2 1/5, A 3/8, C 19.

1.2.4 Geographical Distribution

Seas and estuaries of India, Ceylon and Bangladesh to throughout most of northern part of Eastern Indian Ocean, western central pacific area and south ward to northern coasts of Australia; also westward to Karachi (Fishcher *et al.,* 1974).

Bangladesh, India, Pakistan, Myanmar and Thailand (Yadav, 1999); also Southward to Queensland (Australia) and west land to East Africa (Kungvankij *et al.,* 1986).

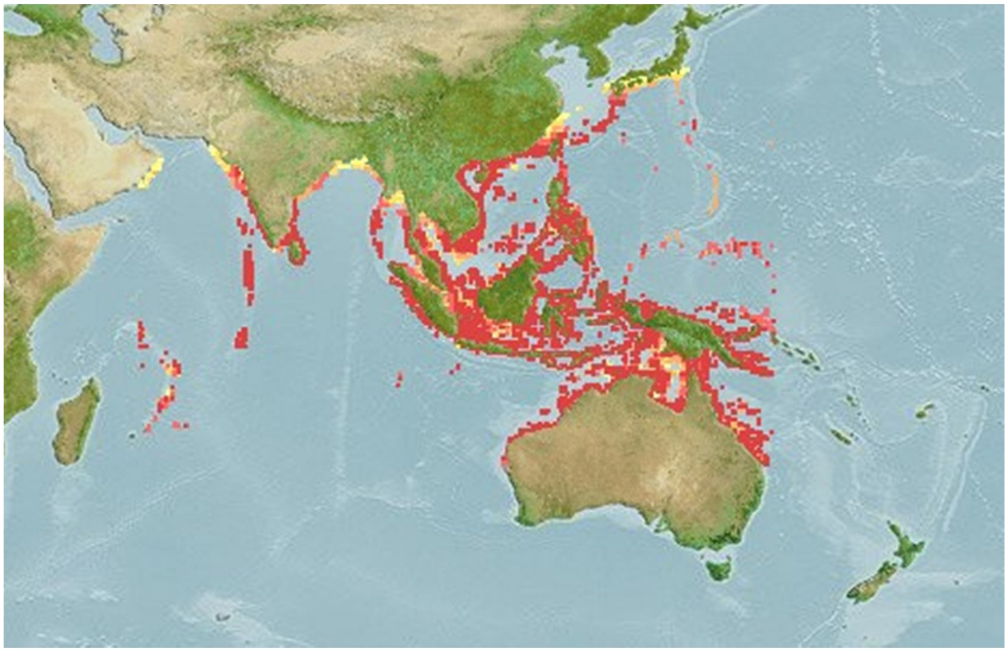

Figure 1: Distribution map of *Lates calcarifer*

1.2.5 Habit and Habitat

Lates calcarifer is an eurihaline and catadromous species (Kungvankij *et al.,* 1986). Some common habitats are the Bay of Bengal, estuaries and tidal rivers, sometimes in freshwater; commonly found in estuaries of Barishal, Patuakhali and Khulna (Rahman, 1989; Mohsin *et al.*, 2014).

1.3 Rationale and aim of the Present Study

To the best knowledge of the researcher, no detailed research work has been performed on *Lates calcarifer* (Bloch, 1790) in Bangladesh, except Kamruzzaman *et al.* (2013) and Mushahida-Al-Noor *et al.* (2012), who worked on some aspects of biology. However, works by Kamruzzaman *et al.* (2013) and Mushahida-Al-Noor *et al.* (2012) did not cover issues like body composition. Though several scientists (Giuguen *et al*., 1994; Shazili, 1995; Nocillado, 2000; Dayal *et al.*, 2003) have already been worked various aspects regarding this species but no such scientific research work is not available in Bangladesh which is very much necessary for the sustainable management of this species.

The present work is a step in the direction of the efforts to get much of information as possible on various aspects of the ecology, biology and fishery and chemical composition of the fish. This work has been divided into four parts.

The first part deals with the physico-chemical conditions of three water bodies *viz.* Shibsa river in Dacope upazila, Kapatakkha river in Paikgacha upazila and ghers (polder area) in Dumuria upazila of Khulna where the research was conducted. The physical parameters include the air and water temperature, rainfall, water transparency and the chemical parameters include the p^H, dissolved oxygen (DO), free carbon dioxide and salinity of water.

The second part of deals with food and feeding habits of the species such as composition of food items, monthly variation in the degree of feeding, seasonal occurrence of various food items, feeding is relation to sexual cycle and the relation between total length and alimentary canal lengths.

The third parts deals with the biochemical composition of *L. calcarifer*. The present work is a step to get some information on the comparative biochemical composition and some mineral contents of *L. calcarifer* in the fresh (indifferent life stages, such as size: juvenile, adult and spent) fishes.

The fourth part deals with the fishery of the species, *i.e.*, gears and fishing method and season, month wise landing, marketing channel and its activities, marketing margin, marketing costs, profit and intermediaries, seasonal price variation and importance of the species etc.

Though *L. calcarifer* is a popular food fish in Bangladesh but there is no detailed information or research on body composition. In the present study various nutritional parameters of *L. calcarifer* will be studied to study a comprehensive detail of body composition. Consumers will have an idea about body composition of studied fish after this study. This study will encourage other scientists and serve as a basis for conducting further research on similar issues.

1.4 Overall Objects of the Study

Lates calcarifer (Bloch, 1790) is one of the most important food fish in southern part of Bangladesh as well as overall country. This species is preferred in aquaculture in costal ghers because of its great consumer demand, growth rate and overall size. However, the present study was conducted with the following objectives-

- to know the ecology of *Lates calcarifer* in open running waters;
- to find out the food and feeding of selected fish species;
- to study the body composition of studied species; and
- to know about the fishery of *Lates calcarifer*

Chapter Two

Review of Literature

REVIEW OF LITERATURE

Before beginning a research work it is essential to find out the exiting state of the field. Although a large number of literature on the fecundity, gonadal and embryonic developments of various fishes are available but there was none on the eco-biology of *Lates calcarifer*. In recent years there has been growing awareness amongst the researchers in our country to study reproductive biology, hydrological limnology and other environmental conditions. Some of the important works, which have been done on the physico-chemical conditions in relation to fish, food and feeding habit and fishery are reviewed chronologically here in this chapter.

2.1 Physico-Chemical Studies

Chakraborty *et al*. (1959) observed the abundance, seasonal fluctuations and diurnal variation of plankton in relation physico-chemical conditions of water in the river Jamuna at Alahabad.

Vyas and Kumar (1968) studied the water conditions of Indrasagar Tank, India. They observed that the periods of high temperature nearly coincided with those of low oxygen content.

Dhawan (1970) studied the hydrological factors at Kandla in the gulf of Kutch. He noticed seasonal variation in the temperature, salinity, p^H, dissolved oxygen, inorganic phosphate, nitrate and silicate and their influence on plankton.

Saha *et al.* (1971) worked on the seasonal and diurnal variation in physico-chemical and biological conditions of a perennial freshwater pond of Bangladesh.

Islam *et al.* (1974) studied the physical and chemical factors and their affects upon the general biological condition of the water of the river Buriganga in Bangladesh.

Khalaf and MacDonald (1975) conducted a hydrological investigation in the temporary ponds in New Forest. They observed that the p^H of the ponds fluctuated with the change in dissolved oxygen concentration and heavy rainfall which produced an immediate decrease in the p^H of the ponds.

Islam and Mendes (1976) made and observation on the limnology of a jheel of Sher-E-Bangla Nagar in Dhaka.

Ali *et al.* (1978) observed the physico-chemical characteristics of the river Brahmaputra at Mymensingh. They found an inverse relationship between carbon dioxide and p^H.

Islam *et al.* (1978) worked on some physico-chemical parameters and growth of major carps in two ponds of village boyar, Mymensingh. They noticed that the water temperature was closely related with air temperature. The water transparency value increased with the increase in water volume and consequent decrease in concentration of microscopic organisms. The study indicated an inverse correlation of CO_2 with dissolved oxygen and direct correlation with temperature.

Ali *et al*. (1980) made and observation on the ecology and seasonal abundance of zooplankton in an artificial fish pond. The role of temperature, p^H, hardness of water as $CaCO_3$ and total alkalinity and the abundance of different of genera were discussed.

Chowdhury and Mazumder (1981) made a limnological survey of the Kaptai lake a tropical impoundment. Emphasis was given on the seasonal vertical, horizontal and diurnal fluctuations in some physico-chemical parameters of the lake water. This lake was found to be of oligotrophic nature in acidic to near neutral p^H and low nitrate phosphate content.

Rahman *et al.* (1982) studied the physico-chemical conditions of four ponds. The physico-chemical aspects investigated were average depth, temperature, dissolved oxygen, free carbon dioxide, p^H, carbonate etc. They stated that the water temperature, dissolved oxygen and p^H values were higher at the surface water than those at the bottom waters and free carbon dioxide contents in vertical variation, were low at the bottom waters than those at the surface waters. Some of the physico-chemical conditions were affected by heavy rainfall.

Ali and Islam (1983) investigated the variation of abundance and distribution of plankton in lake of Bangladesh Agricultural University, Mymensingh. They stated that maximum phytoplankton density was found in the month of May.

Miah *et al.* (1983) studied some ecological parameters and growth of major craps in two ponds of Bangladesh Agricultural University campus, Mymensingh. They recorded water temperature, highest and lowest water transparency, dissolved oxygen and carbon dioxide. They stated that dissolved oxygen and p^H were higher in the surface whereas hardness, free carbon dioxide, phosphate and nitrate were higher at the bottom water.

Rahmatullah *et al.* (1983) studied the qualitative and quantitative nature of phytoplankton in a pond in Bangladesh Agricultural University campus, Mymensingh. The maximum and the minimum average number of phytoplankton were recorded.

Habib *et al.* (1984) studied the monthly fluctuation in zooplankton population in relation to physico-chemical factors of water. The successful fisheries management basically depends upon limnological aspects of bottom soil and water bodies.

Alam *et al.* (1985) investigated the correlations of some physico-chemical properties of water with zooplankton in nursery ponds. During the study they observed that water temperature, p^H, dissolved oxygen, free carbon dioxide, nitrate, phosphate and exchangeable potassium, calcium were the growth influencing factors for the various genera of zooplankton.

Ali *et al.* (1985) studied the metrological factors and temperature, transparency and p^H of water had combined effect upon the fluctuation of various species of phytoplankton. They observed that various species of phytoplankton were inversely corrected with rainfall. The total hours of sunshine influenced the growth and abundance of various species. The quality and quantity of phytoplankton and zooplankton are both equally important for fish production.

Ronald *et al.* (1985) observed the physical and chemical parameters of water of Halda river, Chittagong at a spawning site for the three major carps. High water level, strong water current and high turbidity, comparative low water temperature, low conductivity, low dissolved oxygen content and p^H influenced spawning of the major carps in the Halda river.

Alam *et al.* (1987) investigated the abundance of zooplankton of four newly constructed ponds with reference to some meteorological and limnological factors. Zooplankton populations were found to be correlated directly to dissolved oxygen and p^H while inversely to free carbon dioxide.

Begum and Alam (1987) studied the relationship between the different physico-chemical variables and abundance of plankton of two ponds in Maijdee court, Noakhali. They stated that in the pond phytoplankton dominated over zooplankton.

Patra and Azadi (1987) presented the qualitative and quantitative studies of plankton and corresponding physico-chemical condition of the Halda River. They stated that zooplankton cycle was noticeably less than the plankton. The seasonal abundance of plankton was mostly controlled by the combination of various hydrological factors.

Khondker *et al.* (1988) studies the gross primary productivity in Dhanmondi lake at Dhaka. The water temperature, Secchi disc visibility, p^H, DO, free CO_2 and alkalinity were determined and their spatial and temporal variations were shown.

Ali *et al.* (1989) investigated the seasonal variation of physico-chemical condition of water, plankton and benthic macro invertebrates in a perennial pond. There were considerable variations in water quantities in different seasons. The temperature of water varied from 20.5 to 36 ^{0}C, p^H 6.7 to 8.4, the highest value of CO_2 42 ppm, carbonate 3.2 to 24 ppm and higher dissolved oxygen content value in winter and early summer. They observed inverse relationship between the abundance of phytoplankton and zooplankton and between zooplankton and macro invertebrates.

Begum *et al.* (1989) studies the limnology in a mini pond and growth of Talapia. They discussed seasonal variations and interrelationship of physico-chemical parameters and plankton. An inverse relationship was noted between phytoplankton zooplankton. They also stated the possible reasons for higher yield in the mini pond.

Bhuiyan (1989) observed the value of p^H, dissolved oxygen and turbidity of the Padma water near Rajshahi city during the spawning season of *Cirrhina reba* from June to September.

Chowdhury *et al.* (1989) observed the occurrence of seasonal of zooplankton in a fish pond in relation to some physico-chemical factors. The coefficient of correlation of between temperature and occurrence of zooplankton showed an inverse relationship.

Bhuiyan and Sen (1990) recorded the influence of temperature and light penetration on the productivity of Foy's lake in Chittagong.

Munjurul *et al.* (1990) studied the seasonal variation in physico-chemical conditions of Dhanmondi lake water. In summer, the water was chemically richest because of the mixing of surface and bottom water. An inverse correlation between temperature and dissolved oxygen was observed throughout the year.

Khondker and Parveen (1992) showed depth wise distribution of temperature and DO in Dhanmondi lake throughout the year. Average value of nutrients, dissolved conductivity and alkalinity were seen higher when compared with some other typical ecosystem. However, depletion in the concentration of some of the above mentioned parameters in the lake water had been observed during monsoon.

Begum *et al.* (1994) observed the physico-chemical parameters of a semi- intensively managed fish pond noticed fluctuations. The p^H value of pond was found to have lowest variability while carbonate had the highest variability.

Banik (1995) studied the zooplankton abundance in a freshwater farming in west Bengal in relation to environmental factors. Zooplankton showed the highest numbers in the winter and in lowest in the summer.

Bhuiyan and Nahar (1996) studied some physico-chemical parameters of a fish pond. They stated that free CO_2 and HCO_3 were inversely related with DO. The relationship between HCO_3 and free CO_2 were positive and negative with p^H. They indicated the pond to be suitable for pisciculture.

Chowdhury *et al.* (1996) investigated the impact of industrial effluents on the physico-chemical biological conditions in the polluted area of Padma River. High p^H, conductivity, COD, BOD and chloride value of lower DO content followed by a lower variety of plankton indicate an approach towards a higher condition.

Bhuiyan *et al.* (1997) studied the physico-chemical condition in relation to meteorological condition of a fish pond in Rajshahi. They observed that the pond was eutrophic in nature with slightly acidic to alkaline p^H, with high bicarbonate content.

Das *et al.* (1997) studied the ecological parameter such as water temperature, salinity, dissolved oxygen, p^H etc. which greatly influence the ovary maturation embryonic development and spawning capability of shrimp.

Ehsan *et al.* (1997) made and observation on limnological conditions of the floodplain Halti beel. They noticed that the p^H values remained slightly alkaline whereas turbidity was found to be higher in the canal.

Hossain *et al.* (1997) studied some physical and chemical parameters of the BSKB beel, a completely closed system floodplain. Emphasis was given on temporal and spatial fluctuation in respect of turbidity values. They observed dissolved oxygen which showed an unusual event and maintained an inverse relationship with temperature.

Pavel *et al.* (1997) analyzed some aspects of physico-chemical properties of a pond bottom soil of Jahangirnagar University campus. They found that the soil was clay to loamy and indicated that the experimental pond was a favorable condition for fish culture.

Islam *et al.* (1998) studied the seasonal occurrence of zooplankton in four hatchery ponds in Rajshahi. They worked on the physico-chemical factor in relation to meteorological condition of the ponds.

Chowdhury and Zaman (1999) investigated zooplankton content and physico-chemical conditions of the river Padma near Rajshahi. They stated that the abundance of zooplankton was found to be affected by the physico-chemical condition of water, current and turbidity during the study period.

Ahmed *et al.* (2000) observed the physico-chemical characteristics in Bangladesh Agricultural University, Mymensingh under two different treatments. Mean value of temperature, secchi depth, dissolved oxygen, p^H, chlorophyla, alkalinity, phosphorus etc. were recorded. All the measured water quality parameters varied little among the ponds.

Bhuiyan and Nahar (2000) made and observation on the migration of some zooplankton in a fish pond for light, dissolved oxygen and availability of food. The zooplankton varied in different hours of the day. They also observed that p^H, DO value were higher at evening and CO_2 was high in the morning.

Chandra *et al.* (2001) observed the seasonal variations of zooplankton and their relationship with some physico-chemical parameters. They stated that seasonal changes of zooplankton showed positive correlation with water temperature, CO_2 and rainfall whereas negative correlation showed with p^H. Long term fish production depended on the proportion of plankton productivity.

Alam *et al.* (2002) investigated seasonal changes of physico-chemical parameters of freshwater wetlands of greater Dhaka district. They stated that water quality of any water body depended on the interactions of various physico-chemical factors which influence its biotic communities.

Bhaumik *et al.* (2003) investigated the ecology of Barnoo reservoir, Madhya Pradesh for augmenting fish production. Their study revealed that water and soil quality of the reservoir fluctuated with season and location. They stated that temperature showed negative correlation with dissolved oxygen.

Rao *et al.* (2003) studied limnology of Markanohalli reservoir across river Shima. They noticed that seasonal variation of physical and chemical parameters influenced fish production.

Sultan *et al.* (2003) investigated physico-chemical features and productivity status of Pahunj reservoir located at Jhansi in Uttar Pradesh. They stated that higher primary productivity indicated congenial environment for biological production.

Other workers who worked on the limnology of different water bodies include those of Devasy and Gopinathan, 1970; Ruttner, 1975; Mahmood *et al.*, 1976; Stanley and Daley, 1976; Golterman *et al.*, 1978; Rob *et al.*, 1978; Shafi *et al.*, 1978; Miah *et al.*, 1981; Islam, 1983; Wetzel, 1983; Ismail *et al.*, 1984; Bhiuyan and Das, 1985; Mahmood, 1986; Ameen, 1987; Jhingran and Pattak, 1987; Rahman, 1988; Sladecek, 1988; Ali *et al.*, 1989; Sharma, 1989; Shaha *et al.*, 1990; Ahmed *et al.*, 1992; Islam *et al.*, 1992; Rahman, 1992; Khanna, 1993; Begum *et al.* 1994; Singh and Singh, 1994; Khondker *et al.*, 1995; Ahmed and Sarker, 1997; Bishnu, 1997a; Coche *et al.*, 1998; Hasan *et al.*, 1999; Rao *et al.*, 1999; Anon, 2001; Samanta and Das, 2002 and others.

2.2 Food and Feeding Habit

Mukerjee *et al.* (1946) reported on the food and percentage composition of the common adult food fishes of Bengal. They observed that the food of *Labeo rohtia* consists of algae 35%, higher plants 20%, protozoans 23%, crustaceans 15% and mud and sand 7%.

Hynes (1950) reviewed different methods of analysis for fishes and stated that if a large number of guts are analyzed for food study, result obtained by occurrence, dominance and points methods re-approximately the same.

Alikunhi (1952) published a report on the food of young carp fry and found that the fry were mainly phytoplankton and zooplankton feeders.

Pillay (1952) made a critical review of different methods of food analysis of fishes. He stated that the best methods of ascertaining the food and feeding habit of fishes is the examination of its gut contents. In certain fishes, the food of the juvenile may be very much different from that of the adults which makes essential, the study of food of different age group separately.

Misra (1953) observed that *Labeo rohita* was a bottom feeder, *Cirrhina mrigala* a middle feeder and *Catla catla* a surface feeder.

Das and Moitra (1955) studied the food habit of some common fishes of Uttar Pradesh in India and observed that the food of *Labeo rohita* and *Labeo bata* consists of algae, aquatic plants, crustaceans, insects and their larvae and muds and decaying substances. They recorded *Labeo rohita* and *Labeo bata* as the mid-feeder.

Karim and Hossain (1972) observed that the stomach contents of *Mastacembalus pancalus* included larvae of Lepidoptera, Diptera, Hemiptera and sand grains and debris.

De Silva (1973) noted that the food of *Clupeaha rengus* and *Clupeasprattus* comprised mainly crustaceans with cepepods contributing the major share.

Lande (1973) recorded that the polycheats were the most important of plaice, *Pleuronectes pltessa* in winter while molluscs were the more important food in summer and autumn.

Doha (1974) studied the food and feeding habit, length-weight relationship and condition and breeding habits of *Glossogobius giuris*. He observed that the juveniles were carnivorous and insectivorous, while the adults were piscivorous and mollucs eaters. Cannibalisms were common in both the juveniles and adults.

David and Rajagopal (1975) described the food and feeding habits of different commercial fishes. They stated that during rainy season, submerged vegetation offers masses of decaying food of the fishes. Grasses and their seeds and the terrestrial insects formed important food items of several fishes.

Dewan *et al.* (1979) published a paper on the seasonal pattern of feeding of juvenile major carp *Labeo rohita* in Bangladesh and observed that the change in volume of food of *Labeo rohita* occurs with the change of season. Amount of food consumed was higher in warmer months and was lower in winter. Animal food was not consistently taken by the fish.

Dewan and Saha (1979) studied the seasonal pattern of feeding of *Talapia nilotica* and found that the fish is a herbivorous and continuous feeder. The fish showed seasonal variation in feeding activity. The feeding activity was greater in summer than in winter. A comparatively greater amount of phytoplankton during winter and debris during summer were recorded in the stomachs.

Mustafa and Ahmed (1979) described *Notoptereus notopterus* as a predominantly carnivorous, column feed which consumed mainly protozoans, crustaceans, algae, insects and small qualities of other food items.

Mustafa *et al.* (1981) studied the seasonal pattern of feeding of the fresh water fish *Colisa fasciata* (Bloch). Among the major food items, the fish was found to prefer algae in winter, insect in summer, diatoms and protozoans in autumn.

Davis (1985) studied the food of barramundi, *Lates calcarifer* (Bloch), in coastal and inland waters of Van Diemen Gulf and the Gulf of Carpentaria, Australia.

Bhuiyan and Islam (1988) observed the *Xenentodon cancila* is piscivorous and surface feeder mainly feeding on the major carp fry, minor carps and other fish fry.

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

Tacon *et al.* (1991) studied the food and feeding of tropical marine fishes in floating net cages. Fishes were Asian seabass, *Lates calcarifer* (Bloch) and brown-spotted grouper, *Epinephelus tauvina* (Forskal).

Alam *et al.* (1994a) 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 *Clupisoma atherinodes* is a carnivorous fish and the most important food items are the crustaceans, protozoans, insects and rotifers.

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

Bhuiyan *et al.* (1999b) studied the food and feeding habit of *Mugil cephalus* (L.). They observe that *Mugil cephalus* (L.) was a herbivorous fish.

Bhuiyan *et al.* (2001) reported that the *Puntius ticto* (Hamilton) is a herbivorous fish. The fish is 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+2.808TL (r=0.992). The total length and alimentary canal length ratio are 1:3.

Rahman *et al.* (2002) studied food and feeding habit of pond reared young *Gudusia chapra* (2 to 8 cm total length). Fish feed on a range of food items including phytoplankton, zooplankton and detritus. Food analysis by point method indicated that fish feed mainly on detritus and phytoplankton having a change of food habit to mainly phytoplankton and debris over time.

Hussain *et al* (2002) stuied 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 Cyanophyceae (35.34%), Bacillariophyceae (26.07%) and Chlorphyceae (12.97%).

Hossain, M.D. (2002) published a paper on eco-biology and biochemical composition of *Liza parsia* and observed that the fish is herbivorous. The food consists mainly of algae, higher plant parts, protozoans, crustaceans, debris, sand and mud. Monthly variations in the percentage of the food items in the different stages of the fish were recorded. The fish changed its food and feeding habit seasonally was very poor in mature fishes during the spawning period. The immature fishes feed activity throughout the year. The ratio of the total length and alimentary canal length of the juvenile and adult stages of the fish is 1:9.37 and 1:9.51 respectively.

Mahmud *et al.* (2005) studied the food and feeding of Chapila, *Gudusiachapra*, on ponds in Mymensingh, Bangladesh.

2.3 Body Composition

Latifa *et al.* (2014) studied the issue of the traditional fish salting by using NaCl which are easily available and cheaper cost wise and evaluate the difference between biochemical composition (moisture, protein, fat, ash, TVB-N, pH and FFA) of Dry-salted (DS) and pickle-salted (PS) *M. tengra* fish-products in laboratory condition using standard methods of analyses. In processed condition (after salting) the values of moisture (%), protein (%), fat (%), ash (%), TVB-N, pH and FFA were 41.41%, 22.05%, 10.65%, 26.15%, 3.90 mg N/100 gm, 6.0 and 2.8% respectively in case of DS *M. tengra* fish and 45.88%, 20.43%, 9.40%, 24.62%, 4.92 mg N/100 g, 6.0 and 3.2% respectively in case of PS *M. tengra* fish-product. During storage period, moisture (%), TVB-N, pH and FFA value were increased significantly ($p<0.05$) whereas total protein, lipid and ash contents were significantly ($p<0.05$) decreased. The values of moisture (%) content were increased 44.82 (7 month) and 49.09 (6 month), in DS and PS *M. tengra* respectively. The values of protein (%), fat (%) and ash (%) content were decreased 20.99%, 9.59% and 25.00% respectively in case of DS (7 month) and 19.28%, 8.68% and 23.41% (6 month) respectively in case of PS *M. tengra* fish. There were no significant ($p<0.05$) different among the samples and between this two salted products, TVB-N, pH and FFA value rapidly increased in PS than DS *M. tengra* fish-products and at the end of 6 month, pickle salted (PS) *M. tengra* fish-product became spoiled whereas dry salted tengra fish-product still remained fresh. Experimentally it has been proved that the fishes preserved in Dry-salt (DS) has longer shelf life (7 month) and has found better way for preservation.

Islam *et al.* (2013) conducted a research to characterize the lipids isolated from *Clarias batrachus* and to analyze the nutrient contents of these fishes. The specific gravity (0.87 at 30°C), refractive index (5.19 at 30°C), co-efficient of viscosity (448.26) were measured. Besides, the quantitative analysis of acid value (1.93), percent of free fatty acids (0.97%), saponification value (179.88), saponification equivalent (311.87), iodine value (53.93), peroxide value (43.63), ester value (177.95), unsaponificable matter (1.96%), acetyl value (16.09), reichert-meissel value (3.13), cholesterol (15.46%) were evaluated. Likewise, carbohydrate, protein and lipids were 6.26, 14.14and 6.91% respectively. Moisture contents were 78% but ashes were (0.1%). Further, the mineral studied as calcium, phosphorus and iron were 210.10, 70.05 and 7.06 mg/kg respectively, whereas zinc contents were trace amount. The fatty acids profile of *C. batrachus* was identified as lauric acid (2.6%), palmitic acid (37.41%), oleic acid (49.1%) and stearic acid (3.6%) arachidic acid (3.04%) andbehanic acid (4.21%) respectively.

Monalisa *et al.* (2013) studied the proximate composition, heavy metals, minerals and amino acid profile were determined for the two species of native and hybrid fishes (*Anabas testudineus*, *Pangasius pangasius*, *Pangasius hypophthalmus*) from different local market of Dhaka city of Bangladesh. In the proximate composition, higher amount of protein 20.22±1.94% and fat 11.28±1.35% found in hybrid Koi in contrast of protein 18.05±1.06% and fat 8.64±0.56% of native Koi, whereas native Pangas showed higher protein 26.06±1.27% and fat 14.79±2.47 % than protein 23.18±2.11% and fat 11.11±1.75% of hybrid Pangas. Minerals included Zn, Na, Ca, K, Fe, Cu, Mg and Al was higher in native species. The distribution of heavy metal: Pb, Hg, Cd and As were not significantly differed at $p<0.05$ in native and hybrid fishes; except Cr in Pangas. The concentrations of all heavy metals were below toxic levels. A total of fourteen amino acids were identified and mean value of lysine, leucine, valine, methionine, threonine, serine, glutamic acid, glycine and arginine in native and hybrid Koi showed the significant differences ($p<0.05$). In case of Pangas fish lysine, isoleucine, valine, threonine, histidine, aspartic acid, glutamic acid, glycine, alanine and tyrosine in native and hybrid Panagas significantly differed ($p<0.05$). The overall results indicated that hybrid Koi is better than native Koi; whereas native Pangas is well again than hybrid Pangas in addition to good dietetic fish food.

Paul *et al.* (2013) studied on the determination of lipids isolated from *Channa striatus* and *C. marulius* and to analyze the nutrient contents of both fish. The specific gravity, refractive index and viscosity co-efficients were (0.93 ± 0.03 and 0.91± 0.03 at 30°C), (1.76 ± 0.21 and 1.34 ± 0.22 at 30°C) and (438.43 ± 2.5 and 411.34 ± 1.2) for *C. striatus* and *C. marulius*, respectively. Besides, the lipids of both fish showed significant results in case of chemical characterization. On the contrary, *C. striatus* and *C. marulius* contained expected amount of carbohydrate, protein, lipid and cholesterol. The percentages of moisture, dry matter and ash were found in fair amounts. Furthermore, the minerals of *C. striatus* such as calcium and magnesium contents were higher but iron and zinc contents were lower than *C. marulius*. But, the percentages of lead, mercury and chromium of both fish were precisely in traces amounts. The fatty acids in C*. striatus* and *C. marulius* were identified respectively; lauric acid (2.73 and 5.55 %), palmitic acid (17.79 and 27.74 %), oleic acid (36.81and 31.35 %), linoleic acid (3.45 and 2.49 %) and stearic acid (25.79 and 21.81%).

Ahmed *et al.* (2012) carried out a study to find out the nutrient composition of fishes collected from six different water logged areas locally known as *Dogi.* The common carp, *Cyprinus carpio* contained the highest moisture 83.70% and *Puntius ticto* the lowest 75.02%. The highest amount of ash (3.56%) was found in *Puntius sophore* and the lowest (0.26%) in *Cyprinus carpio*. The highest percentage of protein (19.50%) was found in *Anabus testudineus* and the lowest (15.14%) in *Heteropneustes fossilis*. The highest percentage of lipid (4.52%) was found in *Lepidocephalus guntea* and the lowest (1.40%) was found in *Pangasius pangasius*. The small indigenous fish species (SIS) contented the highest percentage of nutrient except moisture than the introduced fishes in *Dogi*. The moisture, protein and lipid were the highest in semi intensive cultured fishes than the waterlogged paddy fishes. The nutrient qualities of fishes for two culture systems (Semi-intensive and *Dogi*) were significantly varied (P<0.05) except ash content. In conclusion it can be stated that, *Dogi* fish culture may be used as a tool for sustainability of fish resources of an area, where natural fish can be conserved and the added culture fishes can be used for consumption as well as to support livelihood of the poor and fulfill the nutrient requirement.

Hei and Sarojnalini (2012) studied the proximate composition, macro and micro mineral element contents of some smoke- dried hill stream fishes *Neolissochilus stracheyi, Labeo pangusia, Semiplotus manipurensis, Schizothora xrechardsonii* and *Ompok bimaculatus* were determined. The range of moisture contents in all the fishes was between 9.36±0.01% and 15.77±0.02%. The highest protein level (71.31±3.11%) was found in *Schizothora xrechardsonii* and the lowest

(30.51±2.19%) in *Ompok bimaculatus.* The highest lipid content (19.63±.88%) was found in *Ompok bimaculatus* and the lowest (6.68±.34%) in *Schizothora xrechardsonii.* The ash content was between 4.33±0.02-5.55±0.00% in all fishes. The macro elements Ca, Mg, K, Na and P were abundant in all the fishes examined while micro elements Cu, Co, Zn, Fe, Ni and Cr were present in trace amounts. The toxic metal element Hg was absent and As, Pb and Cd were negligibly low. The P contents were most dominant in most fishes, with the highest in *Schizothora xrechardsonii* (973.15 mg/100g). The next dominant contents in most fishes were K, the highest being in *Semiplotus manipurensis* (284.24 mg/100g). Among the micro elements, Fe contents were dominant in most fishes examined. The fishes examined were good sources of minerals, proteins and other nutrients required for the balanced diet of human consumption.

Sarower-E-Mahfuj *et al.* (2012) studied the biochemical composition of an endangered fish of Bangladesh, *Labeo bata* and found that the amount of moisture was 72.41±0.81%.

Kamal *et al.* (2007) studied the chemical composition of several freshwater small indigenous fish species of the Maouri river of Khulna, Bangladesh. The researchers have studied the composition of *Clarias batrachus, Heteropneustes fossilis, Nandus nandus, Anabas testudineus, Notopterous notopterus* and *Channa punctatus*.

Islam and Joadder (2005) studied the biochemical composition of freshwater goby, *Glossogobius giuris* from the river Padma of Bangladesh. They have found that the proximate composition of fish varies with the season as well as reproductive periodicity.

2.4 Fishery

Ahmed (1962) described fishing gears of Bangladesh and mentioned that dip nets (veshal jal) and traps (Dohair) are used for fishing tengra.

Kohls (1970) studied the marketing of agriculture products.

Bucksimiar (1977) observed the problem of transport and marketing of marine fishery products and their remedy.

Sharker (1977) studied the marketing of marine fisheries products.

Sabur and Rahman (1979) made an observation on marine fish marketing in Bangladesh.

Bhuiyan and Rahman (1982) worked on the percentage of fish fauna and fishery researches of the "Benchijal" catch (a kind of fixed purse net) of the upper and lower Sundarbans estuaries of Khulna district in Bangladesh. Fishermen mainly capture fishes with "Benchijals" throughout the winter season. These nets are laid in the months of the rivers or canals and the catches are collected every after six hours.

Khaleque and Islam (1985) studied the relative use and efficiency of fishing gears in the Chandpur irrigation project area. The use of gill nets and cast nets remained relatively constant the entire period. The relative efficiency of the different gears for catching fish showed marked difference. The construction of artificial barriers, the recruitment of fish within the project were drastically reduced.

Ali and Hossain (1986) observed the performance of fishermen's cooperatives in fish practices in some areas in Bangladesh. The amount of loan both per society and members was not sufficient and timely. All the loan receiving member utilized their major portion of loans for fishing gears and nylon twine only 5% of the total catches was marketed through the societies.

Alam *et al.* (1988) conducted a study in the haor area to identify the sources of fishing, types of fishes and their catching with different fishing gears. The fishing sources were river, haor, beel and ditches. Two types of commercial and eight types of traditional fishing gears were used. About 45 species of fishes were identified in the haor area. The amount of fishes harvested and consumed varied in both dry and rainy seasons.

Lokkeborg and Bjordal (1992) reviewed and discussed the species and size selectivity of long lining. Important selection factors in this fishery are fish distribution, fishing strategy, feeding range, fish composition, type and size of bait and hook design. Larger species and specimens have large feeding rang and are more successful in competing for baits, which may explain the higher selectivity of long lining.

Losanes *et al.* (1992) conducted fishing experiments for entangling nets (semi trammel and trammel nets) of different mesh sizes and vertical slacks in Tokyo Bay. The purpose of the experiment was to compare the catch and to study the effect on the catching efficiency and selectivity of variations in the construction of the nets. From the overall catch, it was found out that the semi trammel net was more efficient than the trammel net.

Quddus (1993) studied the fishing season which started from late August and continued to April and peak season from mid November to mid April. Most of the fishes were caught during mid night to noon due to transportation and marketing facilities. Fishing hour and peak season mainly depended on major fishing areas.

Mazid *et al.* (1997) worked on the gear selectivity of flood plain fishery in Bangladesh.

Rokeya *et al.* (1997) studied the marketing system of native and exotic carps in three major fish markets in Rajshahi. The study revealed that the peak season of the landing especially for major carps in those three markets extended from October to December. They also observed that maximum profit was earned by the contractors, fishing parties and commission agents in all those markets. The transportation of fish was also traditional and mostly done by van or Rickshaw. The market was running with many problems related to selling procedure, preservation, landing and water supply.

Das (2000) *Lates calcarifer* grows to comparatively large size with delicate, flavoured flesh and commands high price in the markets.

Khanam *et al.* (2003) observed that there was a great seasonal and regional variation in the supply and type of small indigenous fish species (SIFS) all over Bangladesh. The peak harvest season of riverine SIFS was November to December. SIFS from the flood plain are brought to the markets between May to December with a peak in October to December. SIFS from other water bodies were harvested January to April. They stated that low income, lack of capital, very poor or no handling preservation and processing facilities, uncertainty in SIFS marketing and pricing system, very poor educational background and ill health were among the main problems in the livelihood of SIFS retailer.

Nurullah *et al.* (2003) observed the present status of harvesting transportation and marketing of fresh small indigenous species of fish in Bangladesh. Fresh marketing in Bangladesh was entirely in the hand of the private sector, three level of marketing systems were observed. These were primary, secondary and final consumer markets. The fish collectors commonly known as aratders procure fish from local fishermen. The aratders sell the fish to the retailers. The retailers sell the fish to the consumers in the urban markets.

Vinod *et al.* (2003) studied the fishery of *Cyprinus carpio* in Umiam reservoir of Maghalaya. The highest monthly total catch was recorded in October and lowest total catch was recorded in April due to lowest water level.

Other notable works on the gears, transportation, preservation and marketing system of different fishes include, those of Bhanot, 1973; Chakraborty *et al.*, 1975; Rout *et al.*, 1979; Coulter and Disney, 1987; Agaral, 1990; Biswas, 1990; Gupta *et al.*, 1991; Ahmed *et al.*, 1993; Hossain, 1994; Mazid, 1994; Ali and Ahmed, 1995; Bhuiyan and Chowdhury, 1995; Hossain and Uddin, 1995; Khan, 1995; Hossain, 1996; Morrice, 1996; Bishnu, 1997b; Collis and Sarker, 1997; Ahmed and Hossain, 2000 etc.

Chapter Three

Ecology of *Lates calcarifer*

ECOLOGY

3.1 Introduction

Ecological condition is now recognized as a major factor affecting the productivity of key species in world fisheries. Bangladesh is abounds with large number of natural bodies of inland water, known as rivers, khals, beels, haors, ponds, ditches and marshes. Many of these lentic and lotic systems are permanent bodies of water and many have a temporary period inundation due to the influx of water and drainage congestion during the monsoon period. These large wetlands with their characteristic ecology represents old and mature ecosystem. Wetland has great ecological economic, commercial and socio-economic importance and values with its vital function i.e. ground water recharge, ground water discharge, storage of flood water, shoreline stabilization and reduction of erosion, sediment trapping, nutrient retention support for food chains, fisheries production, habitat for wild life recreation, natural heritage preservation and micro climate, stabilization (IWRB, 1992; Dugan, 1990; IUCN 1993).

The biological activities of any kind of aquatic organism are closely related to the physico-chemical condition of the habitat concerned. The present study area comprised the rivers Shibsa, Kapatakkha and some ghers (polder area) which are the habitats of *Lates calcarifer.* The production and availability of fisheries species depends on the physico-chemical condition of the water, which they live.

Different environmental factors, which determine the characters of water, have great importance upon the growth, maturity, reproduction and development of fisheries species.

The relationship between fisheries species, their biotic and abiotic factors are not isolated phenomenon but changes of one may reflect on the other. Fishes are more dependent on water temperature, turbidity, p^H, dissolved oxygen (DO), free carbon dioxide, alkalinity and some salts for growth and development (Nikolsky, 1963). Any changes of these parameters many affect the growth, development and maturity of fish (Nikolsky, 1963; Ali *et al.*, 1989; Begum *et al.,* 1994 and Bhuiyan *et al.* 1997).

Up to date, numerous works on the limnology of lentic type including ponds, lake or reservoir and few works in lotic environment which included the river like the Brahmaputra, the Bhairale, the Halda, the Karnafully, the Meghna including few works in the estuarine water have been done in Bangladesh. But no research work is available on the physico-chemical condition of the brakish water habitat of lotic type including rivers, tributaries, rivulets and flood plain in relation to biology and fishery of fish.

Information of some fragmentary works related to physico-chemical parameters of different rivers, tributaries, flood plains, estuaries and coastal areas of lotic type have been done by the workers like Devasy and Gopinath (1970), Islam *et al.* (1974), Mahmood *et al.* (1976), Shafi *et al.* (1978), Patra and Azadi (1987), Shaha *et al.* (1990), Ehshan *et al.* (1997), Ali *et al.* (1985), Dhawan (1970), Geisler *et al.* (1975), Jhingran and Pathak (1987), Mahmood (1986) and so on.

In the present investigation carried out to known the physico-chemical condition of the rivers Shibsa, Kapatakkha and some ghers (polder area) in Khulna district and a comprehensive observation do however make it possible to describe which factors play a definite role are in need of more precise analysis for physico-chemical condition of the water areas concerned in which the life of *Lates calcarifer* is being adapted.

The present investigation is aimed on the following objects

- To know the climatic condition of the study area
- To find out the mean value of some important physical parameters *viz.* air and water temperature, rainfall and water transparency in the study areas
- To find out the mean values of qualitative estimation of some chemical parameters like dissolved oxygen (DO), free carbon dioxide (CO_2), salinity and p^H of water.

3.2 Materials and Methods

The present work was conducted through a period of one year in three categories of coastal water bodies in Khulna district, the Shibsa and the Kapatakkha rivers and ghers (polder area) (Fig. 3.1). The experiment was started in July, 2013 and continued up to June, 2015. The water samples were collected at 15 days interval, once a day (10.00 am – 12.00 pm). Water samples were collected from the depth of 20-30cm below the surface and also from above the bottom. The water was collected into a coloured glass bottle of 500ml capacity with glass cork.

Physical characteristics of the sampling spots were recorded all months of the study period.

The water temperature was recorded with mercury thermometer (-1^{0}C to 50^{0}C) on the sampling spot. The monthly meteorological data on the air temperature and rainfall were collected from the Meteorological Department, Khulna. Water transparency was recorded by using secchi disc.

For the chemical analysis of water at sampling spots a kit box was used. The pH of water was recorded with the help of p^H paper (LOGAK, Korea) and occasionally water quality checker [WQC-HACH Kit (FF-2) HACH, USA]. Dissolved oxygen (DO) was determined using azide modification of Winker's method (APHA, 1995). Salinity was determined by using Refractometer and free carbon dioxide (CO_2) was measured by titration method with N/44 NaOH solution using phenolphthalein as indicator (Welch, 1948).

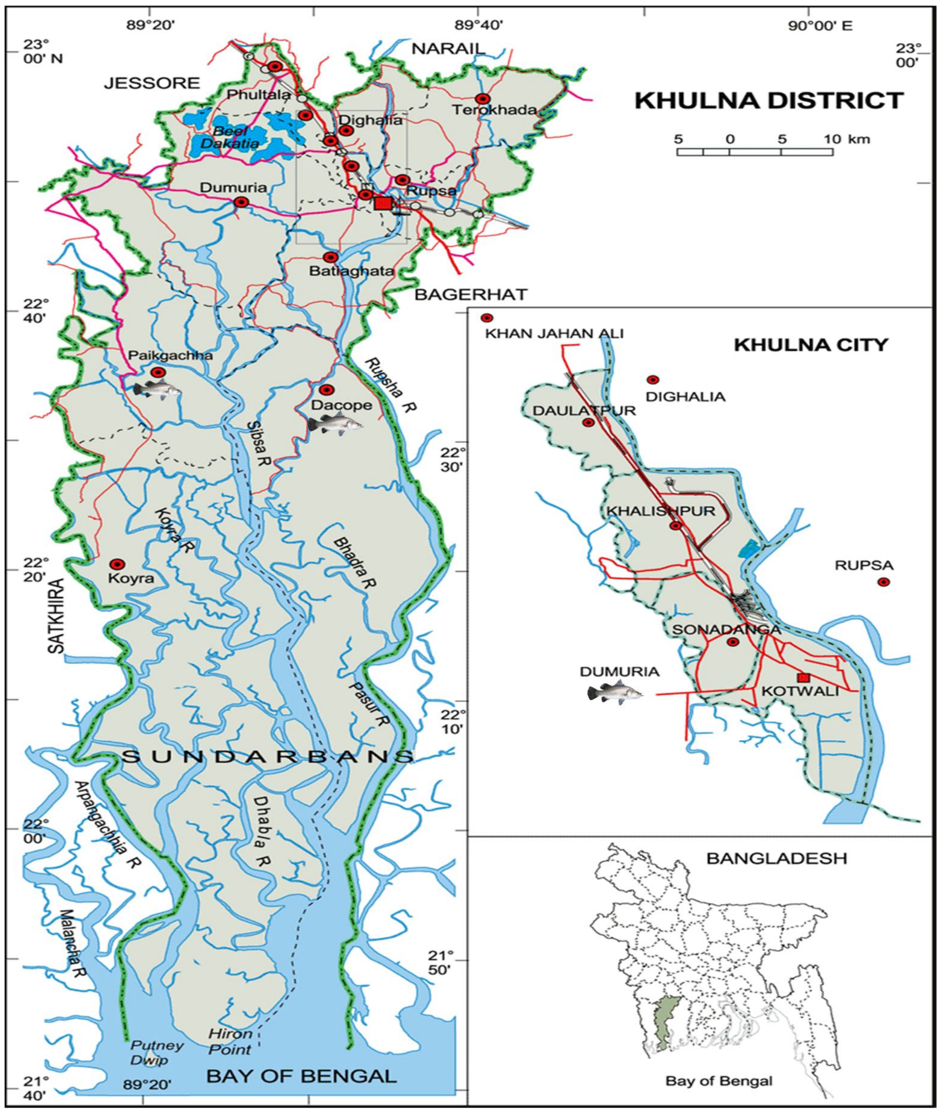

Fig 3.1: Map of Khulna district including the studied rivers and ghers ( )

Fig 3.2: A view of Shibsa river

3.2.1 Physical Factors

The physical factors such as temperature and water transparency of selected water bodies were measured.

3.2.1.1 Temperature

A centigrade thermometer with the range of -1^{0}C to 50^{0}C was used to measure the temperature of water at the time of sample collection. In order to record the temperature of water the thermometers mercury valve was kept at the depth of 15-25cm below the surface for 2-3 minutes. The temperature was read from the scale of the thermometer before with drawl from water.

3.2.1.2 Transparency of Water

The measurement of limit of visibility, *i.e.* penetration of light was carried out by secchi disc is a circular metal plate 20cm in diameter, the upper surface of which is divided into four equal quadrants and is so painted that two quadrants laying directly opposite to each other. The secchi disc was slowly lowered in to the water and the depth was noted at which it disappeared. Then the disc was lifted and the depth at which it reappeared was noted. The average of two readings is considered to be the limit of visibility, i.e. the penetration of light in water. The visibility was expressed in centimeters.

3.2.2 Chemical Factors

For the quantitative determination of the chemical factors of the selected water bodies, the analytical methods described in APHA, 2005. Limnological methods (Welch, 1948-1952) and FAO (1984) etc. were followed. These included the p^H of water, dissolved oxygen content (DO), salinity and free carbon dioxide (CO_2). All of the chemical parameters were observed are weekly intervals, with a long and narrow rubber tube without any back age. The rubber tube was slowly bowered down till it reached the required sampling depth the bottom. At this time enough water was removed by pumping to assure the inflow of water from the spot. The water was collected into a glass bottle connected between the rubber tube and the hand section pump. Care was taken to avoid mixing of air with the water in the bottle. Dissolved oxygen was estimated immediately after collection on the samples were treated with manganese sulfate solution, alkaline iodide solution and acidified with conc. Sulfuric acid for later estimation. The treated samples were transferred to the laboratory and the remaining steps of analysis were done. No noticeable changes occurred in the treated samples within 24 hours. The quantity of dissolved oxygen, thus estimated was expressed in milligrams per liter of water (mg/l).

3.2.2.1 p^H Content

Two digital p^H meters (model-HANNA) instruments Tokyo, Japan, had been used extensively for the instant determination of H^+ ion concentration during the field trips. Water samples were collected by dipping a mouth glass stopped red bottle from a depth of 20-30cm below the surface of water where as samples water were collected by a portable hand section pump with a long narrow rubber tube. p^H of water samples was determined immediately after collection. Each time ten reading were taken each spot and an average of the p^H values was recorded. Care was taken to avoid mixing of air with the water in the bottle.

3.2.2.2 Dissolved Oxygen (DO) Content

Winkler's method (unmodified) was followed for the estimation of dissolved oxygen content of water below the surface. A glass stopper bottle of 250ml capacity was dipped in to water from 20-30cm below the surface. The bottle was help under water and the glass stopper was toxin off and replaced again when the bottle was completely filled with water. The water filled bottle was taken up for analysis in the field. Reagents used in determining the dissolved oxygen ware, manganese sulphate solution, alkaline-iodied solution, concentrated acid, N/50, sodium thio-sulphate solution and just prepared starch solution.

3.2.2.3 Free Carbon Dioxide (CO_2)

Carbon dioxide is a colourless, odourless gas; resulting from the oxidation of carbon; formed in the tissues and eliminated by the lungs. In measuring water quality of any water body, the free carbon dioxide is considered very important. There is an inverse relationship between dissolved oxygen content and free carbon dioxide content in water. The value of free carbon dioxide was measured using HACCH Kit Box (Model FF-2) at the field situation.

3.3 Results and Observation

3.3.1 Air and Water Temperature

The average monthly air and water temperatures of the Shibsa river, the Kapatakkha river and ghers (polder area) are shown in Figure 3.3, 3.4 and 3.5 respectively which show considerable variation throughout the study period.

In the Shibsa river, the highest average air temperature (33.24±4.78°C) was recorded in the month of September 2013; whereas, the lowest air temperature (20.43±5.89°C) was recorded in December 2013 (Fig. 3.3 and Appendix Table 3.1). In case of water temperature, the highest measurement (32.18±3.12°C) was found in September 2013 and the lowest value (19.32±5.89°C) was recorded in December 2013 (Fig. 3.3 and Appendix Table 3.1). The overall mean air and water temperatures were found 28.71±4.03°C and 27.52±3.99°C respectively.

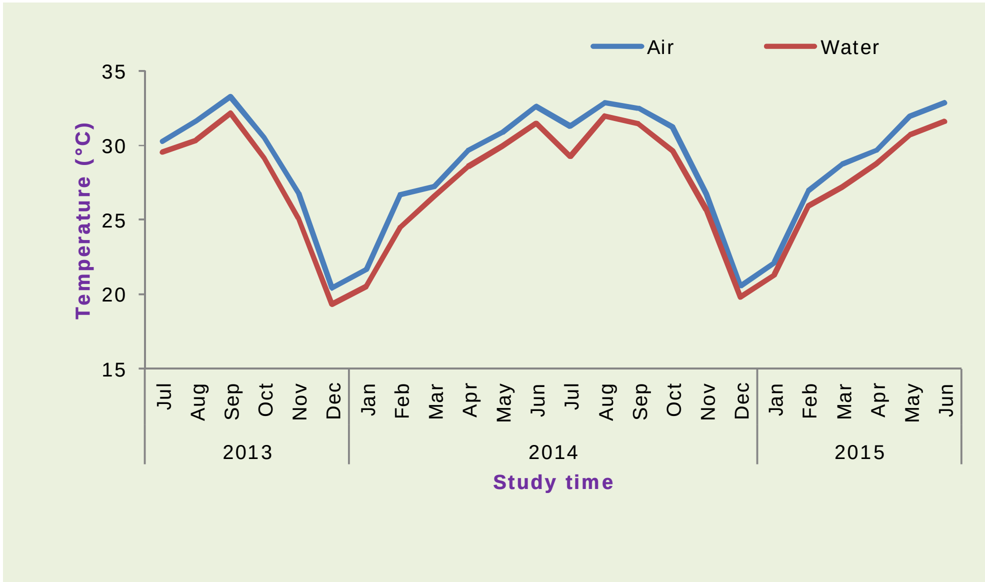

Fig. 3.3: Air and water temperature in the Shibsa river during the study period

In the Kapatakkha river, the highest mean air temperature (33.60±0.29°C) was recorded in the month of September 2013; whereas, the lowest air temperature (21.65±0.25°C) was recorded in December 2014 (Fig. 3.4 and Appendix Table 3.3). In case of water temperature, the highest measurement (32.25±0.29°C) was found in September 2013 and the lowest value (20.32±0.29°C) was recorded in December 2014 (Fig. 3.4 and Appendix Table 3.3). The overall mean air and water temperatures were found 28.69±3.91°C and 27.66±4.06°C respectively.

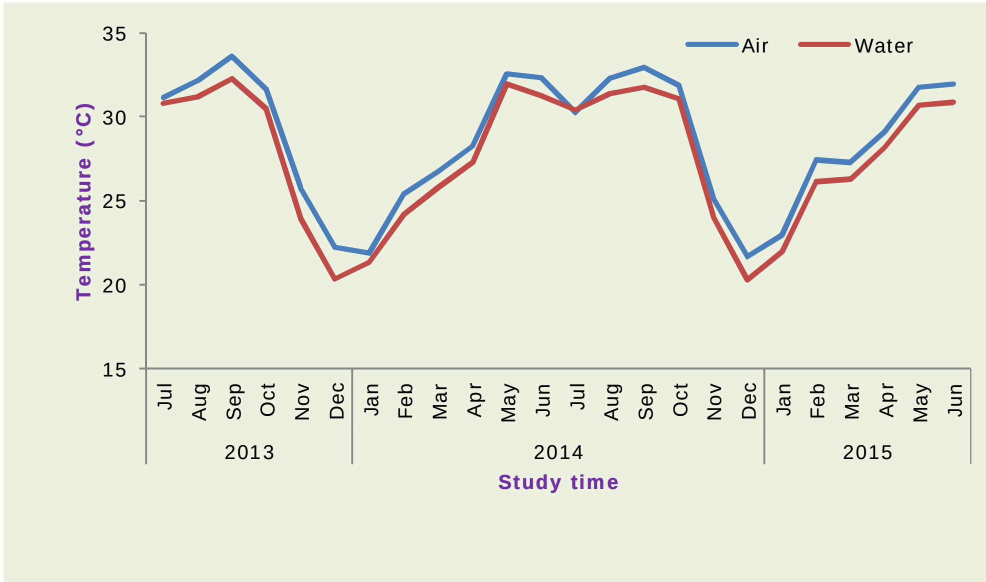

Fig. 3.4: Air and water temperature in the Kapatakkha river during the study period

In gher, the highest average air temperature was recorded in the month of September 2014 (32.83±0.29^{0}C); whereas, the lowest air temperature (21.67±0.29^{0}C) was recorded in December 2014 (Fig. 3.5 and Appendix Table 3.5). In case of water temperature, the highest measurement (31.83±0.29^{0}C) was found in September 2014 and the lowest value (20.00±0.50^{0}C) was recorded in December 2014 (Fig. 3.5 and Appendix Table 3.5). The overall mean air and water temperatures were found 29.03±3.45°C and 27.70±3.50°C respectively.

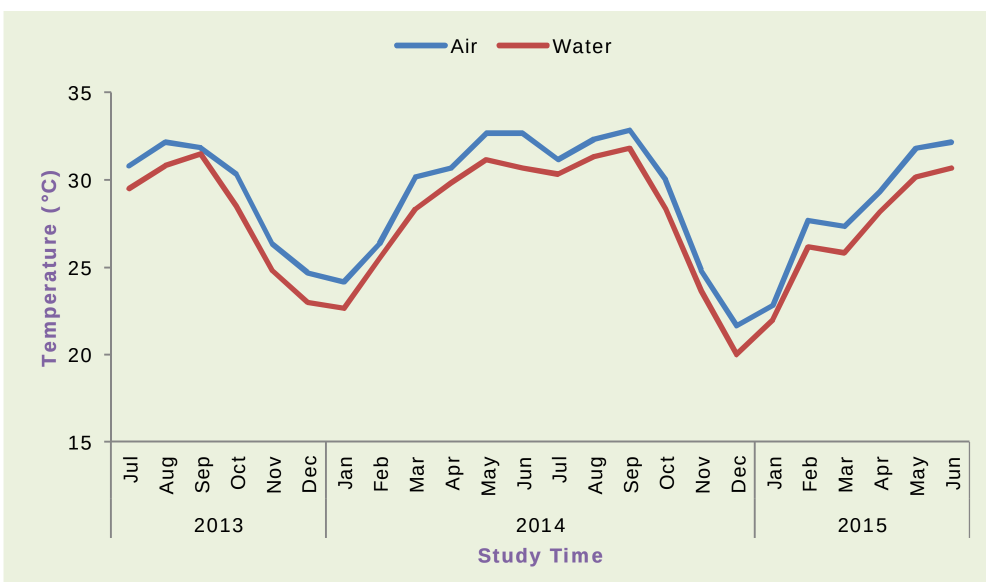

Fig. 3.5: Air and water temperature in the gher (polder area) during the study period.

3.3.2 Water Transparency, Rainfall and Salinity

The rainfall has great effects on both water transparency and water salinity. There is an inverse relationship between rainfall and water transparency and salinity *i.e.* if rainfall increases the level of water transparency and water salinity will decrease. However, recorded values of these parameters are presented in Figures 3.6, 3.7 and 3.8.

In the Shibsa river, the highest monthly average water transparency was measured 49.95±0.50cm (in May 2014) and the lowest was 24.50±0.32cm (September 2014) (Fig. 3.6 and Appendix Table 3.1). In the Kapatakkha river the highest water transparency (37.65±.18cm) was found in April 2015 and the lowest measurement (24.10±.13cm) was recorded in June 2014 (Fig. 3.6 and Appendix Table 3.3). In ghers, the highest monthly average water transparency was measured 62.00±2.65cm (in January 2015) and the lowest was 08.00±2.00cm (June 2015) (Fig. 3.6 and Appendix Table 3.5).

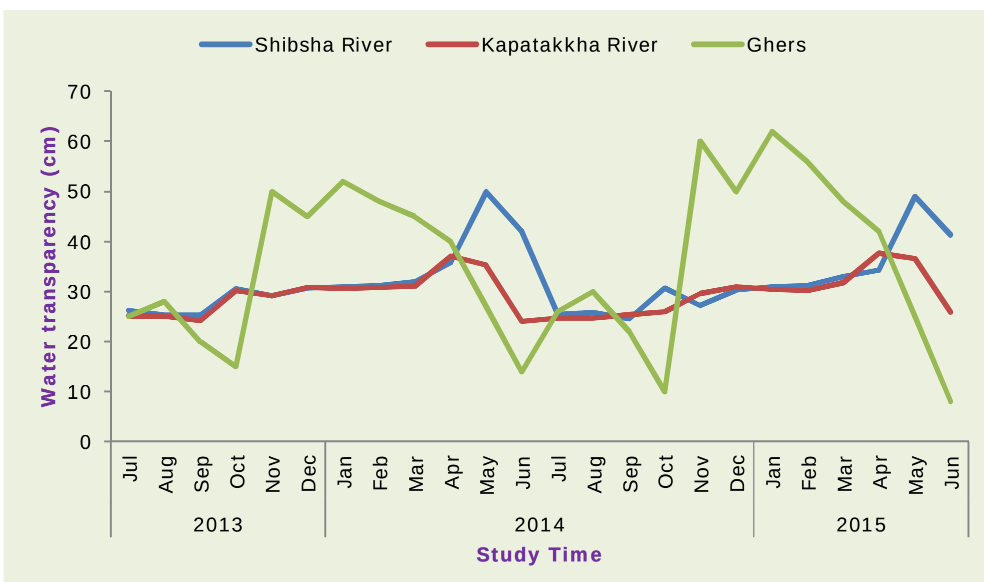

Fig. 3.6: Water transparency studied water bodies

The rainfall level in both the Shibsa river and Kapatakkha river was found same. The highest monthly average rainfall was measured 382mm (in June 2014) and the lowest was 00 cm (November 2013 and 2014, and January 2015) (Fig. 3.7; Appendix Table 3.1 and 3.3). In ghers, the highest monthly rainfall was measured 282mm (in June

2014) and the lowest was 00mm (November 2013 and 2014, and January 2014, 2015) (Fig. 3.7 and Appendix Table 3.5).

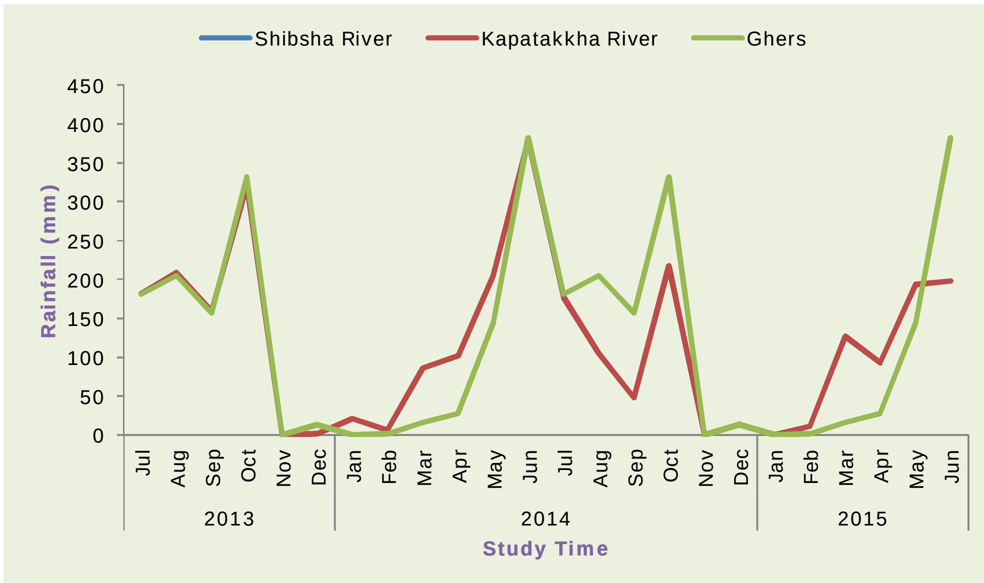

Fig. 3.7: Rainfall level in studied water bodies

In the Shibsa river, the highest monthly average water salinity was measured 19.25±3.66ppt (in June 2015) and the lowest was 4.10±0.06ppt (October 2014) (Fig. 3.8 and Appendix Table 3.2). In the Kapatakkha river the highest water salinity (18.10±0.21ppt) was found in November 2014 and the lowest measurement (08.15±2.65ppt) was recorded in June 2014 (Fig. 3.8 and Appendix Table 3.4). In ghers, the highest monthly average water salinity was measured 18.00±3.61ppt (in January 2015) and the lowest was 04.00±2.18ppt (June 2014) (Fig. 3.8 and Appendix Table 3.6).

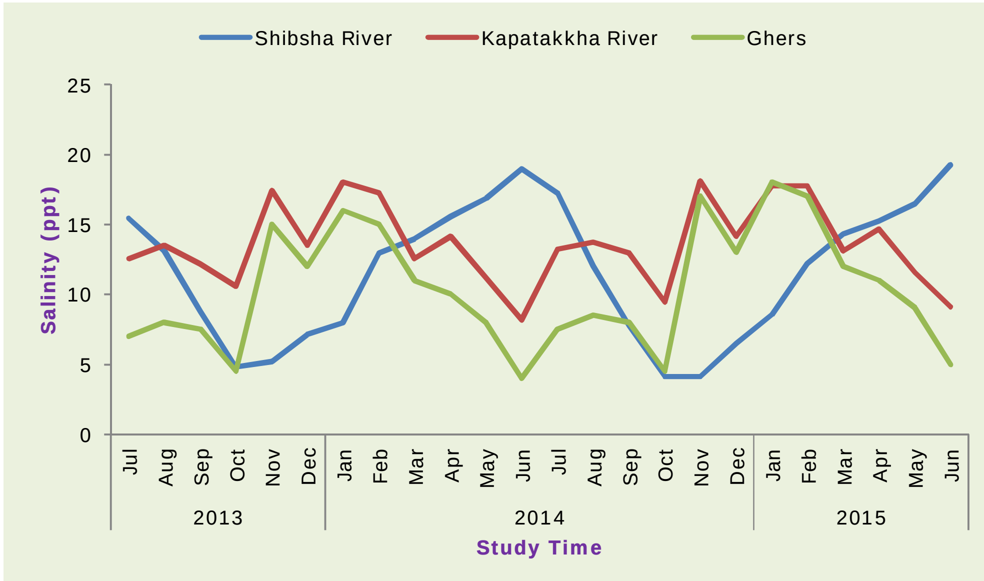

Fig. 3.8: Water salinity level in studied water bodies

3.3.3 p^H

The average monthly pH level in the Shibsa river, Kapatakkha river and ghers are shown in Figure 3.9.

In the Shibsa river, average yearly p^H was calculated 7.58±0.32. The highest p^H values were found 8.26±0.56 in February, 2015. The lowest value was recorded in July 2014 (7.12±0.39) (Fig. 3.9 and Appendix Table 3.2).

In the Kapatakkha river, yearly average p^H was found 7.13±0.35. The highest monthly average p^H (7.61±0.40) was recorded in the month of December 2013, whereas the lowest value was found 6.52±0.21 in June 2014 (Fig. 3.9 and Appendix Table 3.4).

In the ghers (polder area), the highest and lowest p^H values were found 8.00±0.00 (May, 2014) and 6.50±0.50 (July 2013) respectively (Fig. 3.9 and Appendix Table 3.6). Whereas the yearly average p^H was calculated 7.34±0.43.

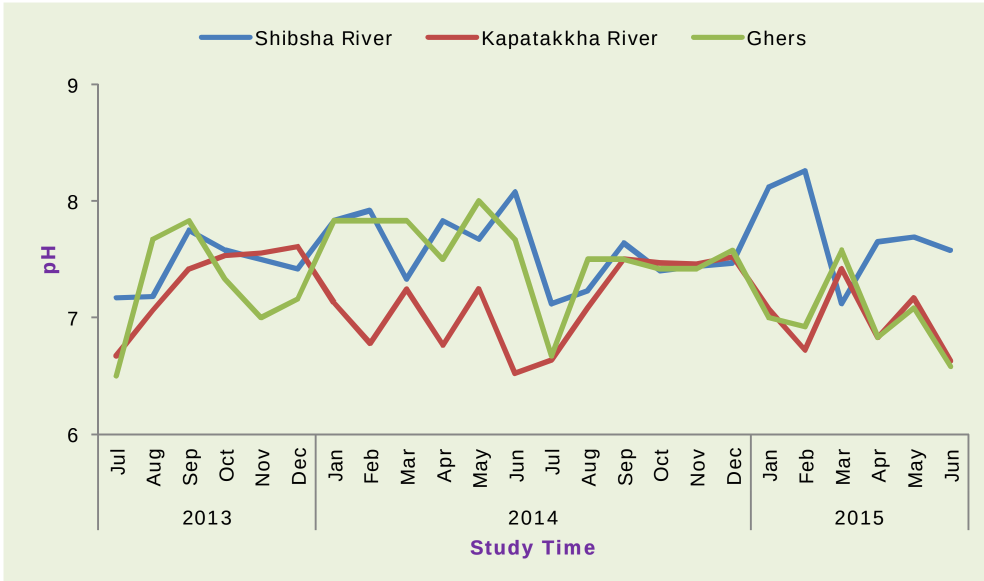

Fig. 3.9: Seasonal variation of p^H level in studied water bodies

3.3.4 Dissolved Oxygen (DO) and Free Carbon Dioxide (CO_2)

The average monthly dissolved oxygen (DO) and free carbon dioxide (CO_2) levels in the Shibsa river, the Kapatakkha river and ghers are shown in Figures 3.10, 3.11 and 3.12 respectively. Comparatively higher DO and lower free CO_2 were found in almost all cases which may be due to presence of water current and turbulence in rivers and presence of gentle water flow in ghers.

In the Shibsa river, the yearly average DO was found as 5.91±0.71 mg/l. The highest monthly average DO (7.78±0.54 mg/l) was recorded in December 2014 and the lowest monthly mean DO (5.08±0.08 mg/l) was found in February 2014 (Fig. 3.10 and Appendix Table 3.2).

Whereas the yearly average free CO_2 was found as 5.53±0.81 mg/l with the highest value (7.58±0.29 mg/l) in the month of August 2014 and the lowest (4.22±0.02 mg/l) in January 2015 (Fig. 3.10 and Appendix Table 3.2).

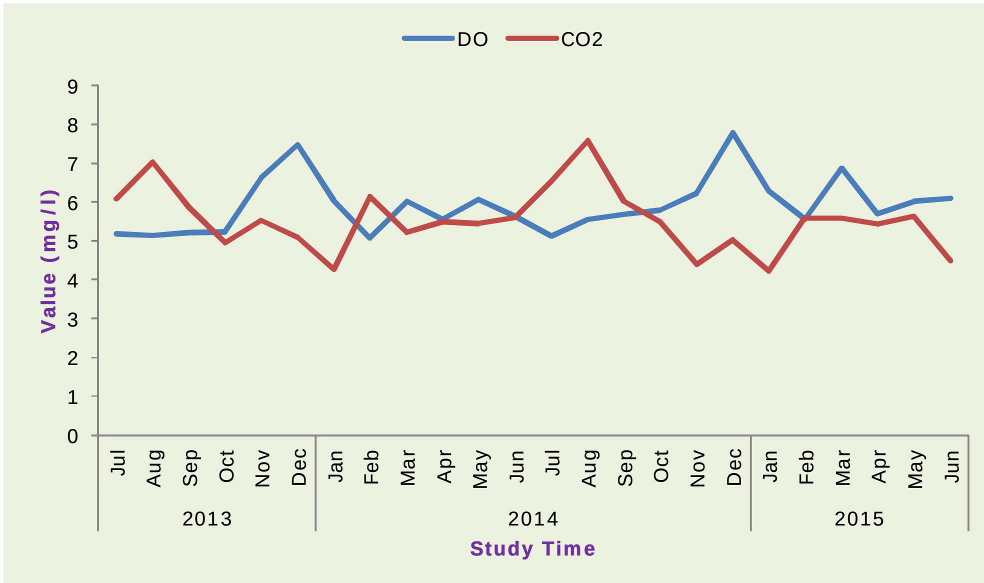

Fig. 3.10: Dissolved oxygen and free carbon dioxide level in the Shibsa river

In the Kapatakkha river, the yearly average DO was found as 5.73±0.51 mg/l. The highest monthly average DO (6.71±0.12 mg/l) was recorded in December 2014 and the lowest monthly mean DO (5.02±0.02 mg/l) was found in July 2014 (Fig. 3.11 and Appendix Table 3.4).

Whereas the yearly average free CO_2 in the Kapatakkha river was found as 5.73±0.51 mg/l with the highest value (6.78±0.08 mg/l) in the month of July 2014 and the lowest (4.10±0.06 mg/l) in May 2015 (Fig. 3.11 and Appendix Table 3.4).

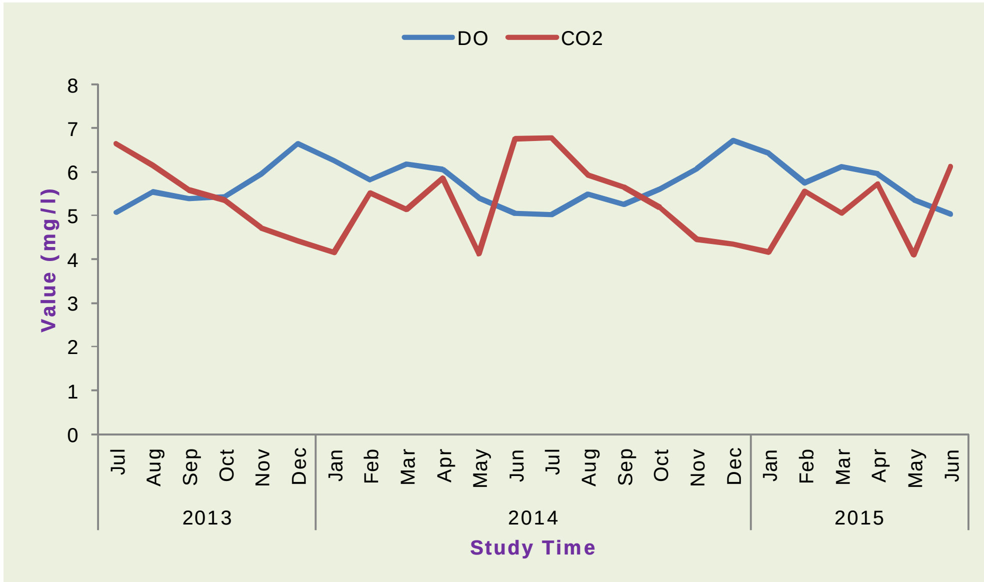

Fig. 3.11: Dissolved oxygen and free carbon dioxide level in the Kapatakkha river

In the ghers, the yearly average DO was found as 5.55±0.52 mg/l. The highest monthly average DO (6.71±0.02 mg/l) was recorded in December 2014 and the lowest monthly mean DO (4.51±0.57 mg/l) was found in October 2013 (Fig. 3.12 and Appendix Table 3.6).

Whereas the yearly average free CO_2 was found as 5.23±0.88 mg/l with the highest value (6.85±0.52 mg/l) in the month of October 2013 and the lowest (4.12±0.03 mg/l) in September 2013 (Fig. 3.12 and Appendix Table 3.6).

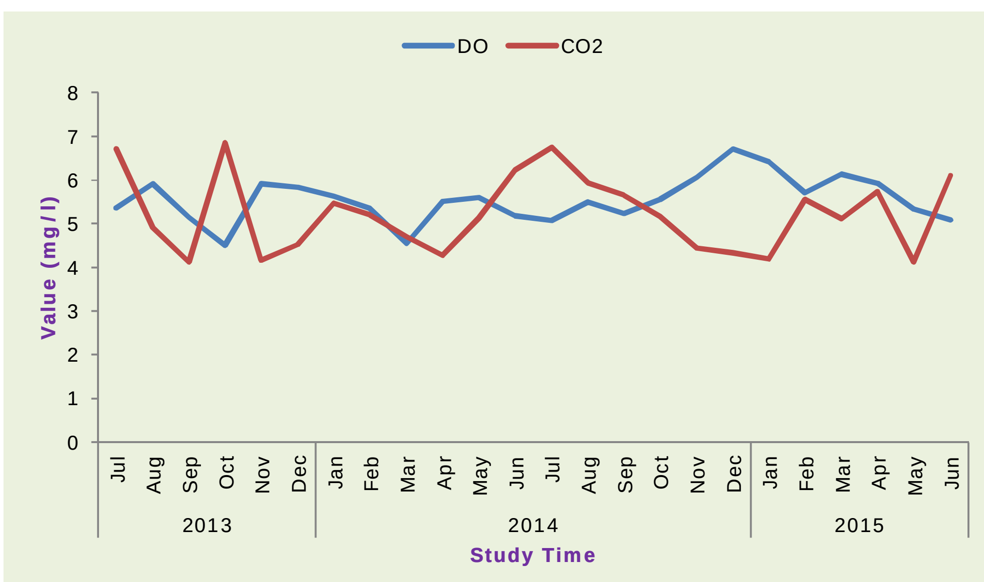

Fig. 3.12: Dissolved oxygen and free carbon dioxide level in the ghers (polder area)

3.4 Discussion

3.4.1 Air and Water Temperature

In the Shibsa river, the highest average air temperature (33.24±4.78°C) was recorded in the month of September 2013; whereas, the lowest air temperature (20.43±5.89°C) was recorded in December 2013 (Fig. 3.3 and Appendix Table 3.1). In case of water temperature, the highest measurement (32.18±3.12°C) was found in September 2013 and the lowest value (19.32±5.89°C) was recorded in December 2013 (Fig. 3.3 and Appendix Table 3.1). The overall mean air and water temperatures were found 28.71±4.03°C and 27.52±3.99°C respectively. In the Kapatakkha river, the highest mean air temperature (33.60±0.29°C) was recorded in the month of September 2013; whereas, the lowest air temperature (21.65±0.25°C) was recorded in December 2014 (Fig. 3.4 and Appendix Table 3.3). In case of water temperature, the highest measurement (32.25±0.29°C) was found in September 2013 and the lowest value (20.32±0.29°C) was recorded in December 2014 (Fig. 3.4 and Appendix Table 3.3). The overall mean air and water temperatures were found 28.69±3.91°C and 27.66±4.06°C respectively. In gher, the highest average air temperature was recorded in the month of September 2014 (32.83±0.29^{0}C); whereas, the lowest air temperature (21.67±0.29^{0}C) was recorded in December 2014 (Fig. 3.5 and Appendix Table 3.5). In case of water temperature, the highest measurement (31.83±0.29^{0}C) was found in September 2014 and the lowest value (20.00±0.50^{0}C) was recorded in December 2014 (Fig. 3.5 and Appendix Table 3.5). The overall mean air and water temperatures were found 29.03±3.45°C and 27.70±3.50°C respectively.

Rahman and Das (2001) recorded an average air temperature of 27.00±4.65^{0}C in the Rajdhala Beel and Padmai Beel of Netrakona district of Bangladesh. They also recorded mean water temperature of 26.13±4.13^{0}C (Rajdhala Beel) and 25.57±5.20^{0}C (Padmai Beel).

Saha and Hussain (2002) recorded the minimum (19.25±0.25^{0}C) and maximum (31.00±0.50^{0}C) water temperatures in January and August respectively which are more or less similar to the present findings. They also mentioned sunshine and rain as the causes of temperature fluctuation. Ahmed *et al.* (2004) recorded remarkable fluctuation in air temperature (ranges from 22.0^{0}C to 34.0^{0}C) with a mean value of 29.8±4.60^{0}C while working on a beel of Brahmanbaria district of Bangladesh. They also reported an average water temperature of 28.5±3.90^{0}C with maximum 32^{0}C and minimum 21.0^{0}C from the same water body.

Rahman *et al.* (2006) reported variation of average water temperature from 26.33±0.47^{0}C to 29.50±0.41^{0}C in Rajdhala beel in which the highest temperature was recorded in July and the lowest in November.

In a study by Hossain *et al.* (2013), they have reported that water temperature vary from 15.4±0.1°C in January to 32.3±0.26°C in June. The highest temperature is similar to the preset findings but the lowest temperature reported by Hossain *et al.* (2013) is much lower than that of present results.

Chaki *et al.* (2014) recorded the highest air temperature of 33.15±0.87°C in the month of August in the Atrai river. Whereas, the lowest air temperature was reported 17.20±3.53°C by them in the same water body. The water temperature was also recorded by them and the highest and lowest water temperature were recorded in the month of October (30.90±0.50°C) and December (17.20±2.27°C) respectively.

3.4.2 Rainfall, Water Transparency and Salinity

In the Shibsa river, the highest monthly average water transparency was measured 49.95±0.50cm (in May 2014) and the lowest was 24.50±0.32cm (September 2014) (Fig. 3.6 and Appendix Table 3.1). In the Kapatakkha river the highest water transparency (37.65±.18cm) was found in April 2015 and the lowest measurement (24.10±.13cm) was recorded in June 2014 (Fig. 3.6 and Appendix Table 3.3). In ghers, the highest monthly average water transparency was measured 62.00±2.65cm (in January 2015) and the lowest was 08.00±2.00cm (June 2015) (Fig. 3.6 and Appendix Table 3.5).

The rainfall level in both the Shibsa river and Kapatakkha river was found same. The highest monthly average rainfall was measured 382mm (in June 2014) and the lowest was 00cm (November 2013 and 2014, and January 2015) (Fig. 3.7; Appendix Table 3.1 and 3.3). In ghers, the highest monthly rainfall was measured 282mm (in June 2014) and the lowest was 00mm (November 2013 and 2014, and January 2014, 2015) (Fig. 3.7 and Appendix Table 3.5).

In the Shibsa river, the highest monthly average water salinity was measured 19.25±3.66ppt (in June 2015) and the lowest was 4.10±0.06ppt (October 2014) (Fig. 3.8 and Appendix Table 3.2). In the Kapatakkha river the highest water salinity (18.10±0.21ppt) was found in November 2014 and the lowest measurement (08.15±2.65ppt) was recorded in June 2014 (Fig. 3.8 and Appendix Table 3.4). In ghers, the highest monthly average water salinity was measured 18.00±3.61ppt (in

January 2015) and the lowest was 04.00±2.18ppt (June 2014) (Fig. 3.8 and Appendix Table 3.6).

Boyd (1982) recommended a transparency between 15 and 40 cm as appropriate for fish culture. In another study by Hossain *et al.* (2013), the lowest amount of transparency varied from 17±2.65 cm in June to 24±2.65 cm in January.

Chaki *et al.* (2014) found that water transparency changed in course of time. In their study, the highest transparency was found 36.40±3.52 cm in September and the lowest value of water transparency was recorded 14.90±3.42 cm in January.

3.4.3 p^H

In the Shibsa river, average yearly p^H was calculated 7.58±0.32. The highest p^H values were found 8.26±0.56 in February, 2015. The lowest value was recorded in July 2014 (7.12±0.39) (Fig. 3.9 and Appendix Table 3.2). In the Kapatakkha river, yearly average p^H was found 7.13±0.35. The highest monthly average p^H (7.61±0.40) was recorded in the month of December 2013, whereas the lowest value was found 6.52±0.21 in June 2014 (Fig. 3.9 and Appendix Table 3.4). In the gher (polder area), the highest and lowest p^H values were found 8.00±0.00 (May, 2014) and 6.50±0.50 (July 2013) respectively (Fig. 3.9 and Appendix Table 3.6). Whereas the yearly average p^H was calculated 7.34±0.43.

Rahman and Das (2001) reported an average p^H of 7.73±0.35 in Rajdhala beel and 7.65±0.28 in Padmai beel of Netrakona district.

Saha and Hussain (2002) reported the minimum (7.18±0.03) and maximum (8.45±0.05) p^H in the month of May and April respectively recorded from a beel of Tangail district, Bangladesh.

Ahmed *et al.* (2004) also reported somewhat alkaline p^H level (7.3 to 8.5) in the water of a beel of Brahmanbaria district.

Rahman *et al.* (2006) found p^H range from 7.55±0.40 to 8.03±0.07 with the highest in June and the lowest in October.

Chaki *et al.* (2014) recorded the highest pH of 8.10±0.29 in December and the lowest pH was found 6.75±0.22 in March in the Atrai River of Bangladesh.

3.4.4 Dissolved Oxygen (DO) and Free Carbon Dioxide (CO_2)

In the Shibsa river, the yearly average DO was found as 5.91±0.71 mg/l. The highest monthly average DO (7.78±0.54 mg/l) was recorded in December 2014 and the lowest monthly mean DO (5.08±0.08 mg/l) was found in February 2014 (Fig. 3.10 and Appendix Table 3.2). Whereas the yearly average free CO_2 was found as 5.53±0.81 mg/l with the highest value (7.58±0.29 mg/l) in the month of August 2014 and the lowest (4.22±0.02 mg/l) in January 2015 (Fig. 3.10 and Appendix Table 3.2).

In the Kapatakkha river, the yearly average DO was found as 5.73±0.51 mg/l. The highest monthly average DO (6.71±0.12 mg/l) was recorded in December 2014 and the lowest monthly mean DO (5.02±0.02 mg/l) was found in July 2014 (Fig. 3.11 and Appendix Table 3.4). Whereas the yearly average free CO_2 in the Kapatakkha river was found as 5.73±0.51 mg/l with the highest value (6.78±0.08 mg/l) in the month of July 2014 and the lowest (4.10±0.06 mg/l) in May 2015 (Fig. 3.11 and Appendix Table 3.4).

In the gher, the yearly average DO was found as 5.55±0.52 mg/l. The highest monthly average DO (6.71±0.02 mg/l) was recorded in December 2014 and the lowest monthly mean DO (4.51±0.57 mg/l) was found in October 2013 (Fig. 3.12 and Appendix Table 3.6). Whereas the yearly average free CO_2 was found as 5.23±0.88 mg/l with the highest value (6.85±0.52 mg/l) in the month of October 2013 and the lowest (4.12±0.03 mg/l) in September 2013 (Fig. 3.12 and Appendix Table 3.6).

The higher concentration of dissolved oxygen was reported in post-monsoon period by Ahmed *et al.* (2004) who have worked on a beel in the Brahmanbaria district and recorded an average DO as 7.30±1.60 ml/l with maximum 8.9 mg/l and minimum 4.5 mg/l. These scientists also reported wide fluctuation in free carbon dioxide level which was found to be varied from 0.8-16.3 mg/l with an average value of 9.6±6.7 mg/l.

Rahman and Das (2001) recorded mean DO level as 7.30±0.21 mg/l in Rajdhala Beel and 5.93±0.19 in Padmai Beel; whereas the average free CO_2 levels were 5.14±0.61 mg/l in Rajdhala Beel and 5.18±0.19 mg/l in Padmai Beel.

An irregular pattern of fluctuation of DO was reported by Rahman *et al.* (2006) who have recorded the highest average DO value (8.26±1.01 mg/l) in July and the lowest mean value (6.95±0.20 mg/l) in September from a beel of northeastern part of Bangladesh.

In a study in the Atrai River by Chaki *et al.* (2014), dissolved oxygen level reached its peak (9.57±0.56 mg/l) in the month of September and downed to the lowest level (4.83±0.29 mg/l) in January. The lowest free CO_2 was recorded13.10±0.98 mg/l in August and the highest value (16.30±1.82 mg/l) was recorded in May.

Chapter Four

Food and Feeding of *Lates calcarifer*

FOOD AND FEEDING HABIT

4.1 Introduction

Food and feeding habit of fish are important biological factors for selecting a group of fish for culture in ponds to avoid competition for food among themselves and live in association and to utilize all the available food (Dewan and Saha, 1979). It is virtually impossible together sufficient information of the food and feeding habit of fish in their natural habitat without studying its gut contents. A thorough knowledge on the food and feeding habit of fishes provide keys for the selection of culturable species and the importance of much information is necessary for successful fish farming. Feeding is the dominant activity of the entire life cycle of fish. The success of good scientific planning and management of various fish species largely depends on the knowledge of their biological aspects in which food and feeding habits include a valuable portion.

The food habits 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. Every animal requires energy for living for growth, maintenance and reproduction which it must obtain from its food. Each starts life with a bit of food received from the parents, it soon needs to feed itself. It must continue it feed itself regularly with suitable food or die. Studies on the food and feeding of different fishes have been made by many workers home and abroad like Hynes (1950), Karim and Hossain (1972), Doha (1974), Dewan and Saha (1979), Bhuiyan and Islam (1991), Bhuiyan *et al.*, (1997, 1998), Kamruzzaman *et al.* (2013), Mushahida-Al-Noor *et al.* (2012) and many others.

Jhingran (1983) stated that the natural foods of fishes are classified under three groups: (i) main food, (ii) Occasional food, and (iii) Emergency food. Khanna (1978) reported that the natural food of fishes can be divided into (a) main or basic food, Which is natural food consumed by fish under favourable 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 other items and (d) Emergency or obligatory food, which is ingested in the absence of basic food and on which the fish is able to survive. The stimuli to food are of two kinds: (a) factors affecting the internal motivation or drive for feeding, including season, time of day, light intensity, lime and nature of last feeding, temperature and internal rhythm that may exists; (b) food stimuli received by the sense like smell, taste, sight and the lateral line system that release and control the momentary feeding act. The interaction of these two groups of factors determines when and how a fish will feed and what it will feed upon.

To manage fish population efficiently there is a need for an understanding of interspecific competition among the different species of fishes *Lates calcarifer* is cultured in brakish water (like river, gher etc) in our country. Although it is a large size fish, it is already being cultivated in the country singly as well as along with prawn. This fish grows very fast and is prone to artificial feeds. So, the study of food and feeding habit immense ecological values, because by studying the food and feeding habit the pattern of interspecific competition of fishes can easily be known.

The knowledge of food and feeding habit helps to select such species of fish for culture and produce an optimum yield by utilizing all the available potential food of the water bodies without any competition. No work on the food and feeding habit of this fish is available. The present study deals with the food and feeding habit of *Lates calcarifer*.

The present work has been conducted with a view to gaining some information on the following aspects such as:

- To know the food and feeding habit of *Lates calcarifer*
- To observe the stomach contents and the relationship between total length and alimentary canal length
- To find out the monthly variation in the degree of feeding.

4.2 Materials and Methods

To study the food and feeding habit of *Lates calcarifer* a total of 300 (25 in every month) specimens were collected from local markets, rivers and ghers (polder area) in Khulna during the period from July 2014 to June 2015. The experiment of estimation of food and feeding habit was done from July 2014 to June 2015. The specimens were collected randomly once in every month (Fig. 4.1). The specimens were preserved in 10% formalin solution in order to stop digestion of food items. Out of 300 specimens, 120 juveniles (15-25cm total length) and 180 adult (more than 25cm) fishes were used in the food analysis.

Firstly collected specimens were dissected. Then contents of the stomach of all the specimens were detected and the stomach were visually classified into full, ¾ full, ½ full, ¼ full, ¼ full and empty. Food items were dissected out from the guts, individual item separated in petridish and indentified with help of a simple and compound microscopes. The undigested food items were sorted into the different taxonomic groups. Gravimetric method (Hynes, 1950; Pillay, 1954) was followed for estimation of the percentage composition of different food items. For the identification of smaller food organisms Ward and Whipple (1959) were consulted.

Mathematical relationship between the total length (TL) of the fish and the alimentary canal length (ACL) of the different stages such as juvenile and adult were established by using the statistical formula:

$y = a + bx$ was followed

where, y = Alimentary canal length (ACL)

x = Total length (TL)

“a” is the interception on the ordinate

and “b” is the regression co-efficient.

Fig. 4.1: Collected fish specimens of different sizes for studying food and feeding.

Fig. 4.2: Measuring total length of a specimen.

Fig. 4.3: Weighting of a specimen before dissection.

4.3 Results and Observation

The stomach contents of 300 specimens of *Lates calcarifer* (120 juvenile and 180 adult specimens) were examined. For analyses of the food and feeding habit of *L. calcarifer*, an investigation on the basis of following headlines was undertaken.

4.3.1 Food of Juvenile *Lates calcarifer*

The food analyses of 120 specimens (15-25cm in total length) of juvenile *L. calcarifer* were dissected and examined. The specimens were collected between July 2014 and June 2015 (10 in each research month) from the fishermen of the Shibsa river and the Kapatakkha river and ghers (polder area) owners of research site *i.e.* Khulna district.

The month-wise status of stomachs (either it is empty or filled with food items) of 120 juvenile are shown in the Table 4.1. Empty stomach or stomachs with poor food contents were found also rare. Maximum 20% of the observed specimen's stomachs were found empty in the month of December 2014 (Table 4.1). Whereas, 10% stomachs were found empty in October and November 2014; and January and February 2015 (Table 4.1).

Monthly variation in the degree of feeding of juvenile *Lates calcarifer*

All fishes do not feed in the same intensity. The feeding intensity as well as the feeding condition vary from individuals to individuals. There is seasonal variation in the degree of feeding too. For the determination of the condition of feed or the degree of feeding of juvenile *Lates calcarifer*, all the stomachs examined were classified as full, ¾ full, ½ full, ¼ full, 1/8 full and empty by visual estimation depending on the distension or fullness of the stomachs. The total number of stomachs examined in each month, the actual number and percentage occurrence of stomachs under each category was classified and presented in Fig. 4.5 and Appendix Table 4.1.

Table 4.1: Percentage of the empty stomachs of the juvenile *Lates calcarifer* (15-25cm in total length)

Year	*Month*	*Observed stomachs*	*Stomach with food*	*Empty stomach*	*Percentages of empty stomach*
2014	Jul	10	10	00	00
	Aug	10	10	00	00
	Sep	10	10	00	00
	Oct	10	09	01	10
	Nov	10	09	01	10
	Dec	10	08	02	20
2015	Jan	10	09	01	10
	Feb	10	09	01	10
	Mar	10	10	00	00
	Apr	10	10	00	00
	May	10	10	00	00
	Jun	10	10	00	00

Out of 120 stomachs of juvenile *Lates calcarifer* collected in different months over the study duration, maximum 26.67% stomachs were found as ½ full followed by full (25%), ¾ full (17.50%), 1/3 full (15%), ¼ full (8.33%), empty (4.17%) and 1/8 full (3.33%) stomachs (Fig. 4.5 and Appendix Table 4.1).

Fishes with full, ¾ full, ½ full and 1/3 full stomachs were considered to be actively fed, while fishes with ¼ full, 1/8 full and empty stomachs were considered to be poorly fed. The feeding activities *i.e.* the percentage of fullness and emptiness of the stomachs of juvenile *Lates calcarifer* are shown in Appendix Table 4.2.

The feeding intensity *i.e.* the percentage of fullness of the stomachs was found the highest (100%) in July and September 2014 and June 2015 whereas, the lowest (50%) was found in the month of December 2014 (Appendix Table 4.2).

On the other hand, the maximum emptiness (50%) was found in the month of December 2014 and the lowest was found in July and September 2014 and June 2015 (Appendix Table 4.2).

From the above investigation, in the month of July and September 2014 and June 2014 there were higher feeding intensities and the month of December 2014 there was the weak feeding intensities (Appendix Table 4.2).

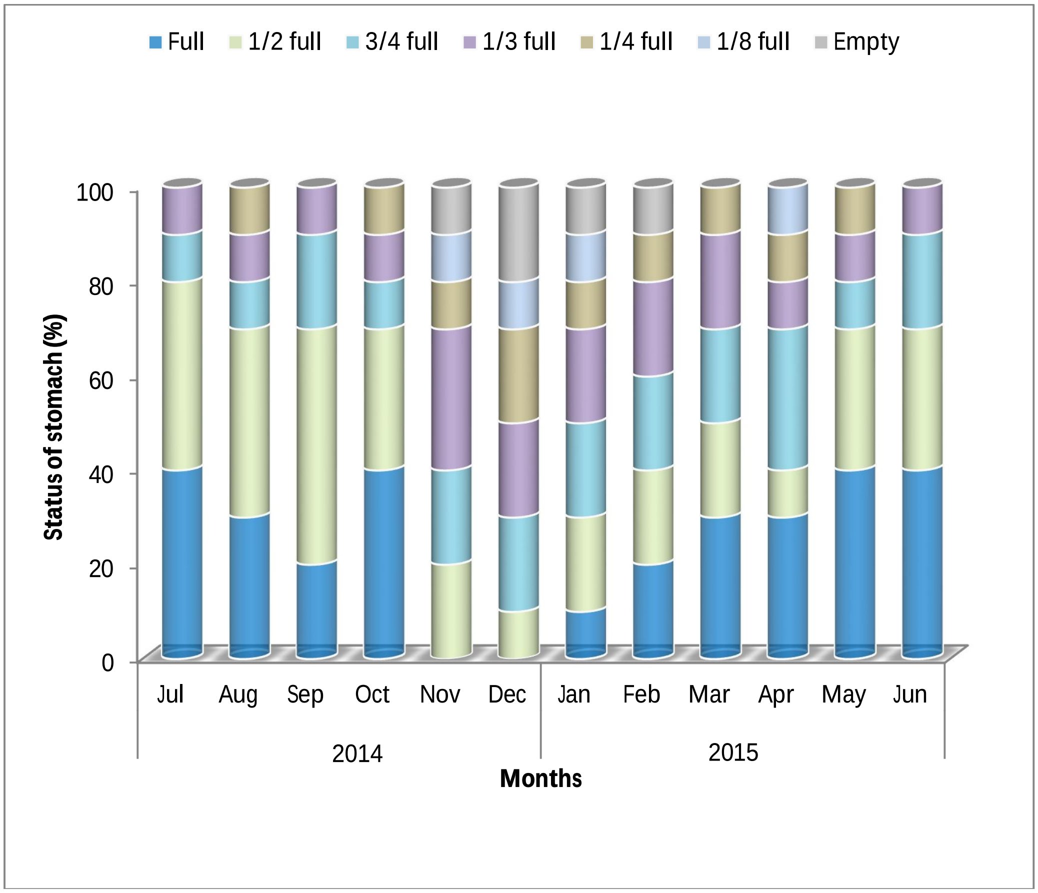

Fig. 4.4: Month-wise status of stomach contents of juvenile *Lates calcarifer* during the period of research.

Food composition of juvenile *Lates calcarifer*

The percentages of various groups of food items in the stomachs of juvenile *Lates calcarifer* are shown in Fig. 4.6 and 4.7 and Appendix Table 4.3. Foods of juvenile *L. calcarifer* were grouped under the following categories- algae or phytoplankton, zooplankton (protozoans and small crustaceans), large crustaceans, insects, teleosts and unidentified food materials (Fig. 4.6 and 4.7 and Appendix Table 4.3). The following food organisms were identified from 120 stomachs contents of juvenile *Lates calcarifer* (15-25cm in total length):

a. Algae / Phytoplankton
b. Zooplankton (protozoans and small crustaceans)
c. Large crustaceans
d. Insects
e. Teleosts
f. Unidentified food materials

a. *Algae / Phytoplankton*

The average percentage composition of algae or phytoplankton in the stomachs of juvenile *Lates calcarifer* was found 7.69±2.20% (Table 4.2 and Appendix Table 4.3). The highest percentage (12%) was detected in the month of March 2011 and the lowest percentage (4.5%) was found in July 2014 (Appendix Table 4.3). This group of food is composed of *Coscinodiscus* spp. and phytoplankton species of Bacillariophyceae (Table 4.2).

b. *Zooplankton (Protozoan and small crustaceans)*

The average percentage composition of zooplankton (protozoan and small crustaceans) in the stomachs of juvenile *Lates calcarifer* was found 19.91±4.37% (Table 4.2 and Appendix Table 4.3). The highest percentage (26.25%) was detected in the month of June 2011 and the lowest percentage (13.5%) was found in December 2010 (Appendix Table 4.3). This group of food is composed of Euglena, Cladocera, Copepoda (calanoid group), shrimp larvae and megalopa larvae of crabs (Table 4.2).

c. *Large crustaceans*

The average percentage composition of large crustaceans in the stomachs of juvenile *Lates calcarifer* was found 26.32±5.76% (Table 4.2 and Appendix Table 4.3). The highest percentage (36%) was detected in the month of October 2014 and the lowest percentage (17.5%) was found in August 2014 (Appendix Table 4.3). This group of food was represented by Decapoda (shrimps and crabs), Stomatopoda and Branchiura (Table 4.2).

d. *Insects*

The average percentage composition of insects in the stomachs of juvenile *Lates calcarifer* was found 09.02±1.79% (Table 4.2 and Appendix Table 4.3). The highest percentage (12%) was detected in the month of February 2015 and the lowest percentage (6.25%) was found in December 2014 (Appendix Table 4.3). This group of food was represented an unidentified group of insects (Table 4.2).

e. *Teleosts*

The average percentage composition of insects in the stomachs of juvenile *Lates calcarifer* was found 33.70±3.40% (Table 4.2 and Appendix Table 4.3). The highest percentage (40.45%) was detected in the month of November 2015 and the lowest percentage (28.75%) was found in September 2014 (Appendix Table 4.3). This group of food was represented *Apocryptes, Jonieops, Otolithoides, Harpodon, Coilia, Polynemus, Pama, Therapon*, *Chanda* and unidentified genus of family Gobiidae (Table 4.2).

f. *Unidentified food materials*

The average percentage composition of insects in the stomachs of juvenile *Lates calcarifer* was found 03.35±0.75% (Table 4.2 and Appendix Table 4.3). The highest percentage (4.35%) was detected in the month of December 2014 and the lowest percentage (2.1%) was found in June 2015 (Appendix Table 4.3).

Table 4.2: Percentage composition and the list of food organisms of the juvenile *Lates calcarifer* (15-25cm TL)

Serial	*Food group*	*Food organisms*	*Percentage*
01	Algae or phytoplankton	*Coscinodiscus*, Bacillariophyceae	6.69
02	Zooplankton (Protozoans and small crustaceans)	*Euglena*, Cladocera (*Daphnia* and some others), Copepoda (calanoid group), shrimp larvae, megalopa larvae of crabs	22.1
03	Large crustaceans	Decapoda (shrimps and crabs), Stomatopoda and Branchiura	26.73
04	Insects	Unidentified group	8.12
05	Teleosts	*Apocryptes, Jonieops, Otolithoides, Harpodon, Coilia, Polynemus, Pama, Therapon, Chanda* and unidentified genus of family Gobiidae	34.2
06	Unidentified food		2.16

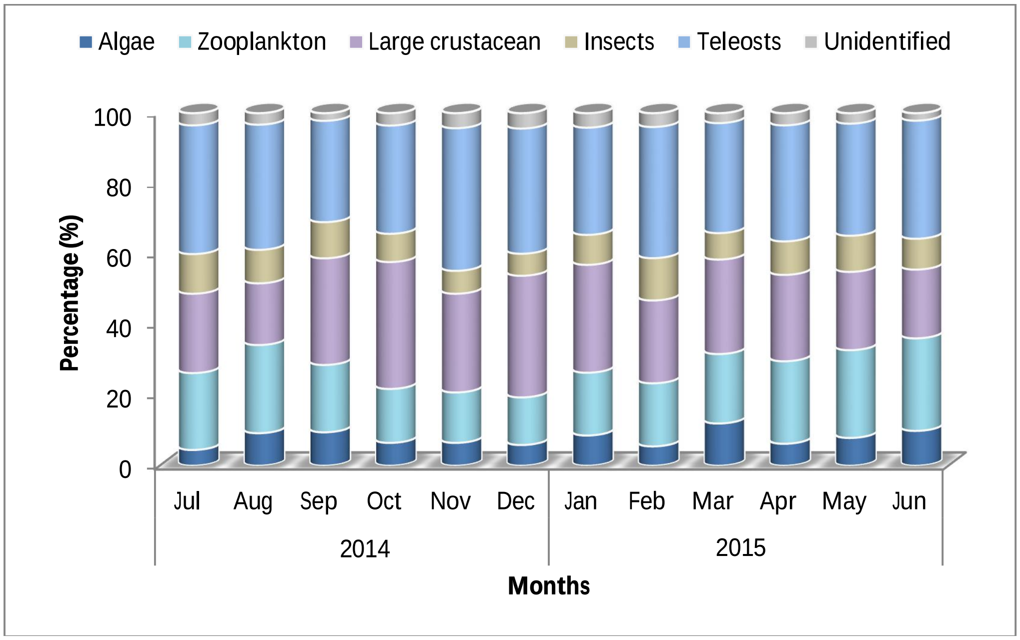

Fig. 4.5: Monthly variation in the percentage composition of different groups of food items of juvenile *Lates calcarifer* during the period of study.

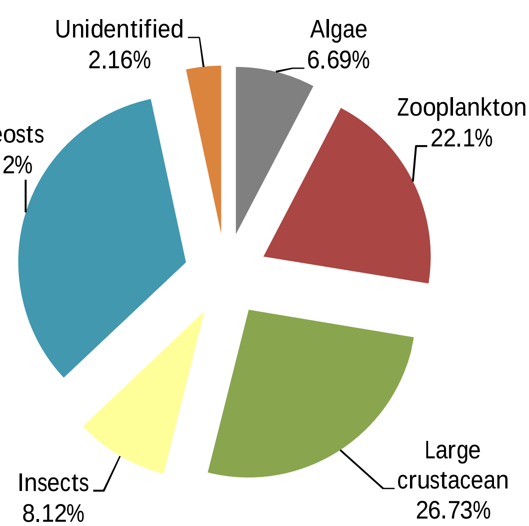

Fig. 4.6: Percentage occurrence (mean) of different food items of juvenile *Lates calcarifer* during the period of research.

4.3.2 Food of Adult *Lates calcarifer*

Monthly variation in the degree of feeding of adult Lates calcarifer

For the determination of the condition of feed or the degree of feeding of adult *Lates calcarifer*, all the stomachs examined were classified same as of juveniles *i.e.* full, ¾ full, ½ full, ¼ full, 1/8 full and empty by visual estimation depending on the distension or fullness of the stomachs. The total number of stomachs examined in each month, the actual number and percentage occurrence of stomachs under each category was classified and presented in Fig. 4.8 and Appendix Table 4.4.

Out of 160 stomachs of adult *Lates calcarifer* (more than 25cm in total length) collected in different months over the study duration, maximum 28.89% stomachs were found as full followed by ¾ full (22.78%), ½ full (20%), empty (11.67%), 1/3 full (9.44%), ¼ full (5%) and 1/8 full (2.22%) stomachs (Fig. 4.8 and Appendix Table 4.4).

Fishes with full, ¾ full, ½ full and 1/3 full stomachs were considered to be actively fed, while fishes with ¼ full, 1/8 full and empty stomachs were considered to be poorly fed. The feeding activities *i.e.* the percentage of fullness and emptiness of the stomachs of adult *Lates calcarifer* are shown in Appendix Table 4.5.

The feeding intensity *i.e.* the percentage of fullness of the stomachs was found the highest (100%) in July 2014 and June 2015 whereas, the lowest (53.33%) was found in the month of December 2014 (Appendix Table 4.5).

On the other hand, the maximum emptiness (46.67%) was found in the month of December 2014 and the lowest was found in July 2014 and June 2015 (Appendix Table 4.5).

From the above investigation, in the month of July 2014 and June 2014 there were higher feeding intensities and the month of December 2014 there was the weak feeding intensities (Appendix Table 4.5).

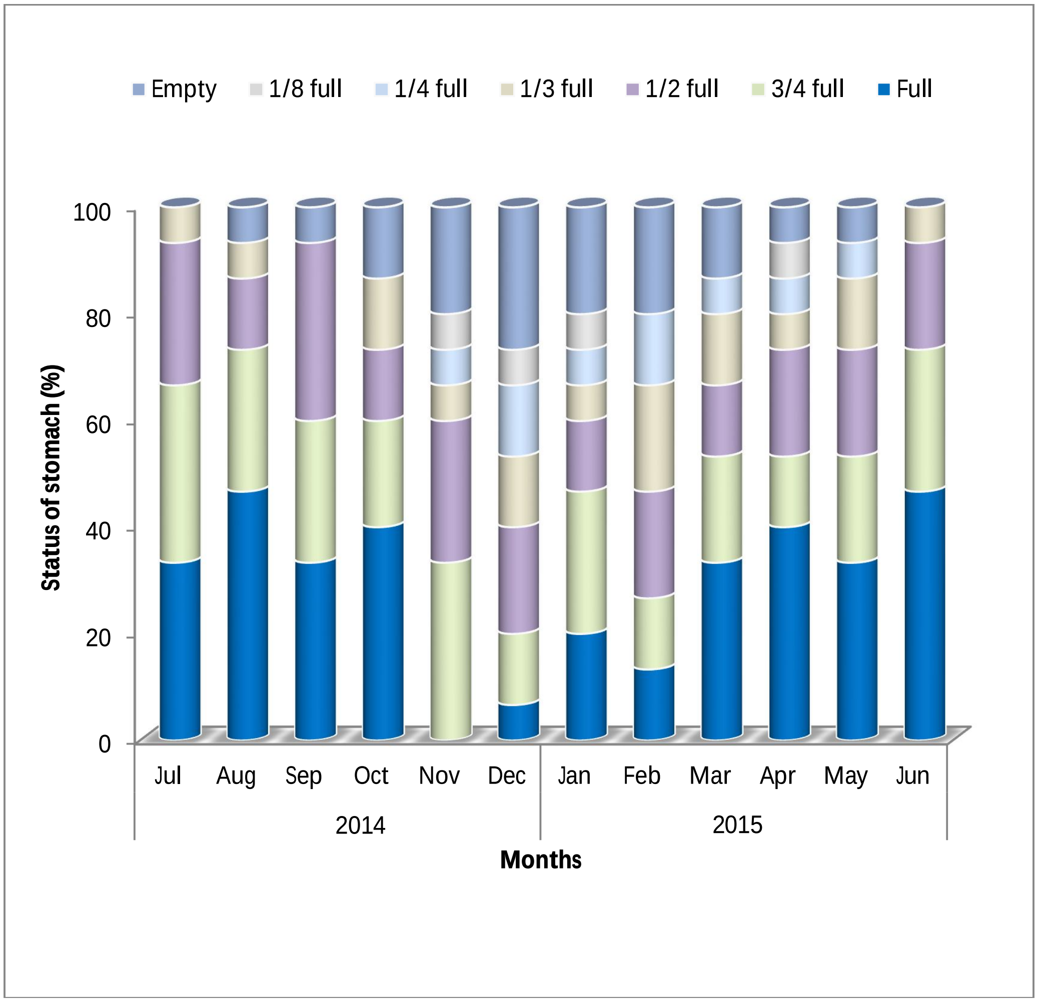

Fig. 4.7: Month-wise status of stomach contents of adult *Lates calcarifer* during the period of research.

Food composition of adult *Lates calcarifer*

The percentages of various groups of food items in the stomachs of juveniles *Lates calcarifer* is shown in Fig. 4.9 and 4.10 and Appendix Table 4.6. Foods of juvenile *L. calcarifer* were grouped under the same categories like juvenile *L. calcarifer* (Fig. 4.9 and 4.10 and Appendix Table 4.6). The following food organisms were identified from 180 stomachs contents of juvenile *Lates calcarifer* (more than 25cm in total length):

a. *Algae/Phytoplankton*

The average percentage composition of algae or phytoplankton in the stomachs of adult *Lates calcarifer* was found 04.55±0.94% (Table 4.3 and Appendix Table 4.6). The highest percentage (6.25%) was detected in the month of October 2014 and the lowest percentage (3.5%) was found in July, December 2014 and February, April 2015 (Appendix Table 4.6). This group of food is composed of *Coscinodiscus* and phytoplankton species of Bacillariophyceae (Table 4.3).

b. *Zooplankton (Protozoan and small crustaceans)*

The average percentage composition of zooplankton (protozoan and small crustaceans) in the stomachs of adult *Lates calcarifer* was found 17.41±3.04% (Table 4.3 and Appendix Table 4.6). The highest percentage (24.40%) was detected in the month of August 2014 and the lowest percentage (14.5%) was found in December 2014 (Appendix Table 4.6). This group of food is composed of *Euglena*, Cladocera, Copepoda (calanoid group), shrimp larvae and megalopa larvae of crabs (Table 4.3).

c. *Large crustaceans*

The average percentage composition of large crustaceans in the stomachs of adult *Lates calcarifer* was found 27.88±5.48% (Table 4.3 and Appendix Table 4.6). The highest percentage (34.80%) was detected in the month of October 2014 and the lowest percentage (15.5%) was found in August 2014 (Appendix Table 4.6). This group of foods was represented by Decapoda (shrimps: *Macrobrachium rosenbergii*, *Penaeus monodon*; *Metapenaeus monoceros*, an unidentified species and crabs: *Caphyra* and *Grapsus*), Stomatopoda and Branchiura (Table 4.3).

d. *Insects*

The average percentage composition of insects in the stomachs of adult *Lates calcarifer* was found 09.83±1.51% (Table 4.3 and Appendix Table 4.6). The highest percentage (12.5%) was detected in the month of May 2015 and the lowest percentage (7%) was found in November 2014 (Appendix Table 4.6). This group of food was represented an unidentified group of insects (Table 4.3).

e. *Teleosts*

The average percentage composition of insects in the stomachs of adult *Lates calcarifer* was found 35.98±3.06% (Table 4.3 and Appendix Table 4.6). The highest percentage (40%) was detected in the month of August 2014 and the lowest percentage (29.5%) was found in September 2014 (Appendix Table 4.6). This group of food was represented *Apocryptes lanceolatus, Jonieops, Otolithoides, Harpodon, Coilia dussumieri, Polynemus paradiseus, Pama pama, Therapon jarbua, Chanda* *nama, Lactarius lactarias, Setipinna taty*, an unidentified genus of family Gobiidae and an unidentified genus of family Mugilidae (Table 4.3).

f. *Unidentified food materials*

The average percentage composition of insects in the stomachs of adult *Lates calcarifer* was found 04.34±3.06% (Table 4.3 and Appendix Table 4.6). The highest percentage (5.80%) was detected in the month of February 2015 and the lowest percentage (2.4%) was found in September 2014 (Appendix Table 4.6).

Table 4.3: Percentage composition and the list of food organisms of the adult *Lates calcarifer* (more than 25cm TL)

Serial	*Food group*	*Food organisms*	*Percentage*
01	Algae or phytoplankton	*Coscinodiscus*, Bacillariophyceae	5.12
02	Zooplankton (Protozoans and small crustaceans)	*Euglena*, Cladocera (*Daphnia* and some others), Copepoda (calanoid group), shrimp larvae, megalopa larvae of crabs	16.17
03	Large crustaceans	Decapoda (shrimps: *Macrobrachium rosenbergii*, *Penaeus monodon*; *Metapenaeus monoceros*, an unidentified species and crabs: *Caphyra* and *Grapsus*), Stomatopoda and Branchiura	28.77
04	Insects	Unidentified group	9.11
05	Teleosts	*Apocryptes lanceolatus, Jonieops, Otolithoides, Harpodon, Coilia dussumieri, Polynemus paradiseus, Pama pama, Therapon jarbua, Chanda nama, Lactarius lactarias, Setipinna taty*, an unidentified genus of family Gobiidae and an unidentified genus of family Mugilidae	34.99
06	Unidentified food		5.84

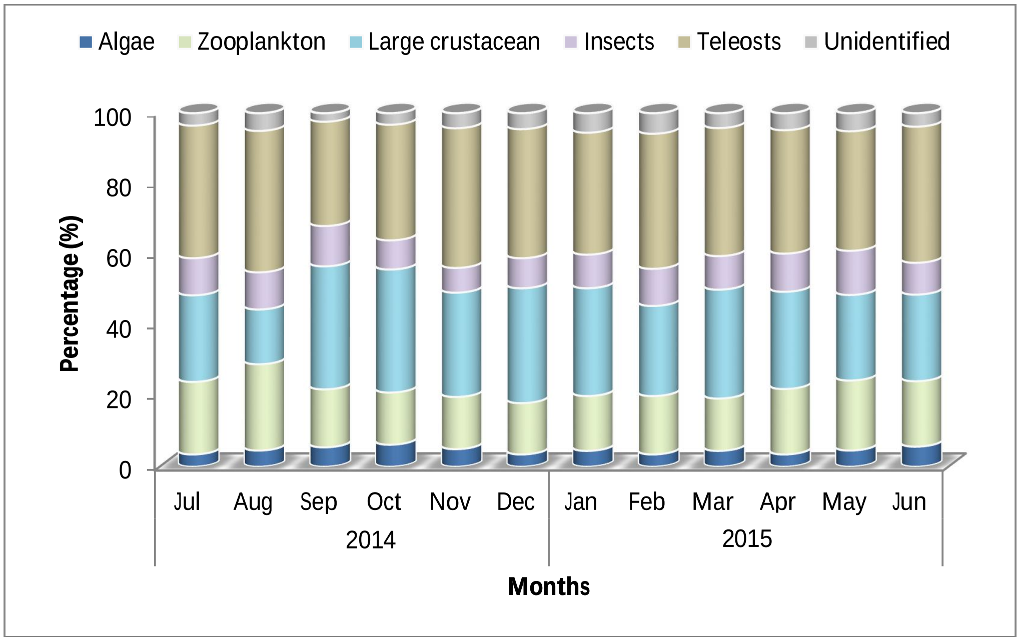

Fig. 4.8: Monthly variation in the percentage composition of different groups of food items of adult *Lates calcarifer* during the period of study.

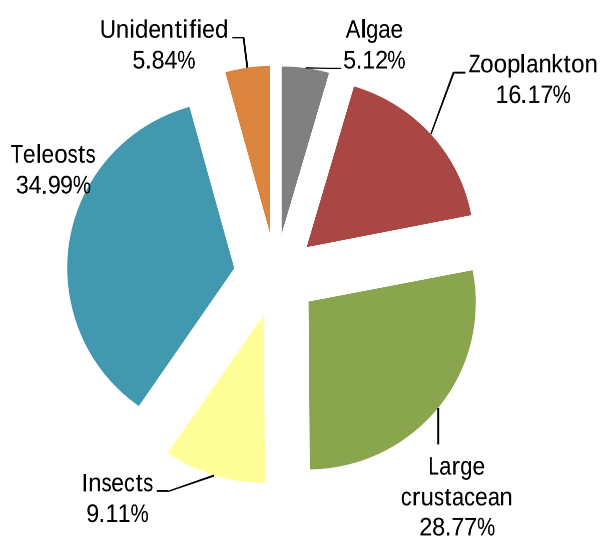

Fig. 4.9: Percentage occurrence (mean) of different food items of adult *Lates calcarifer* during the period of research.

4.3.3 Feeding Habits

From the present findings it is noted that the food and feeding habits of *Lates calcarifer* has almost the same in both juvenile and adult stages. In the juvenile stage (15-25cm TL) the food of *L. calcarifer* consists of algae or phytoplankton (6.69%), zooplankton (22.10%), large crustaceans (26.73%), insects (8.12%), teleosts (34.2%) and unidentified food materials (2.16%).

Whereas in the adult stage (more than 25cm TL) the food of *L. calcarifer* consists of algae or phytoplankton (5.12%), zooplankton (16.17%), large crustaceans (28.77%), insects (9.11%), teleosts (34.99%) and unidentified food materials (5.84%).

From the above findings, it was very much clear that amount of foods ingested by both juvenile and adult *L. calcarifer* were mainly composed of animals rather than plants. So the concerned fish species was obviously a carnivore fish species.

4.3.4 Total Length (TL) and Alimentary Canal Length (ACL) Ratio

The ratio of the total length (TL) and alimentary canal length (ACL) of the juvenile and adult stages of *Lates calcarifer* is shown in Table 4.4, Fig. 4.11 and 4.12. Almost same ratio between alimentary canal length and total length was found in case of juvenile (1:0.62) and adult specimens (1:0.63) (Table 4.4). Positive relationship was observed in maximum cases between body length and alimentary canal length *i.e.* length of alimentary canal is increased with total length of the body. The present investigation reveals that since the juvenile and adult *Lates calcarifer* feed primarily on other aquatic animals.

4.3.5 Relationship Between Total Length (TL) and Alimentary Canal Length (ACL)

The relationship of the total length (TL) and alimentary canal length (ACL) of the juveniles and adults stages of *Lates calcarifer* were established. To establish the relationship between the above parameters, the values of intercepts (a), regression co-efficient (b) and co-efficient of correlation (r) the statistical formula $y = a + bx$ was followed and the results are given in Table 4.4 and Fig. 4.11 and 4.12. The relationship of the total length with alimentary canal length of the fish was established as follows:

For juvenile, $ACL = - 0.354 + 0.642\ TL$

For adult, ACL = 2.238 + 0.562 TL

All the relationships mentioned above are shown by scattered diagrams. It was observed that in all the cases there existed strong linear relationships. The regression equations were found to be linear and the co-efficient of correlation were highly significant (Table 4.4; Fig. 4.11 and 4.12).

Table 4.4: Total length and alimentary canal length ratio and relationships, values of intercepts (a), regression co-efficient (b) and co-efficient of correlation (r) of juvenile and adult *Lates calcarifer*

Stage	*Mean ratio (TL:ACL)*	*Value of a*	*Value of b*	*Value of r*
Juvenile	1:0.62	-0.354	0.642	0.996
Adult	1:0.63	-2.238	0.562	0.986

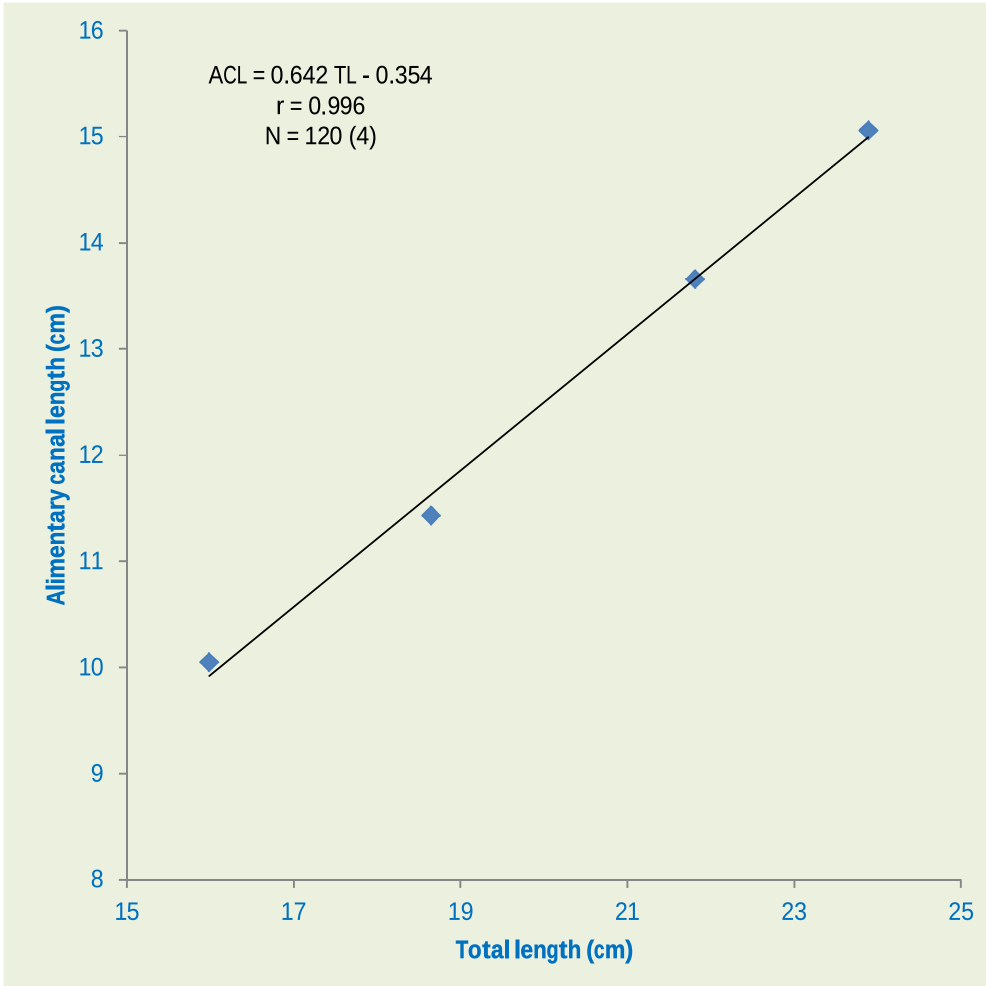

Fig. 4.10: Relationship between alimentary canal length (ACL) and total length (TL) of juvenile *Lates calcarifer*.

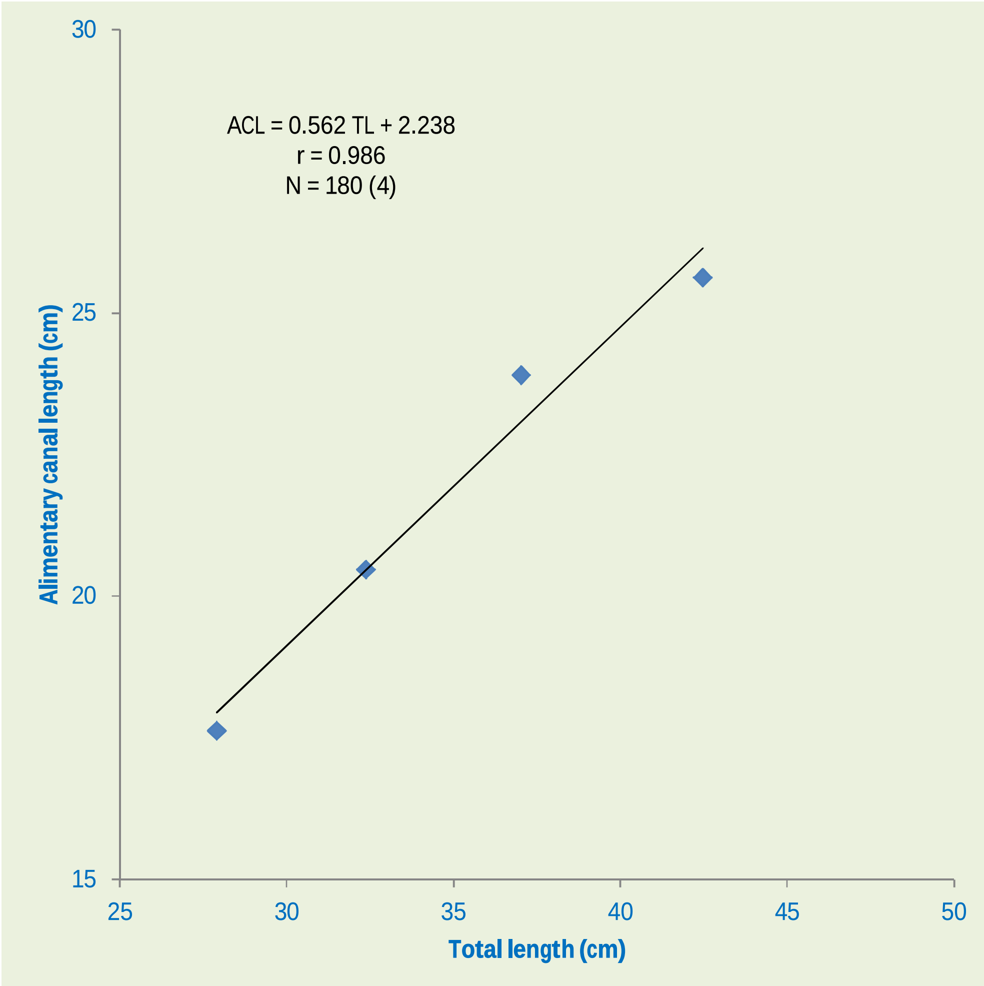

Fig. 4.11: Relationship between alimentary canal length (ACL) and total length (TL) of adult *Lates calcarifer*.

4.4 Discussion

On the basis of present study, it was found that *Lates calcarifer* is a culturable species in our country. The food and feeding habit and the body length, gut length relationship of the juvenile and adult *L. calcarifer* were studied. Specimens for the present study were collected from different localities near Khulna.

4.4.1 Food of Juvenile *Lates calcarifer*

The food analysis of 120 juvenile specimens (15-25cm TL) of *Lates calcarifer* revealed that the food of the juveniles consisted of algae or phytoplankton, zooplankton (protozoan and small crustaceans), large crustaceans, insects, teleosts and unidentified food materials. In case of algae or phytoplankton, the highest percentage (12%) was detected in the month of March 2015 and the lowest percentage (4.5%) was found in July 2014 (Appendix Table 4.3). The highest percentage of zooplankton (26.25%) was detected in the month of June 2015 and the lowest percentage (13.5%) was found in December 2014 (Appendix Table 4.3). Whereas the highest percentage of large crustaceans (36%) was detected in the month of October 2014 and the lowest percentage (17.5%) was found in August 2014 (Appendix Table 4.3). The highest (12%) and the lowest (6.25%) percentages of insects were observed in the month of February 2015 and December 2014 respectively (Appendix Table 4.3). In case of teleosts, the highest percentage (40.45%) was detected in the month of November 2015 and the lowest percentage (28.75%) was found in September 2014 (Appendix Table 4.3). And last, the highest percentage (4.35%) of unidentified food material was calculated in the month of December 2014 and the lowest percentage (2.1%) was found in June 2015 (Appendix Table 4.3).

The average percentage occurrence of the food items of juvenile *Lates calcarifer* was algae or phytoplankton (6.69%), zooplankton (22.10%), large crustaceans (26.73%), insects (8.12%), teleosts (34.2%) and unidentified food materials (2.16%).

The present investigation reveals that the juvenile *L. calcarifer* is carnivorous in feeding habit, mainly feeding on zooplankton, large crustaceans, insect and teleosts. Shiva and Radhakrishnan (2011) conducted a study on feeding habit of *Scatophagus argus* and found that prime food items were algae and detritus. Hossain (2002) recorded that the most important food item of the juvenile *Liza parsia* was the algae and higher aquatic plants. Dewan *et al.* (1979) recorded that the most important food item of the juvenile *Labeo rohita* was organic detritus, phytoplankton and aquatic macrophytes. Bhowmick (1965) worked on *Glossogobius giuris* and found that crustaceans formed the major food of the juvenile while the most preferred food of the adults was fish.

4.4.2 Monthly Variation in the Degree of Feeding of the Adult *Lates calcarifer*

The study of monthly variation in the degree of feeding of the adult *L. calcarifer* reveals that the highest percentage of emptiness of stomach was detected that the feeding intensity *i.e.* the percentage of fullness of the stomachs was found the highest (100%) in July 2014 and June 2015 whereas, the lowest (53.33%) was found in the month of December 2014 (Appendix Table 4.5). On the other hand, the maximum emptiness (46.67%) was found in the month of December 2014 and the lowest was found in July 2014 and June 2015 (Appendix Table 4.5). In the month of July 2014 and June 2014 there were higher feeding intensities and the month of December 2014 there was the weak feeding intensities (Appendix Table 4.5).

From the present investigation, it can be concluded that the fish changes its food habit with the change of season. These findings agree with those of Dewan and Saha (1979), Joadder and Hossain (2008a) who reported that *Tilapia nilotica*, *Liza parsia* change its food habit with the change in seasons. Analyzing the present findings, it is clear that *L. calcarifer* reduces its feeding activity during winter season and increased feeding activities were recorded during summer-monsoon period.

These findings are, to some extent, conformity with those of Moffet and Hunt (1943) who recorded a higher rate of feeding activity during summer and lower rare during winter in blue gill. Joadder and Hossain (2008b) recorded similar observations in *Cyprinus carpio* var. *communis*. Khan (1947) and Bhuiyan *et al.* (1992) also noted similar findings in blue gill and *Labeo rohita* respectively. Land (1973) observed the food intake of plaice, *Pleuronectes platessa* in winter was scare and stopped when the water temperature fell below 2-4 ^{0}C.

4.4.3 Seasonal Occurrence of Various Food Items of Adult *Lates calcarifer*

Seasonal occurrences of various food items were studied. The highest percentage of algae (6.25%) was found in the month of October 2014 and the lowest percentage (3.5%) was found in July, December 2014 and February, April 2015 (Appendix Table 4.6). In case of zooplankton, the highest percentage (24.40%) was detected in the month of August 2014 and the lowest percentage (14.5%) was found in December 2014 (Appendix Table 4.6). Whereas, the highest percentage of large crustaceans (34.80%) was recorded in the month of October 2014 and the lowest percentage (15.5%) was found in August 2014 (Appendix Table 4.6). The highest percentage of insects (12.5%) was found in the month of May 2015 and the lowest percentage (7%) was found in November 2014 (Appendix Table 4.6). In case of teleost, the highest percentage (40%) was detected in the month of August 2014 and the lowest percentage (29.5%) was found in September 2014 (Appendix Table 4.6). And lastly, the highest percentage of unidentified food materials (5.80%) was recorded in the month of February 2015 and the lowest percentage (2.4%) was found in September 2014 (Appendix Table 4.6).

The average percentage occurrence of the food items of the adult *Lates calcarifer* were algae or phytoplankton (5.12%), zooplankton (16.17%), large crustaceans (28.77%), insects (9.11%), teleosts (34.99%) and unidentified food materials (5.84%).

The present investigations reveals that the most important food item of the adult *Lates calcarifer* were zooplankton, large crustaceans, insects and teleosts. Bhuiyan and Islam (1991) recorded that the most important food item of the adult *Ompok padba* was the fishes, crustaceans, protozoans and insects. Hossain *et al.* (1990), Bhuiyan *et al.* (1999a) and Joadder and Hossain (2008a) carried out research on *Notopterus notopterus*, *Mugil cephalus* and *Liza parsia* respectively and obtained similar results from the research efforts.

4.4.4 Feeding Habits

From the present findings it is observed that the food and feeding of *Lates calcarifer* is almost the same in both juvenile and adult stages. The food and feeding during juvenile and adult stage of concerned species reflected that it is a carnivore fish species.

Jobs (1941) concluded that *Therapon jarbua* was a surface feeder due to the presence of insects larvae and adult mosquitoes in its stomach contents. Mookerjee *et al.* (1946) held that fishes living at the surface feed on crustaceans and algae, whereas the fishes which feed on rotten plants, sands and mud are bottom feeder. Das and Moita (1955) noted that the surface feeders are both omnivorous and carnivorous which feed on algae, rotifers, micro-crustaceans and the larvae; the mid or column feeders are herbivorous and carnivorous which feed on decomposed aquatic vegetation, bryozoans, insects, crustaceans, mollusks, fishes, sand, mud etc. They further concluded that the surface feeders feed on sub-surface food organisms and the bottom feeders feed on mud, decaying substances and bottom fauna and flora.

4.4.5 Total Length (TL) and Alimentary Canal Length (ACL) Ratio

The ratios of the total length (TL) and alimentary canal length (ACL) of the juvenile and adult stages of the *Lates calcarifer* were found as 1:0.62 and 1:0.63 respectively. These ratio indicate that this species is a carnivore species.

The present observation is in conformity with that of Lagler *et al.* (1977) who showed that the fishes which are carnivorous, are provided with shortened alimentary tracts while the herbivore fishes have highly elongated alimentary tracts.

4.4.6 Relationship Between Total Length (TL) and Alimentary Canal Length (ACL)

The relationship of the total length with alimentary canal length of the fish was established as follows:

For juvenile, ACL = - 0.354 + 0.642 TL
For adult, ACL = 2.238 + 0.562 TL

All the relationships mentioned above are shown by scattered diagrams. It was observed that in all the cases there existed strong linear relationships. The regression equations were found to be linear and the co-efficient of correlation were highly significant (Table 4.4; Fig. 4.11 and 4.12).

Chapter Five

Body Composition of *Lates calcarifer*

BODY COMPOSITION

5.1 Introduction

Being one of the richest sources of proteins, vitamins and minerals fishes are widely used in Bangladesh as essential source of nutrients required for people (Farid *et al.* 2014). Most of the people of our country are suffering from mental and physical disease for nutritional deficiencies. The lack of balanced food ingredients is the main cause of their malnutrition. The lack of protein is very conspicuous in various kinds of food ingredients. There are two kinds of proteins such as plant protein and animal protein. Generally animal protein is better than plant protein in respect of qualities (Hossain, 1990 and Afroze, 1990).

In our country, 60% of the total animal protein comes from fishes (DoF, 2015). Because meat, egg, milk etc. are not easily available to the people. Fish is also considered the cheapest among all other available sources of animal protein in Bangladesh. As rice is the main carbohydrate source of our people. In the same way, fish is the best and available source of protein. The live weight of majority of fishes composed of water (70-80%), protein (20-30%) and of lipid (2-12%) (Love, 1980). However, this composition varies greatly from species to species because of age, sex, environment, feeding, time of the year and physical activity (Huss, 1995; Weatherley and Gill 1987).

L. calcarifer contains polyunsaturated fatty acids (PUFA) enriched of omega-3 fatty acid, which play important roles in cardiovascular system to reduce the risk of heart attack (Islam, 1983). Omega-3 fatty acids are helpful to reduce cholesterol level in blood and helpful in the prevention of hyperlipidemia, secondary cardiovascular disease and high blood pressure. The nature and quantity of lipid in fish are dependent on species and habitats. Lipids and fatty acids also play a significant role in membrane biochemistry and have direct effect on the membrane-mediated process in human such as osmoregulation, nutrient assimilation and transport (Ibrahim *et al*., 2004).

The production of fish is less in comparison to its need. Besides, the production of fish is decreasing day by day. Twenty years ago the fish production per head was 30g daily. Now it is less than 21g. At least 80g fish per day is necessary for every man.

Price of fish is very high in market because of its less availability in the market. It is very expensive to buy fish by most the ordinary people.

Bangladesh is a very riverine country. There are plenty of rivers, ponds, ditches and other water bodies in our country for fish production. So it is necessary to use every kind of water bodies for the fish culture.

Medicinal and dietary use of fats and oils from both the plant and animal sources are also very old and by no means it can be said to be recent. Human beings have been using fats and oils as food for centuries (Martinadle, 25th edition). Fats and oils are widely distributed both in plants and animal kingdom. They are found to vary in quantity with the sources. They consist of a single cell.

Bangladesh has very rich fishery resources both marine and fresh water. Favorable geographical condition, mild climate, numerous rivers, canals, beels, haors, baors, tanks, ponds etc. give a unique opportunity for development and expansion of this important industry. About 90% of total demand of the fish in the southern part of the country comes from brackish water. *L. calcarifer* is a brackish water fish which plays an important role for protein nutrient. This fish is delicious and so every body likes it.

Hunger and nutritive deficiency is one of the greatest problems in our life. Among the nutritive deficiencies, the protein deficiency is the greatest. The fish is a good and cheap source of protein can't be denied. Our over increasing populations need a huge amount of protein which can easily be fulfilled by producing adequate fishes.

Bangladesh is rich for her vast water resources. Both fresh and coastal water producing number of fish species can be utilized by proper management as the main source of protein supply for our nation.

As such it is evident that the study of fisheries is essential in our country considering from the economic point of view.

Fishes provide maximum protein for human bodies and it has also a great demand for good taste. The fishes are highly perishable commodities.

There are many reports on the macro-nutrients contents of marine and fresh water fishes and some of them are well known throughout the world such as Rubbi *et al.,* (1987), Kamal *et al.* (2007), Sabina *et al.* (2011). Begum and Minar (2012), Mahfuj *et al.* (2012), Pervin *et al.* (2012) and Ali (2014).

The present work is a step to get some information on the comparative proximatic composition and some mineral contents of different life stages (Juvenile, adult and spent) in *L. calcarifer* in Bangladesh.

5.2 Materials and Methods

L. calcarifer was collected from two rivers and ghers (polder area) of the Khulna district, between 2013 and 2015. It was netted from the rivers Shibsa in Dacope, Kapotakkha in Paikgacha and ghers (polder area) in Dumuria. About 150g-200g of fish (*L. calcarifer*) were collected as juvenile fish sample, 1200g- 1500g of fish as adult sample and 300g-3500g of fish as spent sample. After collection the specimens were immediately brought to the Laboratory of the BCSIR of Rajshahi in ice box.

In the laboratory specimens were washed with clean tap water, beheaded, degutted again washed. The specimens were sliced (3-3.5cm thick) dorsally and ventrally. Only the fresh edible portions (scale, skin-free and bone free fillets) from two regions were taken for the estimation of proximate composition.

The proximate composition (moisture, protein, fat and ash contents) of fish muscles were determined by methods of analysis of official agricultural chemists (AOAC, 1990). The experiments were performed in triplicate and values are expressed as mean± standard deviation.

Statistical analysis was performed by using the SPSS (Statistical Package for Social Science, evaluation version 16). Significance was assigned at the 0.05% level. The mean values also compared to see the significant difference through DMRT (Duncan Multiple Range Test).

5.2.1 Determination of Moisture Content

Principle:

The change of weight is estimated under certain temperature and pressure. Moisture of fish is commonly determined by drying a sample at some elevated temperature and reporting the loss in weight as moisture.

Procedure:

Four sets of experiments were done for the fish. For each set of experiment, about 10g (accurately weighted by loarding Top Balance, al-1800) of fairly minced fish sample was taken in weighted crucible. Crucible 1 and Crucible 2 were used for juvenile and adult of *L. calcarifer* (male). Crucible 3, crucible 4 and crucible 5 were used for juvenile, adult and spent *L. calcarifer* (female).Then the crucibles with fish contents were placed in an oven at about 105°C for 5 to 6 hours. The weight was recorded every single hour until three constant weights were observed. Each time before weighing the crucible containing the fish muscles were cooled in adesicator. The differences in the weight of fresh fish muscles were cooled in adesicators. The difference in the weight of fresh fish and the constant dry weight gave the moisture content.

Calculation:

The percentage (%) moisture content was calculated by the following equation.

Moisture content (g/100g) of sample = $\frac{Initial\ weight - Final\ weight}{Weight\ of\ the\ sample}$x100

5.2.2 Determination of Protein Content

Principle:

The universally accepted method for determining total nitrogen of crude protein in fish is the 'Micro-Kjeldahl' method. This involves the oxidation of organic matter with sulfuric acid in the presence of catalyst and then the formation of ammonium salts and amines from the nitrogen components of fish. The solution is then alkaline and the amines and ammonia is distilled into standard acid. The solution is then back titrated with standard alkaline and the amount of nitrogen of ammonia calculated. The nitrogen value was then multiplied by 6.25 to give value for crude protein.

Reagents:

1. Concentrated Sulfuric Acid
   A.R.: The concentrated Sulfuric Acid of BDH Chemical Ltd. Poole. England, specific gravity 1.84 was used.

2. Digestion mixture;

   2.5g of powder selenium dioxide (SeO_2) with 100g of K_2SO_4 and 20g of $CuSO_45H_2O$ were taken in making this mixture.

3. 30% Sodium hydroxide;

   150g of NaOH was dissolved in 500ml of distilled water.

4. 0.01N Hydrochloric Acid

5. 2% Boric Acid;

   10g of boric acid was dissolved in 500ml of boiling water.

6. Mixed Indicator;

   0.1% bromoeresol green and 0.1% of methyl red indicator was dissolved in 95% alcohol separately. Then 10ml of bromoeresol green was added with 2ml of methyl red solution.

Procedure:

At first the “Micro-Kjeldahl” flask (100ml) was cleaned and also dried for this experiment. Five sets of samples (2g each) for male and female in different stages of each species of fish were weighed into a dry “Kjeldahl” flask. About 2g of digestion mixture and 25ml of pure concentrated sulfuric acid were added into the sample and the mixture digested by heating for 4 to 5 hours till the mixture became clear (in Kjeidahl Nitrogen and Distilling Apparatus model no. OSK 8417). Glass beds were added to prevent bumping. The digested products were then cooled and after that 30ml of distilled water was added. The digested products were transferred to 100ml volumetric flask and were volume to 100ml with distilled water. Then 5ml from diluted digest was transferred in “Kjeldahl” Distillation Apparatus and distilled with 10ml of 30% NaOH. The distillate was collected in excess of 2% boric acid solution with indicator and was titrated by 0.01N HCl. A similar digestion and distillation was carried out without samples.

Calculation:

The percentage of nitrogen was calculated from the formula:

$$\% \text{ Nitrogen} = \frac{(S-B)x\ N\ x\ 14\ x\ C\ x\ 100}{A\ x\ W\ x\ 1000}$$

Where,

S=Titration reading for sample

B=Titration reading for blank

N=Strength of 0.01N HCl

C=Volume made up of the digest

A=Aliquots of the digest taken

W=Weight in g of the sample.

The protein content was obtained by multiplying the nitrogen value by 6.25.

Therefore, % of crude protein= Nitrogen × 6.25

Ref. I.Ma.T.S. and G. Zuazaga. Ind. Eng. Chem. Annual. Ed-14.280 (1942).

5.2.3 Determination of Fat Content

Principle:

The fat was extracted from the sample with ethyl ether or petroleum ether; after extraction, the solvent was removed from the sample by evaporation. The residue was then weighed and reported as fat. In the present investigation, the fat content was determined by "Soxhlet Apparatus Method".

Reagent:

Ether $(C_2H_2)_2O$ the either of BDH Led. Poole, England; boiling point 40°C-60°C was used.

Procedure:

For male (juvenile, adult) and female (juvenile, adult and spent) fish five disparate samples were taken for this experiment. About 10g (accurately weighted by Larding Top Balance, AL-1800) of fresh sample was taken in a thimble and plugged with fat free cotton. The thimble was then placed in 'Soxhlet' apparatus and extracted with petroleum ether for about 16 hours. The ether extract was filtered into a dried and weighed conical flask. The thimble containing the fish was washed 4-5 times with small quantities of ether and washing were also transferred into the conical flask. The ether in the conical flask was then removed by slow evaporation in a water bath. The flask with the residue was finally dried in an oven at 90-100°C until constant weight was attended.

Calculation:

Fat content (g/100g of sample) = $\frac{Weight\ of\ the\ ether\ extractive}{Weight\ of\ the\ sample}$x100

5.2.4 Determination of Ash Content

Principle:

Ash in the fish and fish products is readily determined by incineration either raw or dried sample at about 600°C for 3-5 hours, depending on the methods used. The residue is weighed and reported as ash. Care was taken to oxidizes all the carbon during the determination. Refined vegetable oil was added to the ash and continue the incineration continued for several hours to obtain a pure white ash.

Procedure:

About 10g (accurately weighted by Loarding Top Balance. Al-1800) macerated of the sample was weighed accurately into a weighed crucible. The crucible with the contents was heated first over a low flame till all the material was completely charred. These charred samples were kept in an Electric Muffle Furnace (NABER, Model No. L51/s) for 3-5 hours at about 600°C with a view to ashing completely. To ensure the completion of ashing the crucibles were again heated for half an hour and cooled and then weighed. This was repeated till two consecutive weights for each sample which was same in weight. Ashes were almost white in color. Here also five sets of experiments were done for male (juvenile, adult) and female (juvenile, adult, spent) fish.

Calculation:

The percentage of ash content was determined as follows:

Ash content (g/100g of sample) = = $\frac{Weight\ of\ Ash}{Weight\ of\ the\ sample}$x100

5.2.5 Determination of Mineral Content

Preparation of Mineral Solution:

The ash (obtained in the previous experiment) in the crucible was moistened with 1ml of distilled water and 5ml of distilled HCl. The mixture was then evaporated to dryness on a boiling water bath. Another 5ml of HCl were added again and the solution was evaporated to dryness as before. 4ml of HCl and a few ml of distilled water were then added and the solution warmed over a boiling water bath and filtered into a 100ml volumetric flask using “Whatman” no. 40 filter paper. The volume was made up to 100ml with distilled water after cooling. For the estimation of phosphorus, iron and calcium, this mineral solution was used.

5.2.5.1 Determination of Phosphorus Content

Principle:

Phosphorus was usually estimated by measuring calorimetric procedure. A blue colour formed when the ash solution was treated with ammonium molybdate. Thus the phosphorus-molybdate is reduced.

Reagent:

1. Ammonium molybdate and sulphuric acid reagent:

25g ammonium molybdate was dissolved in 300ml distilled water; 75ml of concentrated H_2SO_4 dukyted to 200ml was then added to ammonium molybdate solution.

2. Hydroquinone solution:

0.5g hydroquinone dissolved in 100ml distilled water and one drop of concentrated H_2SO_4 was added to retard oxidation.

3. Sodium sulfate solution:

200g Na_2SO_3 dissolved in distilled water and diluted to 500ml and then filtered.

4. Standard phosphate solution:

0.4393g pure dry KH_2PO_4 dissolved in dist. Water and diluted to 1000ml. of this 10ml solution was then taken to 100ml volumetric flask and was diluted to 100ml. This was the working standard phosphate solution (1ml=0.01mg phosphorus).

Procedure:

1ml of mineral solution was taken and was added with 1ml ammonium molybdate; 1ml hydroquinone and 1ml of Na_2SO_3 solution- in this order mixing well after each addition. The volume was then made up to 15ml of distilled water and the solution was thoroughly mixed up. After 30 minutes, the optical density of the solution was measured in a photoelectric colorimeter, against a reagent blank (prepared in the same way as the test, except that, the test solution was omitted) using a filter (660 m/μ).

The phosphorus content of the sample was read of from a standard curve prepared with standard solution (0.01-0.1mg P) following the same procedure as described above. For each sample of fish the experiment was done there three times.

5.2.5.2 Determination of Iron Content

Principle:

Iron is determined calorimetrically by using the fact that ferric iron forms blood red colour with potassium thiocyanate.

Reagents:

1. 30% Sulfuric Acid, 30ml of concentrated H_2SO_4 diluted to 100ml.
2. Standard Potassium persulfate solution. 7g potassium persulfate (A.R.) was dissolved in distilled water and the solution made upto 100ml.
3. Potassium thiocyanate solution (40%):

   40g potassium thiocyanate solution was dissolved in 90ml distilled water, 4ml acetone was added and volume made up to 100ml.
4. Standard Iron solution: 0.7022g A.R. ferrous ammonium sulphate was dissolved in 100ml distilled water and after addition of 5ml of HCl in 1: 1 ratio; the solution was made upto 100ml and mixed thoroughly (1m = 0.1mg Fe). By using distilled water, all the reagents were made free from iron.

Procedure:

To an aliquot 6.5ml of the mineral solution was followed by 1ml of 30% sulfuric acid, 1.0ml potassium persulphate solution and 1.5ml 40% potassium thiocyanate solution.

The red colour that developed was measured within 20 minutes at 540 m/µ (in Spectronic 20, Milton Roy Co.).

5.2.5.3 Determination of Calcium Content

Principle:

Calcium was determined by precipitating it as calcium oxalate and titrating the solution of oxalate in dilute sulphuric acid against standard potassium permanganate ($KMnO_4$).

Reagent:

1. Ammonium oxalate (6%):

   Ammonium oxalate (6g) was dissolved in distilled water and the final volume was adjusted to 100ml.

2. Strong ammonia:

   The ammonia used to prepare the strong ammonia solution, was manufactured by the BDH laboratories, having a specific gravity of 0.91.

3. Methyl red indicator:

   0.1g of the indicator dissolved 60ml of alcohol and volume to 100ml with distilled water.

4. Dilute sulphuric acid (2N):

   5.60ml of concentrated H_2SO_4 was dissolved in 100ml of distilled water.

5. N/100 $KMnO_4$ solution:

   3.45g of $KMnO_4$ was dissolved in 250ml of distilled water.

Procedure:

25ml of the mineral solution was diluted to about 150ml with distilled water. A few drops of methyl red indicator were added and the mixture was then neutralized with ammonia till the pink colour changed to yellow. Then added 10ml of 6% ammonium oxalate and the solution was heated to boiling point. The mixture was then allowed to boil for a few mutinies and glacial acetic acid added till the colour was distinctly pink. The mixture was then kept in an oven at low temperature to settle down the precipitate. The supernatant was tested with a drop of ammonium oxalate solution to make sure that the precipitation was completed. The precipitate was filtered through filter paper and washed gradually by pouring warm water over the funnel with filter paper with its contents, till it was free from oxalate which was again ensured by observing that the water washing the precipitate was absolutely colourless.

The precipitate was transferred into a beaker by piercing a hole in the filter paper and washing it down by gradually pouring 10ml of 2N sulphuric acid. After washing, the solution was then heated to about 70°C and titrated against N/100 $KMnO_4$ solution. 1ml of N/100 $KMnO_4$ = 0.2004mg of calcium.

5.2.5.4 Determination of Magnesium Content

Reagent:

1. Concentrated nitric acid
2. Concentrated hydrochloric acid
3. 10% Ammonium phosphate solution
4. 10% Sodium citrate solution
5. 0.1% Methyl red indicator

Procedure:

To the calcium free filtrate (obtained from the filtrate after precipitation of calcium as oxalate) was added 30ml of nitric acid and the solution evaporated completely on a boiling water bath. 5ml of concentrated hydrochloric acid and 100ml of distilled water were then added and the solution stirred well with a glass rod. It was followed by the addition of ×10ml of 10% ammonium phosphate solution and 5ml of 10% sodium citrate solution and the mixture stirred. After adding two or three drops of methyl red indicator, the solution was neutralized with the addition of 1:4 dilute ammonia. 25ml of strong ammonia was added, stirred vigorously and the mixture was allowed to stand overnight, filtered through " Whatman" no 40 or 44 filter paper and washed free from chlorides using 1 : 10 dilute ammonia (tasted with HNO_3 + $AgNO_3$ solution). The funnel with the precipice of the filter paper was dried in crucible (crucible was previously heated, cooled and weighed) and ashed slowly over a burner. Then it was kept in Muffle furnace at 900°C for two hours, the crucible and the contents were cooled in adesicator and weighed to get magnesium as its pyrophosphates.

Calculation

Weight of the ash = $\frac{48.64}{222.6} x \frac{100}{ash\ solution\ taken\ for\ calcium\ estimation} x \frac{100}{Wt\ of\ sample} x100$

=mg of magnesium/ 100 of sample.

Ref. "A manual of laboratory techniques" National Institute of Nutrition, Indian Council of Medical Research, Jamal Osmania, Hyderabad-7 A.P. India.

5.3 Results and Observation

The result of comparative proximate composition of fresh *L. calcarifer* are shown in Figures 5.1, 5.2, 5.3 and 5.4; and also in Appendix Table 5.1

5.3.1 Moisture Content

Moisture contents of the studied species are shown in Figure 5.1 and also in Appendix Table 5.1. In case of male *L. calcarifer* the highest moisture was found in spent which was 71.230±0.843% and the lowest amount was found in adult fish which was 69.633±0.464%. On the other hand, the highest moisture in female *L. calcarifer* was found 72.453±0.552% in spent and the lowest moisture in female was found 70.190±0.877% in adults (Figure 5.1).

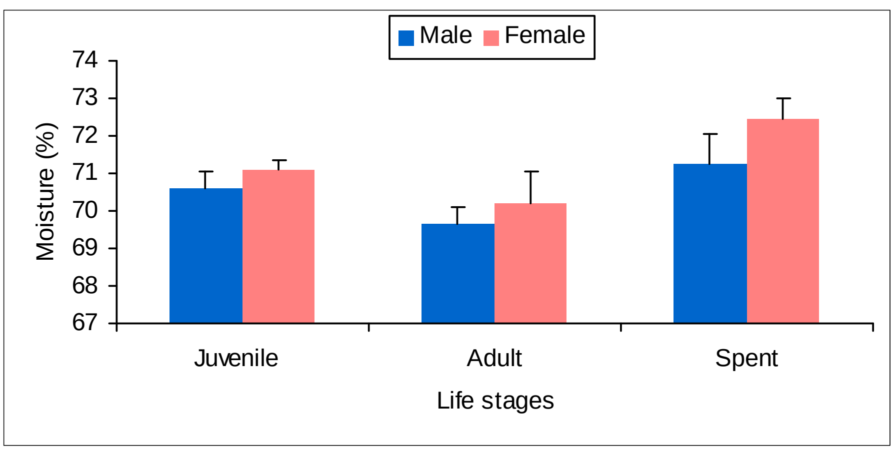

Figure 5.1: Moisture content at different life stages of *Lates calcarifer*

5.3.2 Protein Content

The protein contents of the studied species are shown in Figure 5.2 and also in Appendix Table 5.1. In case of male *L. calcarifer* the highest protein was found in adult which was 22.940±0.255% and the lowest amount was found in spent fish which was 18.323±0.304%. On the other hand, the highest protein in female *L. calcarifer* was found 22.457±0.514% in adult and the lowest protein in female was found 16.207±50.342% in spent fish (Figure 5.2).

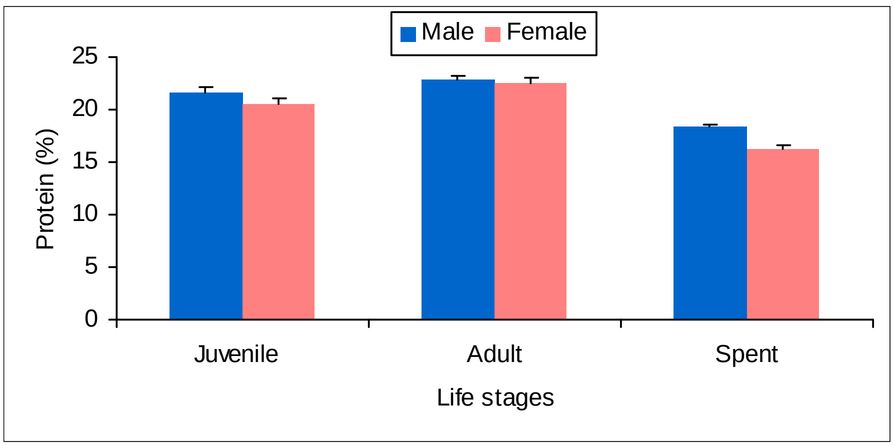

Figure 5.2: Protein content at different life stages of *Lates calcarifer*

5.3.3 Fat Content

The fat or lipid contents of the studied species are shown in Figure 5.3 and also in Appendix Table 5.1. In case of male *L. calcarifer*, the highest amount of fat was found in adult individuals which was 6.017±0.235% and the lowest amount was found in spent fish which was only 3.837±0.214%. On the other hand, the highest fat content in female *L. calcarifer* was found 6.370±0.236% in adult and the lowest amount in female was found 3.117±0.440% in spent fish (Figure 5.3).

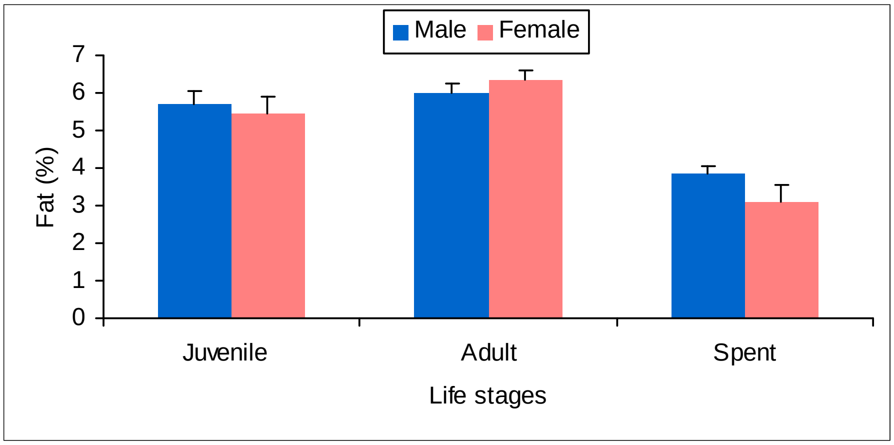

Figure 5.3: Fat content at different life stages of *Lates calcarifer*

5.3.4 Ash Content

The ash contents of the studied species are shown in Figure 5.4 and also in Appendix Table 5.1. In case of male *L. calcarifer*, the highest amount of ash was found in adult individuals which was 4.537±0.476% and the lowest amount was found in spent fish which was only 4.160±0.066%. On the other hand, the highest ash content in female *L. calcarifer* was found 5.110±0.235% in adult fish and the lowest amount in female was found 4.473±0.156% in juvenile individuals (Figure 5.4).

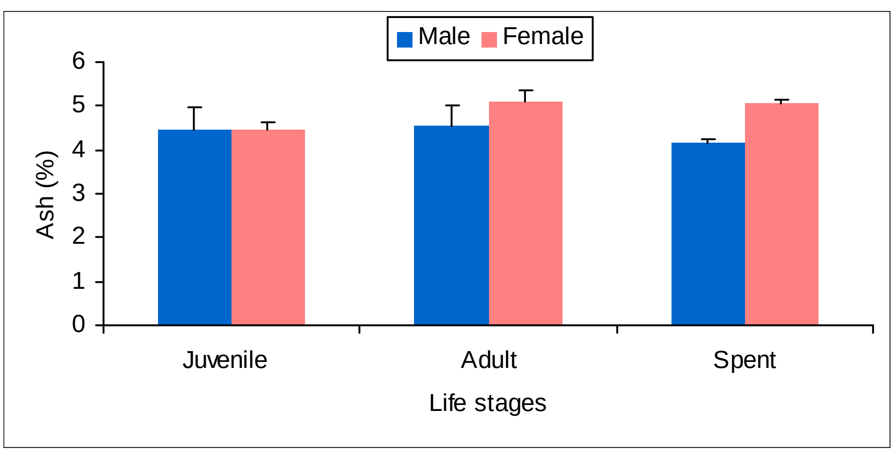

Figure 5.4: Ash content at different life stages of *Lates calcarifer*

5.3.5 Mineral Content

Different mineral contents of the studied species are shown in Appendix Table 5.2 and in Figures 5.5, 5.6, 5.7 and 5.8.

5.3.5.1 Phosphorus (P)

The phosphorus contents of the studied species are shown in Figure 5.5 and also in Appendix Table 5.2. In case of male *L. calcarifer*, the highest amount of phosphorus was found in adult individuals which was 190.2±1.43 mg/100g and the lowest amount was found in spent fish which was only 172.5±3.55 mg/100g.

On the other hand, the highest phosphorus content in female *L. calcarifer* was found 198.3±2.22 mg/100g in adult fish and the lowest amount in female was found 176.4±2.54mg/100g in spent individuals (Figure 5.5).

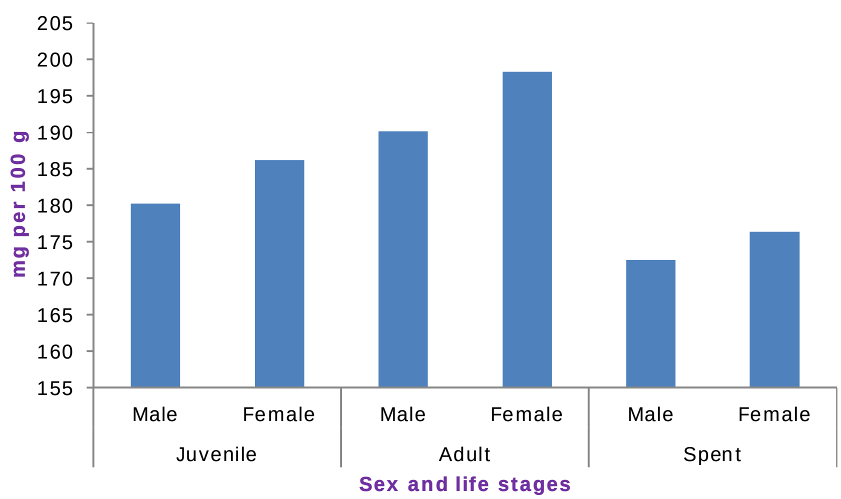

Figure 5.5: Phosphorus content at different life stages of *Lates calcarifer*

5.3.5.2 Calcium (Ca)

The Ca contents of the studied species are shown in Figure 5.6 and also in Appendix Table 5.2. In case of male *L. calcarifer*, the highest amount of Ca was found in adult individuals which was 143.9±3.54 mg/100g and the lowest amount was found in spent fish which was only 135.3±2.24 mg/100g.

On the other hand, the highest Ca content in female *L. calcarifer* was found 151.1±2.13 mg/100g in adult fish and the lowest amount in female was found 136.9±4.24 mg/100g in spent individuals (Figure 5.6).

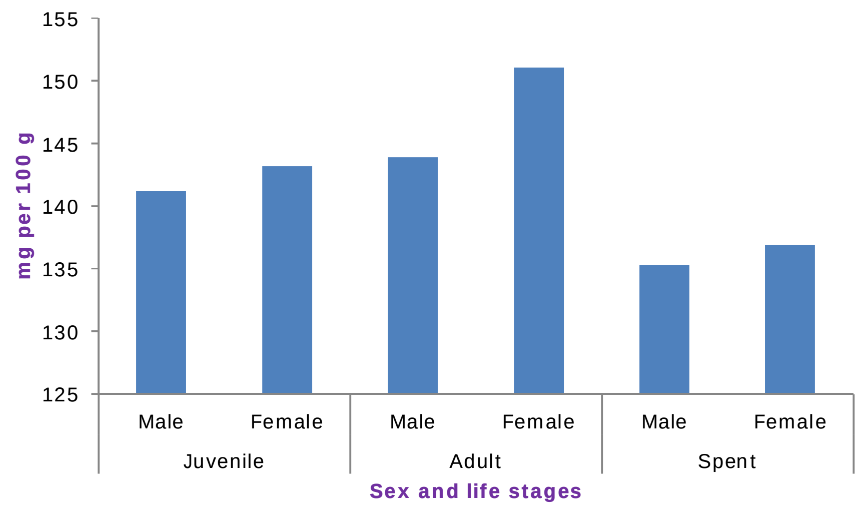

Figure 5.6: Calcium content at different life stages of *Lates calcarifer*

5.3.5.3 Magnesium (Mg)

The Mg contents of the studied species are shown in Figure 5.7 and also in Appendix Table 5.2. In case of male *L. calcarifer*, the highest amount of Mg was found in adult individuals which was 123.2±0.33 mg/100g and the lowest amount was found in spent fish which was only 119.4±2.23 mg/100g.

On the other hand, the highest Mg content in female *L. calcarifer* was found 125.3±1.12 mg/100g in adult fish and the lowest amount in female was found 120.6±1.32 mg/100g in spent individuals (Figure 5.7).

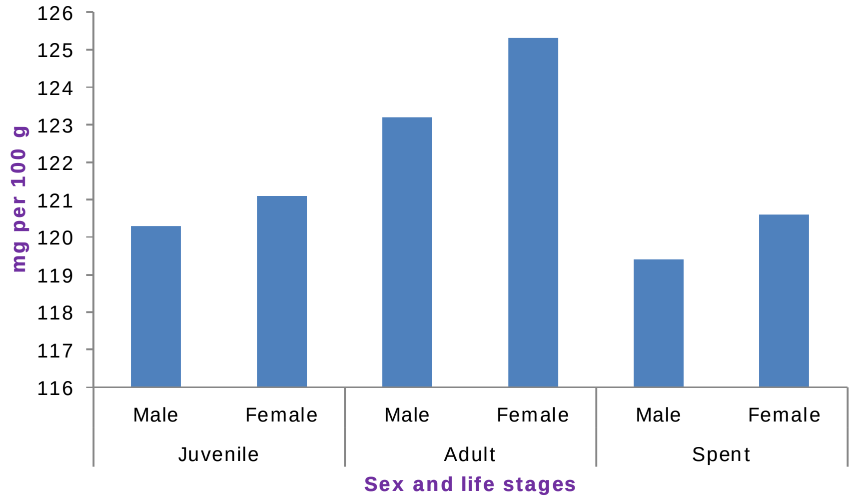

Figure 5.7: Magnesium content at different life stages of *Lates calcarifer*

5.3.5.4 Iron (Fe)

The Fe contents of the studied species are shown in Figure 5.8 and also in Appendix Table 5.2. In case of male *L. calcarifer*, the highest amount of Fe was found in juvenile individuals which was 14.34±1.23 mg/100g and the lowest amount was found in spent fish which was only 09.11±0.45 mg/100g.

On the other hand, the highest Fe content in female *L. calcarifer* was found 15.35±1.22 mg/100g in juvenile fish and the lowest amount in female was found 09.11±0.45 mg/100g in spent individuals (Figure 5.8).

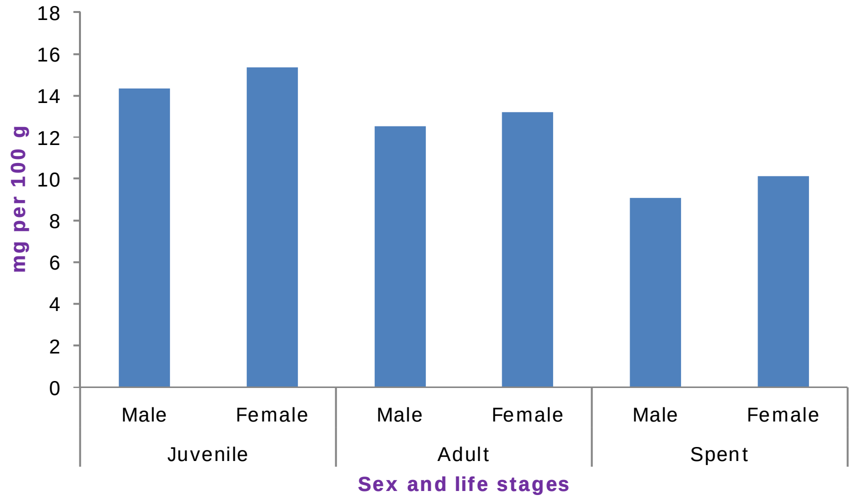

Figure 5.8: Iron content at different life stages of *Lates calcarifer*

5.4 Discussion

The present investigation was carried out on the comparative proximate composition and some mineral contents of the different stages of *L. calcarifer* (male and female).

The studied species is a very delicious and comparatively an expensive fish. In Khulna, Barisal, Patuakhali and Chittagong districts this species is very popular for its delicious taste. However, no or almost little documents could be cited to compare the present finding against the previous one.

In a study by Monalisa *et al.* (2013), higher amount of minerals were found in native species (koi) than that of exotic species (hybrid koi).

Ahmed *et al.* (2012) studied the body compositions of various native and exotic fishes of Bangladesh. They recorded that moisture, protein, ash, protein and lipid contents of koi (*Anabas testudineus*) were 76.6%, 1.62%, 19.5% and 2.27% respectively.

Hei and Sarojnalini (2012) studied the biochemical composition of *Ompok bimaculatus* and found following compositions- moisture (15.54%), protein (30.02%), lipid (19.63%), and ash (5.33%). They also recorded the following macro and micro nutrients- Ca (24.25mg/100g), Mg (106.75mg/100g), K (121.05mg/100g) and P (483.33mg/100g).

Sarower-E-Mahfuj *et al.* (2012) studied the biochemical composition of an endangered fish of Bangladesh, *Labeo bata* and found that the amount of moisture was

72.41±0.81%. There was a great similarity between this result and present research findings.

Kamal *et al.* (2007) found that 14.87±0.63% and 19.63±0.50% protein in the flesh content of *Clarias batrachus* and *Heteropneustes fossilis* respectively.

Ibrahim *et al.* (2004) studied the lipids and fatty acids also play a significant role in membrane biochemistry and have direct effect on the membrane-mediated process in human such as osmoregulation, nutrient assimilation and transport.

Khurseed and Mosharaff (1998) studied the fish flesh contains four basic ingredients in varying proportions major nutrients such as water (70-80%), protein (18-20%), fat (5%) and minerals (5%) and major nutrients such as vitamin, carbohydrate.

Islam (1983) studied *L. calcarifer* contains polyunsaturated fatty acids (PUFA) enriched of omega-3 fatty acid, which play important roles in cardiovascular system to reduce the risk of heart attack.

Stansby (1962) categorized all the fishes according to their fat and protein contents. According to stansby the species *L. calcarifer* (male) could be categorized as medium fat-very high protein group and female low fat – high protein group.

Rubbi *et al.* (1987) found that the fat and protein content in case of *Heteropneustes fossils* were 1.73% and 18.25% respectively in the present investigation fat and protein content for this species was found higher.

Kamaluddin *et al.* (1977) found that the fish *Heteropneustes fossils* contained 68% moisture. They also reported that 1% fat and 15% protein were present in fresh catfish *Clarius batrachus.* The present record is much higher for the different stages of *L. calcarifer* (male and female).

Standby (1954) worked out the macro nutrient content from the edible flesh of certain fresh water fishes and observed that their fishes contained 76.8% moisture, 1.2% ash, 5% fat and 19% protein.

Jacobs (1958) showed that when fat was deposited in the fish flesh it replaced equal amount of moisture.

Thurston (1958) analyzed the Alaska pink salmon and observed that there were inverse relationship between moisture and fat content. In the present investigation, the relationship among moisture, fat and protein contents of both the male and female studied were:

(i) Protein content was directly related to fat, $F \propto P$ or $F=K_1P$

(ii) Higher the moisture content lower the fat or vice versa, i.e. inversely related to each other, $F \propto 1/M$ or $F=K_2/M$

(iii) Higher the moisture content lower the protein, i.e. an inverse relationship $M \propto 1/P$ or $M=K_3/P$.

Where, P=Protein

M=Moisture

F=Fat

K_1, K_2 and K_3 = Proportionality contents

In this observation the values of K_1 were 0.4083 and 0.1011 for male and female respectively and K_2 was 577.0685 and 144.0644, while K_3 were 1413.2995 and 1425.318 for the same fishes respectively. The ash represents the total mineral contents of fishes. The ash obtained in this investigation for four minerals (P, Ca, Mg and Fe). The results of these minerals are shown in App. Table 5.2.

The result of the present investigation i.e. the mean value of the male and female did not show significant difference except in case of iron (Fe). In male the P, Ca and Mg were found higher than female except the iron (Fe) content.

The studied nutrients of male and female fishes revealed that they were very high in food value.

Chapter Six

Fishery of *Lates calcarifer*

FISHERY

6.1 Introduction

Bangladesh is a rich country of freshwater resources and manpower. It is a drainage outlet for a vast river basin complex made up of the Ganges-Brahmaputtra-Meghna river system. We have a sustainable scope for fish culture. There are numerous rivers, haors, baors, ponds and lakes in our country. Probably over a thousand beels present in Bangladesh (Rashid, 1991). At present only 80.59% of fish production comes from inland waters (DoF, 2007-2008). The supply of small fish in the market is merely 25% of the total fish (Khanam *et al.*, 2003). Fishes and fisheries products have more or less local and worldwide demands either as food or as by-products and therefore, there should be well organized marketing system for the people of Bangladesh as because fishes are the second staple food and the foreign exchange earner.

In Bangladesh, fishes of inland water are caught by traditional gears. The successful culture and capturing of *Lates calcarifer* by traditional but efficient gears show an additional importance for the expansion of increased production and can be regarded as the index of economic as well as fisheries development. Jones (1974) stated that knowledge about the action of crafts and gears for any type of fishing is essential to secure the physical parameters, disposition and hydrology of that particular water bodies. Khaleque and Islam (1985) stated that fishery gears used in Bangladesh are many and depend on tradition, nature of water bodies expected species, low cost but minimum exploitation with maximum efficiencies of gears etc.

For fisheries purpose, varieties of fishery gears and crafts are necessary. The fishing gears along with vessels, auxiliary equipments constitute the “fishing unit”. Most of the fishing gears have to break off operations after a certain period of activity for rest and repair work (Ahmed, 1953). Some crafts are also essential to assure a good and effective fishing. The indigenous fishes are caught in Bangladesh using a variety of gears. A total 10 types of nets (seine nets, dip nets, fixed nets, cast nets, etc.) and 8 type of crafts (dohar, anta, kholson, jangla, etc) were found in the area. The fishes are also caught with bare hands after dewatering.

Fishes are caught using a variety of gears and traps from the inland open water resources in our country. A number of workers have studied the different aspects of fishing gears in several countries including the Indo-Pak sub continent. Willey (1911) noted on the freshwater fishing of Ceylon; Ahmed (1962) carried out a synopsis on fishing gears of East Pakistan; Van Brandt (1963) worked on the modern fishing gears of the world; Anon (1969) carried out researches on the fishing gear of India; Bhanot (1973) investigated the common fishing methods in India; Garner (1986) stated how to make and set nets. Mazid *et al.* (1997) studied gear selectivity of flood plain fishery.

Rout *et al.* (1979) studied on efficiency of gears for sampling and harvesting of bottom dwelling fish; Thompson (1981) described the seine fishing; Klust (1982) described the netting materials for fishing gear; Rahman *et al.* (1983) worked on bait and bait-fishing of the river Padma; Alam *et al.* (1988) studied on fishing in a haor village of Bangladesh; Anon (1992) reported Kuralon nets and gears; MacLennan (1992) has reported the gear selectivity; Shrestha (1994) investigated on the freshwater fishing implements of Nepal; Islam (1999) described the fishing gears and their operation.

In the present study, the fishery of *Lates calcarifer* in adjacent water bodies (e.g. rivers, estuaries, seas and ghers etc.) of Khulna, were considered because of its habitat. Available records show that the *L. calcarifer* form a fishery of some magnitude in river areas throughout the year along with the other small size fishes. Thus its fishing method in these places could depict more or less the entire picture all over Bangladesh. The fishing of *L. calcarifer* was investigated on the basis of interviews collected from the different fishermen.

Kohls (1970) defined marketing as “the business activities involved in the flow of goods and services from the point of initial production until they reach the ultimate consumer”. The marketing system comprises a market and a marketing channel along with a transportation system and some storage facilities. The marketing system lies in between the production and the final consumer (Kohls, 1970), i.e. the activities of the products after the hand of the producer up to the final consumption is treated as ‘marketing system’.

The “marketing channel” or marketing chain comprises the producers, the different intermediaries and the final consumers, which may be a complicated one or a simple one.

Marketing is the process of planning and executing the conception, pricing, promotion and distribution of ideas, goods, services to create exchanges that satisfy individual and organizational goals. Marketing is typically seen as the task of creating, promoting and delivering goods and services (Kotler, 2001). Traditionally, a 'market' is a physical place where buyers and sellers gather to exchange goods. Sellers and buyers are connected by four flows; the sellers send goods to the market; in return they receive money and information; an exchange of money for goods and services, and an exchange of information (Kotler, 2001).

A large number of workers such as Kohls (1970) described the problems of transportation and marketing of the marine fisheries products and their remedy. Sharker (1977) reported on the landing of exportable commercial fishes in Chittagong; Sabur and Rahman (1979) worked on the marine fish marketing and their existing problems in Bangladesh with special emphasis on marketing cost analysis; Bhuiyan and Das (1985), Rokeya *et al.* (1997) etc. have worked on fish marketing of several species or a group of fishes in Bangladesh; Ahmed *et al.* (1993) reported fish marketing in two thanas of Bangladesh; Mazid (1994) delivered speech on fish markets in the SAARC workshop; Hossain (1996) reported the marketing system of prawns and small indigenous fishes; Ahmed and Hossain (2000) studied on marketing of freshwater prawn; Nurullah *et al.* (2003) described harvesting, transportation and marketing of small fishes; Khanam *et al.* (2003) worked on marketing of small indigenous species of fishes.

L. calcarifer fish forms an important brackish water capture fishery, which is found in rivers, estuaries, seas and ghers (polder area) of Bangladesh. It is caught largely from river, ghers with other small size fishes. During the study period, the marketing of *Lates calcarifer* was investigated on the basis of interviews collected from the different fish traders and fisherman. According to those findings, it was noticed that the demand of this species was more than the other fishes because of its taste, marketable value and medicinal SIS in Bangladesh. The demand elasticity (consumers' performance) is the guideline for the fishermen as well as other fish traders to determine the price.

L. calcarifer is not directly transported to the wholesalers of Dumuria Bazar, Khornia Bazar and Paikgacha Bazar rather the selling began from the producing area by the fishermen themselves and some percentage of the products reach a main market through different intermediaries. The intermediaries (e.g. faria) again sell the product at the nearby smaller markets and also handover to another intermediary (e.g. bepari) for selling at a big market.

The present work deals with the fishing methods, fishing gears used for catching of *Lates calcarifer*, fishing season, fish landing, the existing marketing channel and its activities, marketing margin, marketing cost and profit of the different intermediaries of the fish markets in Khulna.

The present study was undertaken on the following objects-

1. To identify the fishing gears used to harvest *Lates calcarifer*.
2. To find out the type and amount of *Lates calcarifer* harvested.
3. To know the landing, marketing channel, marketing margin, marketing cost, profit of intermediaries, seasonal price variation and the importance of this species in fishery.

6.2 Materials and Methods

6.2.1 Study Area

The study area consists of different fish catching and landing centers and fish markets of Khulna district. The species is abundantly found in the rivers and ghers (polder area). The site of the study area was selected on the basis of frequent of the species of these are Paikgacha Bazar, Dumuria Bazar, Khornia Bazar and Khulna City Corporation (KCC) fish market (Fig. 6.1). The fishing of *Lates calcarifer* was investigated on the basis of interviews made from the different fishermen and field survey at different fish landing centers and markets in the study area.

6.2.2 Study Period

This data was collected for a period of one year, from July 2014 to June 2015.

6.2.3 Data Collection

Information regarding the fishery of *Lates calcarifer* has collected by visiting various fishing and landing centre's of southern region of Bangladesh (Khulna). Three visits were made in each month and necessary data were recorded. In very possible case measurements of different fishing nets and traps were recorded. Mode of operation, materials used, advantages and disadvantages of their uses etc. were also recorded from interviews of experienced persons and self witness in different places. Survey was carried on different seasons of the year.

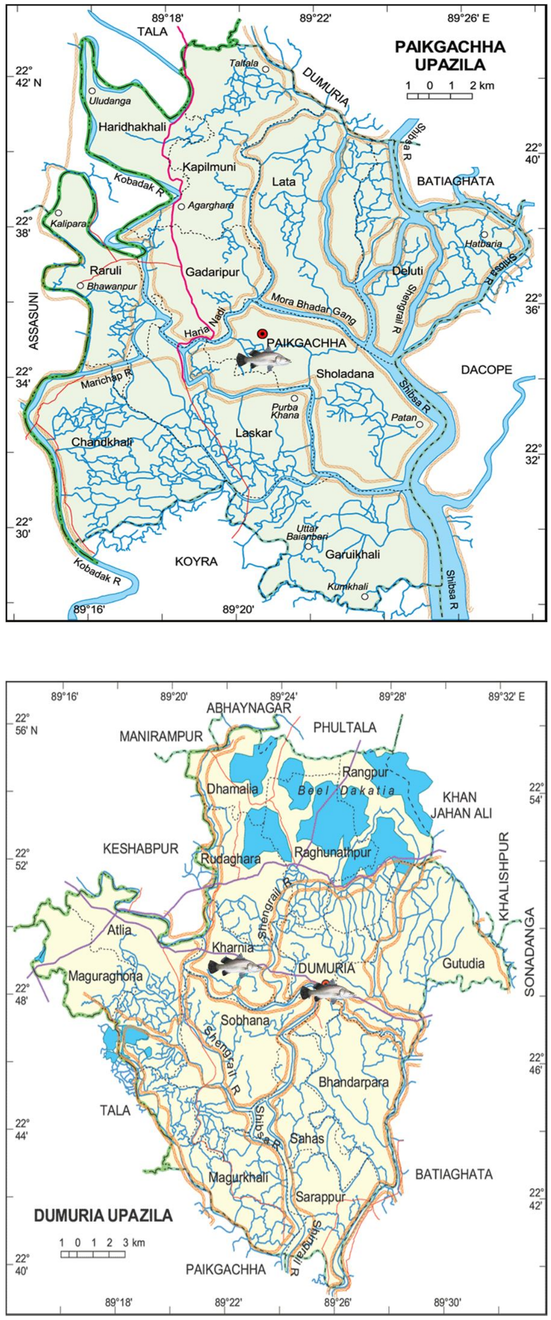

Fig. 6.1: Location of studied fish markets ( )

Fig. 6.2: Overview of a gher in the study area

Fig. 6.3: Khulna City Corporation (KCC) fish market

The information on marketing system of *Lates calcarifer* was also collected from different fish landing centers of Khulna on the basis of interviews taken from different fish traders engaged with the business of the studied species. The data pertaining to daily landing total landing centre's were recorded for the convenience of their tax collection. The daily landing of each month was recorded for that particular month.

As the price of *Lates calcarifer* at different levels of marketing varies with its size, the studied species was grouped under three size-categories to obtain reliable results from the present research effort. To serve this purpose, selected fish landing centers and markets were pre-surveyed and price at various levels of marketing (e.g. wholesale price, retail price etc.) were observed and recorded. Then the studied species was grouped into suitable size-categories on the basis of similarity in price.

Collected data were analyzed by MS Excel 2007. Each fish market was surveyed for three days a month and the data for every day was collected from the records kept by *Lates calcarifer* business associated people and also by self investigation. The average landing value and the average price value were calculated with the same computer software.

6.3 Results and Observation

6.3.1 Fishing Methods

The term 'fishing' means to capture fish by any process. The types of fishing method chosen for use in rivers are conditioned by three factors; the nature of the fish stock, the form of the river and the degree of development of the fishing commodity. The fishes of tropical and subtropical rivers are particularly diverse, most of which differ to some degree in their selection of habit, diet and migration pattern. Many fisheries exploit all species that are catchable and so a great number of fishing methods have evolved.

From the prehistoric times various types of fishing methods have been developed in our country and it depended on season, locality and species. For this purpose varieties of fishing gears, traps and crafts etc. are made which have undergone evolution in different parts of the world giving rise to various methods of the present day (Khanna, 1978). Various types of locally made traditional gears and traps are used in Khulna since centuries for capturing *Lates calcarifer* along with other small species.

6.3.2 Fishing Nets

Different types of nets are used in the river Shibsha and Kapatakkha both by professional and non-professional fishermen. The fiber used and the mesh size are very important for nets. The thickness of the fiber used, mesh size, floats and sinkers in the nets differ in quality, quantity and design depending on the size of fish catch and depth of water. The designs of nets are not changed from the centuries but a little bit exception is found in the river Shibsha and Kapatakkha. Some important fishing nets which are used to capture *Lates calcarifer* in the river Shibsha, Kapatakkha and ghers (polder areas) are described below:

6.3.2.1 Veshal Jal

'Veshal Jal' is triangular in shape. Two margins or the net are attached to the bamboo frames to apply the name for 'Khora'. The mesh size was found as 0.5 to 1.5 cm.

The landing capacity of this net was found as 1 kg to 8 kg per catch according to the population density of fishing season of the species. The nets were found to be used in rivers and also in ghers. The net was found to be operated either from a boat permanently set up with the help of bamboo sticks or used directly in the water and then raised up.

'Veshal' jal is used rivers and ghers. Materials required to make the net is nylon thread, ropes or nylon and jute yarn and several bamboo poles and sticks. The length of the veshal jal varies from 11-16 m similarly the length of front margin is 7-12 m.

6.3.2.2 Khepla Jal

'Khepla Jal' (cast net) is commonly used in the rivers and ghers more or less round the year both by professional and non-professional fishermen. The length of this net is 3.5m to 4.5m long, the low size of the net is surrounded by sinkers made of iron. The sinkers are attached to the mouth by sewing the margin resulting in small pockets. It is a conical shaped net having a circular mouth like a large umbrella.

Fig. 6.4: Fishing by Khepla Jal in a gher to harvest *Lates calcarifer*

The mesh size is about 0.7cm to 1.5cm. A strong cord is attached to the apex of the umbrella and numbers of led or iron weights are fixed along with the margin. The margins of pockets are provided with iron weights. As soon as the net is thrown, it goes down due to its weight as well as the weight of the sinkers. When the net is hauled the sinkers disturb the fish, which enter the pockets and are secured there.

6.3.2.3 Ber Jal

'Ber jal' is used in the river Shibsha, Rupsha and Kapatakkha etc. during winter to early summer to catch all types of large, medium and small size fishes. The shape of this net is rectangular. The length ranges from 70m to 150m depth from 5m to 8.5m. The head rope contains floats and bottom rope contains sinkers. The 'ber jal' is made of comparatively thicker nylon thread with 0.7cm to 1.7cm mesh size. The net are prepared in small pieces which are joined together at the time of operation according to the necessity. All types of fishes are caught by this net. The length, depth and meshes of the nets vary with the stretches of water to the netted and the type of fish to be caught.

Fig. 6.5: Fishing by Ber Jal in a river to harvest *Lates calcarifer*

6.3.2.4 Punti Jal

Usually 'Punti jal' (small mesh gill net) is 10m to 12m long and 0.6m to 1.0m wide. It is made of fine mono filamentous or multi filamentous nylon twine with mesh size from 1.0cm to 3.18cm. Floating stick with a coarse rope is used from the beginning to end margin of the surface portion. This gear is fixed with the border of gher. Border of the net is tied with pole or weeds. Sometimes more than one net is set in combination.

Table 6.1: Related information on the gears used in fishing of *Lates calcarifer*

Considerations			Fishing nets			
			Veshal jal	**Khepla jal**	**Ber jal**	**Punti jal**
Type of thread used			Nylon	Nylon	Nylon	Nylon
Materials used in fishing nets	Sinker		Bamboo	Iron	Rope	Bamboo
	Float		No	No	Sponge, wood	No
	Other occasion		Long rope	Long rope	Long rope	Long stick and rope
Gear size	Total length (m)	Min	11.00	03.50	70.00	
		Max	16.00	04.50	100.0	
	Breadth (m)	Min	07.00	N/A	05.00	
		Max	12.00	N/A	08.50	
	Mesh (cm)	Min	00.50	00.70	00.70	
		Max	01.50	01.50	01.70	
Operation areas	Depth (m)		5.0-7.0	1.0-7.0	7.0-10.0	1.0-6.0
	Water type		Both clean and turbid in tide	Both clean and turbid	Clean	Clean
	Season		Rainy season	Year round	Winter to early summer	Rainy season
Manpower involved			1	1	10-16	3-5
Mode of operation			Boat	Boat optional	Boat	Boat optional

6.3.3 Katha Fishing

Katha fishing is a special type of fishing method used in different parts of the country. In the study areas, this method was found only in rivers (Shibsa and Kapatakkha rivers). In suitable places of rivers (of suitable depth, near river bank) tree branches with leaves and bamboo poles are kept during rainy season to create a suitable habitat or place for fishes, which is locally known as katha. In the Shibsa and Kapatakkha rivers, local fishermen and some other people perform this to harvest lots of fishes at a time. Cow dung was supplied to the katha to enhance primary production so that natural food availability can be increased to a great extent.

Sometimes boiled rice was also supplied. Fishes of various species came at these kathas as they get more natural foods in these areas. Between August and September, these areas (katha areas) are enclosed by bana (locally known as Pata) or vertically placed seine nets. Then the vegetative supports removed from katha and fishing was done by cast net (Khepla jal). Hand fishing was also a common method of fishing in kathas.

6.3.4 Fish Landing

Daily average amount of fish landed in the studied fish landing centers and markets are shown in Fig. 6.6 and 6.7. Amount of landing of *Lates calcarifer* is varied from market to market. More or less higher amount of landing was observed at the Paikgacha fish landing center and market (Fig. 6.6 and Appendix Table 6.1).

Fig 6.6: Landed *Lates calcarifer* in a fish landing center

In the Paikgacha fish landing center and market, the highest average daily fish landing (347.00±37.51kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (138.33±40.81kg) was found in June 2015 (Fig. 6.7 and Appendix Table 6.1).

In the Dumuria fish landing center and market, the highest average daily fish landing (340.00±38.22kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (100.00±14.42kg) was found in June 2014 (Fig. 6.7 and Appendix Table 6.1).

In the Khornia fish landing center and market, the highest average daily fish landing (290.33±28.59kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (118.67±31.56kg) was found in November 2014 (Fig. 6.7 and Appendix Table 6.1).

In the Khulna City Corporation (KCC) fish market, the highest average daily fish landing (55.00±07.55kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (27.33±05.13kg) was found in November 2014 (Fig. 6.7 and Appendix Table 6.1). Overall landing value was found lower in this fish market because there was no commission agents (Aratdar) in this market and all the fishes were brought by the middlemen involved in the marketing channel of *Lates calcarifer* in the study area.

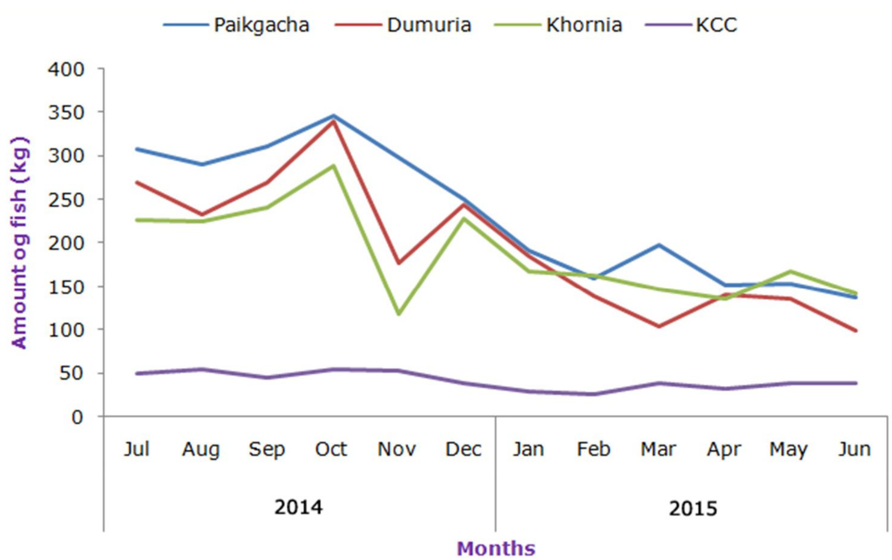

Fig. 6.7: Daily average amount of *Lates calcarifer* landed in four studied fish landing centers and markets of Khulna district.

6.3.5 Distribution / Marketing Channel of *Lates calcarifer*

The nature of marketing channel or distribution channel of *Lates calcarifer* was 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. Marketing activities and distribution of harvested *Lates calcarifer* from the study areas are shown in Figure 6.8 and 6.9. Comparatively short marketing channel of *Lates calcarifer* was observed in the study areas, which is composed of following categories of people-

a. Fishermen/Fish farmer/Producer
b. Aratdar (Commission agents)
c. Beparies
d. Retailer
e. Consumer

a. Fishermen / Fish farmer / Producer

Fishermen are involved in fishing of *Lates calcarifer* from studied water bodies (i.e. Shibsa river, Kapatakkha river and ghers) with their fishing nets or other fishing gears. Fish farmers are the producer who cultured concerned fish species in their ghers. During harvesting period, these producers or fish farmers hire fishermen to catch fishes from ghers. In the study area, these people (fishermen from rivers, fish farmers or producers from ghers) directly sell their harvested or captured *Lates calcarifer* to the commission agents of the local fish landing centers. In addition, small amount of fishes are also sold directly to the consumers by these people at the harvesting spots.

b. Aratdar / Commission agents

In the Paikgacha, Dumuria and Khornia fish landing centers and markets, commission agents were available. In these landing centers and markets, harvested *Lates calcarifer* are brought by the fishermen or fish farmers. These commission agents act as a media to sell these fishes to local retailers, beparies or sometimes directly to the consumers on a fixed rate of commission. In these fish landing centers and markets, the commission agents take 3% commission. They sell fishes on wholesale basis through open or public auction and considered 1100g as 1kg during wholesale, *i.e.* the fishermen or fish farmers have to give 100g fish for free in every kg.

Fig. 6.8: Open auction of *Lates calcarifer*

c. Beparies

The beparies are the middlemen involved in the distribution of concerned fishes from the local area to distant areas. Two types of beparies were identified during the period of study- beparies, who buy fishes from the commission agents of Paikgacha, Dumuria and Khornia fish landing centers and brought to the Khulna City Corporation (KCC) market and beparies, who buy fishes from the mentioned fish landing centers and brought to other large cities of the country, like Dhaka and Chittagong.

d. Retailers

Retailers are involved in selling *Lates calcarifer* to the consumers or customers. They collect fishes from the commission agents or beparies (in KCC market only).

e. Consumers

The consumers are general customers who buy fishes mainly from the retailers at the studied fish landing centers and markets. Sometimes, consumers also buy fishes directly from the commission agents (in Paikgacha, Dumuria and Khornia) or from the fishermen (when fishermen landed their fish at river banks) or from fish farmers (from ghers at the time of harvesting).

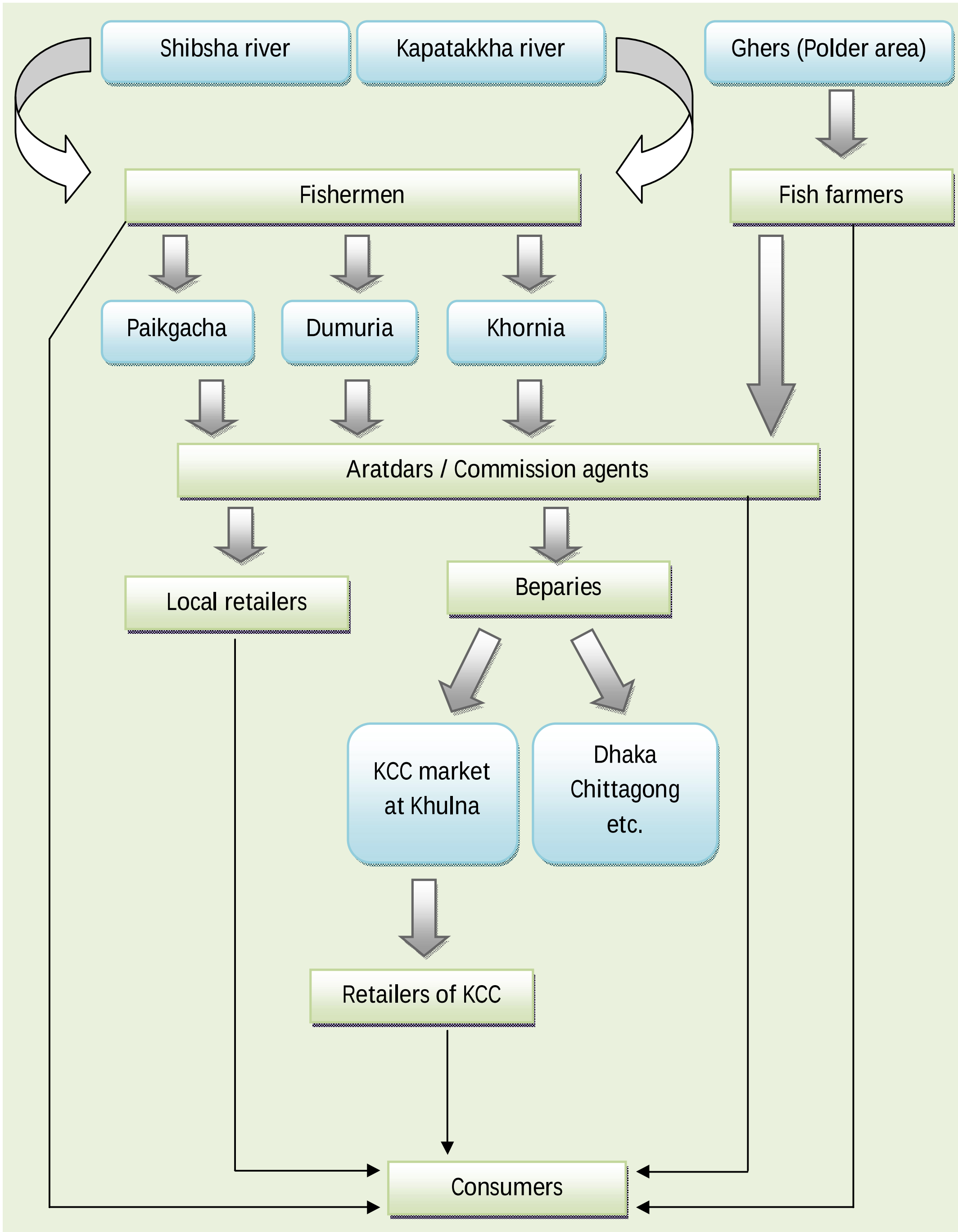

Fig. 6.9: Distribution or marketing channel of *Lates calcarifer* from the study spots

6.3.6 Variation in Wholesale and Retail Prices

250-750g fishes

Average wholesale price of 250-750g *Lates calcarifer* in Paikgacha, Dumuria and Khornia fish landing centers and markets are shown in Fig. 6.10. Wholesale price was found comparatively low in Paikgacha followed by Khornia and Dumuria.

In Paikgacha fish landing center and market, the highest wholesale price (203.67±07.64 BDT/kg) was recorded in the month of March 2015 and the lowest (172.00±05.00 BDT/kg) was found in July 2014 (Fig. 6.10 and Appendix Table 6.2).

In Dumuria fish landing center and market, the highest wholesale price (210.33±02.89 BDT/kg) was recorded in the month of April 2015 and the lowest (180.33±05.77 BDT/kg) was found in July 2014 (Fig. 6.10 and Appendix Table 6.2).

In Khornia fish landing center and market, the highest wholesale price (207.00±08.66 BDT/kg) was recorded in the month of March 2015 and the lowest (172.00±08.66 BDT/kg) was found in July 2015 (Fig. 6.10 and Appendix Table 6.2).

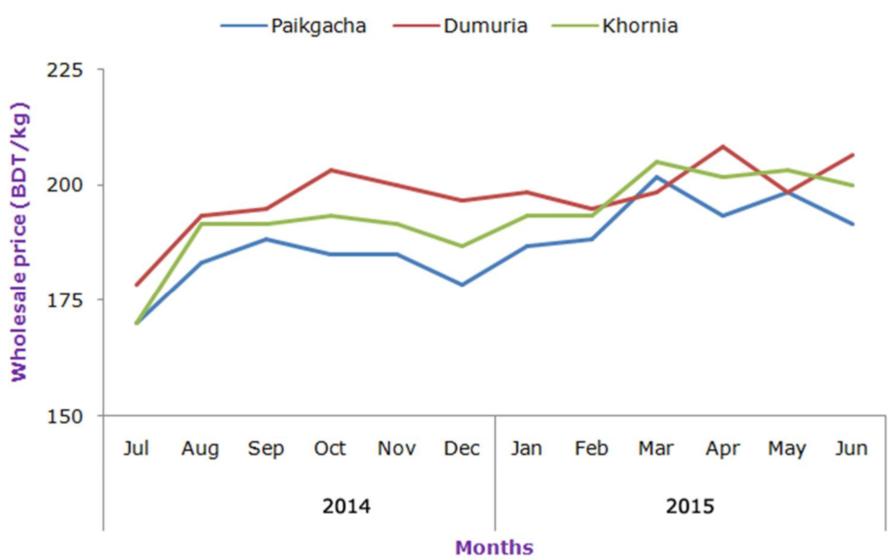

Fig. 6.10: Variation in wholesale price of 250-750g *Lates calcarifer* in three fish landing centers and markets during the period of research

Average retail price of 250-750g *Lates calcarifer* in Paikgacha, Dumuria, Khornia and Khulna City Corporation (KCC) fish landing centers and markets are shown in Fig. 6.11. Retail price was found higher in KCC than that of Dumuria, Khornia and Paikgacha.

In Paikgacha fish landing center and market, the highest retail price (228.67±05.77 BDT/kg) was recorded in the month of March 2015 and the lowest (190.67±08.08 BDT/kg) was found in July 2014 (Fig. 6.11 and Appendix Table 6.3). Yearly average retail price in Paikgacha was calculated 212.64 BDT/kg (Appendix Table 6.3).

In Dumuria fish landing center and market, the highest retail price (232.67±05.13 BDT/kg) was recorded in the month of April 2015 and the lowest (200.67±03.21 BDT/kg) was found in July 2014 (Fig. 6.11 and Appendix Table 6.3). Yearly average retail price in Dumuria was calculated 224.19 BDT/kg (Appendix Table 6.3).

In Khornia fish landing center and market, the highest retail price (230.33±02.89 BDT/kg) was recorded in the month of May 2015 and the lowest (198.67±07.51 BDT/kg) was found in July 2014 (Fig. 6.11 and Appendix Table 6.3). Yearly average retail price in Khornia was calculated 220.78 BDT/kg (Appendix Table 6.3).

In KCC fish market, the highest retail price (268.67±02.89 BDT/kg) was recorded in the month of June 2015 and the lowest (232.67±11.02 BDT/kg) was found in August 2014 (Fig. 6.11 and Appendix Table 6.3). Yearly average retail price in KCC was calculated 250.25 BDT/kg (Appendix Table 6.3).

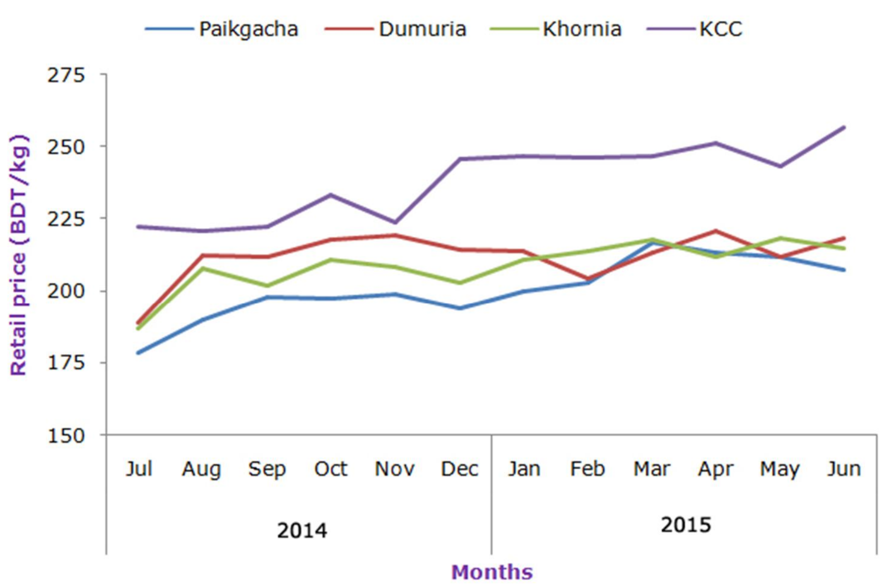

Fig. 6.11: Variation in retail price of 250-750g *Lates calcarifer* in four fish landing centers and markets during the period of research

750-2500g fishes

Average wholesale price of 750-2500g *Lates calcarifer* in Paikgacha, Dumuria and Khornia fish landing centers and markets are shown in Fig. 6.12. Wholesale price was found comparatively low in Paikgacha followed by Khornia and Dumuria.

In Paikgacha fish landing center and market, the highest wholesale price (285.33±02.89 BDT/kg) was recorded in the month of May 2015 and the lowest (238.67±02.89 BDT/kg) was found in July 2014 (Fig. 6.12 and Appendix Table 6.4). Yearly average wholesale price in Paikgacha was calculated 268.67 BDT/kg (Appendix Table 6.4).

In Dumuria fish landing center and market, the highest wholesale price (300.33±02.89 BDT/kg) was recorded in the month of March 2015 and the lowest (245.33±02.89 BDT/kg) was found in July 2014 (Fig. 6.12 and Appendix Table 6.4). Yearly average wholesale price in Dumuria was calculated 276.56 BDT/kg (Appendix Table 6.4).

In Khornia fish landing center and market, the highest wholesale price (297.00±05.00 BDT/kg) was recorded in the month of May 2015 and the lowest (243.67±05.77 BDT/kg) was found in August 2014 (Fig. 6.12 and Appendix Table 6.4). Yearly average wholesale price in Khornia was calculated 272.86 BDT/kg (Appendix Table 6.4).

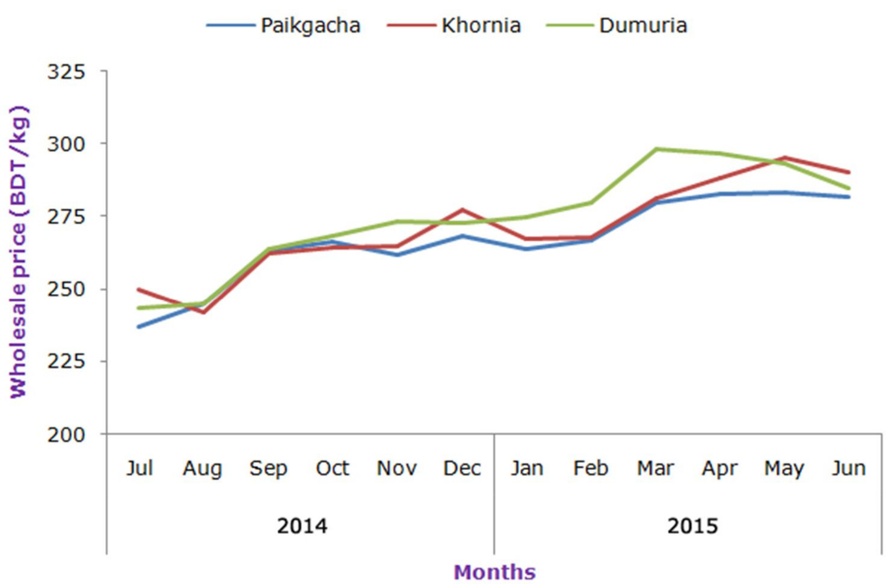

Fig. 6.12: Variation in wholesale price of 750-2500 g *Lates calcarifer* in three fish landing centers and markets during the period of research

Average retail price of 750-2500g *Lates calcarifer* in Paikgacha, Dumuria, Khornia and Khulna City Corporation (KCC) fish landing centers and markets are shown in Fig. 6.13. Retail price was found higher in KCC than that of Khornia, Dumuria and Paikgacha.

In Paikgacha fish landing center and market, the highest retail price (308.67±02.89 BDT/kg) was recorded in the month of March 2015 and the lowest (190.67±08.08 BDT/kg) was found in July 2014 (Fig. 6.13 and Appendix Table 6.5). Yearly average retail price in Paikgacha was calculated 292.44 BDT/kg (Appendix Table 6.5).

In Dumuria fish landing center and market, the highest retail price (320.00±02.65 BDT/kg) was recorded in the month of March 2015 and the lowest (267.00±10.00 BDT/kg) was found in August 2014 (Fig. 6.13 and Appendix Table 6.5). Yearly average retail price in Dumuria was calculated 295.92 BDT/kg (Appendix Table 6.5).

In Khornia fish landing center and market, the highest retail price (347.00±51.96 BDT/kg) was recorded in the month of May 2015 and the lowest (265.33±02.89 BDT/kg) was found in July 2014 (Fig. 6.13 and Appendix Table 6.5). Yearly average retail price in Khornia was calculated 295.95 BDT/kg (Appendix Table 6.5).

In KCC fish market, the highest retail price (328.67±05.77 BDT/kg) was recorded in the month of April 2015 and the lowest (275.33±05.77 BDT/kg) was found in August 2014 (Fig. 6.13 and Appendix Table 6.5). Yearly average retail price in KCC was calculated 301.91 BDT/kg (Appendix Table 6.5).

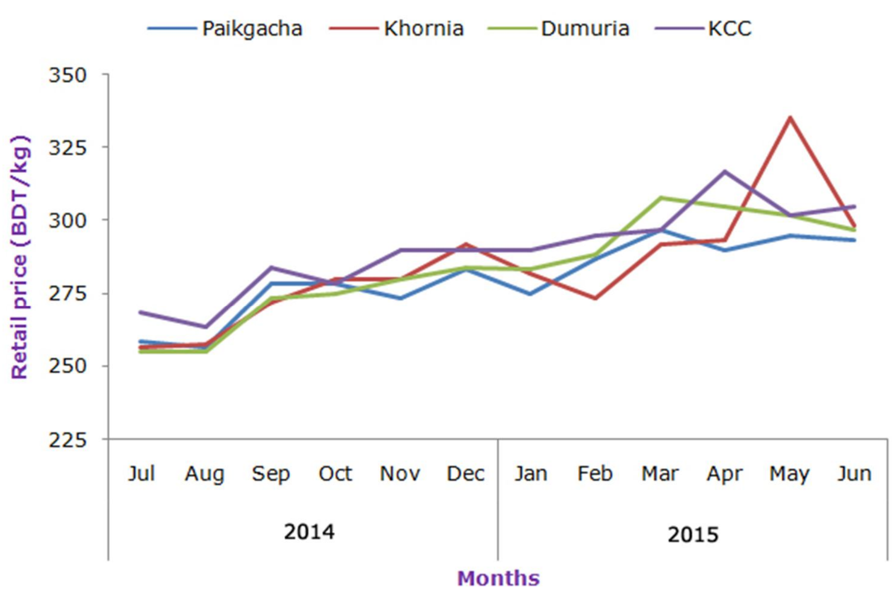

Fig. 6.13: Variation in retail price of 750-2500g *Lates calcarifer* in four fish landing centers and markets during the period of research

2500-5000g fishes

Average wholesale price of 2500-5000g *Lates calcarifer* in Paikgacha, Dumuria and Khornia fish landing centers and markets are shown in Fig. 6.14. Wholesale price was found comparatively low in Paikgacha followed by Khornia and Dumuria.

In Paikgacha fish landing center and market, the highest wholesale price (398.67±11.55 BDT/kg) was recorded in the month of April 2015 and the lowest (332.00±08.66 BDT/kg) was found in June 2014 (Fig. 6.14 and Appendix Table 6.6). Yearly average wholesale price in Paikgacha was calculated 368.81 BDT/kg (Appendix Table 6.6).

In Dumuria fish landing center and market, the highest wholesale price (405.33±02.89 BDT/kg) was recorded in the month of June 2015 and the lowest (323.67±02.89 BDT/kg) was found in July 2014 (Fig. 6.14 and Appendix Table 6.6). Yearly average wholesale price in Dumuria was calculated 377.14 BDT/kg (Appendix Table 6.6).

In Khornia fish landing center and market, the highest wholesale price (435.33±07.64 BDT/kg) was recorded in the month of June 2015 and the lowest (337.00±00.00 BDT/kg) was found in July 2014 (Fig. 6.14 and Appendix Table 6.6). Yearly average wholesale price in Khornia was calculated 392.39 BDT/kg (Appendix Table 6.6).

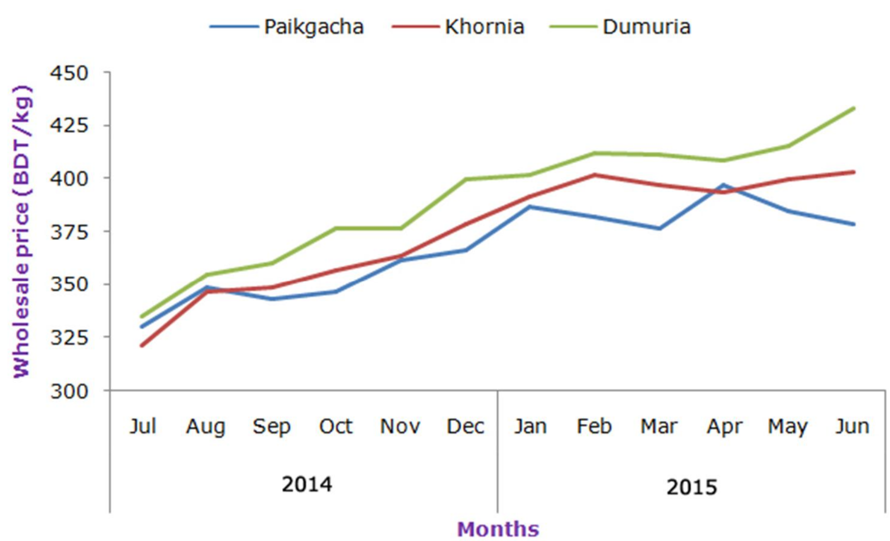

Fig. 6.14: Variation in wholesale price of 2500-5000g *Lates calcarifer* in three fish landing centers and markets during the period of research.

Average retail price of 2500-5000g *Lates calcarifer* in Paikgacha, Dumuria, Khornia and Khulna City Corporation (KCC) fish landing centers and markets are shown in Fig. 6.15. Retail price was found higher in KCC than that of Khornia, Dumuria and Paikgacha.

In Paikgacha fish landing center and market, the highest retail price (420.33±18.93 BDT/kg) was recorded in the month of April 2015 and the lowest (348.67±11.55 BDT/kg) was found in July 2014 (Fig. 6.15 and Appendix Table 6.7). Yearly average retail price in Paikgacha was calculated 388.81 BDT/kg (Appendix Table 6.7).

In Dumuria fish landing center and market, the highest retail price (432.00±05.00 BDT/kg) was recorded in the month of June 2015 and the lowest (343.67±05.77 BDT/kg) was found in July 2014 (Fig. 6.15 and Appendix Table 6.7). Yearly average retail price in Dumuria was calculated 397.69 BDT/kg (Appendix Table 6.7).

In Khornia fish landing center and market, the highest retail price (452.00±10.00 BDT/kg) was recorded in the month of June 2015 and the lowest (353.67±02.89 BDT/kg) was found in July 2014 (Fig. 6.15 and Appendix Table 6.7). Yearly average retail price in Khornia was calculated 411.58 BDT/kg (Appendix Table 6.7).

In KCC fish market, the highest retail price (457.00±05.00 BDT/kg) was recorded in the month of April 2015 and the lowest (348.67±11.55 BDT/kg) was found in July 2014 (Fig. 6.15 and Appendix Table 6.7). Yearly average retail price in KCC was calculated 414.42 BDT/kg (Appendix Table 6.7).

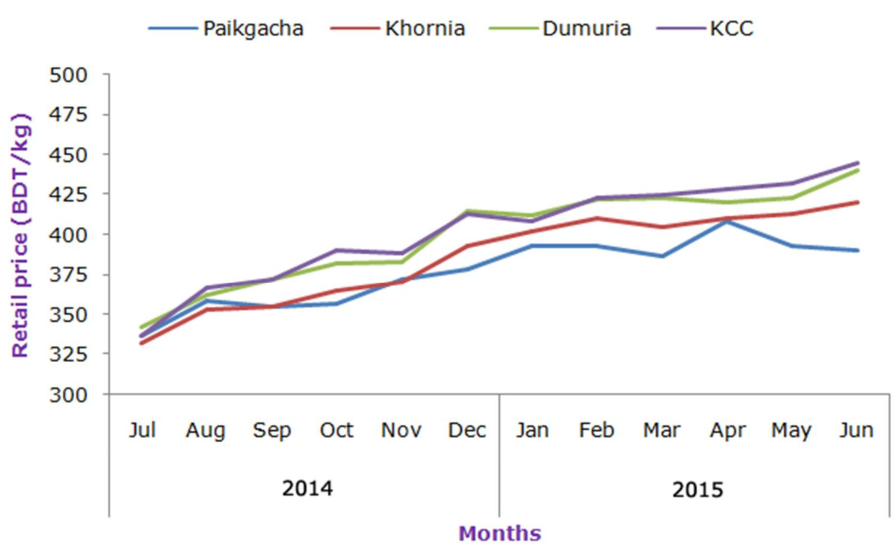

Fig. 6.15: Variation in retail price of 2500-5000g *Lates calcarifer* in four fish landing centers and markets during the period of research

6.3.7 Profit Analysis

250-750g fishes

Monthly average marketing margin of 250-750g *Lates calcarifer* in Paikgacha, Dumuria and Khornia fish landing centers and markets are shown in Fig. 6.16, 6.17 and 6.18.

In the Paikgacha fish landing center and market, the yearly average marketing margins of 250-750g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 181.87±08.23 BDT/kg, 5.63±0.25 BDT and 13.14±3.58 BDT/kg respectively (Fig. 6.16 and Appendix Table 6.8).

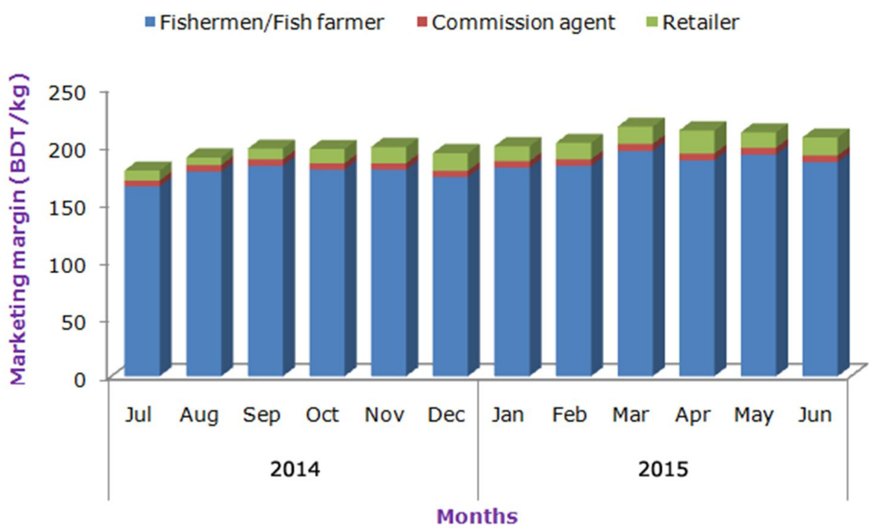

Fig. 6.16: Marketing margin of 250-750g *Lates calcarifer* in Paikgacha fish landing center.

In the Dumuria fish landing center and market, the yearly average marketing margins 250-750g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 191.71±7.41 BDT/kg, 5.93±0.23 BDT and 14.56±3.26 BDT/kg respectively (Fig. 6.17 and Appendix Table 6.9).

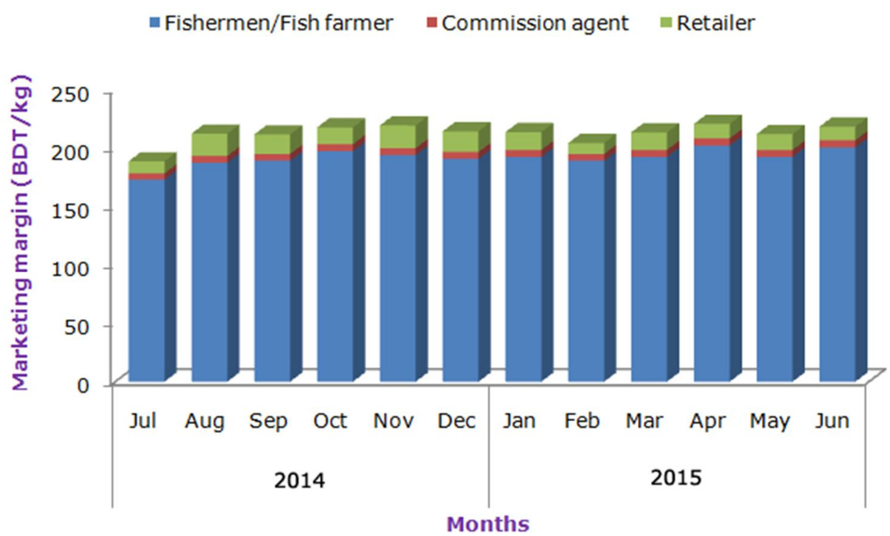

Fig. 6.17: Marketing margin of 250-750g *Lates calcarifer* in Dumuria fish landing center

In the Khornia fish landing center and market, the yearly average marketing margins 250-750g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 187.67±9.00 BDT/kg, 5.81±0.28 BDT and 15.31±3.02 BDT/kg respectively (Fig. 6.18 and Appendix Table 6.10).

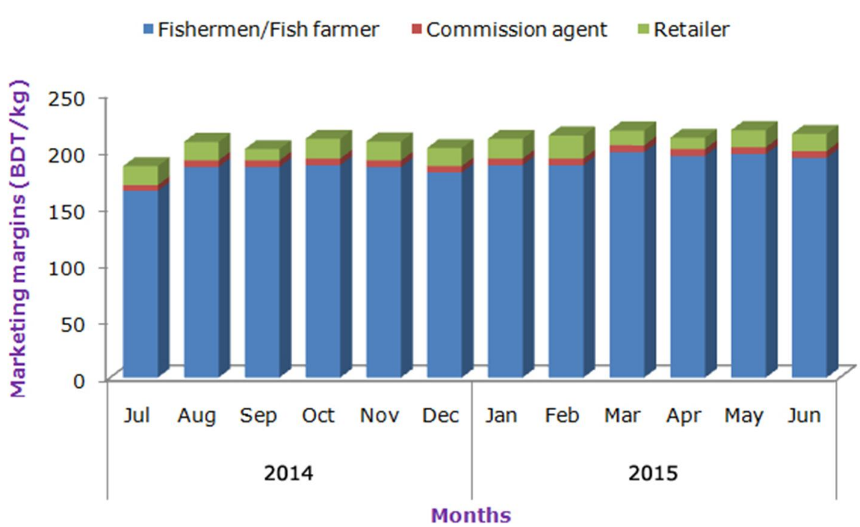

Fig. 6.18: Marketing margin of 250-750g *Lates calcarifer* in Khornia fish landing center and market during the period of study.

750-2500g fishes

Monthly average marketing margin of 750-2500g *Lates calcarifer* in Paikgacha, Dumuria and Khornia fish landing centers and markets are shown in Fig. 6.19. 6.20 and 6.21.

In the Paikgacha fish landing center and market, the yearly average marketing margins of 750-2500g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 258.67±14.22 BDT/kg, 8.00±0.44 BDT and 13.78±4.18 BDT/kg respectively (Fig. 6.19 and Appendix Table 6.10).

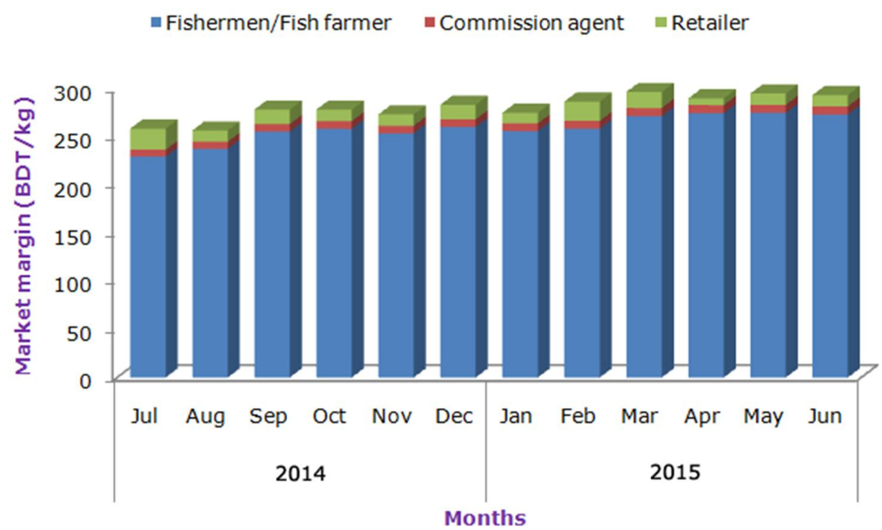

Fig. 6.19: Marketing margin of 750-2500g *Lates calcarifer* in Paikgacha fish landing center.

In the Dumuria fish landing center and market, the yearly average marketing margins of 750-2500g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 266.32±17.44 BDT/kg, 8.24±0.54 BDT and 9.36±1.97 BDT/kg respectively (Fig. 6.20 and Appendix Table 6.12).

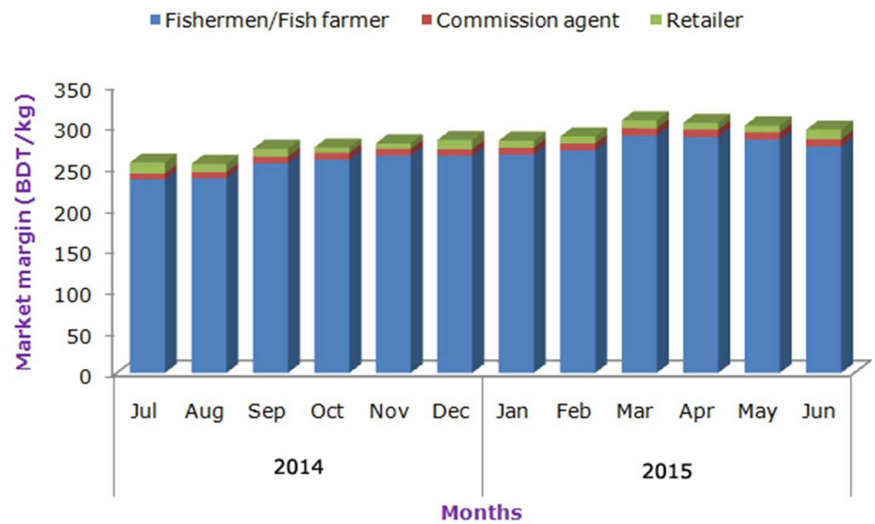

Fig. 6.20: Marketing margin of 750-2500g *Lates calcarifer*in Dumuria fish landing center

In the Khornia fish landing center and market, the yearly average marketing margins of 750-2500g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 262.73±15.65 BDT/kg, 8.13±0.48 BDT and 13.09±9.56 BDT/kg respectively (Fig. 6.21 and Appendix Table 6.13).

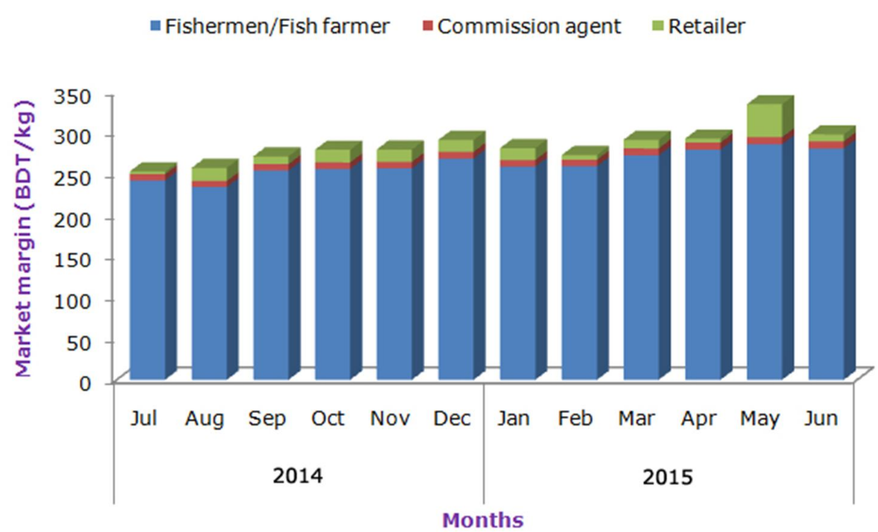

Fig. 6.21: Marketing margin of 750-2500g *Lates calcarifer* in Khornia fish landing center and market during the period of study.

2500-5000 g fishes

Monthly average marketing margin of 2500-5000g *Lates calcarifer* in Paikgacha, Dumuria and Khornia fish landing centers and markets are shown in Fig. 6.22, 6.23 and 6.24.

In the Paikgacha fish landing center and market, the yearly average marketing margins of 2500-5000g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 355.80±20.15 BDT/kg, 11.00±0.62 BDT and 10.00±1.88 BDT/kg respectively (Fig. 6.22 and Appendix Table 6.14).

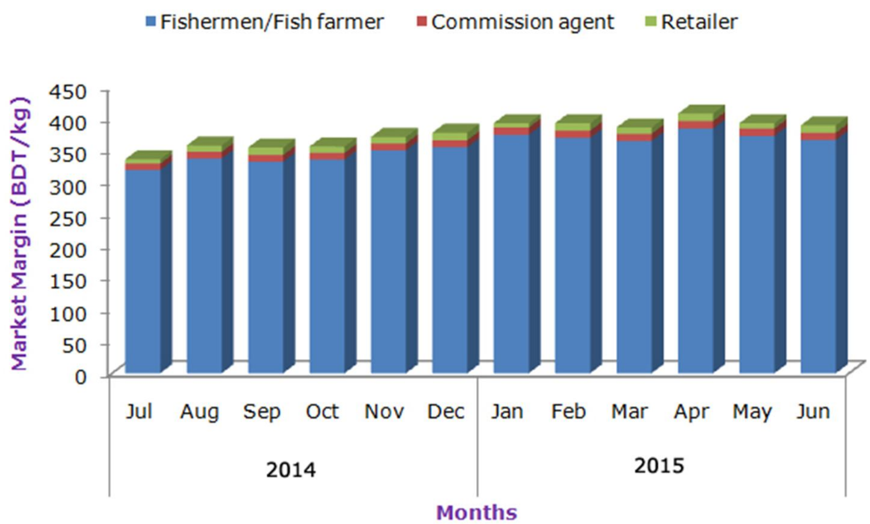

Fig. 6.22: Marketing margin of 2500-5000g *Lates calcarifer* in Paikgacha fish landing center

In the Dumuria fish landing center and market, the yearly average marketing margins of 2500-5000g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 378.68±28.51 BDT/kg, 11.71±0.88 BDT and 9.20±3.04 BDT/kg respectively (Fig. 6.23 and Appendix Table 6.15).

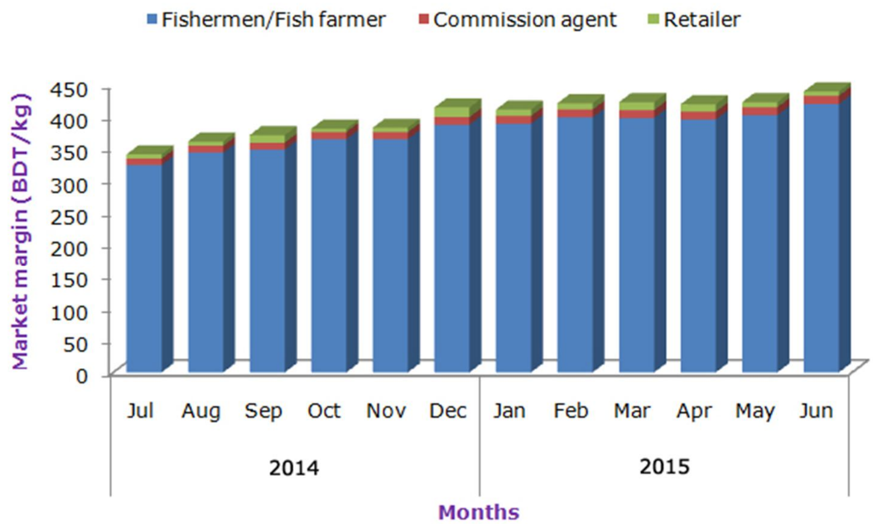

Fig. 6.23: Marketing margin of 2500-5000g *Lates calcarifer* in Dumuria fish landing center

In the Khornia fish landing center and market, the yearly average marketing margins of 2500-5000g *Lates calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 363.89±26.26 BDT/kg, 11.25±0.81BDT and 10.56±3.85 BDT/kg respectively (Fig. 6.24 and Appendix Table 6.16).

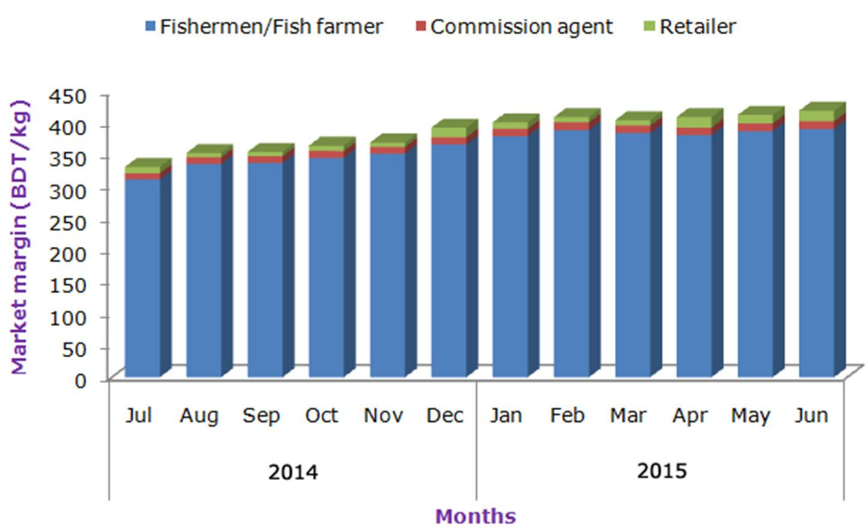

Fig. 6.24: Marketing margin of 2500-5000g *Lates calcarifer* in Khornia fish landing center.

6.4 Discussion

The nature of marketing channel or distribution channel of commodities is found to depend on the distance between the producing areas and the markets and on the conditions of transportation system. The channel becomes more complex regarding the greater distance and undeveloped communication system.

Marketing system mainly depends on the technique applied in buying and selling activities. The condition of transport, storage facilities, grade of commodity, effectiveness of the marketing organization and management and margin of the middlemen are the main aspects of marketing system. On the other hand a better marketing system is needed for steady supply, demand and moderate price of *Lates calcarifer* which is landed at Paikgacha, Dumuria and Khornia fish landing centers and markets and captured mainly from the Shibsa river, Kapatakkha river and local ghers (polder). The demand of this fish is high against its supply for its delicious taste.

In order to manage fisheries intelligently it is necessary to have some knowledge of various types of fishing gears. Gears used for fishing in different sampling areas are of traditional and seldom meet the fishermen's demand to catch adequate fish. In the present investigation, only four types of fishing nets and katha fishing method were applied to catch the concerned species which are already described. Among fishing nets, the fishermen use 'veshal jal', 'khepla jal', 'ber jal' and 'punti jal' for fishing of *L. calcarifer*. Off which, ber jal and khepla jal were used in both rivers and ghers and veshal jal and punti jal were only used in rivers.

The nature of marketing channel or distribution channel of *Lates 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.

Supply of *Lates calcarifer* to the studied fish landing centers and markets is continuous throughout the year. However, the amount of supply varied with the season.

Comparatively short marketing channel of *Lates calcarifer* was observed in the study areas, which is composed of following categories of people: fishermen or fish farmer or producer, aratdar (commission agents), beparies, retailers and consumers.

Average wholesale price of 250-750g *Lates calcarifer* was found comparatively low in Paikgacha followed by Khornia and Dumuria; whereas, the retail price was found higher in KCC than that of Dumuria, Khornia and Paikgacha (Appendix Table 6.2 and

6.3). Average wholesale price of 750-2500g *Lates calcarifer* was found comparatively low in Paikgacha followed by Khornia and Dumuria; whereas, retail price was found higher in KCC than that of Khornia, Dumuria and Paikgacha (Appendix Table 6.4 and 6.5). Average wholesale price of 2500-5000g *Lates calcarifer* was found comparatively low in Paikgacha followed by Khornia and Dumuria; whereas, Retail price was found higher in KCC than that of Khornia, Dumuria and Paikgacha fish landing centers and markets (Appendix Table 6.6 and 6.7).

Thakur (1974) described the importance of analysis of marketing margin to determine the marketing. In an efficient marketing system, the margin will be small as the percentages of marketing costs and profits of the traders mainly low. The marketing cost depends mainly on the distance between producing areas and the markets and on the efficiency of the transporting system. The cost involved in the marketing channel of *Lates calcarifer* for different fish landing centers and markets of Khulna are found to be vary mainly for the profit of amount supply and distance between production and selling sites.

Depending on the producing season of concerned fish species the price varies among the landing centers and markets. As a whole the marketing cost was higher in KCC market where the profit level was also higher than other landing centers and markets. When the fishermen or fish farmers sell directly to the consumers, they receive a good price for their fishes in the study areas. Similar results were also noted by Ahmed (1977).

Galib *et al.* (2009a and 2009b) reported that 27 fishing gears and 2 FADs were usedin the Chalan Beel of north-west Bangladesh for catching fishes. Jewel (2006) identified 6 types of net, 4 types of traps and 1 type 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 BDT 400 per kg of *Clarias batrachus*.

Chapter Seven

Summary

SUMMARY

7.1 Ecology of *Lates calcarifer*

In the Shibsa river, the highest average air temperature (33.24±4.78°C) was recorded in the month of September 2013; whereas, the lowest air temperature (20.43±5.89°C) was recorded in December 2013 (Fig. 3.3). In case of water temperature, the highest measurement (32.18±3.12°C) was found in September 2013 and the lowest value (19.32±5.89°C) was recorded in December 2013 (Fig. 3.3). The overall mean air and water temperatures were found 28.71±4.03°C and 27.52±3.99°C respectively.

In the Kapatakkha river, the highest mean air temperature (33.60±0.29°C) was recorded in the month of September 2013; whereas, the lowest air temperature (21.65±0.25°C) was recorded in December 2014 (Fig. 3.4). In case of water temperature, the highest measurement (32.25±0.29°C) was found in September 2013 and the lowest value (20.32±0.29°C) was recorded in December 2014 (Fig. 3.4). The overall mean air and water temperatures were found 28.69±3.91°C and 27.66±4.06°C respectively.

In ghers, the highest average air temperature was recorded in the month of September 2014 (32.83±0.29°C); whereas, the lowest air temperature (21.67±0.29^{0}C) was recorded in December 2014 (Fig. 3.5). In case of water temperature, the highest measurement (31.83±0.29°C) was found in September 2014 and the lowest value (20.00±0.50°C) was recorded in December 2014 (Fig. 3.5). The overall mean air and water temperatures were found 29.03±3.45°C and 27.70±3.50°C respectively.

In the Shibsa river, the highest monthly average water transparency was measured 49.95±0.50cm (in May 2014) and the lowest was 24.50±0.32cm (September 2014; Fig. 3.6). In the Kapatakkha river the highest water transparency (37.65±.18cm) was found in April 2015 and the lowest measurement (24.10±.13cm) was recorded in June 2014 (Fig. 3.6). In ghers, the highest monthly average water transparency was measured 62.00±2.65cm (in January 2015) and the lowest was 08.00±2.00cm (June 2015; Fig. 3.6).

The rainfall level in both the Shibsa river and Kapatakkha river was found same. The highest monthly average rainfall was measured 382mm (in June 2014) and the lowest was 00 cm (November 2013 and 2014, and January 2015) (Fig. 3.7). In ghers, the highest monthly rainfall was measured 282mm (in June 2014) and the lowest was 00 mm (November 2013 and 2014, and January 2014, 2015) (Fig. 3.7).

In the Shibsa river, the highest monthly average water salinity was measured 19.25±3.66ppt (in June 2015) and the lowest was 4.10±0.06ppt (October 2014) (Fig. 3.8). In the Kapatakkha river the highest water salinity (18.10±0.21ppt) was found in November 2014 and the lowest measurement (08.15±2.65ppt) was recorded in June 2014 (Fig. 3.8). In ghers, the highest monthly average water salinity was measured 18.00±3.61ppt (in January 2015) and the lowest was 04.00±2.18ppt (June 2014) (Fig. 3.8).

In the Shibsa river, average yearly p^H was calculated 7.58±0.32. The highest p^H values were found 8.26±0.56 in February, 2015. The lowest value was recorded in July 2014 (7.12±0.39) (Fig. 3.9). In the Kapatakkha river, yearly average p^H was found 7.13±0.35. The highest monthly average p^H (7.61±0.40) was recorded in the month of December 2013, whereas the lowest value was found 6.52±0.21 in June 2014 (Fig. 3.9). In the ghers (polder area), the highest and lowest p^H values were found 8.00±0.00 (May, 2014) and 6.50±0.50 (July 2013) respectively (Fig. 3.9). Whereas, the yearly average p^H was calculated as 7.34±0.43.

In the Shibsa river, the yearly average DO was found as 5.91±0.71mg/l. The highest monthly average DO (7.78±0.54mg/l) was recorded in December 2014 and the lowest monthly mean DO (5.08±0.08mg/l) was found in February 2014 (Fig. 3.10). Whereas the yearly average free CO_2 was found as 5.53±0.81mg/l with the highest value (7.58±0.29mg/l) in the month of August 2014 and the lowest (4.22±0.02mg/l) in January 2015 (Fig. 3.10).

In the Kapatakkha river, the yearly average DO was found as 5.73±0.51mg/l. The highest monthly average DO (6.71±0.12mg/l) was recorded in December 2014 and the lowest monthly mean DO (5.02±0.02mg/l) was found in July 2014 (Fig. 3.11). Whereas the yearly average free CO_2 in the Kapatakkha river was found as 5.73±0.51mg/l with the highest value (6.78±0.08mg/l) in the month of July 2014 and the lowest (4.10±0.06mg/l) in May 2015 (Fig. 3.11).

In the ghers, the yearly average DO was found as 5.55±0.52mg/l. The highest monthly average DO (6.71±0.02mg/l) was recorded in December 2014 and the lowest monthly mean DO (4.51±0.57mg/l) was found in October 2013 (Fig. 3.12).

Whereas the yearly average free CO_2 was found as 5.23±0.88mg/l with the highest value (6.85±0.52mg/l) in the month of October 2013 and the lowest (4.12±0.03mg/l) in September 2013 (Fig. 3.12).

7.2 Foods and Feeding Habit

Chapter four describes the food and feeding of *Lates calcarifer* and this result is based on stomach contents of 300 specimens including 120 juvenile and 180 adult specimens

The food analyses of 120 specimens (15-25cm in total length) of juvenile *L. calcarifer* were dissected and examined. The specimens were collected between July 2014 and June 2015 (10 in each research month) from the fishermen of Shibsa river and Kapatakkha river and ghers (polder area) owners of research site *i.e.* Khulna district. The month-wise status of stomachs (either it is empty or filled with food items) of 120 juvenile are shown in the Table 4.1. Empty stomach or stomachs with poor food contents were found also rare. Maximum 20% of the observed specimen's stomachs were found empty in the month of December 2014 (Table 4.1). Whereas, 10% stomachs were found empty in October and November 2014; and January and February 2015 (Table 4.1).

Monthly variation in the degree of feeding of juvenile *Lates calcarifer* revealed that all fishes do not feed in the same intensity. The feeding intensity as well as the feeding condition vary from individuals to individuals. There is seasonal variation in the degree of feeding too. For the determination of the condition of feed or the degree of feeding of juvenile *Lates calcarifer*, all the stomachs examined were classified as full, ¾ full, ½ full, ¼ full, 1/8 full and empty by visual estimation depending on the distension or fullness of the stomachs. The total number of stomachs examined in each month, the actual number and percentage occurrence of stomachs under each category was classified and presented in Fig. 4.5 and Appendix Table 4.1.

Out of 120 stomachs of juvenile *Lates calcarifer* collected in different months over the study duration, maximum 26.67% stomachs were found as ½ full followed by full (25%), ¾ full (17.50%), 1/3 full (15%), ¼ full (8.33%), empty (4.17%) and 1/8 full (3.33%) stomachs (Fig. 4.5 and Appendix Table 4.1). Fishes with full, ¾ full, ½ full and 1/3 full stomachs were considered to be actively fed, while fishes with ¼ full, 1/8 full and empty stomachs were considered to be poorly fed. The feeding activities *i.e.*

the percentage of fullness and emptiness of the stomachs of juvenile *L. calcarifer* are shown in Appendix Table 4.2.

The feeding intensity *i.e.* the percentage of fullness of the stomachs was found the highest (100%) in July and September 2014 and June 2015 whereas, the lowest (50%) was found in the month of December 2014 (Appendix Table 4.2). On the other hand, the maximum emptiness (50%) was found in the month of December 2014 and the lowest was found in July and September 2014 and June 2015 (Appendix Table 4.2).

Food composition of juvenile *Lates calcarifer* showed that the percentages of various groups of food items in the stomachs of juvenile *L. calcarifer* are shown in Fig. 4.6 and 4.7 and Appendix Table 4.3. Foods of juvenile *L. calcarifer* were grouped under the following categories- algae or phytoplankton, zooplankton (protozoans and small crustaceans), large crustaceans, insects, teleosts and unidentified food materials (Fig. 4.6 and 4.7 and Appendix Table 4.3). The following food organisms were identified from 120 stomachs contents of juvenile *L. calcarifer* (15-25cm in total length): algae / Phytoplankton, zooplankton (protozoans and small crustaceans), large crustaceans, insects, teleosts, and unidentified food materials.

The average percentage composition of algae or phytoplankton in the stomachs of juvenile *Lates calcarifer* was found 7.69±2.20% (Table 4.2 and Appendix Table 4.3). The highest percentage (12%) was detected in the month of March 2011 and the lowest percentage (4.5%) was found in July 2014 (Appendix Table 4.3). This group of food is composed of *Coscinodiscus* spp. and phytoplankton species of Bacillariophyceae (Table 4.2). The average percentage composition of zooplankton (protozoan and small crustaceans) in the stomachs of juvenile *L. calcarifer* was found 19.91±4.37% (Table 4.2 and Appendix Table 4.3). The highest percentage (26.25%) was detected in the month of June 2011 and the lowest percentage (13.5%) was found in December 2010 (Appendix Table 4.3). This group of food is composed of Euglena, Cladocera, Copepoda (calanoid group), shrimp larvae and megalopa larvae of crabs (Table 4.2). The average percentage composition of large crustaceans in the stomachs of juvenile *L. calcarifer* was found 26.32±5.76% (Table 4.2 and Appendix Table 4.3). The highest percentage (36%) was detected in the month of October 2014 and the lowest percentage (17.5%) was found in August 2014 (Appendix Table 4.3). This group of food was represented by Decapoda (shrimps and crabs), Stomatopoda and Branchiura (Table 4.2). The average percentage composition of insects in the stomachs of juvenile *L. calcarifer* was found 09.02±1.79% (Table 4.2 and Appendix Table 4.3). The highest percentage (12%) was detected in the month of February

2015 and the lowest percentage (6.25%) was found in December 2014 (Appendix Table 4.3). This group of food was represented an unidentified group of insects (Table 4.2). The average percentage composition of insects in the stomachs of juvenile *L. calcarifer* was found 33.70±3.40% (Table 4.2 and Appendix Table 4.3). The highest percentage (40.45%) was detected in the month of November 2015 and the lowest percentage (28.75%) was found in September 2014 (Appendix Table 4.3). This group of food was represented *Apocryptes, Jonieops, Otolithoides, Harpodon, Coilia, Polynemus, Pama, Therapon, Chanda* and unidentified genus of family Gobiidae (Table 4.2). The average percentage composition of insects in the stomachs of juvenile *L. calcarifer* was found 03.35±0.75% (Table 4.2 and Appendix Table 4.3). The highest percentage (4.35%) was detected in the month of December 2014 and the lowest percentage (2.1%) was found in June 2015 (Appendix Table 4.3).

Monthly variation in the degree of feeding of adult *Lates calcarifer* also included in this study. 160 stomachs of adult *L. calcarifer* (more than 25 cm in total length) collected in different months over the study duration, maximum 28.89% stomachs were found as full followed by ¾ full (22.78%), ½ full (20%), empty (11.67%), 1/3 full (9.44%), ¼ full (5%) and 1/8 full (2.22%) stomachs (Fig. 4.8 and Appendix Table 4.4). Fishes with full, ¾ full, ½ full and 1/3 full stomachs were considered to be actively fed, while fishes with ¼ full, 1/8 full and empty stomachs were considered to be poorly fed. The feeding activities *i.e.* the percentage of fullness and emptiness of the stomachs of adult *L. calcarifer* are shown in Appendix Table 4.5. The feeding intensity *i.e.* the percentage of fullness of the stomachs was found the highest (100%) in July 2014 and June 2015 whereas, the lowest (53.33%) was found in the month of December 2014 (Appendix Table 4.5).

Study on food composition of adult *Lates calcarifer* showed that the average percentage composition of algae or phytoplankton in the stomachs of adult *L. calcarifer* was found 04.55±0.94% (Table 4.3 and Appendix Table 4.6). The highest percentage (6.25%) was detected in the month of October 2014 and the lowest percentage (3.5%) was found in July, December 2014 and February, April 2015 (Appendix Table 4.6). This group of food is composed of *Coscinodiscus* and phytoplankton species of Bacillariophyceae (Table 4.3). The average percentage composition of zooplankton (protozoan and small crustaceans) in the stomachs of adult *L. calcarifer* was found 17.41±3.04% (Table 4.3 and Appendix Table 4.6). The highest percentage (24.40%) was detected in the month of August 2014 and the lowest percentage (14.5%) was found in December 2014 (Appendix Table 4.6). This group of food is composed of *Euglena*, Cladocera, Copepoda (calanoid group), shrimp larvae and megalopa larvae of crabs (Table 4.3). The average percentage composition of large crustaceans in the stomachs of adult *L. calcarifer* was found 27.88±5.48% (Table 4.3 and Appendix Table 4.6). The highest percentage (34.80%) was detected in the month of October 2014 and the lowest percentage (15.5%) was found in August 2014 (Appendix Table 4.6). This group of food was represented by Decapoda (shrimps: *Macrobrachium rosenbergii*, *Penaeus monodon*; *Metapenaeus monoceros*, an unidentified species and crabs: *Caphyra* and *Grapsus*), Stomatopoda and Branchiura (Table 4.3). The average percentage composition of insects in the stomachs of adult *L. calcarifer* was found 09.83±1.51% (Table 4.3 and Appendix Table 4.6). The highest percentage (12.5%) was detected in the month of May 2015 and the lowest percentage (7%) was found in November 2014 (Appendix Table 4.6). This group of food was represented an unidentified group of insects (Table 4.3). The average percentage composition of insects in the stomachs of adult *L. calcarifer* was found 35.98±3.06% (Table 4.3 and Appendix Table 4.6). The highest percentage (40%) was detected in the month of August 2014 and the lowest percentage (29.5%) was found in September 2014 (Appendix Table 4.6). This group of food was represented *Apocryptes lanceolatus, Jonieops, Otolithoides, Harpodon, Coilia dussumieri, Polynemus paradiseus, Pama pama, Therapon jarbua, Chanda nama, Lactarius lactarias, Setipinna taty*, an unidentified genus of family Gobiidae and an unidentified genus of family Mugilidae (Table 4.3). The average percentage composition of insects in the stomachs of adult *L. calcarifer* was found 04.34±3.06% (Table 4.3 and Appendix Table 4.6). The highest percentage (5.80%) was detected in the month of February 2015 and the lowest percentage (2.4%) was found in September 2014 (Appendix Table 4.6).

Feeding habits of studied species was also studied. From the present findings it is noted that the food and feeding habits of *Lates calcarifer* has almost the same in both juvenile and adult stages. In the juvenile stage (15-25cm TL) the food of *L. calcarifer* consists of algae or phytoplankton (6.69%), zooplankton (22.10%), large crustaceans (26.73%), insects (8.12%), teleosts (34.2%) and unidentified food materials (2.16%). Whereas in the adult stage (more than 25cm TL) the food of *L. calcarifer* consists of algae or phytoplankton (5.12%), zooplankton (16.17%), large crustaceans (28.77%), insects (9.11%), teleosts (34.99%) and unidentified food materials (5.84%). From the above findings, it was very much clear that amount of foods ingested by both juvenile and adult *L. calcarifer* were mainly composed of animals rather than plants. So the concerned fish species was obviously a carnivore fish species.

The ratio of the total length (TL) and alimentary canal length (ACL) of the juvenile and adult stages of *Lates calcarifer* is shown in Table 4.4, Fig. 4.11 and 4.12. Almost same ratio between alimentary canal length and total length was found in case of juvenile (1:0.62) and adult specimens (1:0.63) (Table 4.4). Positive relationship was observed in maximum cases between body length and alimentary canal length *i.e.* length of alimentary canal is increased with total length of the body. The present investigation reveals that since the juvenile and adult *L. calcarifer* feed primarily on other aquatic animals.

The relationship of the total length (TL) and alimentary canal length (ACL) of the juveniles and adults stages of *L. calcarifer* were established. To establish the relationship between the above parameters, the values of intercepts (a), regression co-efficient (b) and co-efficient of correlation (r) the statistical formula y = a + bx was followed and the results are given in Table 4.4 and Fig. 4.11 and 4.12. The relationship of the total length with alimentary canal length of the fish was established as follows: for juvenile, ACL = - 0.354 + 0.642 TL; for adult, ACL = 2.238 + 0.562 TL

7.3 Body Composition

Moisture contents of the studied species are shown in Fig. 5.1. In case of male *L. calcarifer* the highest moisture was found in spent which was 71.230±0.843% and the lowest amount was found in adult fish which was 69.633±0.464%. On the other hand, the highest moisture in female *L. calcarifer* was found 72.453±0.552% in spent and the lowest moisture in female was found 70.190±0.877% in adults (Fig. 5.1).

The protein contents of the studied species are shown in Fig. 5.2. In case of male *L. calcarifer* the highest protein was found in adult which was 22.940±0.255% and the lowest amount was found in spent fish which was 18.323±0.304%. On the other hand, the highest protein in female *L. calcarifer* was found 22.457±0.514% in adult and the lowest protein in female was found 16.207±0.342% in spent fish (Fig. 5.2).

The fat or lipid contents of the studied species are shown in Fig. 5.3. In case of male *L. calcarifer*, the highest amount of fat was found in adult individuals which was 6.017±0.235% and the lowest amount was found in spent fish which was only 3.837±0.214%. On the other hand, the highest fat content in female *L. calcarifer* was found 6.370±0.236% in adult and the lowest amount in female was found 3.117±0.440% in spent fish (Fig. 5.3).

The ash contents of the studied species are shown in Fig. 5.4. In case of male *L. calcarifer*, the highest amount of ash was found in adult individuals which was 4.537±0.476% and the lowest amount was found in spent fish which was only 4.160±0.066%. On the other hand, the highest ash content in female *L. calcarifer* was found 5.110±0.235% in adult fish and the lowest amount in female was found 4.473±0.156% in juvenile individuals (Fig. 5.4).

The phosphorus contents of the studied species are shown in Fig. 5.5. In case of male *L. calcarifer*, the highest amount of phosphorus was found in adult individuals which was 190.2±1.43 mg/100g and the lowest amount was found in spent fish which was only 172.5±3.55 mg/100g. On the other hand, the highest phosphorus content in female *L. calcarifer* was found 198.3±2.22 mg/100g in adult fish and the lowest amount in female was found 176.4±2.54 mg/100g in spent individuals (Fig. 5.5).

The calcium contents of the studied species are shown in Fig. 5.6. In case of male *L. calcarifer*, the highest amount of Ca was found in adult individuals which was 143.9±3.54 mg/100g and the lowest amount was found in spent fish which was only135.3±2.24 mg/100g. On the other hand, the highest Ca content in female *L. calcarifer* was found 151.1±2.13 mg/100g in adult fish and the lowest amount in female was found 136.9±4.24 mg/100g in spent individuals (Fig. 5.6).

The Magnesium contents of the studied species are shown in Fig. 5.7. In case of male *L. calcarifer*, the highest amount of Mg was found in adult individuals which was 123.2±0.33 mg/100g and the lowest amount was found in spent fish which was only 119.4±2.23 mg/100g. On the other hand, the highest Mg content in female *L. calcarifer* was found 125.3±1.12 mg/100g in adult fish and the lowest amount in female was found 120.6±1.32 mg/100g in spent individuals (Fig. 5.7).

The iron contents of the studied species are shown in Fig. 5.8. In case of male *L. calcarifer*, the highest amount of Fe was found in juvenile individuals which was 14.34±1.23 mg/100g and the lowest amount was found in spent fish which was only 09.11±0.45 mg/100g. On the other hand, the highest Fe content in female *L. calcarifer* was found 15.35±1.22 mg/100g in juvenile fish and the lowest amount in female was found 09.11±0.45 mg/100g in spent individuals (Fig. 5.8).

7.4 Fishery

Various fishing gears were used to capture the studied species in the study area. Among different fishing nets, veshal jal, khepla jal, ber jal, punti jal are important.

Some other fishing method like katha fishing was also employed by the fishermen to capture this species.

The amount of *L. calcarifer* landed in different fish landing centers and markets of Khulna area was also studied. In the Paikgacha fish landing center and market, the highest average daily fish landing (347.00±37.51kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (138.33±40.81kg) was found in June 2015 (Fig. 6.7).In the Dumuria fish landing center and market, the highest average daily fish landing (340.00±38.22kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (100.00±14.42kg) was found in June 2014 (Fig. 6.7). In the Khornia fish landing center and market, the highest average daily fish landing (290.33±28.59kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (118.67±31.56kg) was found in November 2014 (Fig. 6.7). In the Khulna City Corporation (KCC) fish market, the highest average daily fish landing (55.00±07.55kg) was recorded in the month of October 2014; whereas the lowest daily fish landing (27.33±05.13kg) was found in November 2014 (Fig. 6.7). Overall landing value was found lower in this fish market because there were no commission agents (aratdar) in this market and all the fishes were brought by the middlemen involved in the marketing channel of *L. calcarifer* in the study area.

Comparatively short marketing channel of *L. calcarifer* was observed in the study areas, which is composed of following categories of people- fishermen/fish farmer/producer, commission agents (aratdar), beparies, retailer, and consumer. Average wholesale and retail price, and profit were also studied in this research for fishes of different size groups.

For 250-750g fish size, in Paikgacha fish landing center and market, the highest wholesale price (203.67±07.64 BDT/kg) was recorded in the month of March 2015 and the lowest (172.00±05.00 BDT/kg) was found in July 2014 (Fig. 6.10). In Dumuria fish landing center and market, the highest wholesale price (210.33±02.89 BDT/kg) was recorded in the month of April 2015 and the lowest (180.33±05.77 BDT/kg) was found in July 2014 (Fig. 6.10). In Khornia fish landing center and market, the highest wholesale price (207.00±08.66 BDT/kg) was recorded in the month of March 2015 and the lowest (172.00±08.66 BDT/kg) was found in July 2015 (Fig. 6.10).

Average retail price of 250-750g *L. calcarifer* was found higher in KCC than that of Dumuria, Khornia and Paikgacha. In Paikgacha fish landing center and market, the highest retail price (228.67±05.77 BDT/kg) was recorded in the month of March 2015 and the lowest (190.67±08.08 BDT/kg) was found in July 2014 (Fig. 6.11). In

Dumuria fish landing center and market, the highest retail price (232.67±05.13 BDT/kg) was recorded in the month of April 2015 and the lowest (200.67±03.21 BDT/kg) was found in July 2014 (Fig. 6.11). In Khornia fish landing center and market, the highest retail price (230.33±02.89 BDT/kg) was recorded in the month of May 2015 and the lowest (198.67±07.51 BDT/kg) was found in July 2014 (Fig. 6.11). In KCC fish market, the highest retail price (268.67±02.89 BDT/kg) was recorded in the month of June 2015 and the lowest (232.67±11.02 BDT/kg) was found in August 2014 (Fig. 6.11).

Average wholesale price of 750-2500g *L. calcarifer* was found comparatively low in Paikgacha followed by Khornia and Dumuria. In Paikgacha fish landing center and market, the highest wholesale price (285.33±02.89 BDT/kg) was recorded in the month of May 2015 and the lowest (238.67±02.89 BDT/kg) was found in July 2014 (Fig. 6.12). In Dumuria fish landing center and market, the highest wholesale price (300.33±02.89 BDT/kg) was recorded in the month of March 2015 and the lowest (245.33±02.89 BDT/kg) was found in July 2014 (Fig. 6.12). In Khornia fish landing center and market, the highest wholesale price (297.00±05.00 BDT/kg) was recorded in the month of May 2015 and the lowest (243.67±05.77 BDT/kg) was found in August 2014 (Fig. 6.12).

Retail price of 750-2500g fish was found higher in KCC than that of Khornia, Dumuria and Paikgacha. In Paikgacha fish landing center and market, the highest retail price (308.67±02.89 BDT/kg) was recorded in the month of March 2015 and the lowest (190.67±08.08 BDT/kg) was found in July 2014 (Fig. 6.13). In Dumuria fish landing center and market, the highest retail price (320.00±02.65 BDT/kg) was recorded in the month of March 2015 and the lowest (267.00±10.00 BDT/kg) was found in August 2014 (Fig. 6.13). In Khornia fish landing center and market, the highest retail price (347.00±51.96 BDT/kg) was recorded in the month of May 2015 and the lowest (265.33±02.89 BDT/kg) was found in July 2014 (Fig. 6.13). In KCC fish market, the highest retail price (328.67±05.77 BDT/kg) was recorded in the month of April 2015 and the lowest (275.33±05.77 BDT/kg) was found in August 2014 (Fig. 6.13).

Average wholesale price of 2500-5000g *L. calcarifer* was found comparatively low in Paikgacha followed by Khornia and Dumuria. In Paikgacha fish landing center and market, the highest wholesale price (398.67±11.55 BDT/kg) was recorded in the month of April 2015 and the lowest (332.00±08.66 BDT/kg) was found in June 2014 (Fig. 6.14). In Dumuria fish landing center and market, the highest wholesale price (405.33±02.89 BDT/kg) was recorded in the month of June 2015 and the lowest (323.67±02.89 BDT/kg) was found in July 2014 (Fig. 6.14). In Khornia fish landing center and market, the highest wholesale price (435.33±07.64 BDT/kg) was recorded in the month of June 2015 and the lowest (337.00±00.00 BDT/kg) was found in July 2014 (Fig. 6.14).

Average retail price of 2500-5000g *L. calcarifer* was found higher in KCC than that of Khornia, Dumuria and Paikgacha. In Paikgacha fish landing center and market, the highest retail price (420.33±18.93 BDT/kg) was recorded in the month of April 2015 and the lowest (348.67±11.55 BDT/kg) was found in July 2014 (Fig. 6.15). In Dumuria fish landing center and market, the highest retail price (432.00±05.00 BDT/kg) was recorded in the month of June 2015 and the lowest (343.67±05.77 BDT/kg) was found in July 2014 (Fig. 6.15). In Khornia fish landing center and market, the highest retail price (452.00±10.00 BDT/kg) was recorded in the month of June 2015 and the lowest (353.67±02.89 BDT/kg) was found in July 2014 (Fig. 6.15). In KCC fish market, the highest retail price (457.00±05.00 BDT/kg) was recorded in the month of April 2015 and the lowest (348.67±11.55 BDT/kg) was found in July 2014 (Fig. 6.15).

In the Paikgacha fish landing center and market, the yearly average marketing margins of 250-750g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 181.87±08.23 BDT/kg, 5.63±0.25 BDT and 13.14±3.58 BDT/kg respectively (Fig. 6.16). In the Dumuria fish landing center and market, the yearly average marketing margins 250-750g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 191.71±7.41 BDT/kg, 5.93±0.23 BDT and 14.56±3.26 BDT/kg respectively (Fig. 6.17). In the Khornia fish landing center and market, the yearly average marketing margins 250-750g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 187.67±9.00 BDT/kg, 5.81±0.28 BDT and 15.31±3.02 BDT/kg respectively (Fig. 6.18).

In the Paikgacha fish landing center and market, the yearly average marketing margins of 750-2500g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 258.67±14.22 BDT/kg, 8.00±0.44 BDT and 13.78±4.18 BDT/kg respectively (Fig. 6.19). In the Dumuria fish landing center and market, the yearly average marketing margins of 750-2500g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 266.32±17.44 BDT/kg, 8.24±0.54 BDT and 9.36±1.97 BDT/kg respectively (Fig. 6.20). In the Khornia fish landing center and market, the yearly average marketing margins of 750-2500g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 262.73±15.65 BDT/kg, 8.13±0.48BDT and 13.09±9.56 BDT/kg respectively (Fig. 6.21).

In the Paikgacha fish landing center and market, the yearly average marketing margins of 2500-5000g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 355.80±20.15 BDT/kg, 11.00±0.62 BDT and 10.00±1.88 BDT/kg respectively (Fig. 6.22). In the Dumuria fish landing center and market, the yearly average marketing margins of 2500-5000g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 378.68±28.51 BDT/kg, 11.71±0.88 BDT and 9.20±3.04 BDT/kg respectively (Fig. 6.23). In the Khornia fish landing center and market, the yearly average marketing margins of 2500-5000g *L. calcarifer* for the fishermen or fish farmers, commission agents and retailers were calculated 363.89±26.26 BDT/kg, 11.25±0.81 BDT and 10.56±3.85 BDT/kg respectively (Fig. 6.24).

Chapter Eight

Conclusion

CONCLUSION

On the basis of present research on various aspects of *Lates calcarifer* of the coastal rivers Shibsa, Kapatakkha and ghers, the following general conclusions were drawn-

The present study has revealed the different physico-chemical parameters of the habitats of the studied species. The production and availability of fish were found to be depended on the physico-chemical conditions of the water in which the fish lives. The different environmental factors which determine the characters of water found to exert significant impact on growth, maturation and development of fish. The abundance of *L. calcarifer* in the Shibsa and Kapatakkha rivers as well as in the ghers was almost continuous throughout the year.

Food items for *L. calcarifer* were identified as algae or phytoplankton, zooplankton (protozoan and small crustaceans); large crustaceans, insects, teleosts and some unidentified food materials. The amount of foods ingested by both juvenile and adult *L. calcarifer* was primarily of animal sources rather than plants and thus concerned fish species is obviously a carnivore fish species. Positive relationship was observed in maximum cases between body length and alimentary canal length *i.e.* length of alimentary canal is increased with total length of the body. Research findings clearly revealed that the juvenile and adult *Lates calcarifer* feed primarily on other aquatic animals.

Study on biochemical composition of an organism is always important and it is of more importance when that organism is taken as food by human being. This study revealed the variation in body composition of the studied species that helps stakeholders to manage this species appropriately.

A variety of fishing gears, especially those are traditional, were found to be used in the study area to harvest *L. calcarifer*. Destructive fishing method like katha fishing was also found to be practiced by the fishermen. A scientific improvement in the fishing gears of *L. calcarifer* can increase its present landing to double throughout the year. At the same time restriction should be made against the use of harmful fishing gears and methods.

Comparatively short marketing channel in the study area was observed. This is usually a positive sign for both the fish producer or fishermen and consumers. Because fishermen or fish producer will get more profit from shorter marketing channel and the consumers will get fishes at comparatively lower price. High price of demand of concerned fish species will inspire fish farmers to produce more fish from culture based sources.

Since the present study showed the ecology, food and feeding habits, biochemical compositions and fishery of *L. calcarifer*, these findings would be helpful for the future researchers who will conduct further research on this fish species.

Chapter nine

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Appendices

APPENDIX

Appendix Table 3.1: Physical parameters of the Shibsa river

Month	Year	Physical Parameters			
		Air Temperature (°C)	Water Temperature (°C)	Transparency (cm)	Rainfall (mm)
Jul	2013	30.25±3.25	29.56±3.79	26.25±0.55	182±.13
	2014	31.27±2.49	29.27±3.56	25.40±0.24	177±0.18
Aug	2013	31.65±3.51	30.34±3.04	25.20±0.43	209±0.17
	2014	32.86±2.22	31.97±2.78	25.80±0.40	105±0.14
Sep	2013	33.24±4.78	32.18±3.12	25.25±0.38	159±0.15
	2014	32.49±3.10	31.43±3.21	24.50±0.32	48±0.11
Oct	2013	30.52±3.75	29.13±3.06	30.50±1.01	321±0.10
	2014	31.23±3.02	29.62±2.89	30.70±1.04	217±0.07
Nov	2013	26.78±4.78	25.10±3.75	29.10±0.98	000±0.00
	2014	26.72±2.21	25.66±2.68	27.20±0.76	000±0.00
Dec	2013	20.43±5.89	19.32±5.89	30.70±1.10	001±0.01
	2014	20.56±2.11	19.83±3.00	30.30±1.18	014±0.01
Jan	2014	21.68±0.29	20.54±0.29	30.95±1.01	021±0.00
	2015	22.12±1.98	21.29±0.54	30.95±1.03	000±0.00
Feb	2014	26.66±0.29	24.48±0.29	31.10±1.19	006±0.03
	2015	26.95±0.76	25.96±0.69	31.20±1.25	011±0.02
Mar	2014	27.25±0.50	26.58±0.29	31.85±0.88	086±0.02
	2015	28.72±0.08	27.19±0.38	32.95±0.98	127±0.01
Apr	2014	29.67±0.58	28.57±0.29	35.75±1.78	101±0.10
	2015	29.68±0.68	28.79±0.25	34.30±0.49	093±0.12
May	2014	30.89±0.29	29.96±0.29	49.95±0.50	205±0.21
	2015	31.95±0.10	30.72±0.29	48.95±4.34	193±0.22
Jun	2014	32.59±0.29	31.47±0.29	42.10±0.65	381±0.16
	2015	32.86±0.02	31.62±0.02	41.25±0.29	198±0.13

Appendix Table 3.2: Chemical parameters of the Shibsa river

Month	Year	Chemical Parameters			
		p^H	DO (mg/l)	CO_2 (mg/l)	Salinity (ppt)
July	2013	7.17±0.58	5.18±0.06	6.08±0.55	15.45±0.14
	2014	7.12±0.39	5.12±0.02	6.55±0.20	17.23±0.13
August	2013	7.18±0.29	5.14±0.02	7.03±0.58	13.10±0.26
	2014	7.23±0.29	5.55±0.08	7.58±0.29	12.05±0.10
September	2013	7.75±0.25	5.22±0.04	5.87±0.53	8.75±0.12
	2014	7.64±0.26	5.68±0.05	6.02±0.10	7.72±0.18
October	2013	7.58±0.14	5.23±0.03	4.95±0.61	4.82±0.08
	2014	7.40±0.18	5.78±0.10	5.50±0.61	4.10±0.06
November	2013	7.50±0.00	6.62±1.03	5.53±0.59	5.20±0.50
	2014	7.44±0.10	6.22±0.02	4.39±0.73	4.12±0.03
December	2013	7.42±0.14	7.48±0.63	5.09±0.58	7.15±0.19
	2014	7.47±0.12	7.78±0.54	5.03±0.45	6.50±0.32
January	2014	7.83±0.29	6.03±0.10	4.27±0.09	7.95±0.22
	2015	8.12±0.25	6.28±0.24	4.22±0.02	8.55±0.54
February	2014	7.92±0.14	5.08±0.08	6.15±0.05	12.95±0.89
	2015	8.26±0.56	5.56±0.31	5.58±0.21	12.20±0.89
March	2014	7.33±0.14	6.02±0.59	5.21±0.04	13.95±1.32
	2015	7.12±0.48	6.87±0.02	5.58±0.30	14.30±1.54
April	2014	7.83±0.29	5.56±0.57	5.49±0.17	15.55±1.78
	2015	7.65±0.17	5.69±0.07	5.43±0.07	15.20±1.45
May	2014	7.67±0.29	6.07±0.54	5.45±0.60	16.85±1.87
	2015	7.69±0.28	6.02±0.54	5.63±0.04	16.46±1.65
June	2014	8.08±0.14	5.63±0.60	5.60±0.03	18.97±3.02
	2015	7.58±0.10	6.10±0.01	4.48±0.10	19.25±3.66

Appendix Table 3.3: Physical parameters of the Kapatakkha river

Month	Year	Physical Parameters			
		Air Temperature (°C)	Water Temperature (°C)	Transparency (cm)	Rainfall (mm)
July	2013	31.15±0.29	30.78±0.29	25.15±.14	182±.30
	2014	30.25±0.25	30.40±0.3	24.70±.1	177±1.00
August	2013	32.17±0.29	31.19±0.29	25.10±.2	209±2.00
	2014	32.29±0.27	31.36±0.29	24.65±.12	105±.10
September	2013	33.60±0.29	32.25±0.29	24.15±.27	159±1.2
	2014	32.95±0.2	31.75±0.25	25.35±0.30	048±1.11
October	2013	31.65±2.00	30.47±2.52	30.20±0.17	321±.59
	2014	31.86±2.1	31.10±2.22	26.00±0.22	217±.2
November	2013	25.80±0.29	23.95±0.58	29.15±0.27	000±.30
	2014	25.18±0.29	24.05±0.31	29.60±0.23	000±.00
December	2013	22.25±0.29	20.34±0.50	30.75±.12	001±.01
	2014	21.65±0.25	20.32±0.29	30.95±1.0	014±.10
January	2014	21.87±0.29	21.33±0.87	30.55±0.9	021±.10
	2015	22.96±0.27	21.95±0.68	30.45±.31	000±00
February	2014	25.43±0.29	24.20±0.29	30.75±.45	006±.01
	2015	27.42±.10	26.15±0.98	30.20±.22	011±.02
March	2014	26.75±0.29	25.80±0.29	31.00±.19	086±.11
	2015	27.30±.25	26.27±1.30	31.75±.32	127±.01
April	2014	28.24±0.57	27.29±0.29	37.10±.18	101±.12
	2015	29.10±0.7	28.20±0.85	37.65±.18	093±.14
May	2014	32.54±0.29	31.93±0.29	35.25±.2	205±.13
	2015	31.75±.5	30.68±0.45	36.55±.11	193±.22
June	2014	32.35±0.29	31.25±0.29	24.10±.13	381±.81
	2015	31.95±.28	30.86±0.14	25.85±.15	198±.88

Appendix Table 3.4: Chemical parameters of the Kapatakkha river

Month	Year	Chemical parameters			
		p^H	DO (mg/l)	CO_2 (mg/l)	Salinity (ppt)
July	2013	6.67±0.15	5.08±0.03	6.65±0.29	12.55±2.29
	2014	6.64±0.12	5.02±0.02	6.78±0.08	13.25±0.56
August	2013	7.06±0.25	5.54±0.07	6.15±0.15	13.50±0.50
	2014	7.08±0.15	5.49±0.06	5.93±0.35	13.70±1.21
September	2013	7.42±0.20	5.39±0.15	5.59±0.81	12.15±1.00
	2014	7.50±0.10	5.25±0.25	5.65±0.06	12.95±0.20
October	2013	7.53±0.30	5.43±0.20	5.35±0.01	10.55±1.00
	2014	7.47±0.20	5.61±0.17	5.19±0.15	09.45±0.10
November	2013	7.55±0.10	5.95±0.06	4.72±0.20	17.40±2.18
	2014	7.46±0.25	6.07±0.14	4.45±0.13	18.10±0.21
December	2013	7.61±0.40	6.65±0.3	4.43±0.07	13.50±2.65
	2014	7.52±0.15	6.71±0.12	4.34±0.17	14.15±2.1
January	2014	7.13±0.13	6.26±0.08	4.15±0.65	18.00±3.61
	2015	7.07±0.10	6.42±0.09	4.17±0.03	17.75±2.00
February	2014	6.78±0.12	5.82±0.30	5.52±0.03	17.25±3.46
	2015	6.72±0.15	5.75±0.20	5.56±0.65	17.75±2.8
March	2014	7.24±0.10	6.17±0.17	5.14±0.04	12.55±2.65
	2015	7.42±0.15	6.12±0.23	5.06±0.29	13.10±0.9
April	2014	6.76±0.13	6.05±0.69	5.86±0.37	14.15±4.36
	2015	6.83±0.18	5.95±0.57	5.72±0.63	14.65±1.3
May	2014	7.25±0.20	5.41±0.48	4.12±0.03	11.18±2.65
	2015	7.17±0.11	5.37±0.09	4.10±0.06	11.56±0.87
June	2014	6.52±0.21	5.05±0.04	6.76±0.07	08.15±2.65
	2015	6.63±0.14	5.03±0.05	6.12±0.17	09.12±0.1

Appendix Table 3.5: Physical parameters of ghers

Year	Month	Temperature (°C)		Transparency (cm)	Rainfall (mm)
		Air	Water		
2013	Jul	30.83±1.04	29.50±0.87	25.00±2.65	181
	Aug	32.17±0.29	30.83±0.50	28.00±5.57	205
	Sep	31.85±0.05	31.51±0.57	20.00±4.27	157
	Oct	30.33±0.57	28.50±0.87	15.00±3.61	332
	Nov	26.33±1.53	24.83±1.44	50.00±2.65	000
	Dec	24.67±0.58	23.00±0.50	45.00±5.29	013
2014	Jan	24.17±0.29	22.67±0.58	52.00±2.65	000
	Feb	26.33±0.29	25.50±0.50	48.00±3.61	001
	Mar	30.17±0.29	28.33±0.29	45.00±2.78	016
	Apr	30.67±0.58	29.83±0.29	40.00±9.54	028
	May	32.67±0.58	31.17±0.29	27.00±5.29	144
	Jun	32.67±0.29	30.67±0.58	14.00±3.61	382
	Jul	31.17±0.29	30.33±0.29	26.00±4.36	181
	Aug	32.33±0.29	31.33±0.29	30.00±1.80	205
	Sep	32.83±0.29	31.83±0.29	22.00±2.50	157
	Oct	30.00±2.00	28.33±2.52	10.00±3.61	332
	Nov	24.83±0.29	23.67±0.58	60.00±2.65	000
	Dec	21.67±0.29	20.00±0.50	50.00±5.29	013
2015	Jan	22.83±0.29	22.00±0.87	62.00±2.65	000
	Feb	27.67±0.29	26.17±0.29	56.00±7.21	001
	Mar	27.33±0.29	25.83±0.29	48.00±4.00	016
	Apr	29.33±0.57	28.17±0.29	42.00±8.89	028
	May	31.83±0.29	30.17±0.29	25.00±5.29	144
	Jun	32.17±0.29	30.67±0.29	08.00±2.00	382

Appendix Table 3.6: Chemical parameters of ghers

Year	Month	pH	DO (mg/l)	Free CO_2 (mg/l)	Salinity (ppt)
2013	Jul	6.50±0.50	5.36±0.31	6.71±0.02	07.00±3.12
	Aug	7.67±0.29	5.92±0.05	4.91±0.03	08.00±1.50
	Sep	7.83±0.29	5.15±0.57	4.12±0.03	07.50±1.80
	Oct	7.33±0.76	4.51±0.57	6.85±0.52	04.50±1.80
	Nov	7.00±0.50	5.91±0.06	4.17±0.08	15.00±1.32
	Dec	7.16±0.29	5.83±0.05	4.52±0.08	12.00±1.32
2014	Jan	7.83±0.29	5.63±0.10	5.48±0.10	16.00±2.65
	Feb	7.83±0.29	5.35±0.05	5.20±0.05	15.00±2.65
	Mar	7.83±0.29	4.55±0.05	4.70±0.05	11.00±2.65
	Apr	7.50±0.00	5.52±0.58	4.27±0.34	10.00±3.46
	May	8.00±0.00	5.60±0.56	5.13±0.03	08.00±1.50
	Jun	7.67±0.29	5.18±0.64	6.23±0.53	04.00±2.18
	Jul	6.67±0.29	5.08±0.08	6.75±0.10	07.50±2.29
	Aug	7.50±0.29	5.50±0.06	5.94±0.01	08.50±0.50
	Sep	7.50±0.00	5.24±0.03	5.65±0.02	08.00±1.00
	Oct	7.42±0.14	5.55±0.03	5.17±0.07	04.50±1.00
	Nov	7.42±0.14	6.07±0.03	4.44±0.01	17.00±2.18
	Dec	7.58±0.14	6.71±0.02	4.33±0.04	13.00±2.65
2015	Jan	7.00±0.00	6.43±0.09	4.19±0.05	18.00±3.61
	Feb	6.92±0.14	5.71±0.10	5.56±0.04	17.00±3.46
	Mar	7.58±0.14	6.13±0.02	5.11±0.05	12.00±2.65
	Apr	6.83±0.29	5.93±0.03	5.74±0.11	11.00±4.36
	May	7.08±0.14	5.33±0.07	4.13±0.03	09.00±2.65
	Jun	6.58±0.25	5.09±0.06	6.11±0.03	05.00±2.65

Appendix Table 4.1: Month-wise status of stomach contents of juvenile *Lates calcarifer* during the period of study (n=10 in each month)

Year	Months	Full	3/4 full	1/2 full	1/3 full	1/4 full	1/8 full	Empty
2014	Jul	4 (40%)	1 (10%)	4 (40%)	1 (10%)	0 (00%)	0 (00%)	0 (00%)
	Aug	3 (30%)	1 (10%)	4 (40%)	1 (10%)	1 (10%)	0 (00%)	0 (00%)
	Sep	2 (20%)	2 (20%)	5 (50%)	1 (10%)	0 (00%)	0 (00%)	0 (00%)
	Oct	4 (40%)	1 (10%)	3 (30%)	1 (10%)	1 (10%)	0 (00%)	0 (00%)
	Nov	0 (00%)	2 (20%)	2 (20%)	3 (30%)	1 (10%)	1 (10%)	1 (10%)
	Dec	0 (00%)	2 (20%)	1 (10%)	2 (20%)	2 (20%)	1 (10%)	2 (20%)
2015	Jan	1 (10%)	2 (20%)	2 (20%)	2 (20%)	1 (10%)	1 (10%)	1 (10%)
	Feb	2 (20%)	2 (20%)	2 (20%)	2 (20%)	1 (10%)	0 (00%)	1 (10%)
	Mar	3 (30%)	2 (20%)	2 (20%)	2 (20%)	1 (10%)	0 (00%)	0 (00%)
	Apr	3 (30%)	3 (30%)	1 (10%)	1 (10%)	1 (10%)	1 (10%)	0 (00%)
	May	4 (40%)	1 (10%)	3 (30%)	1 (10%)	1 (10%)	0 (00%)	0 (00%)
	Jun	4 (40%)	2 (20%)	3 (30%)	1 (10%)	0 (00%)	0 (00%)	0 (00%)
Mean %		25.00	17.50	26.67	15.00	08.33	03.33	4.17
Maximum		4	3	5	3	2	1	2
Minimum		0	1	1	1	1	1	0
Average/month		2.50	1.75	2.67	1.50	1.11	1.00	0.42

Appendix Table 4.2: Seasonalfeeding activity of juvenile *Lates calcarifer* (based on number of fish examined, percentage of fullness and emptiness)

Year	Months	Fish examined	Fullness (%)	Emptiness (%)
2014	Jul	10	100.0	00.00
	Aug	10	90.00	10.00
	Sep	10	100.0	00.00
	Oct	10	90.00	10.00
	Nov	10	70.00	30.00
	Dec	10	50.00	50.00
2015	Jan	10	70.00	30.00
	Feb	10	80.00	20.00
	Mar	10	90.00	10.00
	Apr	10	80.00	20.00
	May	10	90.00	10.00
	Jun	10	100.0	00.00

N.B.

Fullness includes full, ¾ full and ½ stomachs.

Emptiness includes ¼ full, 1/8 full and empty stomachs.

Appendix Table 4.3: Monthly variation in the percentage occurrence of various groups of food items in the stomachs of juvenile *Lates calcarifer* during the study period (n=10 in each month, total of 120 specimens)

Year and months		Algae	Zooplankton	Large crustacea	Insects	Teleosts	Unidentified
2014	Jul	04.50	21.80	22.50	11.25	36.50	03.45
	Aug	09.25	25.00	17.50	09.50	35.50	03.25
	Sep	09.50	19.10	30.25	10.25	28.75	02.15
	Oct	06.50	15.30	36.00	08.00	30.70	03.50
	Nov	06.50	14.30	28.00	06.50	40.45	04.25
	Dec	05.90	13.50	34.50	06.25	35.50	04.35
2015	Jan	08.60	17.80	30.60	08.50	30.40	04.10
	Feb	05.50	17.90	23.50	12.00	37.20	03.90
	Mar	12.00	19.70	26.80	07.50	31.20	02.80
	Apr	06.25	23.40	24.50	09.50	32.90	03.45
	May	07.90	24.90	22.20	10.25	31.80	02.95
	Jun	09.90	26.25	19.50	08.75	33.50	02.10
Mean±SD		7.69±2.20	19.91±4.37	26.32±5.76	09.02±1.79	33.70±3.40	03.35±0.75
Min		04.50	13.50	17.50	06.25	28.75	02.10
Max		12.00	26.25	36.00	12.00	40.45	04.35

Appendix Table 4.4: Month-wise status of stomach contents of adult *Lates calcarifer* during the period of study (n=15 in each month)

Year	Month	Full	3/4 full	1/2 full	1/3 full	1/4 full	1/8 full	Empty
2014	Jul	5 (33.33%)	5 (33.33%)	4 (26.67%)	1 (06.67%)	0 (00.00%)	0 (00.00%)	0 (00.00%)
	Aug	7 (46.67%)	4 (26.67%)	2 (13.33%)	1 (06.67%)	0 (00.00%)	0 (00.00%)	1 (06.67%)
	Sep	5 (33.33%)	4 (26.67%)	5 (33.33%)	0 (00.00%)	0 (00.00%)	0 (00.00%)	1 (06.67%)
	Oct	6 (40.00%)	3 (20.00%)	2 (13.33%)	2 (13.33%)	0 (00.00%)	0 (00.00%)	2 (13.33%)
	Nov	0 (00.00%)	5 (33.33%)	4 (26.67%)	1 (06.67%)	1 (06.67%)	1 (06.67%)	3 (20.00%)
	Dec	1 (06.67%)	2 (13.33%)	3 (20.00%)	2 (13.33%)	2 (13.33%)	1 (06.67%)	4 (26.67%)
2015	Jan	3 (20.00%)	4 (26.67%)	2 (13.33%)	1 (06.67%)	1 (06.67%)	1 (06.67%)	3 (20.00%)
	Feb	2 (13.33%)	2 (13.33%)	3 (20.00%)	3 (20.00%)	2 (13.33%)	0 (00.00%)	3 (20.00%)
	Mar	5 (33.33%)	3 (20.00%)	2 (13.33%)	2 (13.33%)	1 (06.67%)	0 (00.00%)	2 (13.33%)
	Apr	6 (40.00%)	2 (13.33%)	3 (20.00%)	1 (06.67%)	1 (06.67%)	1 (06.67%)	1 (06.67%)
	May	5 (33.33%)	3 (20.00%)	3 (20.00%)	2 (13.33%)	1 (06.67%)	0 (00.00%)	1 (06.67%)
	Jun	7 (46.67%)	4 (26.67%)	3 (20.00%)	1 (06.67%)	0 (00.00%)	0 (00.00%)	0 (00.00%)
Mean %		28.89	22.78	20.00	9.44	5.00	2.22	11.67
Maximum		7	5	5	3	2	1	4
Minimum		0	2	2	0	0	0	0
Mean/month		4.33	3.42	3.00	1.42	1.13	0.80	1.75

Appendix Table 4.5. Seasonalfeeding activity of adult *Lates calcarifer* (based on number of fish examined, percentage of fullness and emptiness)

Year	Months	Fish examined	Fullness (%)	Emptiness (%)
2014	Jul	15	100.0	00.00
	Aug	15	93.33	06.67
	Sep	15	93.33	06.67
	Oct	15	86.67	13.33
	Nov	15	66.67	33.33
	Dec	15	53.33	46.67
2015	Jan	15	66.67	33.33
	Feb	15	66.67	33.33
	Mar	15	80.00	20.00
	Apr	15	80.00	20.00
	May	15	86.67	13.33
	Jun	15	100.0	00.00

N.B.

Fullness includes full, ¾ full, ½ full and 1/3 full stomach.

Emptiness includes ¼ full, 1/8 full and empty stomach.

Appendix Table 4.6: Monthly variation in the percentage occurrence of various groups of food items in the stomachs of adult *Lates calcarifer* during the study period (n=15 in each month, total of 180 specimens)

Year and months		Algae	Zooplank-ton	Large crustacea	Insects	Teleosts	Unidenti-fied
2014	Jul	03.50	20.50	24.50	10.50	37.50	03.50
	Aug	04.60	24.40	15.50	10.50	40.00	05.00
	Sep	05.50	16.40	34.80	11.40	29.50	02.40
	Oct	06.25	14.75	34.80	08.25	32.70	03.25
	Nov	05.00	14.75	29.50	07.00	39.50	04.25
	Dec	03.50	14.50	32.50	08.50	36.50	04.50
2015	Jan	04.50	15.50	30.50	09.50	34.50	05.50
	Feb	03.50	16.50	25.50	10.50	38.20	05.80
	Mar	04.50	14.80	30.80	09.50	36.20	04.20
	Apr	03.50	18.50	27.50	10.80	34.90	04.80
	May	04.60	19.80	24.20	12.50	33.80	05.10
	Jun	05.70	18.50	24.50	09.00	38.50	03.80
Mean±SD		04.55±0.94	17.41±3.04	27.88±5.48	09.83±1.51	35.98±3.06	04.34±3.06
Min		03.50	14.50	15.50	07.00	29.50	02.40
Max		06.25	24.40	34.80	12.50	40.00	05.80

Appendix Table 4.7: Total length and alimentary canal length of juvenile *Lates calcarifer*

Measurements		Size group (cm)			
		15.00-17.50	**17.50-20.00**	**20.00-22.50**	**22.50-25.00**
Number of specimens		48	32	26	14
Total length (TL in cm)	Min	15.00	18.00	20.40	22.70
	Max	17.40	19.20	22.50	25.00
	Mean±SD	15.99±0.78	18.65±0.62	21.81±0.62	23.89±0.75
Alimentary canal length (ACL in cm)	Min	09.40	10.70	12.20	14.10
	Max	10.70	11.90	14.30	15.80
	Mean±SD	10.05±0.42	11.43±0.40	13.66±0.62	15.06±0.46

Appendix Table 4.8: Total length and alimentary canal length of adult *Lates calcarifer*

Measurements		Size group (cm)			
		25.00-30.00	**30.00-35.00**	**35.00-40.00**	**40.00-45.00**
Number of specimens		54	36	24	66
Total length (TL in cm)	Min	25.40	30.50	35.50	40.10
	Max	29.80	34.90	39.90	44.50
	Mean±SD	27.90±1.32	32.38±1.56	37.03±1.35	42.48±1.35
Alimentary canal length (ACL in cm)	Min	15.00	19.00	22.00	22.40
	Max	18.90	22.60	23.90	28.10
	Mean±SD	17.62±1.00	20.47±1.04	23.04±0.68	25.62±1.43

Appendix Table 5.1: Body composition (%) of *Lates calcarifer*

Life Stage	Sex	Biochemical Composition (%)			
		Moisture	Protein	Fat	Ash
Juvenile	Male	70.583±0.447[bc]	21.537±0.639[b]	5.713±0.346[b]	4.477±0.509[bc]
	Female	71.103±0.226[b]	20.450±0.650[c]	5.437±0.460[bc]	4.473±0.156[bc]
Adult	Male	69.633±0.464[c]	69.633±0.464[c]	6.017±0.235[ab]	4.537±0.476[ab]
	Female	70.190±0.877[c]	22.457±0.514[a]	6.370±0.236[a]	5.110±0.235[a]
Spent	Male	71.230±0.843[b]	18.323±0.304[d]	3.837±0.214[c]	4.160±0.066[c]
	Female	72.453±0.552[a]	16.207±0.342[e]	3.117±0.440[d]	5.067±0.091[ab]

Figures bearing common letter(s) in a column as superscript do not differ significantly ($P<0.05$)

Appendix Table 5.2: Mineral contents (mg/100g) in body composition of *Lates calcarifer*

Life Stage	Sex	Mineral Content (mg/100g)			
		Phosphorus	Calcium	Magnesium	Iron
Juvenile	Male	180.2±1.25	141.2±1.13	120.3±2.34	14.34±1.23
	Female	186.2±1.98	143.2±3.53	121.1±0.56	15.35±1.22
Adult	Male	190.2±1.43	143.9±3.54	123.2±0.33	12.55±0.56
	Female	198.3±2.22	151.1±2.13	125.3±1.12	13.20±0.74
Spent	Male	172.5±3.55	135.3±2.24	119.4±2.23	09.11±0.45
	Female	176.4±2.54	136.9±4.24	120.6±1.32	10.15±1.25

* Values are expressed as the mean± standard deviation (n=3)

Appendix Table 6.1: Daily amount of fish landed in four studied fish landing centers and markets in Khulna district (in kg, Mean±SD)

Year	Months	Fish landing centers and markets			
		Paikgacha	Dumuria	Khornia	KCC
2014	Jul	308.67±15.31	269.67±54.64	227.00±82.54	049.67±07.77
	Aug	291.00±22.91	233.00±51.51	226.00±66.57	054.67±06.51
	Sep	312.00±16.82	270.33±49.67	243.00±49.96	046.33±07.23
	Oct	347.00±37.51	340.00±38.22	290.33±28.59	055.00±07.55
	Nov	300.00±55.11	178.00±104.5	118.67±31.56	053.00±04.58
	Dec	250.67±60.37	245.33±25.32	229.00±40.93	040.00±04.58
2015	Jan	192.33±29.94	186.33±27.23	168.33±51.07	029.67±06.11
	Feb	160.00±34.39	140.33±62.43	164.33±71.23	027.33±05.13
	Mar	199.33±25.58	104.33±38.40	148.33±54.64	040.00±08.19
	Apr	152.33±54.52	141.33±40.67	136.33±38.76	033.67±11.02
	May	154.67±48.01	136.33±43.92	169.00±35.79	039.33±08.33
	June	138.33±40.81	100.00±14.42	143.33±33.08	039.67±04.04

Appendix Table 6.2: Wholesale price of 250-750g *Lates calcarifer* in three studied fish landing centers and markets in Khulna district (BDT, Mean±SD)

Year	Months	Wholesale price (BDT/kg)		
		Paikgacha	Dumuria	Khornia
2014	Jul	172.00±05.00	180.33±05.77	172.00±08.66
	Aug	185.33±05.77	195.33±10.41	193.67±05.77
	Sep	190.33±02.89	197.00±05.00	193.67±05.77
	Oct	187.00±05.00	205.33±02.89	195.33±02.89
	Nov	187.00±05.00	202.00±05.00	193.67±07.64
	Dec	180.33±02.89	198.67±02.89	188.67±02.89
2015	Jan	188.67±10.41	200.33±07.64	195.33±07.64
	Feb	190.33±10.41	197.00±05.00	195.33±05.77
	Mar	203.67±07.64	200.33±05.77	207.00±08.66
	Apr	195.33±07.64	210.33±02.89	203.67±05.77
	May	200.33±02.89	200.33±10.41	205.33±02.89
	Jun	193.67±05.77	208.67±02.89	202.00±05.00

Appendix Table 6.3: Retail price of 250-750g *Lates calcarifer* in four studied fish landing centers and markets in Khulna district (Mean±SD)

Year	Months	Retail price (BDT/kg)			
		Paikgacha	Dumuria	Khornia	KCC
2014	Jul	190.67±08.08	200.67±03.21	198.67±07.51	234.33±02.52
	Aug	202.00±05.00	224.33±07.51	220.00±07.21	232.67±11.02
	Sep	209.67±02.52	223.67±07.74	213.67±02.89	234.33±15.04
	Oct	209.33±02.52	229.67±02.52	222.67±01.15	245.33±07.64
	Nov	111.00±03.61	231.33±06.03	220.33±10.41	235.67±03.21
	Dec	205.67±03.21	226.33±04.04	214.67±09.29	257.67±09.29
2015	Jan	211.67±09.50	225.67±03.21	224.67±09.81	258.67±02.89
	Feb	214.67±07.51	216.33±06.03	225.67±10.02	258.33±03.21
	Mar	228.67±05.77	225.33±02.89	230.00±08.19	258.67±10.41
	Apr	225.33±11.55	232.67±05.13	223.67±07.64	263.33±10.02
	May	223.67±07.64	224.00±11.27	230.33±02.89	255.33±10.41
	Jun	219.33±06.43	230.33±02.89	227.00±05.00	268.67±02.89
Average		212.64	224.19	220.78	250.25

Appendix Table 6.4: Wholesale price of 750-2500g *Lates calcarifer* in three studied fish landing centers and markets in Khulna district (BDT, Mean±SD)

Year	Months	Wholesale price (BDT/kg)		
		Paikgacha	Khornia	Dumuria
2014	Jul	238.67±02.89	252.00±05.00	245.33±02.89
	Aug	247.00±05.00	243.67±05.77	247.00±05.00
	Sep	265.33±02.89	264.33±02.52	265.67±03.21
	Oct	268.33±03.21	266.33±06.03	270.33±05.77
	Nov	263.67±05.77	267.00±05.00	275.33±02.89
	Dec	270.33±02.89	279.33±02.52	275.00±02.65
2015	Jan	266.00±03.61	269.33±02.52	276.67±12.86
	Feb	268.67±10.41	269.67±12.50	282.00±13.23
	Mar	282.00±05.00	283.33±02.31	300.33±02.89
	Apr	285.00±05.20	290.33±02.89	298.67±07.64
	May	285.33±02.89	297.00±05.00	295.33±02.89
	Jun	283.67±02.89	292.00±08.66	287.00±05.00
Average		268.67	272.86	276.56

Appendix Table 6.5: Retail price of 750-2500g *Lates calcarifer* in four studied fish landing centers and markets in Khulna district (Mean±SD)

Year	Months	Retail price (BDT/kg)			
		Paikgacha	Khornia	Dumuria	KCC
2014	Jul	270.67±03.21	265.33±02.89	268.67±05.77	280.33±05.77
	Aug	268.67±05.77	269.67±02.52	267.00±10.00	275.33±05.77
	Sep	290.33±05.77	283.67±02.89	285.33±02.89	295.89±03.21
	Oct	290.33±05.77	291.67±04.51	287.00±05.00	290.33±10.41
	Nov	285.33±07.64	292.00±00.00	292.00±05.00	302.00±18.03
	Dec	295.33±02.89	303.67±02.89	296.00±03.61	302.00±05.00
2015	Jan	287.00±05.00	293.67±05.77	295.33±07.64	302.00±08.66
	Feb	298.67±10.41	285.33±10.41	300.33±16.07	307.00±08.66
	Mar	308.67±02.89	303.67±02.89	320.00±02.65	308.67±02.89
	Apr	302.00±05.00	305.33±02.89	317.00±05.00	328.67±05.77
	May	307.00±05.00	347.00±51.96	313.67±02.89	313.67±05.77
	Jun	305.33±02.89	310.33±02.89	308.67±07.64	317.00±08.66
Average		292.44	295.95	283.92	301.91

Appendix Table 6.6: Wholesale price of 2500-5000g *Lates calcarifer* in three studied fish landing centers and markets in Khulna district (BDT, Mean±SD)

Year	Months	Wholesale price (BDT/kg)		
		Paikgacha	Khornia	Dumuria
2014	Jul	332.00±08.66	323.67±02.89	337.00±00.00
	Aug	350.33±02.89	348.67±02.89	357.00±05.00
	Sep	345.33±07.64	350.33±10.41	362.00±00.00
	Oct	348.67±15.28	358.67±05.77	378.67±05.77
	Nov	363.67±02.89	365.33±07.64	378.67±05.77
	Dec	368.67±02.89	380.33±15.28	402.00±08.66
2015	Jan	388.67±10.41	393.67±02.89	403.67±07.64
	Feb	383.67±02.89	403.67±15.28	413.67±10.41
	Mar	378.67±02.89	398.67±07.64	413.00±06.56
	Apr	398.67±11.55	395.33±10.41	410.33±10.41
	May	387.00±05.00	402.00±05.00	417.33±00.58
	Jun	380.33±02.89	405.33±02.89	435.33±07.64
Average		368.81	377.14	392.39

Appendix Table 6.7: Retail price of 2500-5000g *Lates calcarifer* in four studied fish landing centers and markets in Khulna district (Mean±SD)

Year	Months	Retail price (BDT/kg)			
		Paikgacha	Khornia	Dumuria	KCC
2014	Jul	348.67±11.55	343.67±05.77	353.67±02.89	348.67±11.55
	Aug	370.33±07.64	365.33±02.89	373.67±02.89	378.67±05.77
	Sep	367.00±13.23	367.00±08.66	383.67±02.89	384.33±07.51
	Oct	368.67±10.41	377.00±08.66	393.67±05.77	402.00±05.00
	Nov	383.67±07.64	382.00±10.00	395.33±07.64	400.33±07.64
	Dec	390.33±02.89	405.33±14.43	427.00±05.00	425.33±11.55
2015	Jan	405.33±11.55	413.67±07.64	423.67±10.41	420.33±02.89
	Feb	405.33±05.77	422.00±15.00	433.67±12.58	435.33±07.64
	Mar	398.67±05.77	417.00±05.00	435.33±05.77	437.00±10.00
	Apr	420.33±18.93	422.00±13.23	432.00±13.23	440.33±10.41
	May	405.33±02.89	425.33±05.77	435.33±02.89	443.67±02.89
	Jun	402.00±05.00	432.00±05.00	452.00±10.00	457.00±05.00
Average		388.81	397.69	411.58	414.42

Appendix Table 6.8: Average marketing margin of 250-750g *Lates calcarifer* in Paikgacha fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	164.90	05.10	08.67
	Aug	177.83	05.50	06.67
	Sep	182.68	05.65	09.34
	Oct	179.45	05.55	12.33
	Nov	179.45	05.55	14.00
	Dec	172.98	05.35	15.34
2015	Jan	181.07	05.60	13.00
	Feb	182.68	05.65	14.34
	Mar	195.62	06.05	15.00
	Apr	187.53	05.80	20.00
	May	192.38	05.95	13.34
	Jun	185.92	05.75	15.66
Average		181.87±08.23	5.63±0.25	13.14±3.58

Appendix Table 6.9: Average marketing margin of 250-750g *Lates calcarifer* in Dumuria fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	172.98	5.35	10.34
	Aug	187.53	5.80	19.00
	Sep	189.15	5.85	16.67
	Oct	197.23	6.10	14.34
	Nov	194.00	6.00	19.33
	Dec	190.77	5.90	17.66
2015	Jan	192.38	5.95	15.34
	Feb	189.15	5.85	09.33
	Mar	192.38	5.95	15.00
	Apr	202.08	6.25	12.34
	May	192.38	5.95	13.67
	Jun	200.47	6.20	11.66
Average		191.71±7.41	5.93±0.23	14.56±3.26

Appendix Table 6.10: Average marketing margin of 250-750g *Lates calcarifer* in Khornia fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	164.90	5.10	16.67
	Aug	185.92	5.75	16.33
	Sep	185.92	5.75	10.00
	Oct	187.53	5.80	17.34
	Nov	185.92	5.75	16.66
	Dec	181.07	5.60	16.00
2015	Jan	187.53	5.80	17.34
	Feb	187.53	5.80	20.34
	Mar	198.85	6.15	13.00
	Apr	195.62	6.05	10.00
	May	197.23	6.10	15.00
	Jun	194.00	6.00	15.00
Average		187.67±9.00	5.81±0.28	15.31±3.02

Appendix Table 6.11: Average marketing margin of 750-2500g *Lates calcarifer* in Paikgacha fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	229.57	7.10	22.00
	Aug	237.65	7.35	11.67
	Sep	255.43	7.90	15.00
	Oct	258.34	7.99	12.00
	Nov	253.82	7.85	11.66
	Dec	260.28	8.05	15.00
2015	Jan	256.08	7.92	11.00
	Feb	258.67	8.00	20.00
	Mar	271.60	8.40	16.67
	Apr	274.51	8.49	07.00
	May	274.83	8.50	11.67
	Jun	273.22	8.45	11.66
Average		258.67±14.22	8.00±0.44	13.78±4.18

Appendix Table 6.12: Average marketing margin of 750-2500g *Lates calcarifer* in Dumuria fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	236.03	7.30	13.34
	Aug	237.65	7.35	10.00
	Sep	255.76	7.91	09.66
	Oct	260.28	8.05	06.67
	Nov	265.13	8.20	06.67
	Dec	264.81	8.19	11.00
2015	Jan	266.43	8.24	08.66
	Feb	271.60	8.40	08.33
	Mar	289.38	8.95	09.67
	Apr	287.77	8.90	08.33
	May	284.53	8.80	08.34
	Jun	276.45	8.55	11.67
Average		266.32±17.44	8.24±0.54	9.36±1.97

Appendix Table 6.13: Average marketing margin of 750-2500g *Lates calcarifer* in Khornia fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	242.50	7.50	03.33
	Aug	234.42	7.25	16.00
	Sep	254.46	7.87	09.34
	Oct	256.40	7.93	15.34
	Nov	257.05	7.95	15.00
	Dec	269.01	8.32	14.34
2015	Jan	259.31	8.02	14.34
	Feb	259.64	8.03	05.66
	Mar	272.89	8.44	10.34
	Apr	279.68	8.65	05.00
	May	286.15	8.85	40.00
	Jun	281.30	8.70	08.33
Average		262.73±15.65	8.13±0.48	13.09±9.56

Appendix Table 6.14: Average marketing margin of 2500-5000g *Lates calcarifer* in Paikgacha fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	320.10	09.90	06.67
	Aug	337.88	10.45	10.00
	Sep	333.03	10.30	11.67
	Oct	336.27	10.40	10.00
	Nov	350.82	10.85	10.00
	Dec	355.67	11.00	11.66
2015	Jan	375.07	11.60	06.66
	Feb	370.22	11.45	11.66
	Mar	365.37	11.30	10.00
	Apr	384.77	11.90	11.66
	May	373.45	11.55	08.33
	Jun	366.98	11.35	11.67
Average		355.80±20.15	11.00±0.62	10.00±1.88

Appendix Table 6.15: Average marketing margin of 2500-5000g *Lates calcarifer* in Dumuria fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	324.95	10.05	06.67
	Aug	344.35	10.65	06.67
	Sep	349.20	10.80	11.67
	Oct	365.37	11.30	05.00
	Nov	365.37	11.30	06.66
	Dec	388.00	12.00	15.00
2015	Jan	389.62	12.05	10.00
	Feb	399.32	12.35	10.00
	Mar	398.67	12.33	12.33
	Apr	396.08	12.25	11.67
	May	402.87	12.46	08.00
	Jun	420.33	13.00	06.67
Average		378.68±28.51	11.71±0.88	9.20±3.04

Appendix Table 6.16: Average marketing margin of 2500-5000g *Lates calcarifer* in Khornia fish landing center and market in Khulna district.

Year	Months	Marketing margin (BDT/kg)		
		Fishermen/Fish farmer	Commission agent	Retailer
2014	Jul	312.02	09.65	10.00
	Aug	336.27	10.40	06.66
	Sep	337.88	10.45	06.67
	Oct	345.97	10.70	08.33
	Nov	352.43	10.90	06.67
	Dec	366.98	11.35	15.00
2015	Jan	379.92	11.75	10.00
	Feb	389.62	12.05	08.33
	Mar	384.77	11.90	08.33
	Apr	381.53	11.80	16.67
	May	388.00	12.00	13.33
	Jun	391.23	12.10	16.67
Average		363.89±26.26	11.25±0.81	10.56±3.85