Growth performance of Indian major carps on different feeds and cost-benefit analysis

A thesis
submitted for the degree
of
Doctor of Philosophy (Ph. D.)
in Zoology (Fisheries)
University of Dhaka
Dhaka, Bangladesh

Submitted by
Registration No. : 26
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DEDICATED
To
BELOVED WIFE ‘RAZIA SULTANA AKHI’

DECLARATION

I do hereby declare that the thesis entitled **'Growth performance of Indian major carps on different feeds and cost-benefit analysis'** submitted to the in the Department of Zoology, University of Dhaka, Dhaka for the degree of Doctor of Philosophy (Ph. D). The research work is based on my own investigation and carried out in Burgen Laboratory, under the supervision of Dr. Akhtarunnessa Chowdhury, Professor, Department of Zoology, University of Dhaka. This research work as a whole or part has not been submitted in form for another degree or diploma at any university or other institution. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Mohammad Kamrul Hassan

CERTIFICATE

This is to certify that the thesis entitled **'Growth performance of Indian major carps on different feeds and cost-benefit analysis'** is the record of basic research carried out in Burgen Laboratory, Department of Zoology, University of Dhaka under my direct supervisions. Author recorded data on his own effort and practical exercise of experimentation very regularly. All the data, figures and parts presented in this thesis are based on his observations and no portion thereof has been used in any other thesis for a degree.

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November, 2016 *The author*

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ABSTRACT

A study was conducted to establish an optimal methods under two feeding regime (poultry waste and supplementary) for the culture of Indian major carps by comparing the growth patterns and to develop a cost efficient feed and feeding technique through cost benefit analysis for future use in Bangladesh. Static 5.00 mg/L dissolved oxygen content was the remarkable observation during the investigation period in both study ponds except March'14 at treatment I and treatment II. The ponds were slightly alkaline with pH values ranged from 6-7 Hardness, alkalinity and ammonia showed narrow difference in their mean value.

The average survival rate of different species was found satisfactory and comparatively higher in treatment I and were significantly different from treatment II .The highest survival rate was 92.67% for *Labeo rohita* and the lowest was 87.66% for *Cirrhinus mrigala*. In treatment II, the range was 76.33% to 84.66%, the highest survival rate was 84.66% for *L. rohita*, and the lowest was 76.33% in *C. mrigala*. The present study indicated a non significant difference in the growth rate among the individual species in treatment I and II. Highest SGR was calculated as 3.28% in *C. catla* in treatment I and lowest 1.47% in *C. mrigala* in treatment II.

The eighteen months investigation showed the gross final weight gain were for *Labeo rohita, Catla catla* and *Cirrhinus mrigala* were 1520gm., 1860gm. and 1470gm, in treatment I and 870gm., 920gm. and 855gm. at treatment II, respectively. Monthly mean growth gain (gm.) of the species were 92.04±75.38, 100.06±93.79 and 79.41±75.51 at treatment I and 45.96±58.19, 47.61±52.09 and 61.94±97.07 at treatment II.

The main growth performance factor length-weight relationship was calculated with the average data based on measurements of 50 fishes of each species and observed a significant difference between two treatment groups. Monthly mean growth of *L. rohita*, *C. catla and C. mrigala* showed increased rates with onset of rainy period and decreased growth and decreased rates during the winter period. Most of the months showed significant correlation.

All the species showed allometric growth patterns in two feeding regimes with different developmental variances depending on influence of physicochemical and biological influences.

Statistically all independent predictor variables viz. Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Premix vitamin (kg), Fishmeal (kg) in treatment I and temperature °C, CO_2 mg/L, pH, Hardness, NH_3 mg/L, Alkalinity mg/L in treatment II, explains 79.6%, 81% and 80.60% and 29.39%, 29.60% and 29.39 effect on length development variance of *L. rohita, C. catla* and *C. mrigala* in treatment I and treatment II, respectively, which are not significant as indicated by 2.73, 2.09 and 2,90 F values and 0.098^b, 0.080^b, 0.085^b P values and 0.680, 0.701 and 0.649 F values and 0.664^a, 0.656^a and 0.664 P values.

The same predictor explains 89.20%, 87.60%, 89.20% and 39.00%, 39.30%,41.70% effect on growth development variance of *L. rohita, C. catla* and *C. mrigala* in treatment I and treatment II, respectively, which are not significant as indicated by ANOVA F values -5.78, 4, 92, 5.80 and 0.050^a, 0.023^a, 0.15^a P values and 1.02 ,0.87, 1.80 F values and 0.46^b, 0.54^b, 0.30^b P values.

Biological variable planktons viz. Chlorophyceae, Cyanophyceae, Euglenophyceae, Rotifera, Cladocera, Copepoda, Ostracoda, Nauplius as predictor explains 40.40%, 40.570% and 40.40% effect on variance in length development of *L. rohita, C. catla* and *C. mrigala* which were not significant as indicated by ANOVA F values 0.678, 0.682 and 0.677 and P values 0.702b, 0.700b and 0.730b in treatment I. On the other hand 51.30%, 49.70%, 52.10% effect on variance in length development of *L. rohita, C. catla* and *C. mrigala*, which were not significant as indicated by ANOVA F values 0.678, 0.682 and 0.677 and P values 0.702^b, 0.700^b and 0.730^b in treatment II.

In the same way biological variable as predictor explains 42.70%, 42.80% and 42.90% effect on variance in weight development of *L. rohita, C. catla* and *C. mrigala* which were not significant as indicated by ANOVA F values 0.747, 0.747, 0.759 and P values 0.655^b, 0.655^b, 0.653^b in treatment I. A little higher 51.30%, 49.70%, 52.10% effect on variance in weight development of designated species, which were not significant as indicated by ANOVA F values 0.678, 0.682 and 0.677 and P values 0.702^b, 0.700^b and 0.730^b in treatment II.

Standardized coefficient values indicates that none of the physicochemical and biological plankton variables, contributes the prediction of length and weight development of *L. rohita,* *C. catla* and *C. mrigala* and explains an equal non-significant combined influence on the length and weight development of species under investigation.

Biological ecto and endo parasitic variables showed more less same prevalence and infestation with seasonal variation and host selection in I and II Treatment group. Total 8.0% and 24.0% *L. rohita, C. catla* and *C. mrigala* faced the paroasitic death during Winter, 10.0% and 30.0% faced during Summer and 16.0% and 38.7% during Monsoon in treatment I and in treatment II, respectively and showed significant ($p<0.05$) correlation between the two groups.

The study showed that *C. catla* made the highest contribution to the total yield in two treatments. Contribution of *L. rohita* was about 32.84% in treatment I and 34.74% in treatment II. *C. catla* Contributed 35.83% in treatment I and 33.77% in treatment II. *C. mrigala* was found to contribute 31.31% in treatment I and 31.47% in treatment II. Gross production of individual species of fish was calculated from the average final weight multiplied by the actual numbers of fish harvested.

In treatment I, net weight was calculated 407.56, 490.14 and 372.21 in *L. rohita, C. catla* and *C. mrigala* and 198.15, 204.06 and 181.39 in *L. rohita, C. catla* and *C. mrigala* in treatment II. It is obtained from the present investigation that total production of treatment I and treatment II were 1269.91 kg. and 583.60 kg. Unpaired t-value at 0.001 levels indicate final production of *L. rohita, C. catla* and *C. mrigala* of two groups in feed feeding system are positively correlated without influence of feed.

The key financial and economic indication of two feeding regime ponds. The cost for the production was 2,16,471 Tk. in treatment I and 39,952 Tk. in treatment II. Net return was 3,95,677 Tk. and 1,66,582 Tk. in treatment I and treatment II, respectively. Calculated total net return of profit was 1,79,206 Tk. in treatment I and 1,26,630 Tk. in treatment II. Percentage of profit was 83 % in treatment I and 317% in treatment II. Cost and benefit ratio was 121:100 in treatment I and 32: 100 in treatment II. Cost profit ratio and benefit cost ratio were positively significant ($P=0.05$ and $P=0.001$).

The profit function analysis clearly showed that the production and profitability of the system can be increased further by judicious application of fertilizer and feed. Other variables like labour showed negative returns and hence farmers have to carefully manage labour inputs. With the availability of the large amount of feed ingredients in Bangladesh, significant improvements in fish production can be achieved. It is likely that the current level of profitability would encourage more land to be converted to aquaculture, particularly by using the vast amount of waste land available in Bangladesh. It was also observed that there were many possibilities to increase production further by introducing and adopting better management practices.

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GENERAL INTRODUCTION

1.1. Background information

Aquaculture is an important alternative for those countries whose traditional fishing grounds have been severely reduced by the imposition of the 200-mile Exclusive Economic Zone (EEZ), primarily by the introduction of fish farming in areas well within the EEZ (Liao 1988). Aquaculture has emerged as one of the most promising industries in the world with considerable growth potential and is expected to contribute around a quitter of the global fisheries harvest by the year 2000 (Alagh 1991).

Bangladesh has extensive wetlands that form an important fisheries resource, which is very much potential for production of fish and fishery items. The total water resources of the country are estimated as 46,99,345 ha of inland water that comprises of rivers, tributaries, estuaries, beels, haors, baors, ponds, lakes, tanks etc. About 2.46% of the total export earning is contributed by fisheries sector (DoF 2013).

Fish production from inland open water has been decreasing due to various reasons such as changing aquatic ecosystem, soil erosion, siltation in the river, construction of dam to control flood and irrigation, indiscriminate use of agro-chemicals, destructive fishing practices, over fishing etc. Cultural fish production has come from a variety of farms ranging from small-scale owner-operated fish ponds to large scale co-operative and corporate farms, supported by auxiliary industries such as feed and equipment manufacture (DoF 2003). Fishes are cultured traditional extensive techniques in Bangladesh but now fish farmers are adopting scientific technologies instead of ancient culture methods (Joadder *et al.* 2013).

Fisheries is one of the major sub-sector in the agricultural sectors and plays a vital role in the socio-economic development of rural area, fulfilling the animal protein demand, creating employment opportunity, alleviating poverty and earning foreign exchange for the country. About 1.2 million people are directly employed in this sector and another 12 million people indirectly earn their livelihood out of activity related to fisheries. The fisheries sector contributes 3.74% of the gross domestic product (GDP), 20.87% of agricultural resources and 4.04% of foreign exchange earning of Bangladesh (DoF 2009). Total fish production in our country during the 2007-2008 was about 2.57 million metric tons of which 2.065 million metric tons were produced from freshwater including culture fisheries and 0.04 million metric tons from marine water including shrimp (DoF 2009). Bangladesh situated in the north eastern part of the South Asian subcontinent has an area of 147570 sq km. The country is blessed with about 40.47 lakh ha open inland water body, 5.28 lakh ha closed inland water body and marine water covers an area of 1.66 lakh ha. These water bodies are very rich in fisheries resources. Bangladesh has at least 260 freshwater fish species and over 475 marine species (DoF 2009).

Fish and fisheries have been linked to the development of the human's earliest civilization. There was a time when fish was a regular food item in the daily menu of Bengali household and the harvest of natural water bodies was sufficient to meet the requirement of fish. That is why, the people did not seriously think of culturing fish. Most of the farmers are poor. They are not able to buy artificial feed. But they are becoming interested in fish culture as fish is gradually losing its share in the daily menu. Fisherfolk are considered as one of the most backward sections in our society. Information on socio-economic framework of the fish farmers forms a good base for planning and development of the economically backward sector. Lack of adequate and authentic information on socio-economic condition of the target population is one of the serious impediments in the successful implementation of developmental programme (Ellis 2002).

Fish play an important role among the population in Bangladesh. Situated in the delta of the Brahmaputra, Meghna, and Ganges rivers, the climate, water, and soil conditions of Bangladesh are favorable for inland fisheries and aquaculture. At the height of the rainy season, more than a third of the total land area (147,570 square kilometers) of the country is submerged (Khan *et al.* 1994). According to the Bangladesh Bureau of Statistics (BBS 2000), the fisheries sector, including aquaculture and capture fisheries, has had an annual growth exceeding 7% since 1995 and contributed 6% to the country's GDP in 2000. Freshwater aquaculture led this with an annual growth exceeding 10% over the last decade. With annual fish consumption of about 14 kilograms (kg)/person in 2000 fish account for 60%–80% of the animal protein consumed by the population, and also provide essential vitamins, minerals, and fatty acids (BBS 2000). Inland fisheries and freshwater aquaculture are the main source of these nutrients for most of the rural and urban poor (Thompson *et al.* 2002).

Freshwater fish farming plays an important role in rural livelihoods in Bangladesh. Apart from direct self-employment opportunities from fish farming, pond fish farming offers diverse livelihood opportunities for operators farming employees of hatcheries and seed nurseries, and for seed traders and other intermediaries. Most of the freshwater pond fish farming systems in Bangladesh are either extensive or semi-intensive and in very few cases intensive. In semi intensive culture system ponds are stocked mainly with Indian major carps and exotic carps; fertilizer (mainly cowdung, Urea and TSP) is used irregularly and supplemental feed consisting of rice-bran and oilcakes are given. In extensive method fishes are grown on natural feeds and fertilizer. Feeds and fertilizer are rarely used in small quantity and or irregular basis. The stocked fish are not specifically selected, predator are not eliminated and are not fertilized or managed throughout the production cycle. In general fish culture in Bangladesh is characterized by the use of both extensive and semi-intensive systems and semi-intensive farming which began from 1993 onwards has produced on increase in production (Mazid 2002).

Modern fish culture means improvement of culture practices through adopting different measures such as proper doses of fertilizer application, regular feeding, optimum stocking density, maintenance of physicochemical factors, disease prevention and various control measures (Balarin and Hailer 1982). The stocking density is the major concern for culture. Sometimes excellent fish fry do not perform satisfactory growth unless correct stocking practices (Sanches and Hayashi 1999). In general the stocking density and growth of fish are inter related. The optimum stocking density ensures sustainable aquaculture providing proper utilization of feed, maximum production, sound environment and health. In comparison to low stocking density, high stocking density exerts many negative impacts such as competition for food and shelter and rapid outbreak of disease if occurred. Therefore it is important to optimize the stocking density for the target species in aquaculture for desired level of production. Indian major carps have good resistance to poor water quality and disease, tolerance to a wide range of environmental conditions, ability to convert efficiently the organic and domestic waste into high quality protein, rapid growth rate and good flavour (Ballarin and Hallar 1982). Indian major carps are currently having important impacts on poor people in developing countries, both as cultured species in household-management systems and through access to fish produced in informal and formal fisheries (Edwards 2003 and Little 2003).

Aquaculture practice has become a promising and gainful methodology to attain self-sufficiency in food sector and also to alleviate poverty in developing country like Bangladesh. Scientific management techniques are rarely followed by the rural people in this country. It is generally agreed that capture fisheries, both marine and freshwater fishes are declining day by day. To prevent the declining fish catches and malnutrition, excellent opportunities exist for small scale aquaculture development in rural areas, where majority of households have pond and ditches. These water resources are presented unutilized or underutilized. Most farmers in rural areas have access to water bodies such as ponds, ditches, canals etc (Ahmed 2003).

Pond fish farming in Bangladesh is mainly major carps and exotic carps oriented farming. At present major carps such as ruhu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Chirrhinus mrrgala*) along with exotic carps such as silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), bighead carp (*Aristichthys nobilis*) and common carp (*Cyprinus carpio*) are cultured in polyculture system in ponds and gained much popularity because of its easy culture system, rapid growth, disease resistance and high market price.

Fish is an inexpensive source of protein and an important cash crop in Bangladesh. Water is the physical support in which they carry out their life functions viz, feeding, swimming, breeding, digestion and excretion (Bronmark and Hansson 2005).

The desirable requirement of protein of a person is 100 gm. per day, but the present level of fish consumption have fallen to 23 gm. per person per day (Karim 1978). So, it is very simple that the demand for fish far exceeds the supply for the present population. Three million tons of fish is required annually to meet 80% of minimum requirement of animal protein whereas the total fish production of the year 1975-1976 were 8,21,000 metric tons (Statistical pocket book of Bangladesh, 1978). This quantity has not increased notably in 1977-1978, It is thus evident that there exists a very acute problem of protein shortage in the country (Biswas 1977).

Fisheries sector is playing a vital role in the economy of Bangladesh with huge natural resources. Along with potential water resources, Bangladesh is also rich in the diversity of various fish species. It has ranked 3rd in aquatic biodiversity in Asia behind china and India, with approximately 300 species of fresh and brackish water species It has already emerged as one of the leading nations in freshwater aquaculture production during recent years and its growth rate is quite comparable to that of China and India. The commonly used fast growing carp species for composite carp culture in the country are catla, rohu, mrigal, silver carp, grass carp and common carp (Hussain and Mazid 2001).

The term 'Carp' is generally used to mean a group of fishes that belong to the Family Cyprinidae and they together form the largest family of freshwater fish in the world (Michaels 1968). In Bangladesh, more than 200 species from freshwater are known (Shafi and Quddus 1982, Rahman 1989) most of which can be used as food fishes. Carps rank the top in importance among pond and food fishes available in the country. The carps available in Bangladesh may often be grouped - the basis of their natural geographical occurrence as Indian major - which include catla, rohu, mrigal and Carps are mainly thermophilic (warmth-loving), but will tolerate extreme, long-lasting cold as well as rapid fluctuations of temperature. The metabolism of carp and consequently its demand for food slow down gradually along with the decrease in temperature. The capacity for rapid growth which manifests best at a water temperature above 20^{o}C. This fish process very good nutritional quality and has high demand with good price in markets. Carps show high tolerance to variations in the ion concentration of the water, it can live in brackish water as well in alkaline waters of pH 9. It is also less sensitive to fluctuations in oxygen level and can be cultured even at an oxygen cibcebntrations of 3-4 mg/1. Carps feed on benthic and zooplankton organisms, but also on seeds of plants and water weeds, detritus, etc. (Jhingran and Pullin 1985).

The enormous protein supplier, tastier fish, *Labeo rohita* (Hamilton 1822) commonly known as Rohu is the first largest major carp found in freshwater of Bangladesh. It is widely distributed in Bangladesh, India and Burma (Bhuiyan 1964). Due to the excellent test, higher food value, easily culturable and high rate of growth *L. rohita* is widely cultured in the impounded waters like ponds, tanks, deghees etc. in Bangladesh, but without scientific Tcnovledge the yearly out put is not satisfactory. Thus for successful culture of this fish, scientific knowledge of various aspects of biology and population dynamics are essential (Shafi and Quddus 1975).

Catla catla (Hamilton-Buchanon) is one of the major carps commonly available in rivers and their tributaries, lakes, beels, ponds, dighi and tanks of Bangladesh. It is locally known as 'katla' in Bangladesh. The original natural range of distribution of *C. catla* is freshwater rivers throughout Pakistan, India, down the krishna river, Bangladesh and Burma. This fish has also been reported from Nepal. *C.catla is* one of the most important food fishes of Bangladesh and known to be the largest of the carps of this sub-continent (Day 1889).

Among Indian major carps, mrigal is an important species due to its relatively better taste and higher market price. Being a commercially important aquaculture fish, requirement of seed is meet up through induced breeding techniques in hatchery (Rafiquzzaman *et al.* 2007).

The purpose of the Length-weight analysis is to describe mathematically the relationship between length and weight primarily. Length-weight relationship elation also provides a direct way of converting logarithmic growth rates calculated on lengths into growth rates for weight and gives indications of taxonomic differences and events in the life history such as metamorphosis and the onset of maturity (Le Cren 1951).

As longevity, rate of growth and age of maturity or spawning time the evaluation of age helps to understand the population composition and also helps to assessment the sustaining power of the stock in fishery (Menon 1965). The determination of the rate of mortality of the different year-classes, their survival rate and success of the individual year broods, that are of fundamental importance in the forecast and scientific exploitation of a fishery, are based on the knowledge of the age and growth rate of the fish (Lagler 1956).

Fish production is influenced by the productivity of the pond which depends on nutrients derived from the natural sources (water shed, rain, soil) or that introduced into the pond (manure, composed feed, waste feed, chemicals etc.). The use of supplementary feeds in pond is mainly to promote perfect environment for plankton growth. The main aim of the use supplementary feed is to increase the primary production of the pond, as this will allow an increase in phytoplankton, zooplankton and benthos which ultimately increase the fish density with no appreciable decrease in individual growth rate of natural food, i.e. phytoplankton, zooplankton etc, and this will increase the total fish yield (Begum 1984).

Planktons are direct food of many different species of fish. For increasing protein rich fish production, there is an urgent need for increasing plankton production in the ponds. It requires great bulk of knowledge of the species composition and seasonal trends of plankton in the fish culture programs (Michael 1968). Plankton can be used as an index to compare the relative fertility and fishery potential of different waters (Prasad 1969). Both phytoplankton and zooplankton play a vital role in the food-chain and also in the ecosystem (Ali *et al.* 1980, Ali 1985, Habib *et al.* 1984a and 1984b). Again, their growth and abundance depend upon the physico-chemical properties of water (Mollah and Haque 1978, Habib *et al.* 1984a and 1984b).

Both phytoplankton and zooplankton play an important role in the natural food chain and can be enhanced by applying fertilizer in the pond (Huet 1972). The productivity of water is governed by the density and quality of plankton and their interaction while the nutrient status of water play the most important role in governing the production of planktonic organism or primary production, in fish ponds. Therefore, to maintain a healthy aquatic environment for successfully pond fish culture the physical chemical and biological parameters of water to be determined (Banerjee 1967).

The increase in primary productivity following fertilization usually results on greater zooplankton abundance (Boyd 1982). Organic enrichment favours the production of phytoplankton and diatoms, which in turn influence the growth and subsequent rise of the consumers, the fish food organisms (Moitra and Bhowmik 1968).

Inadequate knowledge of the zooplankton and its components is a major setback to a better understanding of the factors influencing biological productivity of the fresh water bodies of Bangladesh. Bangladesh is blessed with innumerable areas of water and the scope of studies on variations of physical, chemical and biological conditions of these waters in different seasons is wide. A number of commendable works on various aspects of plankton is available (Islam and Khatun 1966, Islam and Begum 1970, Dewan 1973) . The limnological investigations of ponds, lakes, rivers were also reported (Islam *et al.* 1974, Islam and Saha 1975, Islam and Mendes 1976, Islam and Paul 1978 and Oppenheimer *et al.*1978).

Mass cultures of zooplankton have become a potential resource for fish food organisms with realization of the importance of secondary productivity of zooplankton in aquatic environments (Jana and Pal 1983). Cladocerans have been the subjects of much research on population ecology (Edmondson 1955). Since Cladocerans are substantially represented in freshwater zooplankton communities, and are an important food of freshwater fishes, mass culture of these organisms is important in many aquaculture systems (Jana and Pal 1983). The adaptive strategies in Cladocerans, as in other zooplanktons, are often encountered in their life history patterns, comprising sexual and parthenogenetic generations. Because it is easy to culture and they have a short multivoltine life cycle (Jana and Pal 1982).

There is ample literature to establish the importance of physical and chemical variables of a pond in utilizing it for fish culture (Welch 1952, Boyd and Lichtkoppler 1979). Various physico-chemical variables which influence fish culture as well as fish food organism culture include temperature, water depth, water transparency, water color, hydrogen ion concentration (pH), dissolve oxygen, acidity, alkalinity, free carbon dioxide, carbonate, bicarbonate, nitrates, sulphates, free ammonia etc. The physical variables studied in the present work are air temperature, water temperature and water color. The chemical variables are dissolved oxygen, free carbon dioxide, hydrogen ion concentration, carbonate and bicarbonate (Miah *et al.* 1983).

It is now an established fact that organic manure has a favourable effect for the high increased production in ponds due to the facts that (I) it brings with nearly all of the nutrient substances indispensable for the biological production, (2) it often has a favourable action on the structure of soil, (3) it favours, the multiplication of bacteria in suspension in the water which have a favourable action on the development of zooplankton if it is not excessive and (4) it is indispensable to the action of phosphate and potassium fertilizer (Huet 1970). Very often, organic manures are cheaper than inorganic manures. Green manures and agricultural by-products can be collected from the field free of cost or can be obtained very cheaply. In some cases animal sheds, chicken and duck drops are found on the bank or close to fishpond so that the droppings can be washed into the ponds daily (Ling and Chen 1967). Poultry manure containing soluble inorganic salts along with other essential nutrients like phosphorus, and nitrogen is more effective and has the combined effect of both organic fertilizers. But as inorganic fertilizers produce relatively more floating algae than rotifers, application of inorganic fertilizers in nurseries does not seem to be beneficial (Swingle 1947).

Green manure and animal manure is the principal feed used for the promotion and maintenance of the rich growth of natural food. Cow dung is one of the best organic manure for use in ponds in India (Alikunhi 1957). At present, poultry manure is used due to its low cost, easy availability and easy application. The biological productivity of a natural pond mainly depends on the rate of use of organic fertilizer and the quality of pond soil base (Jhingran and Pullin 1985). As it is evident from above that the supplementary feed influence the pond production through production of planktonic organism both phyto and zooplankton. However dynamics of the plankton production is always overlooked. There is need to know the turnover rates of planktonic community both quantitatively in relation to the supplementary feed this will help to find out the interval for feeding. Again the pond production also depends on the soil quality. Therefore a uniform feeding rate and schedule is not applicable for all areas of the country. So it is necessary to demonstrate this aspect of pond feeding. Excessive amount of supplementary feed leading to the accumulation of supplementary matter on the pond bottom and the development of undesirable an aerobic interstitial condition. On the other hand excessive use of supplementary feed may deteriorate water quality. Therefore change in water quality after applying the manure data should be documented (Edwards 1980).

The physico-chemical quality of water plays a great role in growth and production in the pond (Boyd and Lichtkoppler 1979). The physical and chemical factor like temperature, p^H, transparency, hardness, dissolved oxygen, free carbondioxide etc. are the basic parameters that are needed to be measured. From a study of a series cf ponds under diverse physical and chemical conditions, it is possible to arrive at some broad generalization which can be gainfully used by fish farmers (Banerjee 1967). A pond with good .water quality will produce more and healthy fish than a pond with poor water quality (Boyd and Lichtkoppler 1979).

Knowledge of age and growth of a fish is an extremely useful part of population dynamics in fishery biology and fishery management. This provides the basic information on sexual maturity, harvestable size and environmental conditions of the water body (Parmar and Bhatia 2014).

Rotifer fauna can be raised without loss of time by application of poultry manure. The analysis reveals that alkalinity hardness and specific conductivity factors indicated high values i.e. nearly double in case of poultry manure than in cow. During the present investigation a preliminary attempt has been made to find out the suitable dose and suitable fertilizer for specific groups of fish food organisms dung (Banerjee *et al.* 1969).

The present study is concerned with performance of growth, factor effecting the growth of three Indian major carps viz, *L. rohita*, *C. catla* and *C. mrigala*. The studies of these aspects bear significance in evolving effective policies for culture, management and conservation of fisheries. The present study also examines the efficacy of some organic wastes for sustainable production of some fish food organisms and explores the possibilities of using these potentialities of species in fish culture. The study are to find out the actual dose of inorganic and organic fertilizer, supplementary prepared feed, healthy water quality and find out the role of effectors in the culture system, and establish a cost-effective optimal procedure for pro-poor population of rural Bangladesh at their homestead pond. With these purpose the present eighteen month investigation started with following objectives.

1.2. Objectives of the research work

The principal objectives of the research programme have been stated as below.

- to investigate the growth performance of Indian major carp *Labeo rohita*, *Catla catla* and *Cirhinus mrigala* feed on high cost supplemental feed and cheaply available indigenous raw materials poultry waste in respect to availability and cost;

- to investigate the role of physic-chemical and biological effectors on growth performance of stated species;
- to formulate a low-cost balanced fish feed to minimize the cost of fish production for maximum yield;
- to study the economics of affirmed carp culture prevalent in ponds with the high cost supplemental feed and cheaply available indigenous poultry waste;
- to study the economics of carp feeding regimes as applied to the different systems and the resulting profitability;
- to develop a suitable polyculture technique for homestead derelict ponds for rural farmers by analyzing cost benefit ratio; and
- to recommend management measures that would help pro-poor farmers to optimize their income.

1.3. Organization of thesis

The thesis is organized into ten chapters. **Chapter-1** begins introducing about the general concept of Indian major carps as well as objectives of the current research work. **Chapter-2** describes reviewing of literature related to length-weight relationship and fish food organism in different culture media with physico-chemical condition of water and production with cost-benefit of Indian major carps based on field work. **Chapter-3** describes materials and methods of the research work. In **Chapter-4** deals length-weight relationship and fish food organism in different culture media of Indian major carps in the experimental site. **Chapter-5** describes growth effectors like climatic parameters, physical parameters, chemical parameters and biological parameters (plankton population and examines parasite of Indian major carps) during the study period. In **Chapter-6,** production and cost-benefit of experimented Indian major carps have been described. **Chapter-7** presents discussion of the research work. **Chapter-8** presents the conclusion of the whole research work. **Chapter-9** deals with the citation of literature that has been used in the thesis. Finally, **Chapter-10** presents raw data of research work in appendix.

REVIEW OF LITERATURE

Various workers have made some excellent studies on Indian major carps. Mainly review of literature have been conducted here growth performance, water quality and different feed in relation to cost-benefit analysis of Indian major carps. A brief account of the available pertinent research work and literatures are cited below year-wise-

Shamsi (2016) studied the qualitative analysis of phytoplankton with some physico-chemical analysis of water in Beesh Dam, Jazan in two different seasons. The study covered the Phytoplanktonic biomass and the analysis of chemical constituents in water. Qualitative analysis showed 30.5% Bacillariophyceae; 32% Chlorophyceae; 20.8% Myxophyceae and 13.0% Desmidiaceae. The remaining (3.7%) were recorded as, Protozoans and Rotifers. For water analysis, the water temperature during the day time ranged from 39.0-42.6 C; pH, 8.9, Dissolved Oxygen in water was found to be 3.5-6.5 mg/L. The value of Carbonate, Bicarbonate and Chloride were also recorded. Apart from the above biodiversity of the macro and micro-organism, the fish species like: *Barbusarabicus* and *Aphaniusdispar* were also observed for the evaluation of some biological parameters.

Chowdhury and Hasan (2015) conducted an investigation to establish and optimal methods under two feeding regime (poultry waste and supplimental) for the culture of Indian major carps by comparing the growth patterns and to develop a cost efficient feed and feeding technique through cost benefit analysis for future use in Bangladesh. The ten months investigation showed the average final weights (gm) of *Labeo rohita, Catla catla*, and *Cirrhinus mrigala* were 700±2.89, 900±0.78, 700±1.55 at treatment I and 170± 2.23, 235± 1.22 165±0.45 at treatment II respectively. Monthly mean weight gain (gm.) of the species were 1.23±0.79, 1.23±0.75, 0.92±0.67 at treatment I and 0.64±0.43, 0.64±0.56 and 0.50±0.47 at treatment II, respectively and specific growth rate (%) of rohu, catla and mrigal were 0.87%, 0.87% and 0.89% at treatment I and 0.40 and 0.39% at treatment II respectively. Weight gain pattern was same for both the treatments. *C. catla* was the fastest growing species among species under investigation. Food conversation ratio was the lowest (0.034) in *C. catla* which indicate better conversion of food into flash and followed by *L. rohita* and *C. mrigala* (0.045) at treatment I. At treatment II, the calculated food conversion ratio showed highest value in *C. mrigala* (5.74) followed by *L. rohita* (5.20) and *C. catla* (3.67) indicated poor growth performance of species under investigation. CB indicate higher profit (53591Tk) at treatment I. The level of input given to the treatment produced 690kg at treatment I and 170kg at treatment II. Which were much higher than the break-even production level (120.24kg and 113.36 kg), the two feeding regimes are economically viable. It was also observed that there were many possibilities to increase production further by introducing and adopting better management practices.

Singh and Lakhwinder (2015) studied Harike wetland a Ramser site and observed important commercial fishes are depleting with a very fast rate due to loss of habitat, discharge of industrial effluents, municipality sewerages, pollution from surface runoff, addition of solid waste. It is observed that the catch, of commercial fish *Catla catla* is depleting drastically from this wetland, shows high value of significant correlation coefficient between total length and total weight. The coefficient correlation (r) was found to be 0.94 indicating a significant linear relationship of length and weight. The exponent value'b' = 3.2028 in this study indicates positive allometric growth in *Catla catla* from the Harike wetland which is not obeying the cube law.

Monir *et al.* (2015) recorded nine ectoparasite species and three endoparasite species from three Indian major carp from three district of Bangladesh. Highest prevalence of infection (94.54%) was recorded in the host *L. rohita* during winter and lowest (72.68%) in *C. catla* during summer. Total economic loss incured BDT 35,552.50 ha/yr due to parasitic infestations by 11% for mortality, 11% for chemicals cost and 65% for reduction of growth of carps in the study areas.

Dash *et al.* (2015) described the isolation and identification of different parasites from Indian Major Carp (IMC) *Catla catla*. The isolated parasites were *Myxobolus*, *Thelohanellus*, *Trichodina*, *Dactylogyrus*, *Gyrodactylus*, Nematodes, *Argulus*, *Lernea* and *Chilodonella* species, along with developmental stages of *Myxobolus*, *Dactylogyrus* and *Gyrodactylhus*s during winter. 1-30 cm. length group fishes were found to be more infested with the parasites compare to 30.5-40 cm length groups.

Ahmed (2015) studied the rate of interrelationship among key water quality parameters in relation to water quality management and productivity. The mean values of pH was (8.15±0.17; 8.69±0.17); temperature (27.95±1.88; 30.21±1.880C) and dissolved oxygen (4.79±3.98; 11.38±3.98mg/l) were obtained in the morning and evening respectively. Mean dissolved oxygen was (7.04±3.98; 9.12±3.98mg/l); pH (7.9±0.17; 8.9±0.17mg/l); and ammonia (0.5±0.24; 2.09±0.24) in concrete tanks and earthen ponds respectively. The highest values of temperature (33.000C); dissolved oxygen (13.00mg/l) were obtained in the evening. The values obtained for dissolved oxygen and temperatures showed significant variations between the time of the day. Mean mortality recorded was (1.2±1.07); (2.6±1.07) in concrete and earthen ponds respectively. Mortality recorded shows positive correlation with temperature and ammonia with correlation coefficient (r=0.18) and (r=0.54) respectively, however, ammonia level had direct significant relationship with mortality. It is concluded that there exist interrelationship among the key water quality parameters examined, and there values varies with time of the day and between different culture facilities.

Bashar *et al.* (2014) suggested creeks of Kaptai Lake, with suitable IMC fry raising techniques. A eight weeks experiment results indicated a significant spatial variation in specific growth rate (SGR) of IMC fry despite uniform stocking densities, attributable to variation in environmental parameters. Rohu was found to have comparatively higher SGR of 2.92±0.86 in Hazachara whereas Vaittapara creek was reported with higher SGR of 3.17±0.64 for mrigal. Islamabad creek was found to be conducive to catla with a SGR of 3.71±1.91. Net productions of IMC fry were reported from Vaittapara creek.

Shoko *et al.* (2014) observed the overall performance of an aquaculture system is partly determined by its water quality parameters. Poor water quality stresses and adversely affects fish growth causing low production, profit and product quality. Diurnal dynamics of water quality parameters were investigated in Nile tilapia (*Oreochromis niloticus*) monoculture and polyculture with *Clarias gariepinus* in earthen ponds. During fish farming, optimum fish growth and hence economic benefits can be accrued by devoting some efforts on monitoring the fish pond water at regular intervals. This quality assurance process will ensure that fish farmers produce fish with maximum growth and yield without polluting pond water and the surrounding environment.

Dutta and Das (2014) studied length-weight relationship and condition factor (K) of *Semiplotus semiplotus* (McClelland 1839). The result revealed that length- weight of the species followed the cube-law indicating an isometric growth pattern of the species in its natural habitat. The length-weight regression equation for *Semiplotus semiplotus* indicate positive correlation between length and weight in regard to their sex as well as growth stages. General wellbeing of the fish is found to be good, as indicated by the values of condition factor, which were nearer to or greater than 1.

Parmar and Bhatia (2014) described age and growth of *Cirrhinus mrigala* from Pong reservoir of the Kangra district of Himachal Pradesh. Linear relationship with a high degree of correlation was recorded between total length and lateral scale radius. Six age classes (3-8) were reported in the present study. Maximum numbers of specimens were reported in the age class 4. The data on growth characteristics revealed that age class 4 is more vulnerable in the catch. Annual increment (h) and index of species average size (ǾL) were also calculated from the data.

Farombi *et al.* (2014) investigated seasonal variations in physicochemical properties of the surface water of a waste effluent River Osun in Osogbo, Nigeria. Investigation result showed some physicochemical parameters were like conductivity (137.00 and 101.33 μscm^{-1}) and chloride (10.47 and 8.20 mg/L) were below desired values, but pH level (5.87 and 6.63) and total alkalinity (90.50 and 21.06 mg/L) were within suggested levels for rainy and dry seasons. The high BOD_5 (2.53 and 1.77mg/L) during rainy season revealed that in most point of the river, rainy season exhibit higher values than the dry season. This could be as a result of the effluence flowing into the river body with more loads during the rainy season as compared to the dry season.

Mamun and Mahmud (2014) studied the growth performance and production of juvenile Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus cirrhosus*) and their hybrids. The autrors observed the growth performances in experiment I, catla showed highest average weight gain

(177.97±1.54 g) that was significantly ($p<0.01$) different from the values of mrigal (123.67±5.77 g) and rohu (177.94±1.73 g). Experiment II showed highest average weight gain in catlaxrohu hybrids 209.2±1.15 g. Experiment III showed the highest average weight gain in pure mrigal 208.43±1.15 g followed by the pure catla 148.5±1.15 g and hybrids of Catlaxrohu 132.53±1.5 g. Catlaxmrigal and Mrigalxrohu showed the lower performances in average weight gain both in experiment II and experiment III. The highest net production was found 961.91±118.64 kg ha^{-1} 10 months in experiment II followed by the net productions of pure and hybrids of juvenile Indian major carps 951.42±39.70 kg ha^{-1} 10 months in experiment III and the same pure species 810.98±24.85 kg ha^{-1} 10 months in experiment I. This study gives a clear concept that unintended hybridization should be avoided as it will cause a lesser production and can damage the purity of the species.

Mir *et al.* (2014) studied the length-weight relationships of 1033 *Labeo rohita* collected from the main channel of Ganga river and its five major drainages and observed allometric positive ($b>3$) the growth for males, females and pooled sexes. The coefficient of determination (r^2) in males ranged from 0,978 to 0,989 and for females from 0,958 to 0,985. The authors acclaimed this was the first attempt to provide information about the growth condition of *L. rohita* from wild population of different geographical locations of river Ganga and its major tributaries, will enlighten the fishery biologists about the status and growth of this fish in natural waters for successful development, management, production and ultimate conservation of *L. rohita.*

Tak *et al.* (2014) studied the monthly parasitic abeoundanc of *Scchizothorax niger* and *Labeo rohita*. Highest prevalence (60%) of infection was been recorded in ciliophorans and the lowest was in crustacean (48%). It was observed that highest parasitic prevalence (54%) was recorded during winter season (December-February) while the lowest prevalence (0%) recorded during rainy season (June-August). The authors concluded with fact that biological factors and water quality has a great impact on the abundance of the parasites and their ability to survive on host. Proper stocking rate and water quality management can be the only solution to keep the infestation.

Dash *et al.* (2014) worked on seasonal abundance, identification and isolation of parasites *Myxobolus* sp., *Thelohanellus* sp., *Trichodina* sp., *Dactylogyrus* sp., *Gyrodactylus* sp., *Argulus* sp., *Lernea* sp., *Chilodonella* sp., *Cosia* sp., Nematodes and unidentified crustaceans. from *Labeo bata.* The winter season was found to be the most vulnerable period for parasitic infestation as water qualities deteriorate and the fishes were in stressed condition which favors the parasites to infest. Prevalence of *Myxobolus* sp. and *Thelohanellus* sp. were highest in winter and spring seasons. Prevalence *of Trichodina* sp. was more in winter whereas prevalence of *Dactylogyrus* and *Gyrodactylus* sp. were highest in rainy season. *Costia* sp. was recorded only in winter with the prevalence of 1.66%. It was also found that 20-25cm length group fishes were more infested with parasites compared to 10-15 cm and 15-20 cm length groups.

Munni *et al.* (2013) assessed water quality for fish culture by measuring various physicochemical parameters of water for fish culture from the seven identified ponds at Tangail. The obtained values of the investigated parameters were temperature 29-38.3°C, pH 6.8- 7.12, DO 1.1-6.9 mg/l, BOD 1.4-4.2 mg/l, transparency 32.5-57.5 cm, TDS 85-164 mg/l, EC 138-274 µs/cm, acidity 20-36.3 mg/l, total alkalinity 43.5-62.5 mg/l and hardness 20-27 mg/l. All the values were compared with the water quality standards for fish culture. The comparative analysis showed that most of the water quality parameters of the 7 ponds were suitable for fish culture while the temperatures recorded were higher in most cases than the desired level, and transparency, TDS and DO level were also fluctuated highly. From this investigation, it is recommended that necessary steps should be undertaken to improve the water quality of the ponds to a suitable level for fish culture. Steps should be implemented in such a way that they not ensure high yield fish production only to bring economic benefit but also conserve environmental quality.

Sarder (2013) described species selection, species composition, stocking densities, production levels, pond preparation and management practices, natural food production, the use of supplemental feeds, its preparation, presentation and storage. In the broodstock systems, variability was observed in terms of the species cultured and stock composition, broodstock management, and supplemental feed and feed management practices. It was found that species selection, stock composition, stocking densities and water management practices varied greatly between the farmers and that there was a wide regional variation in supplemental feeding practices. The majority of farmers use supplemental feeds on a regular basis and only feed irregularly when financial constraints prevent them from buying feeds. Farmmade supplemental feeds, locally produced and industrially manufactured pellet feed are used. In general, farmers demonstrated a poor understanding of the nutritional requirements of the fish, the impacts associated with nutrient losses during feeding, the use of feed conversion ratios as a management tool, and the need for good on-farm record keeping.

Bhatnagar and Devi (2013) described the water quality and the management of pond fish culture. Water quality is determined by variables like temperature, transparency, turbidity, water colour, carbon dioxide, pH, alkalinity, hardness, unionised ammonia, nitrite, nitrate, primary productivity, BOD, plankton population etc. In the present study water quality management principles in fish culture have been reviewed to make aware the fish culturist and environmentalist about the important water quality factors that influence health of a pond and are required in optimum values to increase the fish yields to meet the growing demands of present day scenario of the world, when the food resources are in a state of depletion and the population pressure is increasing on these resources.

Charo-Karisa *et al.* (2013) observed fish feed constitutes 40-60% of the total operational costs of a fish farm. The growth performance and cost-benefit of using pelleted diets formulated from locally available feed ingredients on *C. gariepinus* were evaluated in a rural African setting. Four isocaloric and isonitrogenous diets were formulated from freshwater shrimp (*Caridina nilotica*), rice bran (*Oryza sativa*) and wheat bran *(Triticum aestivum).* The diets were *C. nilotica* and wheat bran pelleted (CWBp), *C. nilotica* and wheat bran un-pelleted (CWBup), *C. nilotica* and rice bran pelleted (CRBp), and *C. nilotica* and rice bran un-pelleted (CRBup). The diets were fed to *C. gariepinus* fingerlings (mean initial weight 1.75±0.03g), in triplicates for 5 months. The pelleted diets showed significantly better performance ($P<0.05$) compared to the un-pelleted diets. Fish grew to a weight of 266.77±6.21g on CWBp, 224.9±3.91g on CRBp, 211.38±4.46g on CWBup and 190.87±4.47g on CRBup. Cost benefit analysis of the pelleted and un-pelleted diets indicated positive net returns of US$ 180.1 for CWBp, US$142.5 for CRBp, US$ 126.8 for CWBup and US$ 115.5 for CRBup. The CWBp had significantly higher net returns than the other diets. This paper demonstrates that although on-farm pelleting of diets adds extra cost of labour, pelleted diets are cost-effective and should be incorporated as an essential part of on-farm feed production.

Ramudu and Das (2013) find out the prevalence or PFI and severity of monogenean parasites on Indian Major Carps in West Bengal fish farms. *Dactylogyrus* sp. infest gill whereas *Gyrodactylus* sp. affect both skin and gill. Prevalence of *Dactylogyrus* sp. were high during August (PFI 83.45%) compared to June where PFI was only 4.5%. Similarly *Gyrodactylus* sp. showed high prevalence in August (PFI 28.88%) compared to it's zero prevalence in June. Prevalence and severity of the infestation were also found to be related to different length group of the hosts. *Labeo rohita* was more susceptible to monogenean parasites. Infestation rate were more in small (1 to 10 cm) and medium (10.5 to 30cm) sized fishes, may be due to poor immune power compare to large size fishes (30.5 to 45 cm). Large size fishes were more susceptible to *Gyrodactylus* sp. as these provide more surface area for attachment.

Mastan and Ahmed (2013) described bacterial kidney disease (BKD) in Indian major carp fishes, *Labeo rohita* (ham.) and *Cirrhinus mrigala* (Ham.) natural occurrence and artificial challenge. Only two species namely, *Labeo rohita* and *Cirrhinus mrigala* were found infected with disease. In severe cases, lesions assumed the shape of ulcers. Internally, Kidney become swollen and showed discrete white areas which contained bacteria. Bacteriological examinations of infected fishes indicate that the occurrence of *Renibacterium salmoninarum*in infected regions of skin and internal organs, particularly from kidneys. Experimental infection trails revealed that the isolated bacterium was pathogenic to both species of fishes.

Perveen and Ullah (2013) studied 2160 host fresh water carp fish (Cypriniformes: Cyprinidae) of different species for ectoparasitic infestation at Charbanda Carp Fish Hatchery (CCFH) Pakistan in which 3 were indigenous including the thaila, *Catla catla* Hamilton; moraki, *Cirrhinus mrigala* Hamilton and rohu, *Labeo rohita* Hamilton, however, 3 were exotic including the grass carp, *Ctenopharyngodon idella* Valenciennes; silver carp, *Hypophthalmichthys molitrix* Valenciennes and common carp, *Cyprinus carpio* Linnaeus. The individual ectoparasitic infestation of 3 different species were: the anchor worm, *Lernaea cyprinacea* Linnaeus (Crustacea: Copepoda) (17.2%); carp lice, *Argulus* sp. Leach (Crustacea: Maxillopoda) (3.6%)

and salmon fluke, *Gyrodactylus* sp. Malmberg (Platyhelminthes: Monogenea) (0.3%). The highest overall prevalence and abundance at CCFH, in *C. idella* was 25.4% and 1.3%, respectively and intensity was more in *C. mrigala* 19.5% while at TFF, the highest overall prevalence and abundance in *L. rohita* was 7.9% and 0.2%, respectively and intensity was more in *C. idella* 3.7%. The lowest overall prevalence and abundance at CCFH in *C. catla* 11% and 0.3%, respectively, and the lowest intensity was seen in *H. molitrix* (6.1%) while at TFF, the lowest overall prevalence and abundance in *C. idella* was 3.3% and 0.1%, respectively, and the lowest intensity was seen in *L. rohita* (3.66%). However, no ectoparasite was recovered from *C. mrigala* and *C. carpio* at TFF.

Hasan *et al*. (2013) observed the culture strategies and fish health and disease problems in pond aquaculture in Mymensingh, Bogra and Pabna districts of Bangladesh. The most prevalent diseases as reported by the farmers were pop eye (57.78%), ventral reddening (55.55%), tail and fin rot (48.89), hemorrhagic lesion over the body surface (45.56%), dropsy (40%), gill rot (40%), white spot (40%) and epizootic ulcerative syndrome or EUS (33.33%). According to farmers opinion most susceptible species to disease was silver carp, *Hypophthalmichthys molitrix* (57.78%); followed by mrigal, *Cirrhinus cirrhosus* (50%); catla, *Catla catla* (47.78%); sarputi, *Barbodes gonionotus* (47.78%); rui, *Labio rohita* (42.22%) and pangas, *Pangasianodon hypophthalmus* (42.22%). Higher mortality was found in pangas (53.56%). Clinically, pangas, koi and sarputi were found severely affected.

Ramudu *et al.* (2013) described the isolation and identification different parasites from *Cirrhinus mrigala*, severity of infestation and to find out Parasitic Frequency Index (PFI, %) months, seasons and lenghth groups wise from different selected districts of West Bengal. The infested fishes suffered mainly from respiratory manifestations, blackness of the skin and mortalities. The parasitic infestations were found to be the major problem and the most prevalent disease causative agents among cultured fish spp. The isolated parasites were *Myxobolus* sp., *Thelohanellus* sp., *Trichodina* sp., *Dactylogyrus* sp., *Gyrodactylus* sp., Nematodes, *Argulus* sp., *Lernea* sp., *Chilodonella* sp., Development stage, Ichthyoptherius multifilus, *Cosia* sp. and unidentified Crustaceans. During study period *Myxobolus* sp. and *Thelohanellus* sp. prevalence were highest in winter and spring seasons (81% and 51%, respectively). *Trichodina* sp.

prevalence was more in summer i.e. 47%. During study period *Dactylogyrus* sp., *Gyrodactylus* sp. prevalence were highest in rainy season 65% and 6.9% respectively. Ichthyoptherius multifilus and *Cosia* sp. were recorded only in spring season. 1cm to 30cm length group fishes were more infested with the parasites compare to 30.5 cm to 40cm length groups.

Kadhar *et al.* (2012) described the growth performance of two Indian Major Carps *Catla catla*, and *Cirrhinus mrigala* fingerlings for period of 40 days. Nine experimental groups fed commercial pellet diet incorporated with three types of nutritional supplements (Gram positive lactobacil probiotic, Parry's Spirulina and Vitamin C – Ascorbic acid) at different concentrations (2 %, 4 %, & 8 %) and one control group maintained separately for both fingerlings. The results revealed that the Catla fingerlings showed maximum increase in length (28.66±0.70mm), weight gain (353.25mg), FCR (1.01) and SGR (0.88) were observed in 4% probiotic and similar growth parameters were observed with 4% spirulina and 2% vitamin C. In mrigal fingerlings fed with 4% probiotic significant increase in length, weight gain, FCR, SGR were observed (32.55±1.94mm), 447.78 mg, 0.80 and 1.11 respectively. Similarly trends were observed in Mrigal fingerlings fed with 4% spirulina and 2% Vitamin C. In both fish fingerlings lipid concentration correlates strong significant ($P<0.01$) with survival rate and FCR strong significant with SGR. Protein levels moderately significant ($P<0.05$) with FCR.

Khan *et al.* (2012) described growth performance and body composition of yearling Indian major carps (*Catla catla, Cirrhinus mrigala* and *Labeo rohita*) was evaluated in semi-intensive (mono and polyculture) systems. In trial 1, all the three species gained significantly higher weights with experimental feed (F1) versus control group (F0). There was non-significant difference observed among species. In trial 2, non-significant difference was observed for net weight gain among species and between feeds. The feed conversion ratio (FCR), protein efficiency ratio (PER), protein utilization (PU), gross nitrogen retention efficiency (GNRE%) and gross energy retention efficiency (GERE%) were found non-significantly different among species in both trials, except GNRE% in polyculture, where *L. rohita* showed significantly higher values than its counterparts. No significant difference was observed in body composition and mineral contents among species and between feeds in both trials. In conclusion, all the three fish species performed well under monoculture system with 35% protein diet and showed significantly higher growth than the control, compared to polyculture, without any significant effect on body composition.

Chakraborty and Nur (2012) observed production potential of shingi, *Heteropneustes fossilis* and koi, *Anabas testudineus* in polyculture were assessed at a stocking density of 2, 47,000 and 3, 70,500 ha-1, respectively in treatment T1 and T2. Monoculture of *H. fossilis* and *A. testudineus* was designed at a stocking density of 2, 47,000 ha-1 in treatment T3 and T4, respectively. Fish production in treatment T1, T2, T3 and T4 were 18,803±111, 12,388±115, 10,042±5 kg ha-1 day-120 and 22,176±7 kg ha-1 day-100, respectively. The feed conversion ratio (FCR) was significantly ($P<0.05$) lower in T4 than that of the other three treatments. The net financial benefits incurred from treatment T1, T2, T3 and T4 were Bangladeshi Taka 17,65,769; 6,691; 15,83,990 and 16,29,409 BDT ha-1, respectively. The mean differences of gross yields and net benefits among different treatments were significant (P<0.05). The polyculture technology of shingi and koi, and monoculture technology of koi may help to meet the dietary needs and improve the socio-economic status of the people of Bangladesh.

Ujjania (2012) studied growth performance of Indian major carp (*Catla catla*, Ham. 1822) using key scales in three different sized water bodies. The annual rings or annuli (+6 to +7) and growth data in samples were observed and used to estimate selected growth parameters. High value of correlation coefficient 'r' 0.946 (MBS), 0.912 (SD) and 0.911 (AP) evident and speak for strong correlation in total length of fish and scale radius. Growth performance estimation in this study on the basis of key scales exhibited that growth of carps in the water bodies of southern Rajasthan could be divided into two phases: the first, phase of sexual immaturity, which lasts up to two years and second, phase of sexual maturity.

Ujjania *et al*. (2012) described length-weight relationships (LWR), condition factor (K) and relative condition factor (Kn) for three commercially important Indian major carps (*Catla catla, Labeo rohita* and *Cirrhinus mrigala*). In LWR (W=aLb) values of exponent 'b' were observed to be 3.275 for *catla*, 3.376 for rohu and 3.362 for *mrigal* from pooled data whereas such values varied from 3.160-3.805 for *catla*, 3.110-4.574 for *rohu* and 2.498-3.375 for *mrigala* in different length groups. The values of 'K' were 3.083 in *catla*, 1.695 in *rohu* and 1.714 in *mrigal* from pooled data. Moreover, it is fluctuated between 2.788-3.094 in *catla*, 2.011-2.213 in *rohu* and 1.523-1.962 in *mrigal* for different length groups. The values of relative condition factor (Kn) were observed in range 1.000-0.999 in different length groups and 1.018-0.998 for the pooled data of selected species.

Dar *et al.* (2012) described the length-weight relationship of *Schizopyge esocinus* were calculated for males, females. The relationship was analyzed using the formula W= a Lb which was further transformed into Log W = a+b logL. A total of 582 specimens comprising 277 males, 305 females with different size groups. The equation obtained for males was; log W = -4.1567 + 2.897 logL; for females: logW = - 4.5089 + 2.8618 logL; The regression coefficients between males and females did not show any significant difference while significant difference could be noticed between males and between females ($p < 0.01$). Studies on relative condition factor (Kn) of *Schizopyge esocinus* revealed that the fluctuations in 'Kn' values can be attributed to spawning cycle as well as feeding intensity.

Ahsan *et al*. (2012) conducted the study to assess biological profile of plankton from the Padma, Meghna and Tetulia reference river sites during 2011spawning season of Hilsa. 58 taxa of plankton were identified, of which 19 taxa (32.76%) were of phytoplankton and 39 taxa (67.24%) of zooplankton. Among 39 taxa of zooplankton, 19 belonged to Rotifera, 10 to Protozoan, 5 to Cladocera, 4 to Copepoda and 1 to Ostracoda. Besides these, dissimilar abundance of plankton throughout the migratory route of Hilsa was revealed during spawning period which would be one of the major restrictions for the migration of Hilsa due to the contribution of plankton as food in that case.

Mozumder *et al*. (2012) studied the structure of zooplankton communities of six ponds of Mathbaria and Bakeganj, Bangladesh throughout six-months analysis. 35species of zooplankton were identified from Mathbaria, of which 24 belonged to Rotifera, 6 to Protozoa, 3 to Copepoda, 1 to Cladocera and 1 to Ostracoda. On the other hand, 42 species of zooplankton were idneitified from Bakerganj, of which 25 belonged to Rotifera, 7 to Copepoda, 6 to Cladocera, 3 to Protozoa and 1 to Ostracoda. Rotifera was the most abundant group in both areas, Mathbaria (64.86%) and Bakerganj (60.98%) than other groups.

Upadhyay *et al.* (2012) examined 144 specimens of *Labeo rohita* (Ham.) for parasites occurrence; as many as 34 fish were found positive to harbour ciliophorans (*Trichodina* spp. and *Ichthyophthirius multifilis* Fouquet, 1876), monogeneans (*Haplocleidus vachi* Tripathi, 1959 and *Dactylogyrus glossogobii* Jain, 1960), trematode (*Allocreadium mahaseri* Pandey, 1939), nematode Camallanus (*Zeylanema anabantis* Pearse, 1933) and acanthocephalan (Sachalinorhynchus spp). Highest prevalence was shown by platyhelminthes (18.75%) followed by ciliophorans (10.41%), nematode (4.16%) and acanthocephalan (2.77%) in succession. Maximum mean intensity and abundance was shown by *C. anabantis* while the monogenean *H. vachi* was on the 2nd rank. On the other hand, the least intensity and abundance was shown by *Ichthyophthirius multifilis*. The prevalence was recorded more in monsoon (52.77%) followed by post-monsoon (22.22%), summer (19.44%) and winter (8.33%) in succession. Further, the unit-wise intensity of parasites was recorded more in males than the females.

Mofasshalin *et al.* (2012) described the parasitic infestations of three Indian minor carps (*Labeobata, Labeogonius* and *Cirrhinusreba*) collected from different fresh water bodies of Rajshahi. A total of 480 host fishes were examined of which 370 fishes were infected by 4 protozoan (*Trichodina* sp., *lchthyophthirius*sp., *Apiosoma* sp. and *Chilodonella* sp.), 2 monogenean (*Gyrodactylus* sp. and *Dactylogyrus* sp.), 2 crustacean (*Argulus* sp. and *Larnaea* sp.), 1 digenean(*Fellodistomum*sp.) and 1 nematoda (*Camallanus* sp.) parasitic species. These parasites were isolated from body slime, gills and intestine of the infected fishes. Among the isolated parasites *Fellodistomum* sp. was found as the highest and *Chilodonella* sp. was found as the lowest in number. These results indicate that infection and infestation rate of parasites varied with fish size and season and found to be high in the post-monsoon and winter periods (November-March), when fish are most susceptible to parasites.

Tasawara *et al.* (2012) studied one hundred and twenty *Cirrhinus mrigala* for lernaeid ectoparasites at private fish farms. Lernaeid ectoparasites showed an overall prevalence of 25%. Four species of genus Lernaea i.e. *L. cyprinacea, L. polymorpha, L. lophiara* and *L. oryzophila* were recorded. The overall prevalence of *L. cyprinacea, L. polymorpha, L. lophiara* and *L. oryzophila* was 13.33, 9.16, 1.66 and 0.83% respectively. The relationship between body weight and lernaeid parasites showed that *L. cyprinacea, L. polymorpha, L. lophiara* and *L. oryzophila* had highest prevalence of 31.81, 18.18, 4.54 and 4.54% respectively in weight group of 1501-2000g. *L. cyprinacea, L. polymorpha* and *L. lophiara* had lowest prevelance 3.70, 4.34 and 2.08% in weight group of 1-500g, 501-1000g and 1001-1500g respectively. *L. oryzophila* showed nil prevalence in other weight groups. The difference was statistically significant ($P<0.05$). The present results revealed that *L. cyprinacea, L. polymorpha, L. lophiara* and *L. oryzophila* had highest prevalence 17.5, 12.5, 2 and 1% respectively in length group of 18-22cm. *L. cyprinacea* showed lowest prevalence (3.2%) in length groups of 8-12cm. *L. polymorpha* had lowest prevalence (11.11%) in length groups of 13-17cm, whereas *L. oryzophila* and *L. lophiara* were not observed in other length groups. The difference was statistically significant ($P<0.05$).

Kanwal *et al.* (2012) studied to determine the prevalence of *Lernaea* species. The prevalence rates of *L. cyprinacea, L. polymorpha, L. oryzophila, L. lophiara* and *Lernaea* spp., were 32.17, 13.24, 3.15, 2.20 and 1.57% respectively. The relationship between body weight and lernaeid parasites of fish showed that *L. cyprinacea* had highest prevalence (38.86%) in weight group of 50-1000g, while lowest prevalence (0%) was recorded in weight group of >2900g. *L. polymorpha* had the highest prevalence (18.18%) in weight group of 1001-1950g, while the lowest prevalence (0%) was observed in >2900g weight group. *L. oryzophila* had the highest prevalence (16.66%) in weight group of 1951-2900g whereas, lowest prevalence (0%) was recorded in weight group of >2900g. *L. lophiara* and *Lernaea* spp., had the highest prevalence (9.09% and 6.49%) in weight group of 1001-1950g whereas, lowest prevalence (0%) was observed in all other fish weight groups. The relationship between body length and lernaeid spp. showed that *L. cyprinacea* had highest prevalence (44%) in length group of 9-12cm while lowest prevalence (11.11%) was recorded in >20cm length group. *L. polymorpha* had highest prevalence (25%) in length group of 13-16cm and lowest prevalence (0%) was observed in >20cm length group. *L. oryzophila* showed highest prevalence (8.88%) in length group of 17-20cm and lowest prevalence (0%) was observed in 9-12 and >20cm length group. *L. lophiara* and *Lernaea* spp., had highest prevalence (7.77%) and (5.55%) respectively in length group of 17-20cm whereas, lowest prevalence (0%) was recorded in all other length groups.

Mozumder *et al.* (2011) observed monthly seasonal diversity and abundance of zooplankton species at three ponds of Mtahbaria, Bangladesh. A total of 36 species of zooplankton were identified, of which 25 belonged to Rotifera, 6 to Protozoa, 3 to Copepoda, 1 to Cladocera and 1 to Ostracoda. Copepoda was the most dominant group, while Ostracoda was the least one. The simultaneous occurrence of zooplankton peak during the outbreak of cholera in the area was also revealed throughout the study.

Nayak and Mukherjee (2011) observed the probotic selection could be detrimental for the success of aquaculture practices. Bacteria like *Aeromonas* (*Aeromonas* species, *A. hydrophila*), *Micrococcus, Corynebacterium, Plesiomonas, Bacillus* (*Bacillus* sp., *B. subtilis*) and *Pseudomonas* (*Pseudomonas* sp., *P. aeruginosa*) exhibited antibacterial activities against different pathogens. Among these, *B. subtilis* was found to grow at a wider range of temperatures, pH and salt concentrations and was non-haemolytic, non-antibiotic resistant, non-pathogenic and inhibited all the tested primary and secondary pathogens. Dietary supplementation of the bacteria at 108 CFUg_1 feed also enhanced the growth of Indian major carp, *L. rohita*. Based upon these characteristics, author aimed to develop a suitable probiotic for aquaculture practices.

Akter *et al.* (2010) observed quality formulated feed of SBF (Saudi-Bangla Feed) and ACIF (Advanced Chemical Industries Feed) were performed in an improved carp polyculture system. The experiment had three treatments: TC (without feed as control), TSBF (with Saudi-Bangla feed) and TACF (with ACI feed) each with three replicates. All ponds (average 760 m2 and depth 1.12 m) were stocked with carp fingerlings at 10,000 ha-1. Same management practices were followed in all treatments except formulated feed of SBF and ACI were provided twice daily at 5-10% body weight (10% body weight up to 30 days and gradually reduced to 5%) in TSBF and TACF treatments. Water temperature, transparency, pH and dissolved oxygen did not differ significantly (P>0.05) among the treatments and were within the suitable range for fish culture, while ammonia concentration were significantly higher (P<0.05) in TSBF and TACF than TC. The growth and production parameters including individual final weight, SGR and production differed significantly (P<0.01) among the treatments with better performance in TACF followed by TSBF and TC treatments. TSBF and TACF treatments yielded 209% (5634 kg ha-1) and 215% (5751 kg ha-1) increased production, respectively with higher economic return over TC treatment (1820 kg ha-1).

Kamal *et al*. (2010) compared plankton communities among nine freshwater prawn post-larvae rearing ponds at Bangladesh Agricultural University, Mymensingh. Along with 40 genera of phytoplankton, 11 genera of zooplankton belonging to Rotifera (5) and Crustacea (6) were identified throughout the study. Interestingly, no significant relation between growth performance of freshwater prawn post-larvae and abundance of plankton was found.

Roy *et al*. (2010) evaluated zooplankton abundance qualitatively and quantitatively of a carp brood fish pond. A total of 6 groups of zooplankton; Copepoda, Rotifera, Cladocera, Ostracoda, Crustacea and Bryozoa were found. Copepoda (55%) was identified as the dominant group while Bryozoa (1%) was as the least one. The monthly zooplankton variation in relation to physic-chemical parameters was also studied.

Ehiagbonare and Ogunrinde (2010) analyzed the Physico-chemical condition of fish pond water in Okada. The values of the parameters ranged from pH 6.75 - 7.10, conductivity 0.012 - 0.017 mS/cm, TDS 22 - 906 mg/l, COD 162 - 397 mg/l, turbidity (NTU) 5 -170, TSS 85 -206 mg/l, BOD 1.69 - 3.38 mg/l, DO 9.3 - 16.2 mg/l, acidity 100 - 575 mg/l, alkaline 35 - 135 mg/l, calcium 16.01 - 50.06 mg/l, magnesium 1.21 - 5.46 mg/l, hardness 0.40 - 1.47 mg/l, chloride 7.1 - 10.65 mg/l, sulphate 0.66 - 0.96 mg/l, phosphate 1.40 - 4.51 mg/l, nitrate 2.21 - 4.91 mg/l, copper 0.01 - 0.07 ppm, and zinc 0.01 - 0.07 ppm; cadmium and lead were not detected in the samples. There was significant variation of values from location to location; generally there was no significant difference from desirable and acceptable standards. Although there is economic advantage to the fish farmers, there is the desirable need to analyze the fish pond water at regular intervals. This quality assurance process is to ensure that there are no toxic substances in ponds leading to possible bio-accumulation and magnification.

Chandra *et al.* (2010) observed wetland-water quality. The pH and total dissolved solids (TDS) values of the lakes were found to be different from those reported almost a decade back. The concentrations of phosphate and sulphate were much lower than the earlier reported values. The present scenario states that though the biochemical oxygen demand and chemical oxygen demand values were lower for the Ukkadam wetland, the values for Perur wetland have shown a gradual increase. Alkalinity and chloride concentrations were thrice higher than the previous findings. Electrical conductivity and TDS ranged from 303.67 to 4,456.7 muS/cm and from 169 to 2,079.3 mg/l, respectively, and were positively correlated with chloride and sulphate ($P < 0.05$). These changes are a reflection of the environmental changes happening in the cityscape.

Kiran (2010) evaluated the physico-chemical characteristics of the waters in two fish ponds. The water quality parameters were water temperature, pH, acidity, total alkalinity, free CO_2, dissolved oxygen, biological oxygen demand, chloride, sulphate, phosphate, nitrate, calcium, magnesium and total hardness. The high phosphate and nitrate concentrations were attributed to water leached surface soil runoff, as well as the addition of organic manure (cowdung and poultry manure) to the ponds. It will be necessary to delimit cattle and poultry manure access points to the ponds to reduce this type of organic pollution in the water bodies. Based on the results of present study it is concluded that the fish ponds are moderately hard to hard category.

Mabwoga *et al.* (2010) studied the classification and water quality assessment of Harike wetland (Ramsar site) in India. The water quality parameters assessed were dissolved oxygen, conductivity, pH, turbidity, total and suspended solids (SS), chemical oxygen demand, and Secchi disk transparency (SDT). Correlations were established between turbidity and SS, SS and SDT, and total solids and turbidity. The NIR band correlated significantly with the water quality parameters, whereas, using SDT values, it was observed that the green and the red reflectance bands were able to distinguish the waters from the two rivers, which have different water qualities.

Mozumder *et al.* (2010) conducted a one-year study to analyze zooplankton composition qualitatively and quantitatively from eight coastal water bodies of Bakerganj, Bangladesh. 47 taxa of zooplankton were identified, of which 31 belonged to Rotifera, 5 to Cladocera, 5 to Copepoda, 4 to Protozoa and 2 to Ostracoda. Rotifera and Copepoda were the most abundant groups and Ostracoda was the least abundant one.

Delwer *et al.* (2010) described the parasitic diseases of three Indian major carps in different fish markets of Rajshahi. Among the 288 species, 238 fishes were found infected and a total number of 2121 parasites were collected during the study period. Among the parasites, 10 were ectoparasites and the rest four were endoparasites. Protozoan and monogeneans were very common on the gills of the host fishes. In *Labeo rohita* a total number of 10 species were identified of which 8 were ectoparasites and the rest 2 were endoparasites. In *Catla catla*a total number of 11 species were identified of which 8 were ectoparasites and the rest 3 were endoparasites. In *Cirrhinus cirrhosus*a total number of 12 species were identified of which 8 were ectoparasites and the rest were endoparasites. The ectoparasites *M. rohitae*was found only in the host *L. rohita* during the study period. The highest (87.50%) prevalence of parasites was recorded in *L. rohita* and lowest value (77.08%) was recorded in *C. cirrhosus*. The abundance of parasites ranged from 5.95 to 9.00 during the study period. The highest abundance (9.00) was recorded in *L. rohita* and the lowest (5.95) was recorded in *C. catla.* The highest mean density of parasites was observed as 10.28 in *L. rohita* and lowest as 7.15 in *C. catla*.

Garg *et al.* (2009) assessed physico-chemical characteristics, trophic status, pollution studies and macrophytic community of Ramsagar reservoir. The range of various parameters of reservoir water (water temperature 15.92-31.87 degrees C, water depth 2.90-8.25 m, transparency 66.59-116.00 cm, electrical conductivity 108-246.30 microS cm(-1), turbidity 2.17-16.72 NTU, total dissolved solids 166.37-239.00 mg l(-1), pH 7 41-8.95, dissolved oxygen 6.78-11.59 mg I(-1), free carbon dioxide nil-6.32 mg l(-1), total alkalinity 64.25-146.25 mg l(-1), total hardness 34.00-75.25 mg l(-1), chlorides 13.13-22.36 mg l(-1), calcium 11.21-33.81 mg l(-1), sulphates 1.50-8.87 mg l(-1), nitrates 0.011-0.033 mg l(-1), nitrites 0.004-0.029 mg l(-1), phosphates 0.013-0.054 mg l(-1), silicates 0.65-8.42 mg l(-1), ammonia nil-0.84 mg l(-1), biochemical oxygen demand 0.93-4.68 mg l(-1), chemical oxygen demand 3.60-17.40 mg l(-1), magnesium 1.17-5.60 mg l(-1), sodium 16.75-34.30 mg l(-1) and potassium 1.97-4.86 mg l(-1)) exhibit monthly as well as seasonal fluctuations. In all 13 species of macrophytes were recorded from the reservoir. Macrophytic diversity was higher at the points where nallahas join the reservoir and in the areas where agricultural practices are performed. This was due to allocthonous nutrients brought into the reservoir from the surrounding catchments area. The above study indicated that the Ramsagar reservoir is under the category of mesotrophic water body slightly inclined towards eutrophication. Therefore, the conservation and management of this water body are very much required.

Rahman *et al.* (2009) observed growth, survival and production performances of *Cirrhinus ariza* fingerlings. Four-day-old hatchling stocked at 0.8 million ha-1 was defined as treatment-1 (T1), 1.0 million ha-1 as treatment-2 (T2) and 1.2 million ha-1 as treatment-3 (T3), respectively. The physico-chemical and biological parameters of pond water were within the suitable range for fish culture. Growth in terms of final weight, final length, weight gain, length gain and specific growth rate, and survival of fingerlings was significantly higher in T1 where stocking density were 0.8 million hatchling ha-1 than those obtained from T2 (1.0 million ha-1) and T3 (1.2 million ha-1), respectively. Feed conversion rate was the lowest in T1 followed by T2 and the highest in T3 ($P<0.05$). Gross and net productions of fingerling were higher in T1 than T2 and T3, respectively ($P<0.05$). Higher number of fingerlings was produced in T3 than those in T2 and T1 ($P<0.05$). Even then, consistently higher net benefits were obtained from T1 than those from T3 and T2. Among the treatments evaluated, 0.8 million hatchling ha-1 (T1) was the best stocking density considering the highest growth, survival, production and net benefits of the fingerlings of *C. ariza* in nursery ponds.

Saksena *et al.* (2008) studied the physico-chemical characteristics of Chambal river water in National Chambal Sanctuary (Madhya Pradesh). The water quality parameters namely transparency (12.12-110 cm), colour (transparent-very turbid), turbidity (1-178 TNU), electrical conductivity (145.60-884 microS cm(-1)), total dissolved solids (260-500 mgl(-1)), pH (7.60-9.33), dissolved oxygen (4.86-14.59 mgl(-1)), free carbon dioxide (0-16.5 mgl(-1)), total alkalinity (70-290 mgl(-1)), total hardness (42-140 mgl(-1)), chloride (15.62-80.94 mgl(-1)), nitrate (0.008-0.025 mgl(-1)), nitrite (0.002-0.022 mgl(-1)), sulphate (3.50-45 mgl(-1)), phosphate (0.004-0.050 mgl(-1)), silicate (2.80-13.80 mgl(-1)), biochemical oxygen demand (0.60-5.67 mgl(-1)), chemical oxygen demand (2.40-26.80 mgl(-1)), ammonia (nil-0.56 mgl(-1)), sodium (14.30-54.40 mgl(-1)) and potassium (2.10 mgl(-1)-6.30 mgl(-1)) reflects on the pristine nature of the river in National Chambal sanctuary. On the basis of various parameters studied, Chambal river in this stretch can be placed under the category of oligosaprobic. The water quality analysis, indicated that the riverwater in the sanctuary area is pollution free and can serve as a good habitat for many aquatic animals including endangered species.

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Bhuiyan *et al.* (2008) investigated to demonstrate the occurrence and abundance of copepods in a fish pond at Rajshahi University Campus, Rajshahi, Bangladesh. 5 genera of copepods were identified throughout ten-months investigation. Seasonal fluctuations of copepods in relation to physic-chemical parameters were also studied.

Naz and Najia (2008) carried out a one-year study to observe the abundance the zooplankton populations of Sona Dighi, Rajshahi. 45 species under 31 genera represented by five major groups of zooplankton were reported. The groups were Copepoda (9 genera, 15 species), Rotifera (7 genera, 11 species), Cladocera (6 genera, 8 species), Protozoa (5 genera, 4 species) and Ostracoda (4 genera, 6 species).

Kamal *et al.* (2007) studied water sample which were collected from six different point of the Mouri River Khulna, Bangladesh. The minimum and maximum value of water temperature, Transparency, Turbidity, TSS, TDS, Electric Conductivity, water pH, dissolve oxygen, free Carbon dioxide, Alkalinity, Acidity, Hardness, BOD, COD, Sulphate, Phosphate, Nitrite, Sodium, Calcium, Potassium, Manganese and Iron were noted as 21.6 and 32.2 degrees C; 15 and 66 cm; 16 and 22 NTU; 74 and 125 mg L(-1); 255 and 305 mg L(-1); 159 and 275 microS cm(-1); 1.10 mg L(-1) 8.18 mg L(-1); 7.5 and 8.3; 1.1 and 8.3 mg L(-1); 27.5 and 35.5 mg L(-1); 350 and 610 mg L(-1); 32.4 and 171 mg L(-1); 310 and 529 mg L(-1); 13 and 31 mg L(-1); 290 and 365 mg L(-1); 42046 and 57.35 mg L(-1); 4.89 and 11.46 mg L(-1); 0.54 and 1.82 mg L(-1); 16.8 and 33.9 mg L(-1); 1.5 and 6.9 mg L(-1); 49 and 94 mg L(-1); 31 and 59 mg L(-1); 2.6 and 3.8 mg L(-1), respectively. River water did not show any significant pollution during the present study. During the study period dissolved oxygen show direct relation with water temperature but inverse with BOD and COD.

Akter *et al.* (2007) studied five exotic carp species viz. *Hypophthalmichthys molitrix, Cyprinus carpio var. specularis, Cyprinus idellus, Cyprinus carpio var. communis and Puntius gonionotus* were examined for parasitic diseases out of which 793 fishes were infected by 3 protozoan (*Trichodina* spp., *Ichthyophthirius* spp. and *Chilodonella* spp.), 2 monogenean (*Gyrodactylus* spp. and *Dactylogyrus* spp.), 2 trematoda (*Gorgotrema* spp., *Metadena* spp.), 4 cestoda

(*Rhopalothyrax* spp., *Marsipometra* spp., *Lytocestus* spp. and *Senga* spp.), 2 nematoda (*Camallanus* spp. and *Procamallanus* spp.), 3 crustacean (*Argulus* spp., *Alitropus* spp. and *Lamproglena* spp.) and 1 insect (*Dipteran larvae*) parasitic species. These parasites were isolated from body slime, gills and intestine of the infected fishes. In general species wise parasitic average prevalence was highest in *Argulus* spp. (20.07%) in *H. molitrix* and lowest in *Metadena* spp. (2.85%) in *C. carpio var. communis.* Average abundance was highest in *Argulus* spp. (0.70) in *H. molitrix* and lowest was in *Lamproglena* spp. (0.04) in *C. carpio var. communis.* Average mean density was highest in *Chilodonella* spp. (10.00) in *C. carpio var. specularis* and lowest in *Procamallanus* spp. (2.08) in *C. carpio var. communis.*

Sahu *at al.* (2007) described inclusion of kalbasu, *Labeo calbasu* as a candidate species in the Indian major carps based polyculture system was evaluated through a six-month grow-out trial in earthen ponds of 0.08 ha each. Species performance was assessed through provision of varied inputs viz., fertilizers (T-1), fertilizers + supplementary feed (T-2) and fertilizers + supplementary feed + periphytic substrate (T-3) as the three treatments, which were evaluated in replicates. Catla (35%), rohu (35%), mrigal (15%) and kalbasu (15%) were stocked at combined density of 7500 fingerlings/ha. The periphytic substrate, comprised stripe bamboo mat, was provided at 10% of the pond surface area. Provision of each additional input caused significantly higher increase in overall mean survival, growth, SGR and net biomass yield of carps. Among the carp species, while only rohu and kalbasu showed significantly higher weight gain (234.4 g and 170.3 g, respectively) in T-3, no such increase was noticed either in catla or mrigal. The net production in T-3 (1516.1 ± 24.3 kg ha^{-1} 6 $months^{-1}$) was 13.0 and 73.2% higher than those of T-2 (1341.7 ± 15.5 kg ha^{-1} 6 $months^{-1}$) and T-1 (875.2 ± 15.6 kg ha^{-1}6 $months^{-1}$), respectively. The study revealed the relative advantage of using periphytic substrates in carp polyculture systems with kalbasu as a component species.

Chandra (2006) described fish parasitological investigation and research performed in Bangladesh has been reviewed through study of available literature. Considerable works mainly on systematics, nature of infestation and pathology of different groups of fish parasites-protozoa, helminths and crustacea have been done. A total of 290 species of parasites have so far been recorded from freshwater and marine fishes in Bangladesh. Ectoparasitic protozoans and monogenetic trematodes are recorded mainly from cultured fish species of farms. Two helminth parasites of zoonotic importance *Dibothriocephaluslatus* and *Gnathostomaspinigerum*are also reported from Bangladesh fishes. Much attention has been given on *Caryophyllidcestodes*of two catfishes Magur and Singhi. Few fish diseases of parasitic origin have been reported and studied. Commonly occurring parasitic diseases are *agrulosis* (fish louse)*, ichthyophthiriasis* (white spot) and *myxoboliasis.*

Chowdhury and Mamun (2006) studied the diversity and abundance of phytoplankton and zooplankton of two fish ponds of Khulna University Campus. Along with 25 genera of phytoplankton, 18 genera of zooplankton were identified throughout a one-year study, of which 7 belonged to Rotifera, 7 to Cladocera and 4 to Copepoda. In addition, some physic-chemical parameters of these ponds were also studied.

Raknuzzaman (2006) conducted a one-year study to observe the abundance of zooplankton of two sites of Buriganga river; one at Hazaribagh receiving tannery waste and the other at Islambagh receiving sewerage waste. Though similar major groups of zooplankton (Rotifers, copepods, cladocerans and ostracods) were identified in both sites, the dissimilarities between two sites in accordance to the monthly abundance of zooplankton as well as physic-chemical parameters were revealed.

Faruk *et al.* (2004) examined the current status of fish disease and health management practices in rural freshwater aquaculture. Average prevalence of fish disease was highest in Jessore district (18.2%) followed by Comilla (13.4%), Mymensingh (11.4%) and Dinajpur district (10.4%). Minimum prevalence (5.5%) was recorded from Natore district. The most prevalent disease was tail and fin rot (20.5%), followed by epizootic ulcerative syndrome or EUS (18.9%), nutritional diseases (15.3%), red spot (13.0%) and gill rot (12.3%). This study identified some fish health management related problems in rural aquaculture, such as lack of assistance, poor technical knowledge and lack of suitable therapeutics and their proper uses.

Kohinoor (2000) conducted an experiment by using cattledung and supplementary feed to evaluate the physico-chemcial parameters, biological productivity of ponds and fish growth in BAU campus. He found 33 genera of phytoplankton belonging to Bacillariophyceae (6), Chlorophyceae (15), Cyanophyceae (8), Euglenophyceae (4) and thirteen genera of zooplankton were also identified which belonged to crustacean (5) and Rotifera (8). The estimated mean phytoplankton number ranged from (4.90 ± 1.3 x 10^3 /L to 71.23 ± .54 x 10^3/L) and mean zooplankton production varied from (2.70±0.41 x 10^3/L to 12.77 ± 1.51 x 10^3/L) Chlorophyceae and Rotifera were the most dominant than others groups of phytoplankton and zooplankton, respectively. pH the physico-chemical parameters were within the productive range during the experimental period.

Hossain (1999) conducted a study to determine the cost, return and profitability of pond fish culture. The author used a higher production function model to see the relationship of major factors employed in pond fish production. The study showed that gross return from pond fish production was Tk. 16,7331.31 ha^{-1} yr^{-1}. In this case of small, medium and large farms net returns were Tk. 25,224.68, 26,060.87 and 32,973.33 ha^{-1} yr^{-1}, respectively.

Desmarais and Tessier (1999) studied performance trade off across a natural resource gradient. An important environmental factor determining both phytoplankton and zooplankton community composition in lake depth and thermal stratification. However, there is little information on how, the interaction between zooplankton grazers and their phytoplankton food changes along an environmental gradient of Lake Depth. Stratified lakes had consistently lower resource richness then shallow unstratified lakes. They conclude that shifts in daphniid species composition along a gradient of Lake Depth involve an adaptive trade off in ability to exploit rich versus poor resource quality.

Akhter (1998) conducted an experiment to evaluate the effects of urea in combination with a constant quantity of poultry manure on plankton production in fish ponds Three treatments were namely T, (urea : 50 kg ha^{-1} + poultry manure : 2000 kg ha^{-1}), T_2 (urea : 100 kg ha^{-1} + poultry manure : 2000 kg ha^{-1}), T_3 (urea: 150 kg ha^{-1} + poultry manure; 2000 kg ha^{-1}). The author found that treatment T_2 is suitable for the production of phytoplankton and treatment T_1 is suitable for zooplankton production.

Bhandari (1998) conducted an experiment to determine the optimum feeding rate for supplementary feeding of carp polyculture and reported that supplemental feeding mainly mixture of nee bran and mustard oil cake (1:1) at the rate of 4% of total fish body weight daily in two installments (morning and afternoon) is economical for composite culture of carps.

Al-Kahem *et al.* (1998) studied planktonic and physico-chemical parameters in Riyadh, Saudi Arabia. A quantitative and qualitative study of phytoplankton and zooplankton community and physico-chemical condition of water they observed. Zooplanktons were prominent forming a peak in July and trough in January. The distribution of the generic composition of phyto- and zooplankton was correlated with some of the physico-chemical changes in the environment.

Anfuso *et al.* (1998) studied analytical assessment of Oreto River water and photo-catalytic degradation tests of dissolved organic pollutants. This paper reports a systematic analytical investigation carried out on four sites and in different seasons. The main physico-chemical parameters that determined are: temperature, pH, specific conductance dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BODS), concentration of nitrogen containing species (NH_4+, $N0_2$ -, $N0_3$ -) total phosphorus and amonic surfactants.

Cyr (1998) studied cladoceran and copepod dominated zooplankton communities' graze at similar rates in low productivity lakes. They said that many studies suggest that the taxonomic composition of a zooplankton community should determine its grazing rate and relativity for different types of particles. It is generally believed that copepod dominated communities should (1) have lower grazing rates and (2) consume large particles then communities dominated by large cladocerans. They concluded that qualitative differences in grazing selectivity of different zooplankton taxa are observed in complex natural communication.

Murdoch *et al.* (1998) studied plankton abundance and dynamics across nutrient levels: Tests of hypotheses. They tests four hypotheses that might account for stability at high nutrient levels: (1) greater abundance of inedible algae with enrichment interferes with *Daphnia's* feeding (2) *Daphnia'* s death rate increase with enrichment (3) *Daphnia's* death rate increase with *Daphnia's* density (4) *Daphnia's* function response depends on *Daphnia's* density. All hypotheses are rejected because they predict much higher biomass of edible algae at high nutrient levels than is observed. Additional evidence on *Daphnia* death rates strengthens the case against hypothesis (2) and (3) . They consider other hypotheses and conclude that three in particular would repay further investigation.

Norberg and DeAngelis (1997) worked on temperature effects on stocks and stability of a phytoplankton-zooplankton model and the dependence on light and nutrients. A model of a closed phytoplankton-zooplankton ecosystem was analyzed for effects of temperature on stocks and stability and the dependence of these effects on light and total.nutrient concentration of the system. An analysis of the steady state equations showed that the effect of temperature on zooplankton and POM biomass was leveled when primary production is nutrient limited Temperature increase had a generally negative effect on all biomasses at high nutrient levels due to increased maintenance costs. They found that the amplitude of fluctuations of the herbivore stock increases with temperature while the mean biomass and minimum values decrease in comparison with steady state predictions.

Paka and Rao (1997) worked on Interrelationship of physico-chemical factors of a pond. They investigate the interrelationships of certain physico-chemical factors like pH, temperature, carbonates, bicarbonates, chlorids, dissolved oxygen, organic matter, total hardness, calcium, magnesium, phosphates, nitrates, silicates and solids have been studied for a period of two years in ponds. All the factors are low concentrations. pH and carbonates varied directly whereas pH and bicarbonates have shown an inverse relationship. Dissolved oxygen and organic matter have shown a negative relationship, which might be due to the utilization of oxygen for the oxidation of organic matter. Hardness of water is temporary due bicarbonates and calcium fluctuated with carbonates. Nitrates and dissolved oxygen have shown a direct relationship and /solids have shown an inverse relationship with temperature.

Shuter and Ing (1997) work on factors affecting the production of zooplankton in lakes. They suggest a simple model of the seasonal production cycle for limnatic zooplankton in which weight-specific rates of biomass production are largely set by temperature, and food resource availability and individual body size largely set levels of biomass accumulation. They briefly discuss the implications of this model for predicting the effects of climate change on Lake Productivity.

Quader (1997) evaluated the effects of fertilizers on the abundance of plankton production in BAU Campus, Mymensingh for the period of four months. Three treatments namely T_1 (urea : 100 kg ha^{-1} + TSP : 50 kg ha^{-1}), T_2 (chicken manure 2000 kg ha^{-1} + urea: 100 kg ha^{-1} + TSP : 50 kg ha-1) and T_3 (cowdung 4000 kg ha^{-1} + urea 100 kg ha^{-1} + TSP : 50 kg ha-1) were applied fortnightly. He observed four groups of phytoplankton namely Chlorophyceae. Bacillariophyceae, Cyanophyceae, Euglenophyceae and four groups of zooplankton rotifer, copepoda, cladocera, nauplius. The maximum abundance of phytoplankton in T_2 treatment where as the maximum production of zooplankton was recorded in T_3. The physico-chemical parameters were within the productive range at the experimental period.

Dhanze and Dhanze (1997) studied two separate equations for the length-weight relationship as W = 1.2735 x 10" SL27433, r = 1.0032; W = 2.6813xl05 TL29002' r = 0.9980 and W = 2.2123x10-" SL25669, r = 0.9961; W = 3.7261x105 TL27988, r = 1.0401 respectively. The perfection of these equations was confirmed by back calculation of the weight and its comparisons with the observed weight. Growth performance of these two species was also studied for a period of eight months in this region and as a result the incremental growth per month has been computed as 14.1 and 82.23 g for *C. carpio communis* and *C. idella* respectively. The analysis and correlation of these data revealed that the grass carp has better yield efficiency as compared to scale carp for culture fisheries in the State. The existing stock of scale carp has been genetically degraded due to the repeated inbreeding which led to the poor yield per unit area in this zone.

Hossain *et al.* (1997) reported highest production of plankton in the pond receiving only inorganic fertilizers lOOg urea and lOOg TSP/30 m^2 applied weekly compared to combination of both inorganic and organic fertilizers.

Wahab *et al.* (1996) observed that daily fertilization with cowdung, urea and TSP was superior to both weekly and fortnightly application when sustainability of plankton was considered. They further reported that the highest concentration of phytoplankton and zooplankton was 1,435.23 x 10^4 cells/litre and 25.74 x 10^4 cells/litre with treatment receiving fertilizers daily at the rate of 3,660 kg ha^{-1} cowdung, 9 kg ha^{-1} urea and 2 kg ha^{-1} TSP.

Miah (1996) conducted an experiment to evaluate the effects of two levels of iso-nitrogenous inputs of both cow and poultry manures on the production of plankton He noted four groups of phytoplankton such as Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae and four groups of zooplankton such as Rotifer, Copepod, Cladocera and Nauplius in the experiment.

Hossain (1996) conducted an experiment to evaluate the effect of organic and inorganic fertilizer on zooplankton production in fish ponds. There were three treatments namely T_1, (urea: 75 kg ha^{-1}), T_2 (cowdung : 6,000 kg ha^{-1}) and T_3 (urea : 75 kg ha^{-1} + cowdung: 6000 kg ha^{-1}). He observed the higher production of zooplankton with the treatment T_2 among all the treatments.

Hossain (1996) conducted on experiment in BAU Campus, Mymensingh for a period of sixty days to find out the effect of fertilization on plankton production. He observed the maximum production of phytoplankton (98.8 kg ha^{-1}) mainly Chlorophyceae with urea and maximum production of zooplankton (8,654 kg ha^{-1}) mainly rotifers with cowdung.

Aktar (1996) conductd an experiment in BAU Campus, Mymensingh and evaluated the effect of fertilizers on plankton production. Four treatments namely T_0 (control), TI (urea: 98.800 kg ha^{-1}), Ta (cowdung; 8645 kg ha-1) and Tj (combination of urea and cowdung) were applied in fortnightly. He found four groups of phytoplankton and zooplankton. The maximum production of phytoplankton was recorded with the treatment TI whereas maximum abundance of sawplankton was found with the treatment T_2. A moderate number of both phytoplankton and zooplankton production were found in all fertilizer treated ponds than that of control ponds.

Miah *et al.* (1996) made an experiment to determine the effect of various inputs viz., organic manure, inorganic fertilizers, supplementary feed, lime and pond size on fish yield and reported that among the inputs supplementary feed, organic manure and inorganic fertilizers had significant effect on fish yield in farmer's ponds.

Monju (1996) obtained the highest yield (3310/5 months) of Thai sharpunti *(Punnus gomonotus)* and highest survival rate i.e. 90% with supplementary feed comprising mixture of mustard oil cake and nee bran (1:1) fed at the rate of 5% of total biomass daily.

Faluroti *et al.* (1996) carried out an investigation on the growth performance of Indian major carps-catla, mrigal, rohu under polyculture system with clarias and tilapia using a 30% crude protein supplementary feed for 120 days in earthen ponds at the following polycultural combination for treatments 1-5, respectively: 1) clarias, tilapia, catla- 2:1:2;2) clarias, tilapia, mrigal-2:l:2;3) clarias, tilapia, rohu-2:l:2;4) clarias, tilapia, catla, mrigal, rohu-2:1:2:2:2,5) catla, rohu, mrigal-1:1:1 using pelleted feed and showed that treatment 4 was the most suitable polycuitural combination with the best growth performance.

Boujard and Luquet (1996) discussed about the feeding rhythms and found the Siluriforms do not refuse to feed when fed during daytime but show a better growth performance in Siluriforms fed by nigh and also provided evidence of a strongest effect of the feeding method (continuous feeding v fractioned feeding into meals), than of the time of feeding, on growth performance.

Mukhopadhyay and Ray (1996) studied the performance of rohu fingerling, *labeo rohita* (Ham.) fed with raw and soaked deoiled salseed *(Shorea robusta)* and found that a diet containing 200g/kg soaked salseed meal resulted in significantly ($p<0.01$) best the food conversion ratio and protein efficiency ratio. Apparent protein digestibility values decreased with increasing level of oilseed meal. Carcass protein was highest in fish fed diets containing 200 g/kg soaked salseed meal and showed that deoiled salseed rneal can be incorporated in carp diets up to 200 g/kg and 300g/kg in raw and treated forms, respectively.

Tacon (1996) reported that in semi-intensive farming systems fish production is achieved using low-cost, locally available materials such as animal manure that are used to control eutrophication and increase production oflive food organisms and low-protein agricultural by products such as gross and green fodder, crop residues, grain and cakes, snails etc' which are used as supplementary feed.

Faluroti *et al.* (1987) conducted an investigation into the economic viability of the polyculture of Indian major carps: catla, rohu and mrigal, *Clarias* and tilapia fed supplementary feed in warm water fish ponds to determine the most productive and profitable combination among the spcies. *Glorias,* tilapia, catla, mrigal and rohu fingerlings were stocked respectively at ratios of 2:1:2:0:0, 2:1:0:2:0. 2:1:0:0:2, 2:1:2:2:2 and 0:0:1:1:1 and the highest projected yield of 2,339.15 kg ha^{-1} yr^{-1} was obtained in pond 5. The best economic returns in term of profit index wee obtained in pond 4.

Rahman (1995) estimated a Cobb-Douglas production function model to explain the contribution of key variables to the production process of pond fish farming. He found that ownership of pond, number of species and human labour had negative impact on fish pond output, while depth of pond water, farm size, fish feed, fertilizer and artificial feed were statistically significant in explaining the variation in fish pond output. He also observed that medium and small farms had the higher gross and net returns because of using higher amount of inputs compared to large farms.

Tacon (1995) reported that the experimental fish be reared under conditions mimicking as far as possible those of the intended farm production unit and environment, including holding facility (indoor or outdoor tank, cage of pond) feed preparation technique (grinding, pelleting drying; pelleting drying; diet texture, form shape, size, buoyancy and water stability), feeding method (hand, demand or automatic feeding; feeding frequency and feeding rate-fixed or satiation feeding), water quality (temperature, turbidity, salinity, oxygen and mineral concentration; water exchange rate, water circulation pattern and artificial aeration), photoperiod (artificial or natural) and fish stocking density and is essential that the growth performance of the experimental fish be at least equal to or greater than that of the target fish species under practical farming conditions so that dietary nutrient requirements can be ascertained under conditions of maximum attainable growth.

Rahman (1995) carried out a study on economics of pond fish production under different management system in Tangail district. He observed that the highest profit amounted to Tk. 137,480 ha^{-1} was earned by farmers under NGO management and the lowest profit Tk. 65,899.77 ha^{-1} was earned by owner operated farmers. He also concluded that scientific use of inputs, normal depth of water, easy flow of capital, smooth extension services will definitely increase the production of fishes.

Azadi *et al.* (1994) worked on the feeding habit of *Notopterus notopterus* from the kaptai Reservoir and found different results. The principal foods were graded as, bivalve molluscs, animal remains, fishes, plant parts, insect larvae, insects, crustaecans, blue green algae, fish scales, green algae and diatom. According to him abundance and availability of organisms depend on its ecological factors. He also reported that a fish would be classified as canivore when more than 75% of its food was represented by animal food.

Wahab *et al.* (1994) recorded identified 25 genera of phytoplankton belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceaeand five genera of zooplankton were also identified belonging to Crustacea and Rotifera from the fish pond of BAU campus. They estimated phytoplankton numbers ranged between 2×10^3 to 2×10^s per liter.

Rosy (1993) conducted an experiment for a period of eight weeks to the effect of cow and chicken manure on the production of plankton. The author noted four groups of phytoplankton such as Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae and four groups of zooplankton such as Rotifer, Copepoda, Cladocera and Nauplius in the experiment.

Pandey *et al.* (1992) observed the daily average weight gain Catla of 0.391 g/day with mixture of rice bran, and mustard oil cake (1:1) as supplemental feed fed at the rate of 5% of total fish body weight daily.

Sumagaysay *et al.* (1991) reported that rice bran diet (containing 11.3% protein), two pelleted diets, containing 22 and 27.4% protein significantly increased growth and production of milkftsh (*Chanos chanos*).

Shah *et al.* (1991) reported an average weight gain of 99 g/fish with a yield of 1,328 kg ha-1 for silver barb in six months raring. They conducted this study in a farmer's pond, using rice bran as supplementary feed and obtained gross profit margin of Taka 43,687 ha^{-1}. They also investigated the prospects of tilapia culture and obtained comparatively better yield (1963 kg ha^{-1} 6 $months^{-1}$) than silver barb However, the gross pofit margin (Taka 13,414.00 ha^{-1}) was lower than silver barb.

Akhtaruzzaman (1991) reported the satisfactory growth (100-200g/fish) and yield (1.5 to 2.0 ton ha^{-1}) for silver barb with a net economic return of Taka 62,720.00 ha^{-1} in 5-monhts rearing period He used rice bran as feed under semi-intensive culture condition.

Joseph (1990) reported that now-a-day Chinese farms are increasingly using supplementary formulated feed. One of the main contributory factors for very high growth rates in aquaculture production in China since 1980 is the use of supplementary pelleted feed.

Gupta (1990) reported the feasibility of raising Nile tilapia and silver barb *(Punttw gonionotus)* in seasonal water bodies and ditches under fanning condition, in seasonal water of Bangladesh which retain water for 4 to 6 months. He suggested that these fish species could be cultured using crop by products such as rice bran as feed with production ranging from 1.2 to 1.6 tons ha^{-1} 6 $months^{-1}$.

Ameen *et al.* (1990) investigated aquarium culture studies on the effects of fertilizers on plankton. Their results showed that significant difference existed between the mean yields of plankton on account of different levels of fertilizer treatments; but the difference due to average and high fertilizer dose treatments was insignificant. The average dies (urea 12.4 kg; TSP 53.5 kg and MP 8.5 kg hal month) was the best of the there does experimented.

Mirza *et al.* (1990) carried out an experiment to study the effect of cowdung on plankton production in the nursery ponds in Bangladesh. Fresh cowdung was weekly applied to a group of nursery ponds of 0.033 ha each at 2,500, 8,000 and 10,000 kg ha^{-1}. They observed an abundant growth of both of phytoplankton and zooplankton in the treated pond. They also observed that plankton production was significantly higher in manure loaded ponds and application of cowdung 10,000 kg ha-1 had adverse effect on the survival rate of fish fry.

Akhtarunnessa *et al.* (1989) investigated occurrence and seasonal variation of zooplankton in a fishpond in relation to some physico-chemical factors. They find that rotifers appeared at the dominant group (52%), followed by protozoans (16%) and ostracods (12%). Monthly fluctuations of the physical as well as chemical variables of the pond were noted and than related to occurrence of zooplankton by estimating the relevant co-efficient of correlation.

Ali *et al.* (1989) worked on studies on seasonal variations on physico-chemical and biological conditions in a pond. They absorbed that the highest value of free $C0_2$ was recorded during summer (42 ppm).The carbonate alkalinity of water varied from 3.2 to 24 ppm and the highest was noted in September. The bicarbonate alkalinity showed the peak value at 170 ppm in October. The dissolved oxygen content recorded high value in winter and early summer. An inverse relationship between the abundance of phytoplankton and zooplankton at r = 0.50.

Hussain (1989) reported that Nile tilnpia could attain 1 SO-2QQg/fish under semi-intensive culture using only dry rice bran as their feed. He reported a yield of-1,440 kg ha-1 with economic return of Taka 52,69g.OO ha in 6 months rearing period.

Karim (1989) also conducted experiments on the growth and production of Thai sharputi. *Puntius, gomonotus* (Bleeker) and were fasted under two improved cultural techniques in one technique the fishes were reared by feeding with rice bran only and in another technique the fishes were reared under fertilized condition without artificial feeding. He stated that the survival rate of this fishes were 93.3% and 94% in supplementary feeding ponds and fertilized ponds respectively. The average increased in length and weight were 49.31% and 330.29 and gross and net yields were 645,79 kg and 179.99 kg ha^{-1} yr^{-1} respectively.

Dhawan and Toor (1989) done the qualitative and quantitative analysis of phytoplankton and zooplankton and their effecte on the growth and fecundity of *Cirrhina mrigafa* (Ham) in ponds using cowdung and poultry dropping alone and in combination (1:30 at 20,000 kg ha^{-1} yr^{-1} (dry weight). Both the phytoplankton and zooplankton and growth mte of fish were significantly higher in ponds receiving poultry droppings alone and in combination with cowdung.

Jhingran (1988) reported that the nature of productivity of a pond could be greatly enhanced by the use of fertilizers which might make up or provide essential nutrients, minerals, vitamins etc. required for the production of aquatic biota serving either directly or indirectly the ecosystems as food for fishes. The author also reported that the phytoplankton formed an important primary link in the food chain of fishes.

Dinesh *et. al.* (1988) worked on effects of poultry manure and varying doses of urea on plankton production in fish pond. They found that a combination of poultry manure and urea is superior to fertilizations by poultry manure alone for plankton production and the low dose of urea is quite sufficient to the used with 2000 kg /ha of poultry manure for initial fertilization of carp ponds.

Mumtazuddin and Khaleque (1987) studied planktonic bimass on the relative growth potential of carp hatchling in relation to fertilization and supplemental feeding. The quantity of phytoplankton (units/1) ranged from 75,000 to 1,92,000 in rohu reared pond and 45,000 to 2,05,000 in silver carp reared pond. The fluctuations of zooplankters were 15,940 to 35,960 in rohu reared pond, 12,180 to 48,750 in.mrigal, while, 39,560 to 65,000 in silver carp reared pond.
Islam (1987) estimated a Cobb-Douglas production function to explain productivity of fish ponds. The selected variables were stocking of fish seeds, fertilizer and artificial feed, human labour, farm size, age of ponds, depth of water and number of owners of the ponds Considering the total sample for all locations, it was found that except the depth of pond water, all other factors were significant in explaining the variation of fish pond out put The results, however, varied in different locations.

Ameen *et al.* (1986) made a comparative limnological study of two fish ponds in . Year round observations of the physical and chemical variables, plankton and production of a freshwater pond with semi-intensive (SI) and extensive (E) fish culture were made and compared. The phytoplankton was nearly 3 times and 1.5 times more than the zooplankton in the SI and -E pond, respectively. Comparatively more zooplankton were present in pond E than in pond SI, possibly due to inadequate number of zooplankton feeders in pond E. Whereas in spite of regular monthly fertilization of pond SI, the plankton crop in it was more or less equal to that of pond E because of the large number of stocked fish grazing on the plankton crop in it.

Islam and Dewan (1986) carried out a study on resource use and economic return in pond fish culture, in which they identified that pond fish production was mainly based on stocking of fish seed, use of fertilizer and feed, and human labour for different operations and management. They observed that the majority of the farmers reared various species of indigenous and exotic carp and produced 1,700-3,889 kg ha-1 yr-1 in different locations. It was also observed that the higher yield was not the only factor affecting higher net return. Net return was influenced by price of output and economic use of both material inputs and labour.

Otubusin and Lin (1985) studied the effect of duration of supplementary feeding using palletized chick starter at the rate of 5% of body weight daily on the growth of milkfish, *Chanos chanos* over the period of 3 months, they found no significant effect on survival, growth and production of milkfish.

Prinsloo and Schoonbee (1984) made observations on fish growth in polyculture during late summer and autumn in fishponds at the Umtata Dam Fish Research, Center, Transkei. Part II: The use of cattle manure with and without pelleted fish feed. They observed water temperatures falling below 15°C may have contributed towards the comparatively poor performance of -the cattle manure. This resulted in higher values, on the average for parameters such as nitrate, ammonia and even phosphates (as may be expected) although the differences were relatively small.

Chakraborty (1984) conducted an experiment to determine the effect of combined application of poultry manure, urea and single super phosphate on chemical and biological properties of soil and water of a brackish water fish pond. The author concluded that poultry manure and inorganic fertilizer were found to be effective in increasing the production of plankton and bottom macrofauna.

Davis *et al.* (1984) conducted and experiment with polyculture of the Chinese and Indian major carps by fertilization with compost and feeding with rice bran and mustard oilcake at the rate of 5% of body weight daily and obtained the average production of fish 2,830 kg ha^{-1} in one year.

Nandeesha *et al.* (1984) evaluated the effect of three organic manures, namely poultry manure, cow manure and silk worm fecal matter on plankton production in fish ponds. They reported that poultry manure applied pond had the highest number of phytoplankton.

Skacelova (1983) observed the declined rate of production of Rotifers with declining temperature (<20 °Q and also observed the enhanced growth of it with repeated fertilization with organic fertilizers.

Geiger (1983) carried out a study on zooplankton in a pond and reported that crustacean zooplankton were highly developed in ponds combination of both organic and inorganic fertilizers.

Jana and Paul (1982) find out some factors affecting the oxygen consumption of common fish food organisms. The rate of oxygen consumption has been measured in Diaptomus, Daphnia, Chironomid larvae, Tubifex and Lvmnaea under different experimental conditions. It has been shown that species, temperature, crowding and oxygen level of water influence the 02 uptake. A reduced level of 02 uptake has been observed in lower temperatures while incubation in higher temperature caused higher respiratory cost. The oxygen consumption was approximately proportional to the 0.5 power if the fresh weight of different species.

Hepher and Pruginin (1982) obtained the significantly high production of both phytoplankton and zooplankton with poultry manure and consequently observed the 3.3 fold production of Tilapia, *Oreochromis niloticus* compared to natural production without fertilization.

Mumtazuddin *et al.* (1982) studied plankton and some limnological parameters of rearing ponds at the Aquaculture Experiment Station (now BFRI), Myrnensingh. They rcorded 33 genera of phytoplankton belonging to Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Euglenophyceae and Myxophyceae and 14 genera of zooplankton belonging to Crustacea and Rotifera.

Miah *et al.* (1981) during sixmonths of studied (March to August, 1979), *L. rohita, C. catla* and *C. mrigala* gained 111.86%, 114.45% and 135.16% in pond I. and 109.64%, 149.29, 15.31% in pond 11 respectively by length. C. *catla* C. *mrigala* showed same tendency in growth rates in both ponds. The rates of growth were more or less directly correlated with temperature, rainfall free carbon-dioxide and phytophankton populations and inversely related to dissolved oxygen and zooplanktons.

Shankar and Varghese (1981) carried out five series of fish pond fertilization study using various combinations of organic manures (pig dung, poultry manure, cattle dung, sheep manure and sewage sludge) on Indian major carp and common carp fingerlings. They manured the ponds in two installments with initial and final dosages of 2,000 kg and 1,000 kg ha-1 on dry weight basis respectively. The observation was that poultry manure was the best among the organic manures. Rohu and catla grew better in poultry manure and sewage sludge, whereas rnrigal grew faster in cattle dung, pig dung and sheep manured ponds due to the presence of high (62-83%) organic matter.

Jana and De (1981) studied measurement of the primary production of phytoplankton in the aquatic environment during the solar eclipse. He marked that the temperature, the specific conductivity and the dissolved oxygen of water decreased markedly on the day of the solar eclipse as compared to other dates of measurement.

Jana *et al.* (1980) recorded the environmental factors affecting the seasonal changes of net plankton in two tropical fish ponds in India. They identify the seasonal changes of phytoplankton number in these ponds showed an inverse characteristic either with absolute concentration or with the rate of concentration changes of bicarbonate in the water, while the former and concentration of dissolved oxygen was positively correlated. It has been fairly well established that the concentration of dissolved oxygen present in different months of the year in two fish ponds was directly dependent upon the density of phytoplankton occurring in these ponds.

Ali *et al.* (1980) investigated ecology and seasonal abundance of zooplankton in a pond in Tongi, Dhaka. A total of 11 genera were recorded out of 6 belong to Arthropoda, 4 to Rotifera & 1 to Protozoa. The role of Temperature, pH, hardness of water as $CaCO_3$ total alkalinity in the abundance of different genera is discussed.

Sinha and Saha (1980) found that the gross and net productions of fish were 4636 and 4,483 kg ha-1 yr-1 respectively when fed mustard oil cake and rice bran mixture containing 16-17% protein for composite fish culture. In Thailand *Clarias* spp, were successfully cultured by using traditional diets consisting of trash fish, rice bran and broken rice having protein levels of 25 to 38% on dry diet basis .

Ali *et al.* (1980) studied the ecology and seasonal abundance of zoo-plankton in an artificial fish pond. The p^H was found to fluctuate between 7.5 to 9.5 and dissolved oxygen varied from 12 to 22 mg/1 during the experiment period.

Cruz and Laundencia (1980) showed that supplemental feeding with fine rice bran or copra meal at a daily rate of 5% of the biomass increased the net production of milkfish but had no influence on all male Nile tilapia. Sanding crop of about 890 kg ha"$^{!}$ in 135 days was obtained in polyculture system of milkfish, all-male Nile tilapia and snakehead when fed rice bran.

Sinha (1979) reported fish production (Indian carp and Chinese carp polyculture) in ponds in India to be 1,053 kg ha-1 yr-1 with organic and organic fertilizer inputs (cowdung, 198:8:4 NPK fertilizer), 3,314 kg ha^{-1} yr^{-1} with both fertilizer and supplementary feed inputs.

Maddox *et al.* (1978) reported that swine manure was effective in producing good crop of zooplankton. Fish production was double when manure was introduced directly into the fish pond than non-manure pond.

Islam and Paul (1978) observed the growth rate of catla and rohu at stocking ponds and reported maximum net yield 108.62 from a pond of 8,992 cm long, 1890 cm wide with a water surface measuring 0.42 acre approximately. They reported that catla fingerlings had a higher growth potential among the species taken by them.

Murty *et al.* (1978) reported the results of application of fertilizer and feed, where nitrogenous fertilizers alone were applied at the 200 kg N ha" yr"', supplementary feed at 4,570 kg ha-1 yr !, who also provided the stocking density was at 5,000 fmgerlmgs ha"' comprising three Indian and three exotic major carps used in composite fish culture The yields offish obtained through fertilization alone were 2,512.67 (gross) and 2,275.37 (net) kg ha-1 yr-1, as against 4,096.09 and 3,858.58 kg ha^{-1} yr^{-1}, respectively with fertilizer and feed indicating a noteworthy effect of nitrogenous fertilizers on the production.

Das *et al.* (1977) conducted experiments on Indian major carps for demonstrating its production potential through scientific method to the farmers. They computed 16months (inputs were supplied for the initial 12 months only) production and obtained 5,200 kg/ha gross production and 4,809 kg/ ha net production.

Grover *et al.* (1976) conducted an experiment on the production and growth of milkfish, common carp and catfish in some newly constructed ponds. They used as fertilizers chicken manure or inorganic fertilizers (N.P) or a combination of manure and inorganic fertilizer. They found that fertilized ponds gave much higher yields than unfertilized ponds. The average production in the fertilized ponds gave much high yields than unfertilized ponds. The average production in the fertilized ponds were 992 kg ha-1 milk fish, 671 kg ha-1 common carp or 295 kg ha-1 catfish.

Chakrabarty *et al.* (1976) under took an experiment on intensive polyculture of the Indian major carps to determine better methods of increasing fish production. The ponds were fertilized with organic and inorganic fertilizers and supplied artificial feed, the ponds were stocked with 600 fingerlings per ha. After a year the gross production as recorded for two ponds were 3,950 kg ha^{-1} yr^{-1} and 3017 kg $ha^{-1}yr^{-1}$ respectively.

Singh and Singh (1975) studied the growth rates of *Catla cat la, Labeo rohila* and *Cirrhimis mrigala* in Tarai. The experimental ponds were fertilized with cowdung at the rate of 25,000 kg ha^{-1}. Two, out of the four ponds were supplied with supplementary feed of rice bran and ground nut oil cake in the ratio of 3:2 at the rate of 2 to 5 percent of the body weight of the fish. The weight gain was 3 to 4 times more than that of fish maintained in fertilized pond.

Safin *et al.* (1974) evaluated the effect of inorganic fertilizer on the plankton production in nursery ponds. They noted higher abundance of zooplankton in ponds treated with calcium ammonium nitrate, phytoplankton. Population was higher in ammonium-sulphate treated ponds. They also advocated the usefulness of sulphate treated ponds. They also advocated the usefulness of urea for successful rearing of carp species in nurseries with neutral soil.

Wohlfarth and Schroeder (1974) in an experiment used manure in fish farming and observed the dynamic aspects of pond manuring in terms of direct feeding, sources of minerals for autotrophic production and sources of organic matter for heterotrophic production.

Khan and Siddiqui (1974) worked on the seasonal changes in physical, chemical and biological characteristics in a perennial fishpond. They observed a uniform distribution of temperature at all the depths, transparency and turbidity were recorded. The transparency was found to be affected by turbidity and phytoplankton crop. Clinograde type of oxygen distribution was noted at different water levels. Fluctuations in the carbonate alkalinity, along with pH values were mainly due to photosynthetic activity of phytoplankton and other higher aquatic plants.

Sinha *et al.* (1973) experimented composite fish culture at kalyani, West Bengal, in a pond having an area of 0.15 ha with water depth of 4o to 92 cm. A remarkable gross production of 3,232.3 kg/ha/six months was obtained from stocking of catla, silver carp, rohu, mrigal, grass carp and common carp.

Dewan (1973) studied the ecology of a lake from Mymensingh established an inverse relationship of dissolved oxygen with temperature and free-CO_2, and direct relationship with p^H and total alkalinity.

Singh *et al.* (1972) studied carp culture of Indian and Chinese species and reported that higher yields were attributable to fertilization and supplementary feeding. They also reported that a higher production of 4,210 kg/ha/yr could be achieved with proper management, fertilization, feeding and stocking at the ratio of catla 1: rohu 3: mrigal 1.25.

Saha *et al.* (1971) studied the physico-chemical factors of water and bottom soil of a fresh water fish pond. They recorded that the combined effect of fertilizers gave the best results for plankton production.

Hepher *et al.* (1971) studied the growth of carp and silver carp with and without supplementary feed. The authors showed that supplementary feeding increased the carp yield four folds and pellets had little effects on the growth of the silver carp. The daily increment per hectare was 10,300 gm with supplementary feed on against 9,050 gm with natural food only.

Lakshmanan *et al.* (1971) in their experiment observed fertilization with raw cow-dung and inorganic fertilizers, ammonium, sulphate, super phosphate, calcium and ammonium nitrate in varying quantities and feeding of grass carp with aquatic weed and other fishes with rice bran and mustard oil cake (1:1 by weight) in polyculture obtained yield ranged from 2,230 kg ha^{-1} yr-1 to 4,209 kg ha^{-1} yr^{-1}.

Banerjee *et al.* (1969) observed that poultry manure with cow-dung together have better results than the cow-dung alone for rearing spawn of major carps. The authors also reported that application of poultry manure regularly in low dose can produce desirable results.

Michael (1969) worked on seasonal trends in physic-chemical factors and plankton of a fresh water fish pond and their role in fish culture and observed DO at any given time is found to be associated with biological activities taking place in the medium. Observed relatively high total alkalinity values help in higher yield of fish. Most plankters exhibit a single annual peak though individual species have different seasons of maxima.

Michael (1968) studies on the zooplankton of a tropical fish pond. Seasonal abundance and the pattern of fluctuations in the zooplankton of a tropical fish pond have been studied at weekly intervals for a period of two years from September 1960 to August, 1962. The effects of temperature, total alkalinity and phytoplankton on these populations have been discussed. The total abundance of this micro-crustacea showed direct relationship with phytoplankton production. The importance of these investigations in fish cultural practices is suggested.

Moitra and Bhowmik (1968) concluded his investigation as organic environment is reflected by a higher species directly along with a lower density. The *Rotifer* densities were directly associated with temperature, dissolved oxygen, carbon dioxide and indirectly with phytoplankton, diatoms, dissolved nitrates and Hydrogen ion concentration (pH). Application of fertilizers is an effective way of increasing primary production of phytoplankton and enhancing fish production.

Koyama *et al.* (1968) reported there is no effect of chemical fertilizers on the production of benthic creatures in Japanese fish farm ponds, but observed eight times greater growth of phyto and zooplankton in fertilized pond than unfertilized ponds.

Banerjee (1967) studied on the water quality and soil condition of fish ponds in some states of India in relation to fish production stated that the nutrient status of water and soil played the most important role in governing the production of plankton organisms or primary production in fish ponds.

Farenska (1965) reported on selected species of zooplankton from a fish pond. The author found that the maximum number of zooplankton during first half of September and the minimum at the beginning of April. *Rotifera* was dominant group. The author further suggested that the abundance of plankton was directly related to the availability of nitrite and nitrogen.

Alikunhi (1957) compared the factors of fish production under mixed culture from Indian natural ponds and stated that lower growth rate occurred where the stocking rate was higher due to the shortage of natural food and living space available in culture ponds. He observed that in Bangal catia rohu and mrigal in the ratio odf 3:3:4 were commonly stocked in ponds.

Villadolid *et al.* (1954) found that the water with pH ranging from 7.3 to 8.4 provided optimum condition for the growth of plankton. They stated that the lower pH values were known to adversely affect the plankton production and subsequently growth of fish.

Le Cren (1951) stated that the condition factor ‘K’ is affected directly by length as well as several other factors like environment, food supply and degree of parasitization. He also stated that it is not surprising that the interpretation of ‘K’ is difficult and often lead to erroneous result. He suggested that the effect of length and its correlated factors may be eliminated by using the relative condition factor ‘Kn’.

Smith *et al.* (1939) reported a close relationship between plankton and fish production in ponds, and the dynamics of both predator and prey species were such that a sustainable yield, satisfactory in number and average size is possible.

MATERIALS AND METHODS

3. Materials and methods

Depending on objectives the current investigation has been adopted procedures and materializes to find out the results. These are described as below.

3.1. Experimental fish

Though Bangladesh has vast inland resources, the production of fish per unit area is still very low in comparison to the neighbouring countries developed in aquaculture. In view some exotic carps have been introduced in Bangladesh in the recent years. Among these exotic carps Indian majors carps are advantageous over the native carps, for possessing some special characteristics, such as Indian major carps are well adapted for pond culture to wide range of habitats and environmental condition. It grows quickly; as a result its production and profit are high; cultured with high density; high disease resistance power; any kind of supplementary feed can eat; marker price, taste and demand are high. For this reason, Indian major carps *Labeo rohita, Catla catla* and *Cirrhinus mrigala* were used as experimental fish.

3.2. Study area

Two perennial ponds were selected naming as treatment I and treatment II located "Chuti Farm House" at the village of Sukundi, Baria Union under Gazipur sadar district within 24° 0′ 0″ N and 90° 25′ 48″ E. (Plate 1a and 1b).

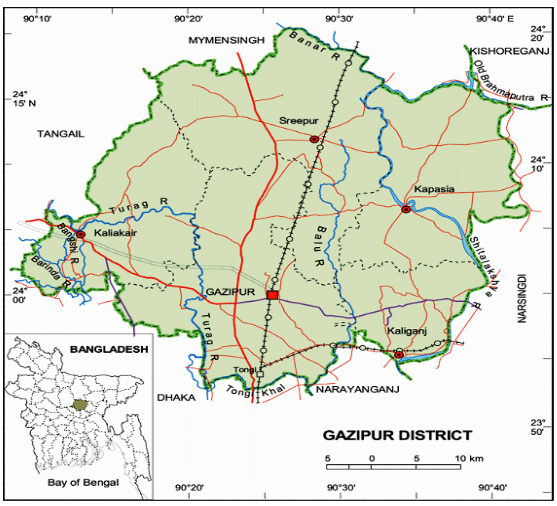

Plate 1a. Map of experimental area (Gazipur District)

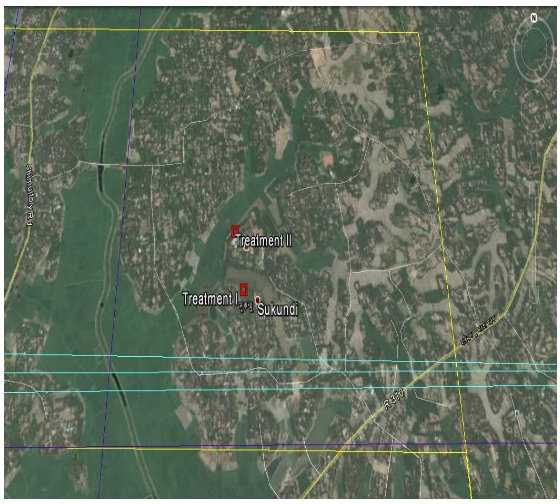

Plate 1b. Satellite image of treatment I and treatment II showing the sampling station

3.2.a. Treatment I: Treatment I is located at the Baria Union under sadar upazila of Gazipur district within 24° 00′ 58.5″ N and 90° 26′ 39.6″ E. (Plate 2a). A 30 decimal in size and rectangular shaped pond with creepy and grassy slopping banks with 73.15 meter length and 16.76 meter width and water level 2.43 meter depth during monsoon and 1.21 meter in winter period. Submerged and floating aquatic plants are totally absent due to repeated netting in the pond. The bottom of the pond is muddy. Soil characteristics of the pond is as like as red clay loamy. The litoral zone of the pond supports some common aquatic plants namely Kolmi (*Ipomoea aquatic, Ipomoea fistula*). In this treatment supplemental feed was applied at the rate of 2%-5% of total body weight of fishes daily basis studied by following the methodology of Delince 1992 (Plate 2a).

Plate 2a. Treatment I Pond

Plate 2b. Treatment II pond

3.2.b. Treatment II: It is adjacent 'Mora Bill' of village Sukundi at Baria Union under sadar upazila of Gazipur district within 24° 01′ 02.5″ N and 90° 26′ 44.5″ E. (Plate 1a and 1b). A 32 decimal in size and rectangular shaped pond with some small to medium trees remain on the banks as well as the sloping zones is 44.19 meter length and 25.90 meter width. The water depth of the study pond was 2.13 meter in monsoon and 1.21 meter in winter during the study. Submerged and floating aquatic plants are totally absent due to repeated netting in the pond. The bottom of the pond is muddy. Soil characteristics of the pond is as like as red clay loamy. The littoral zone of the pond supports some common aquatic plants namely Kolmi (*Ipomoea aquatic,* *Ipomoea fistula*). In this treatment instead of supplemental feed poultry, manure was applied at the rate of 7 kg/decimal once in a week was studied according to Bhatnagar 2008 (Plate 2b).

3.3. Study period

During the study, eighteen months sampling (one in each month) were carried out from December 2013 to May 2015.

3.4. Growth performance of fish

3.4.1. Experimental design

Pond site was selected in the flood and industrial effluent free area. Three Indian major carps were used as experimental species in the culture system. Two perennial ponds were selected naming as **treatment I and treatment II** with an area of 30 and 32 decimal and average depth of water 4 and 8 feet In treatment I there are use supplementary feed and chemical fertilizers and in treatment II use their poultry manure and chemical fertilizers. The experimental layout is shown in table 1.

Table 1. Layout of the experimental system

Experimental pond name	Species combination	Number of Species	Management	Each pond area
Treatment I	*Labeo rohita* *Catla catla* *Cirrhinus mrigala*	300 300 300	Fish meal, Rice polish, Mustard oil cake, Premix vitamin, T.S.P, Urea.	30 decimal
Treatment II	*Labeo rohita* *Catla catla* *Cirrhinus mrigala*	300 300 300	Poultry manure, T.S.P, Urea.	32 decimal

3.4.2. Pond preparation

Pond preparation is one of the most important and essential tasks for successful pond culture operation. The ponds for the present study were prepared followings guidelines for fish culture by the Jhingran (1982). All the ponds were completely dried out by the dewatering through the outlet channel before one and half months of stocking. Then the ponds were kept exposed to sunlight for 15 days for drying. All the aquatic weeds and other debris were removed from the pond bank and bottom. 2kg/decimal crushed limestone soaked with were spread all over the pond. After that, all the ponds were fertilized with Compost, Urea, T.S.P and M. P. at the rate of 450 kg, 8 kg, 4 kg and 1.5 kg was spread around the pond after 7 days of liming.

3.4.3. Stocking of fingerlings

The rate of stocking of cultural species was same in the both treatment. For the present study the ponds were stocked with fingerlings (12.31 cm to 12.57cm) of *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* at the rate of 900 pcs per pond. Treatment I and II were stocked with Indian major carps. Stocking density was planned as shown in table 2. Both of the ponds were stocked with Indian major carps with a total average length of 12.44 cm and average weight of 54.33 gm, respectively.

Table 2. Size and stocking density of fingerlings in treatment I and II

Experimental pond name	Species combination	Stocking Density/pond	Average length (cm)	Total average length (cm)	Average weight (gm)	Total average weight (cm)
Treatment I	*Labeo rohita*	300	12.44	12.44	50	54.33
	Catla catla	300	12.31		65	
	Cirrhinus mrigala	300	12.57		48	
Treatment II	*Labeo rohita*	300	12.44	12.44	50	54.33
	Catla catla	300	12.31		65	
	Cirrhinus mrigala	300	12.57		48	

3.4.4. Sources of fingerlings and releasing

Fingerlings of same batches of major carps *Labeo rohita, Catla catla* and *Cirrhinus mrigala* were collected from Government Fish Hatchery and Training Center (FHTC), Mymensingh, Bangladesh. Acclimatization was done for two week in glass aquaria and feed on rice polishing. Stocking was done in the same day after 10 days of fertilization. Fingerlings of same batches of three Indian major carps were stocked in two designated treatment I and II ponds.

3.4.5. Release of fingerlings

The major characteristics that determine the suitability of species for polyculture is the rate of growth; ability to tolerate unfavorable conditions, utilization of natural food and rate of productions (Pillay 1990).

 

Plate 3. Fingerlings are releasing in the experimental ponds

Releases of some fingerlings in stocking ponds were done it very carefully to avoid any post-stocking mortality due to shock or infections (Kumar 1992). To minimize post-stocking mortality of the fingerlings it was necessary to acclimatize the fingerlings with the temperature and quality of water of the stocking pond.

3.4.6. Post stocking management

Post stocking management involves harnessing the pond production in the form of natural fish food, maintenance of pond environment congenial to the cultivated fish and fish husbandry mainly feeding and health care (Kumar 1992).

3.4.7. Supplementary feed

In treatment I supplementary feed was fish meal, rice polish, mustard oil cake and premix vitamin with chemical fertilizer and treatment II supplementary feed was chemical fertilizer and poultry manure. Pond culture of carp is in most cases based on supplemental feeding (Pillay 1990). Fish production rate may be increased significantly by using supplementary feed. During this study, supplementary feed was used only for treatment I at the rate of 2%-5% of the total body weight of fish per day. The feeding rate was adjusted based on the biomass, which was ascertained through monthly sampling. The supplementary feed was spread over the pond water every morning except winter season. Natural food is not enough for better growth of fishes for commercial aquaculture. Supplementary (homemade or commercial) feed maintaining 24-25% protein were fed everyday (2 hours after sun rise). Feed must be given by calculating the total body weight of fishes at the rate of 5% in the beginning and down to 2% at the end of culture period (table 3). The feeding rate was adjusted based on the biomass, which was ascertained through monthly sampling. Netting must be done once in every month for checking fish health and for calculating the amount of feed to be given for the next month.

Table 3. Composition of feed used in experiment I

Supplied feed	Amount in the feed (%)	Protein in the feed (%)
Fish meal	3.50	12.76
Rice polish	47.89	6.58
Mustard oil cake	48.35	5.66
Premix vitamin	0.25	-
Total	**100**	**25**

3.4.8. Feed preparation

Supplementary feeds were prepared by weighing the feed ingredients according to a defined formulation and mixing them homogenously. Mustard oil cake was first soaked in water for at least 24 hours. Once soaked, the other ingredients were added, and the ingredients were mixed and kneaded into wet dough. The mixed feed was feed to the fish by distributing it between several locations across the pond. The supplemental feed was provided at 5% of body mass per day, and at between 10.00 to 13.00 hours (Plate 4, 5 and 6). The feed is normally consumed within 30 to 60 minutes.

Plate 4. Water soaked mustard oil cake (left) and fishmeal (right)

Plate 5. Hand mixing of the ingredients with water (left) and dough preparation (right)

Plate 6. Wet doughs (left) and feeding the wet dough (right)

3.4.9. Measurement and calculation of growth parameter

Fish sampling was done at an interval of 30 days to adjust the feeding rate by measuring the weight of fish, to observe the health condition and to keep the record of length and weight of fish. Sampling was done at 9 a.m. to 12 a.m. and 3 p.m. to 6 p.m. in average. Fishes were caught by seine net and about 30% of each species were sampled. Length of fishes was measured to the nearest cm with a centimeter scale. Weight to the nearest gram (g) was measured by balance. After recording the length and weight of fishes, they again released to the respective ponds immediately.

Average length increase and weight gain per day of fishes were calculated as follows:

$$\textbf{Length increase per day} = \frac{\text{Length (cm.) in present month – Length (cm.) previous month}}{\text{Days of the month}}$$

$$\textbf{Percent of length increase} = \frac{\text{Final length increase (cm.)- Initial length increase (cm.)}}{\text{Average final weight (g)-Average initial weight (g)}}$$

Average weight gain and weight gain per day of fishes were calculated as follows:

$$\textbf{Weight gain per day} = \frac{\text{Weight (g) in present month - Weight (g) in previous month}}{\text{Days of month}}$$

$$\textbf{Percent weight gain} = \frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Initial weight (g)}} \times 100$$

Average wt. gain (g) = Average final weight (g)-Average initial weight (g)

3.4.10. Specific growth rate (SGR)

Specific growth rate (SGR) is the instantaneous change of body of fish as the percent increase in body weight per day over a certain interval which is measured as outlined by Brown (1957) as the following equation:

$$SGR = (\ln W_f - \ln W_i \text{ x}100) / t$$

Where :

$\ln W_f$ = the natural logarithm of the final weight

$\ln W_i$ = the natural logarithm of the initial weight

t = time (days) between $\ln W_f$ and $\ln W_i$

N.B. - If the Food Conversion Rate is known, the SGR can also be calculated by dividing the Percentage body weight fed per day by the food conversion rate. This calculation can be turned
round to predict growth if the SGR is known.

3.4.11. Survival rate

To determine the survival rate and production of fishes, first seine netting and then by dewatering the ponds caught total fishes. Then, total number of fishes was counted species-wise and calculated the survivability of fishes as follows:

$$\text{Survival rate} = \frac{\text{No. of total fish harvest}}{\text{No. of total fish stocked}} \times 100$$

3.4.12. Feed Conversion Ratio (FCR)

Feed Conversion Ratio was calculated as follows:

$$\text{FCR} = \frac{\text{Feed given (g)}}{\text{Body weight gain (g)}} \times 100$$

3.4.13. Calculation of total growth

During the whole study period, fish specimens were collected by drag net on monthly basis and a number of 15 species were measured for total length in cm. and body weight in gm. After that, fishes were released back to the ponds.

3.4.14. Monitoring of health

Fish sampling was done at an interval of 30 days to adjust the feeding rate by measuring the weight of fish, to observe the health condition and to keep the record of length and weight of fish. Sampling was done at 9 a.m. to 12 a.m. and 3 p.m. to 6 p.m. in average. Fishes were caught by seine net and about 30% of each species were sampled. Length of fishes was measured to the nearest cm with a centimeter scale. Weight to the nearest gram (g) was measured by balance. After recording the length and weight of fishes, they again released to the respective ponds immediately.

3.4.15. Harvesting

Before the harvesting operation, following preparations were taken; Supply of feed and poultry manure in treatment I and treatment II was stopped for 3-4 days before of harvesting. All the anti-poaching devices kept in the pond were removing. For collecting and transfer to harvested fish to the desirable whole sale market numbers of container “Bamboo khachi” were collected. According to the most of the aqua culturists, harvesting of fish in undrainable ponds should be done by seining the entire pond using desired size of drag net, which was also use to harvest the fish during the present study. Before harvesting, about 50%-60% water of the ponds were removed by water pump. 5 to 7 fishermen were engaged during harvesting. “Dinghi nuka” was use at this time to operate the net properly. After the harvesting period, the final length and weight of the captured fishes were record.

3.4.16. Total production

To determine the total production of fishes, total fishes were caught by first seine netting and then by dewatering the ponds. Then, total number of fishes was counted species-wise and calculated the survivability and production of fishes as follows:

Net fish yield = total weight of fish at harvest– total weight of fish at stocking

3.5. Growth effecter parameters

The health and subsequent growth of fish are directly related to the quality of water in which the fish are raised. In general, factors affecting fish growth and production in freshwater aquatic systems can be classified as climate, physical, chemical, biological, or a combination. Water quality is one of the most important physical and chemical factors affecting fish growth and production. Tolerance to changes in water quality constituents may result in decrease in metabolism and immunological response. Consequently, decreased growth and in some cases, mortalities, may result, depending on the magnitude of the deviation from the optimum water quality variables.

3.5.1. Climatic parameters

Some climatic and physical parameters data were recorded in experimental site. The data on air temperature (maximum, minimum and average), total rainfall, average sunshine and relative humidity of the study area were collected from metrological office in Dhaka from December 2013 to May 2015.

3.5.2. Physical parameters

The following physical parameters of the study area were recorded after each sampling.

3.5.2.1. Temperature

Accurate temperature readings are important since temperature is a factor in certain algal blooms, in the degree of dissolved oxygen saturation and in carbon dioxide concentration. The temperature was taken with a centigrade thermometer.

a. Water temperature: The thermometer was held in the culture media until the mercury level stop moving. The temperature was read before withdrawing the thermometer from the media.

b. Air temperature: The corresponding air temperature of the roof area was also recorded simultaneously.

3.5.2.2. Transparency

The transparency of the water was recorded visually from Secchi disk reading**.**

3.5.2.3. Water Depth

Water depth reading was taken with the help of a secchi disc (20 cm diameter and divided into alternative black and white quadrates) following Boyd (1978) formula.

$$Zs = \frac{d1 + d2}{2}$$

Where Zs = Secchi depth.

d1= the depth where the disk went out of sight.

d2= the depth when the disk was again visible.

3.5.3. Chemical parameters

For analyzing the chemical data the apparatus used was the HACH's universal aquaculture testing kit, Model no. FF-1A, USA as per instruction directed in the manual. Detailed analysis process is briefly discussed in the following heading.

3.5.3.1. Fertilization

Application of fertilizer stimulates pond productivity largely through autotrophic and also heterotrophic pathways. Fertilizer was not only replenishment of nutrients but also increase microbial decomposition. Both organic and inorganic fertilizer should be used two times in every month for raising natural food production. Inorganic fertilizer, Urea and TSP (1:1) 50 kg/pond/month. Each fertilizer should be used in every alternate week. Application of fertilizer should be avoided when excessive plankton bloom occur in the pond.

3.5.3.2. Dissolved Oxygen (DO)

Sample for Dissolve Oxygen was collected by DO bottle without air bubbles. Water was than treated with DO 1 and DO 2 reagent, and shake vigorously avoiding air bubbles to become orange brown colour. DO 3 regent was then added to develop a straw colour. 250ml. stock solution was then taken in conical flask for titration was with Sodium Thiosulphate Standard solution from measuring Burret until the sample become colour less. Initial Sodium Thiosullphate reading to last reading indicates the amount of DO mg/l. Average of three readings is the total DO in the invested sample.

3.5.3.3. Free carbon dioxide (CO_2)

10 ml. measuring tube was filled with sample water up to the top and then poured into the mixing bottle. After adding and mixing one drop of phenolphthalein indicator, Sodium Hydroxide Solution was added drop by drop until the solution becomes light pink. Calculate total mg/l CO_2 multiplied total drops of Sodium Hydroxide Solution.

3.5.3.4. Hardness

Hardness of water (total concentration of calcium and magnesium ions expressed as their equivalent calcium carbonate) was measured by HACH water analysis Kit Box. MODEL FF-2, USA and the value was noted in mg/L. plastic measuring tube was filled with simple water to the top and then poured into the mixing bottle that was treated with 3 drops of Hardness 1 Buffer solution. After mixing the solution one or two drops of hardness 2 Test Solution was added to from a pink colour. Titrant Resgent Hardness 3 was then added drop by drop until the solution colour changes from pink to blue. 17.1 to calculate total mg/l hardness as ($CaCo_3$) multiplied total drops of Hardness 3 Reagent.

3.5.3.5. Conductivity

Conductivity of water of sampling area was determined by the conductivity meter (HACH-CO150) and the value was recorded in mg/L.

Plate 7. Water temperature is taken from study ponds

Plate 8. Preparation is going on the determination of water quality by HACH Kit

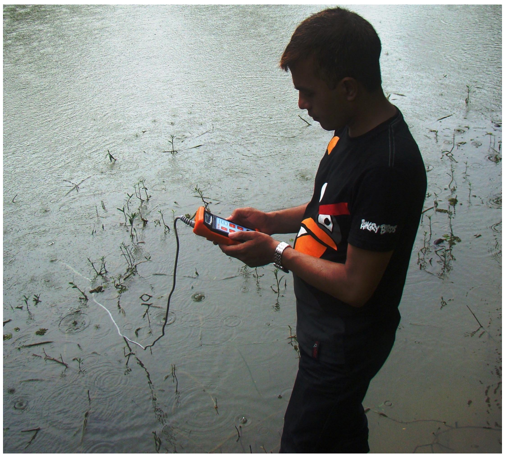

Plate 9. Determination of pH of water by HACH Kit

Plate 10. Determination of NO_2 of water by HACH Kit

Plate 11. Determination of DO of water by HACH Kit

Plate 12. Determination of Secchi disk depth is going on

3.5.3.6. Hydrogen ion concentration (pH)

pH was calculated by colour comparator method. Two viewing tubes were filled with sample water to the 5 ml marks. One of two samples was treated with 6 drops of wide range of pH Indicator Solution. After mixing, the sample was inserted into right hand opening of the colour comparator and untreated sample into the left hand opening of the comparator then comparator was hold up to the light sources. The non-treated sample was compared with the treated sample through a colour disc until a color match is obtained. A "Field water analysis kit" of HACH Company U.S.A was used for determination of hydrogen ion concentration (pH) of culture media.

3.5.3.7. Ammonia

One viewing tube is filled with de-ionized water and another with sample water to the 5 ml mark. One drop of Rochelle Salt Solution is added to each tube. After mixing the sample containing tube, 3 drops of Nessler Reagent is added to tube and again swirled to mix then allowed 10 minute for colour development. Prepared sample tube was inserted into right hand opening and reagent blank tube into left hand opening of colour comparator. Holding the colour comparator up to the light source rotated the colour comparator disc until the colours in the left and right windows were matched.

3.5.4. Biological parameters

Plankton and parasites are the biological parameters.

3.5.4.1. Plankton

Plankton is 'composed of small animals and plants'. These small animals and plants are fish food organism, which is known as zooplankton and phytoplankton.

3.5.4.1.1. Plankton Sampling time and frequency

Fortnightly random sampling was done using plankton net to observe plankton. The On each sampling day, the samplings were done between 9:00 am to 10:00 am.

3.5.4.1.2. Collection of plankton sample

The sampling site was visited once in each month for collection samples. Samples were always collected from a permanent area previously set up in each treatment. A plankton net of 20 µm mesh size having a filtering cone attached to a metal ring terminated in a collecting bottle of 20ml was used to collect the sample one 60 µs mesh size net was also used for separating zooplankton and phytoplankton. Hundred liters of water was taken from within 250 m area by the 5 liters bucket. The water was then filtered though the plankton net and concentrated to 20ml. After finishing sampling all the materials were kept in a cool box and transported to laboratory for the further analysis.

3.5.4.1.3. Preservation of plankton samples

Adding formalin collected plankton in the glass bottles. About 250 µL formaline was added with 50ml of sample by pipette to preserve plankton. The final concentration of formaline becomes approx 5%. On the other hand, 5 litter of water was taken for physical and chemical test.

3.5.4.1.4. Observation of plankton

Plankton samples were studied under microscope using the Sedg Wick Rafter (S-R) cell a special type of slide having a counting chamber which is 50mm long, 20mm wide and 1mm deep. The volume of the chamber was 1 ml (1cc or 1000 cumm). The counting chamber was equally divided into 100 fields, each with a volume of 1 µ. The cell was filled and covered with cover slip so as to eliminate air bubbles, and left to stand for minutes to allow the plankton to settle. Then under microscope plankton were counted randomly.

Plate 13. Planktons are collecting by plankton collecting net

Plate 14. Collected planktons are identifying in the lab

3.5.4.1.5. Quantitative estimate of plankton

Calculation of plankton of concentrated sample was done by using the formula:

$$N = \frac{A \times 100 \times C}{V \times F \times L}$$

Where,

N = No of plankton cells/ liter of original

A= Total no. of plankton counted

C= Volume of final concentrate of the sample in ml

V= Volume of a field (1cumm)

F= No. of fields counted

L= Volume of original water in litre

3.5.4.2. Parasite

3.5.4.2.1. Selection of host Fishes

Three species of Indian major carp (*Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*) were selected as host specimen for the present study. Fifty species of each host fishes were collected randomly per month and a total number of 900 species were examined during the study period from December 2013 to May 2015 in treatment I and treatment II of Gazipur District.

3.5.4.2.2. Collection of specimen for parasite

Live IMC were randomly collected on a regular basis once in every month. The fishes were brought to the laboratory in live condition with water filled buckets and examined immediately. Fishes were collected from treatment I and treatment II. In each sampling about 150 fishes were collected. The length and body weight of the fishes and date and site of collection of host specimens were also recorded.

Plate 15. *Ichthyophthiriu* ssp. on body surface of *C. mrigala*

Plate 16. *Larnaea* ssp. on body surface of *L. rohita*

3.5.4.2.3. Collection of parasites sample

Samples were collected in every month from Treatment I and II. A total of 450 host fish *Labeo rohita* (n=150), *Catla catla* (n = 150) and *Cirrhinus mrigala* (n = 150) were used in this study.

3.5.4.2.4. Collection of parasites

External parasites from body surface, fin and gill were removed by scrapping the slime with a sharp scalpel in a drop of water on a clean dry glass slide and spreaded it evenly. A cover slip was placed over the materials. The gill arches were removed and macerated on slides and examined under a compound microscope (BX51 microscope, Olympus, Japan). In case of monogeneans, the gill were removed into petridishes containing water and gently scrapped to dislodge monogeneans. The monogeneans were removed on to clear slides with a fine pipette through a drop of water and covered with cover slip.

For endoparasites, fishes were dissected out ventrally by a sharp scalpel to observe parasites inside buccal cavity, stomach and intestine. The whole gut was removed in a watch glass containing 0.9% physiological saline afterwards cleaned several times with tap water to free from any unwanted materials. Small worms were searched initially with the help of magnifying glass by scrapping out mucus.

3.5.4.2.5. Identification and preservation of parasites

Parasites were identified according to the description of Yamaguti (1958, 1963), Hafizuddin and Shahabuddin (1996), Agarwal and Sharma (1988).

3.5.4.2.6. Estimation of parasites

Prevalence, abundance and mean density were estimated through the following formula proposed by Margolis *et al*. (1982) as:

$$\textbf{Prevalence} = \frac{\text{Total No of infected fishes}}{\text{Total No. fish host examined}} \times 100$$

$$\textbf{Abundance} = \frac{\text{Total No. of parasite recovered}}{\text{Total No. fish host examined}}$$

$$\textbf{Mean density} = \frac{\text{Total No. of parasite recovered}}{\text{Total No. of infected examined}}$$

3.5.4.2.7. External observation

The external surface of the host body was examined by a magnifying glass to find out ectoparasites if any on the skin, scales, fins or any kind of leisons such as ulcers, raised scales, reddened fins, cyst and injuries resulting from physio-chemical agents. Parasites were collected with the help of fine brush and preserved in individual vials and kept for identification. Then gills were removes from the branchial cavity and placed in a petridish containing saline solution. The gills were carefully separating to dislodge the live monogeneans and placed under a microscope for gross observation (Plate 17 to 20). The monogeneans were removed on to clear slides with a fine pipette in a drop of water and covered with cover slip. The parasites of skin, fin and gill were observed by the methods of Mofasshalin *et al.* (2012).

3.5.4.2.8. Internal observation

To collect the endoparasites, the fishes were dissected and internal organs were examined. The viscera were removed from the body by an incision through the mid ventral longitudinal line. The viscera were put into physiological saline solution (0.7% NaCl Solution) in a Petridish

(Plates 17 to 20). Then the internal organ like stomach, liver, intestine etc. were separated and kept in separate Petridishes with saline solution. Each organ was then examined separately for parasites. The stomach and intestine were split open and were shaken in a tube to dislodge the parasites remaining attached to the epithelial lining. Sometimes the epithelial layer of stomach and intestine were scraped with a scalpel to remove the parasites. When the fishes were dissected without keeping in the refrigerator often the parasites come out it from the organs. The collected parasites in kept Petridishes then washed in fresh saline solution. The contents were stirred well and allowed to settle in the bottom of the Petridishes. The supernatant liquid was removed carefully with a dropper. Washing was repeated until the supernatant liquid became clear. Then the sediment together with distilled water examined under a microscope. The aforementioned procedure was followed for each individual specimen.

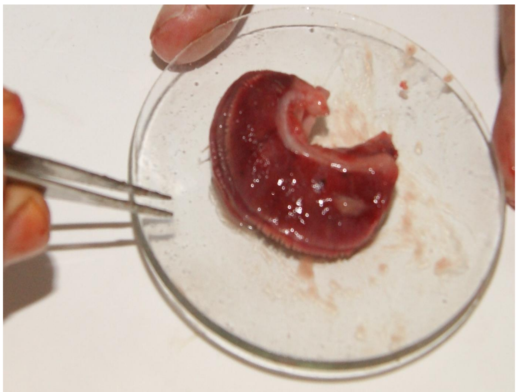

Plate 17. The infected gill of the host specimens

Plate 18. The internal organs of the host specimens after dissection

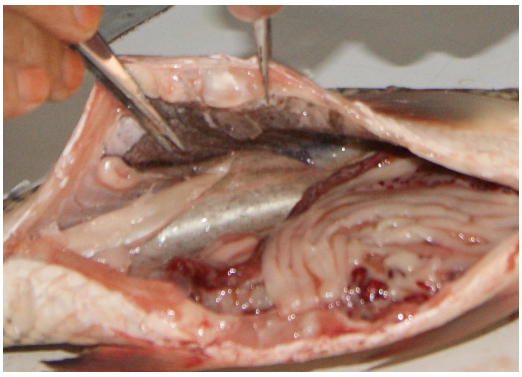

Plate 19. Picking up the internal organs of the host specimens for examine of parasites

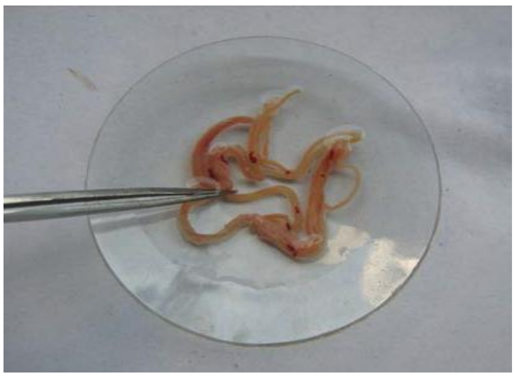

Plate 20. Scrapping of intestine for examines parasites

3.5.4.2.9. Fixation of collected parasites

The collected parasites were sorted out into different groups. Different methods of fixation were employed for different groups of parasites. Mostly the parasites were fixed in 2ml of Formalin Acetic Alcohol (FAA) solution and heated on spirit lamp at $70^{\circ}C$-$75^{\circ}C$.

3.5.4.2.10. Cleaning of parasites

Parasites were removed from Formalin acetic acid solution and carefully washed with 70% alcohol.

3.5.4.2.11. Identification of parasites

Collected parasites were identified according to the "Systema Helminthum' by Yamaguti (1963), vol, 1, Part-II, "Fish Parasitology" by Chandra (2004) and some ectoparasites were identified according to "Fish Disease and Solution" published by Fisheries Research Institute (FRI) Mymensingh.

3.6. Economic and benefit cost analysis

Cost and benefit analysis is a technique, that is used to compare, the various cost associated with the investment of the company with the benefits that is proposes in return. In the calculation of cost-benefit analysis, both tangible and intangible factors are addressed and accounted for (Pearce *et al*. 2006).

3.6.1. Economic analysis

An economical analysis was performed to estimate the net return and benefit–cost ratio in the different treatments. The following equation was used:

$$R = I - (FC + VC + In)$$

Whereas,

R=net return,

I=income from rohu, catla, and mrigal sale,

FC=fixed/common costs,

VC=variable costs and

In=interest on inputs.

The benefit cost ratio was determined by the following equation:

$$\text{Benefit cost ratio (BCR)} = 100 \times \frac{\text{Total net return}}{\text{Total input cost}}$$

3.6.2. Total gross production

Calculation of gross fish production by the following equation:

$$\text{Gross fish production (ton/per pond/yr)} = \frac{\text{Gross weight (Kg) of fish per decimal per month} \times 250 \times 12}{1000}$$

3.6.3. Net return

Calculation of Net fish production by the following equation:

$$\text{Net fish production (ton/per pond/yr)} = \frac{\text{Net weight (Kg) of fish per decimal per month} \times 250 \times 12}{1000}$$

3.6.4. Selling price

In treatment I the selling price of Ruhu was 300 Tk/Kg, Catla was 330 Tk/Kg, Mrigel was 300 Tk/Kg and treatment II the selling price of Rui was 280 Tk/Kg, Catla was 300 Tk/Kg, Mrigel was 275 Tk/Kg.

3.7. Statistical analysis

Length and weight of fish, production of fish, Climatic parameters, Physico-chemical parameters, biological parameters (seasonal abundance of the plankton per unit volume and parasites) have been performed by using Pearson correlation and ANOVA test, Mean and standard deviation of identifying parameter has also been assessed. All statistical analysis has been performed using SPSS software (version 16), ORIGIN software (version 8) and Microsoft Office Excel 2007.

GROWTH PERFORMANCE AND PRODUCTION

4.1. Introduction

In Bangladesh, total fish production is around 2.10 million metric tons and 44% of the production comes from open waters including rivers and 56% from closed water bodies (DoF 2005). For the production in closed water bodies, more than 50% production comes from cultures of Indian major carps and the three species *L. rohita*, *C. catla* and *C. mrigala* cover 90% of the major carps. The above three species are also found in rivers and other big water bodies (Das *et al*. 1980, Padhi and Mandal 1997). They are the most important commercial fishes with a maximum market demand and acceptability as food by the consumers due to their taste and flesh. They contribute about 67% of total freshwater fish production (Iclarm 2001).

Pond fish culture can play an important role to mitigate nutritional deficiency and for the economic development of the country. In Bangladesh, two types of aquaculture have been practicing currently for better production of fish. One is commercial polyculture system and other is commercial monoculture system. Among different technologies of fish culture, polyculture is one of the most acceptable culture techniques (Ling 1974).

Polyculture or composite fish culture is the system in which fast growing compatible species with different feeding habits are grown in the same pond (Jhingran 1975). Polyculture management technique is based on the relationship between fishes at different levels of the food chain and environment. The outcome of fish production from polyculture systems depends on the species combinations and their stocking densities. That is why, natural food utilizations is efficient and thus increased fish yield per unit area can be achieved (Tang 1970). Direct relation exists between food abundance and growth rate if space does not become a limiting factors. Growth rate is inversely related to the population density (Mahmood *et al.* 2004). Application of fertilizers or, use of supplementary feed can play a vital role to increase fish production. Fertilization increased the fish production in polyculture system stated by (Faluroti 1987). Therefore, this polyculture culture technology is a completely new one in South East Asia (Chakraborty and Mirza 2008).

In fish culture operations, feed is the major input and represents up to 60% of the total expenditure (De Silva 1988, Li and Wang 2004). Supplementary feed is offered in the presence of natural food to augment fish growth (Devaraj and Krishna 1981). However, these can provide important analysis of economic viability of the supplementary feed, which comprises single or more than one ingredient in monoculture, as well as in polyculture system. Provision of more nutrient rich and balanced feed can further enhance the existing level of fish production to cater for the continuously emerging demands of the masses (Khan *et al.* 2012).

Artificial feed and chemical fertilizers are considering the main items of aquaculture. Natural food in water bodies can provide only a limited production of fish. To increase the fish production, semi intensive fish culture with balanced artificial feed is necessary but artificial quality feed is not always available in the country. Through if it is available to some extent, the price is so high that the poor farmers cannot afford to procure them. This is one of the main problems of aquaculture in Bangladesh.

Growth may be defined quite simple as an increase in size. However, growth in a general term for a very complex changes depending on many factors from the simple inhabitation by water to the complicated results of nutrition chemistry. Growth is the direct result of the chemical osmotic and other forces by which a material is introduced into an organism and transferred throughout the many parts (Rounsefell and Everhart 1953).

The present study is therefore designed with a view to formulate a supplementary feed from locally available ingredients for yearling fish of Indian major carps, and its effect on comparative growth performance, survival rate, body composition and economic viability under prevailing fish culture practices.

4.2. Objectives

- to observe the growth performance of Indian major carps in polyculture system;
- to assess the yield of Indian major carps;
- to assess the effect of introduction of Indian major carps on growth of rohu, catla and mrigal in polyculture; and
- to develop a suitable polyculture technique by analyzing cost-benefit ratio.

4.3. Results

During the present eighteen months study period growth rate, survival rate, length-weight relationship, production and cost benefit analysis of treatment I and treatment II were observed. The results of this study have been presented under the following headings.

4.3.1. Survival rate

The survival rate was estimated after the total counting of the fishes at the time of harvesting. The average survival rate of different species was found satisfactory and comparatively higher in treatment I and lowest in *C. mrigala* (76.30%) was in Treatment II. In treatment I, the highest survival rate was 92.70% for *L. rohita* and the lowest was 87.70% in *C. mrigala.* Statistical result showed survival rate between two feeding regimes are significant at 99% confidence (P= .001) level (Table 4 and Fig. 1 and 2).

Table 4. Estimation of survival rate of Indian major carps under treatment I and II

Ponds	**Treatment I (n=300)**		**Treatment II (n=300)**		**P value**
	n	**%**	**n**	**%**	
Labeo rohita					
Survival	278	92.7	245	81.7	0.001^{s}
Expired	22	7.3	55	18.3	
Catla catla					
Survival	274	91.3	243	81.0	0.001^{s}
Expired	26	8.7	57	19.0	
Cirrhinus mrigala					
Survival	263	87.7	229	76.3	0.001^{s}
Expired	37	12.3	71	23.7	

s= significant

P value reached from chi square test

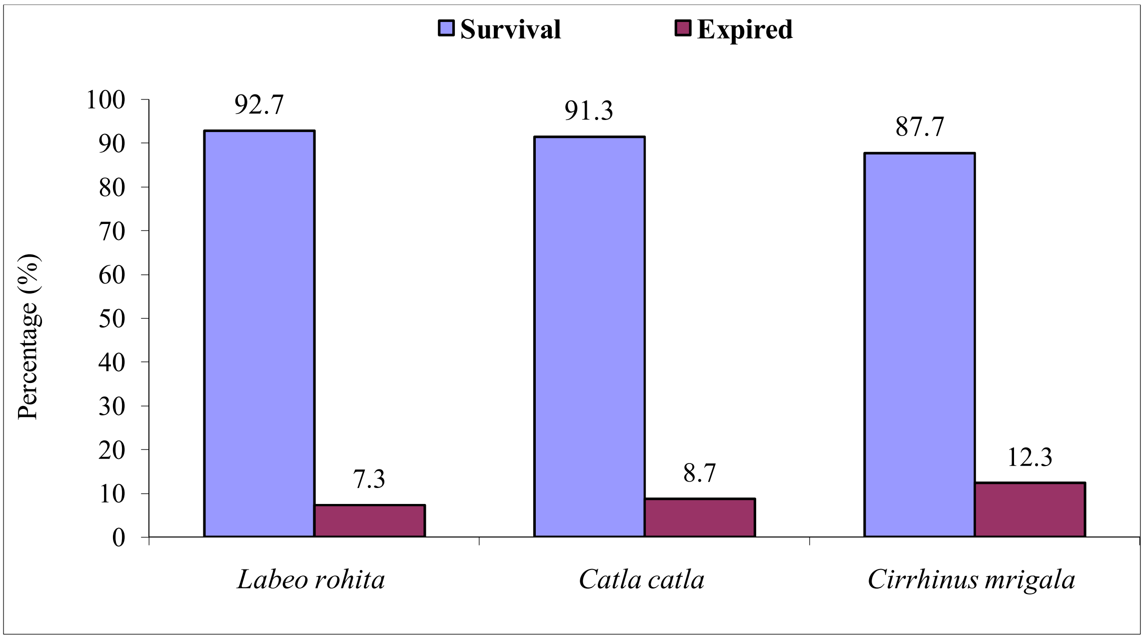

Fig. 1. Survival rate of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* under treatment I.

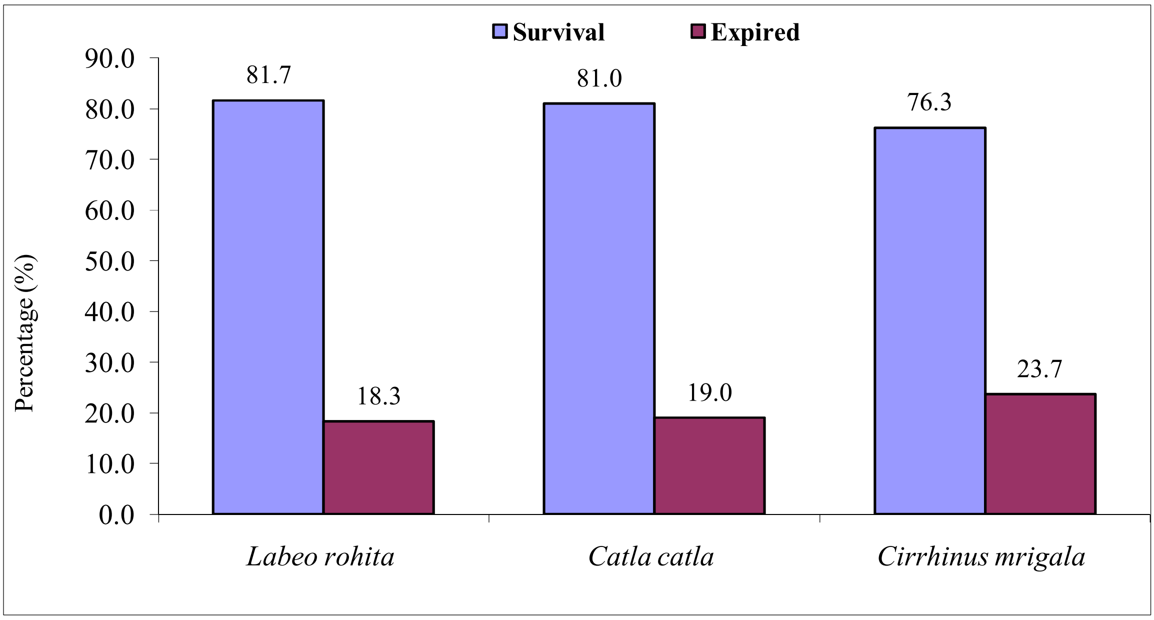

Fig. 2. Survival rate of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* under treatment II

4.4.2. Specific Growth Rate

The present study indicated a pronounced difference in the growth rate among the individual species. The highest SGR was calculated 98.06±93.79 in *C. catla* in treatment I and lowest 47.61±52.09% in *C. mrigala* in treatment II. SGR in *L. rohita, C. catla* and *C. mrigala* was 92.04±75.38, 98.06±93.79 and 79.41±75.51 in treatment I and 45.96±58.19 in *L. rohita*, 47.61±52.09 in *C. catla* and 61.94±97.07 in *C. mrigala* in treatment II (table 5).

Table 5. Specific growth rate of Indian major carps stocked in the treatment I and treatment II

Name of fish	**Monthly mean weight gain (gm)**				**P value**
	Treatment I		**Treatment II**		
	n	Mean±SD	n	Mean±SD	
Labeo rohita	10	92.04±75.38	10	45.96±58.19	0.143^{ns}
Catla catla	10	98.06±93.79	10	47.61±52.09	0.140^{ns}
Cirrhinus mrigala	10	79.41±75.51	10	61.94±97.07	0.659^{ns}

ns= not significant

P value reached from unpaired t-test

4.4.3. Monthly average length increase of *L. rohita, C. catla* and *C. mrigala* in Treatment I and II

In treatment I, the length of *L. rohita* was maximum in the month of July 2014, August 2014 and May 2015 and minimum in December 2014 and January 2015, maximum length of *C. catla* was seen in the month of May 2015, July 2014 and August 2014 and minimum in November 2014, January 2015 and February 2015 and maximum length of *C. mrigala* was June 2014, July 2014 and August 2014 and minimum in December 2014 and January 2015. In treatment II, the length of *L. rohita* was maximum in the month of March 2015, April 2015 and May 2015 and minimum in January 2014 and February 2014. In *C. catla* maximum length was seen in the month of June 2014 April 2015 and May 2015 and minimum in December 2014 and March 2014. Maximum length of *C. mrigala* was April 2015 and May 2015 and the minimum in December 2013, January 2014, February 2014 and March 2014 (Table 6).

Table 6. Monthly average length increase of Indian major carps at treatment I and II

Months	Monthly average length (cm)					
	L. rohita		*C. catla*		*C. mrigala*	
	Treatment I	**Treatment II**	**Treatment I**	**Treatment II**	**Treatment I**	**Treatment II**
Dec. '13	1.905	0.762	1.27	0.635	1.905	0.635
Jan.'14	1.27	0.635	1.27	0.762	1.25	0.635
Feb.'14	1.25	0.635	1.27	0.762	1.24	0.635
Mar.'14	1.77	0.76	1.65	0.63	1.65	0.50
Apr.'14	1.90	0.635	1.65	0.76	1.77	0.635
May.'14	2.54	1.27	2.54	1.27	2.41	1.01
Jun.'14	2.54	1.77	2.54	2.03	2.54	1.77
Jul.'14	3.09	1.65	3.17	1.77	2.79	1.65
Aug.'14	3.04	1.52	2.92	1.77	2.94	1.52
Sep.'14	1.27	1.39	1.30	1.65	1.52	1.39
Oct.'14	1.52	1.02	1.94	0.89	1.27	1.02
Nov.14	1.02	0.76	1.01	0.89	1.27	0.88
Dec.'14	0.76	0.76	1.27	0.81	0.76	0.77
Jan.'15	0.63	1.02	1.02	1.04	0.92	1.01
Feb.'15	1.15	1.14	1.01	1.02	1.37	1.15
Mar.'15	1.01	2.29	1.53	1.02	1.73	2.28
Apr.'15	1.14	2.79	2.28	2.28	2.03	3.05
May.'15	3.31	3.22	2.67	3.43	1.78	2.67

4.4.4. Monthly average weight increase of *L. rohita, C. catla* and *C. mrigala* in Treatment I and II

In treatment I, the weight of *L. rohita* was found to increase rapidly in the June 2014, August 2014 and September 2014 and thereafter lowest in December 2014 and January 2015. The maximum weight of *C. catla* was calculated 260.87 and 300.68 for the month of August 2014 and September 2014 and the lowest was December 2014 and January 2015. In maximum weight of *C. mrigala* was found in the month of August 2014 and May 2015 and minimum in December 2014 and January 2015. In treatment II, the weight of *L. rohita* was found to increase in the months of April 2015 and May 2015 and lowest in December 2013 and January 2014. The maximum weight of *C. catla* was in the month of April 2015 and May 2015 and the lowest was December 2013 and January 2014. The maximum weight of *C. mrigala* was found in February 2015 and May 2015 and the minimum was December 2013, January 2014 and May 2014 (Table 7).

Table 7. Monthly total weight increase of Indian major carps at treatment I and II

Months	Monthly average weight (gm)					
	L. rohita		*C. catla*		*C. mrigala*	
	Treatment I	**Treatment II**	**Treatment I**	**Treatment II**	**Treatment I**	**Treatment II**
Dec. '13	5.12	3.13	5.43	3.90	4.90	2.70
Jan.'14	5.04	3.24	7.90	4.24	5.87	5.23
Feb.'14	12.24	9.32	21.35	10.21	14.78	9.32
Mar.'14	21.16	7.54	12.23	8.45	20.21	6.15
Apr.'14	37.09	12.65	35.12	15.19	39.12	15.54
May.'14	33.16	6.78	45.52	5.26	31.24	5.78
Jun.'14	200.8	15.32	40.65	35.56	21.56	15.41
Jul.'14	77.18	30.34	110.67	35.25	73.80	20.20
Aug.'14	240.09	20.31	260.87	25.78	235.42	25.76
Sep.'14	200.13	15.25	300.68	25.28	210.25	15.87
Oct.'14	100.98	30.29	200.32	75.43	90.89	30.78
Nov.14	50.56	40.61	100.12	50.32	40.78	25.45
Dec.'14	50.34	50.26	50.21	40.63	40.56	35.39
Jan.'15	60.25	35.17	50.31	45.41	40.46	45.31
Feb.'15	90.56	75.94	80.32	55.24	90.76	360.57
Mar.'15	130.21	90.36	100.23	80.25	110.34	90.82
Apr.'15	160.28	205.54	120.26	130.78	140.57	170.79
May.'15	180.34	175.67	260.63	210.65	220.89	235.63
Mean	**91.97**	**45.98**	**100.16**	**47.66**	**79.58**	**62.04**

4.4.5. Species wise length increase

During the 18 months study period mean with standard deviation the length increase *L. rohita* , *C. catla* and *C. mrigala* were higher in treatment I than that of treatment II (Fig. 3). The highest length increase observed in *C. catla* (29.72±10.70cm) followed by both *L. rohita* and *C. mrigala* (29.59±9.4cm.) and in treatment I and in treatment II again *C.catla* was the higher length increaser (22.76±6.9), followed by *L. rohita* (22.50±6.9) and *C. mrigala* (22.29±6.9). The co-efficient of correlation of three species *L. rohita, C. caila* and *C. mrigala* showed the mean total length of two treatments possessed highly significant (P=0.015, 0.027 and 0.012) correlation (Table 8 and fig. 3).

Table 8. Species wise length increase in treatment I and II

Name of fish	Total length (cm)				P value
	Treatment I		Treatment II		
	n	Mean±SD	n	Mean±SD	
Labeo rohita	18	29.59±9.4	18	22.5±6.9	0.015[s]
Catla catla	18	29.72±10.7	18	22.76±6.9	0.027[s]
Cirrhinus mrigala	18	29.59±9.4	18	22.29±6.9	0.012[s]

s= significant

P value reached from unpaired test.

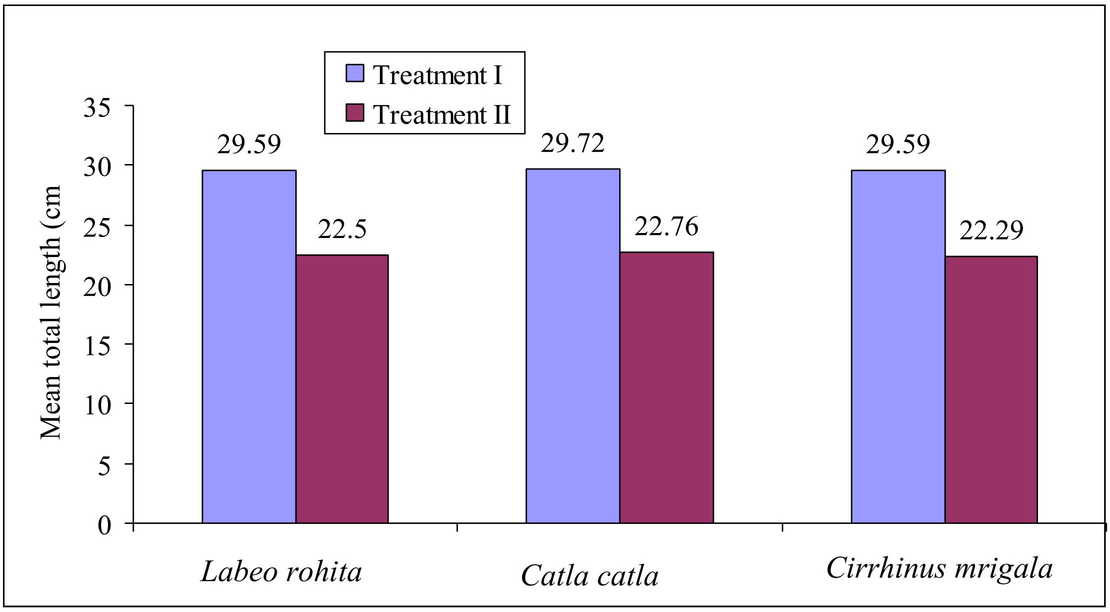

Fig. 3. Comparison of average monthly increase in length of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* in treatment I and treatment II.

4.4.6. Species wise growth gain

During the 18 months study period mean with standard deviation the weight *L. rohita* , *C. catla* and *C. mrigala* were higher in treatment I than treatment II (Fig. 4). The highest weight gain was observed in *C. catla* (774.36±626.20g) followed by both *L. rohita* (601.41±491.20g) and *C. mrigala* (579.28±467.30g) treatment I and in the treatment II *C.catla* was hightest gainer (308.14±245.30g), followed by *L. rohita* (250.23±232.30g) and *C. mrigala* (234.70±218.10g).

The co-efficient of correlation of three species *C. catla, L. rohita* and *C. mrigala* showed the mean total weight of two treatments possessed highly significant (P=0.006, 0.015 and 0.012) correlation (Table 9 and fig. 4).

Table 9. Species wise weight increase in treatment I and II

Name of fish	Total weight (gm)				**P value**
	Treatment I		Treatment II		
	n	Mean±SD	n	Mean±SD	
Labeo rohita	18	601.41±491.2	18	250.23±232.3	0.010^{s}
Catla catla	18	774.36±626.2	18	308.14±245.3	0.006^{s}
Cirrhinus mrigala	18	579.28±467.3	18	234.7±218.1	0.008^{s}

s= significant
P value reached from unpaired t-test

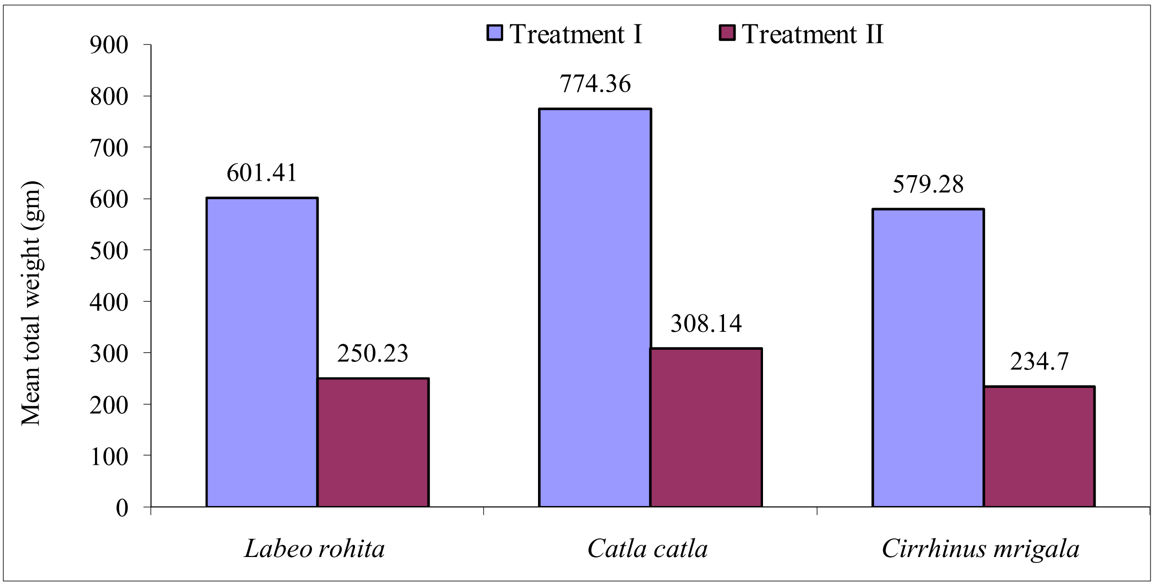

Fig. 4. Showing species wise total mean with standard deviation of weight gain of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* in treatment I and treatment II.

4.4.7. Length-weight relationship

The relationships between length and weight of fish were analyzed by measuring length and weight of fish specimens collected from the study areas. The statistical relationship between these parameters of fishes was established by using the parabolic equation by Froese (2006). The relationship (W = *a*L*b*) when converted into the logarithmic form gives a straight line relationship graphically. Additionally, 95% confidence limits of *b* and the coefficient of determination r^2 were estimated.

The regression parameters for length-weight relationships, coefficient of determination (r^2), 95% confidence interval of *a* and *b,* total length and body weight range in *L. rohita* is shown in the linear regressions of different feeding group were highly significant (*P*<0,001). The regression correlation value r2 was 0.950 in treatment I and 0. 930 in treatment II. The regression coefficient of LWRs of two different feeding regimes showed positive allometric growth. Both the groups exhibited positively allometric growth irrespective feed differences (Fig. 5 and 6).

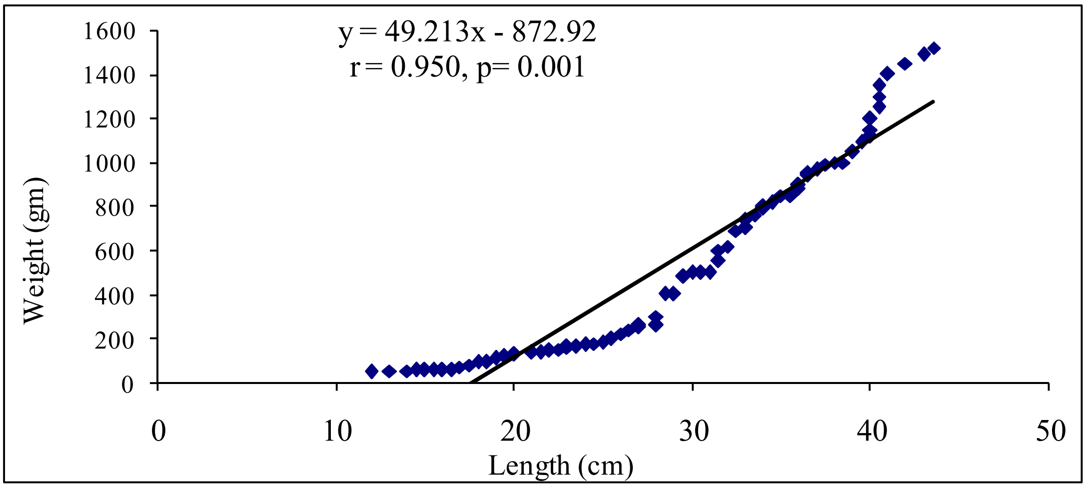

Fig. 5. Showing positive correlation (r=0.950; p=0.001) between length and weight with *Labeo rohita* in treatment I

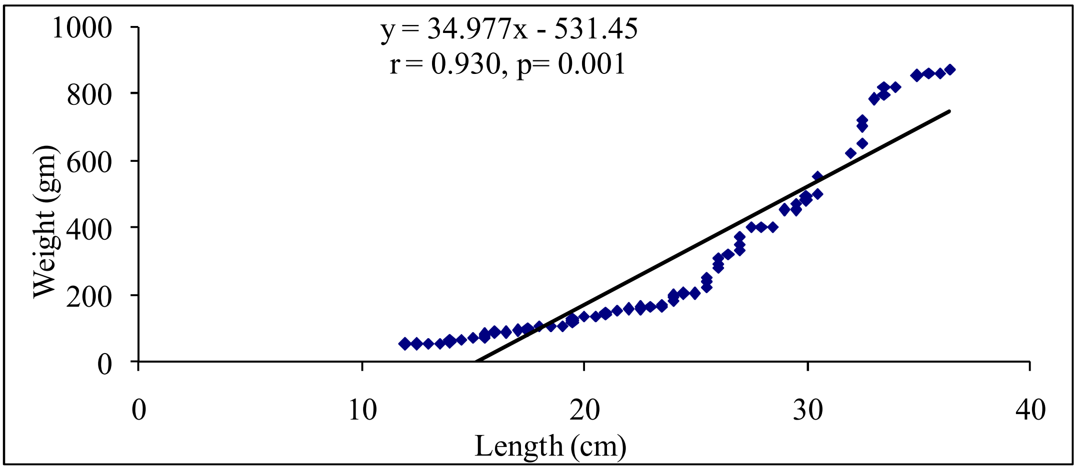

Fig. 6. Showing positive correlation (r=0.930; p=0.001) between length and weight with *Labeo rohita* in treatment II

The regression parameters for length-weight relationships, coefficient of determination (r^2), 95% confidence interval of *a* and *b,* total length and body weight range in *Catla catla* is shown in the linear regressions of different feeding group were highly significant (*P*<0,001). The regression correlation value r^2 was 0.967 in treatment I and 0.965 in treatment II. The regression coefficient of LWRs of two different feeding regimes showed positive allometric growth. Both the groups exhibited positively allometric growth irrespective feed differences (Fig. 7 and 8).

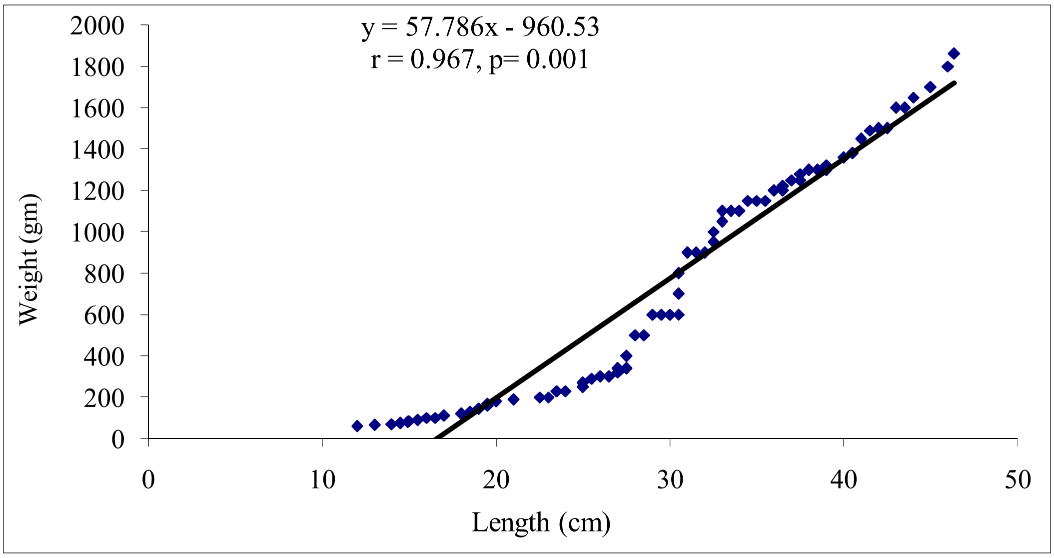

Fig. 7. Showing positive correlation (r=0.967; p=0.001) between length and weight with *Catla catla* in treatment I.

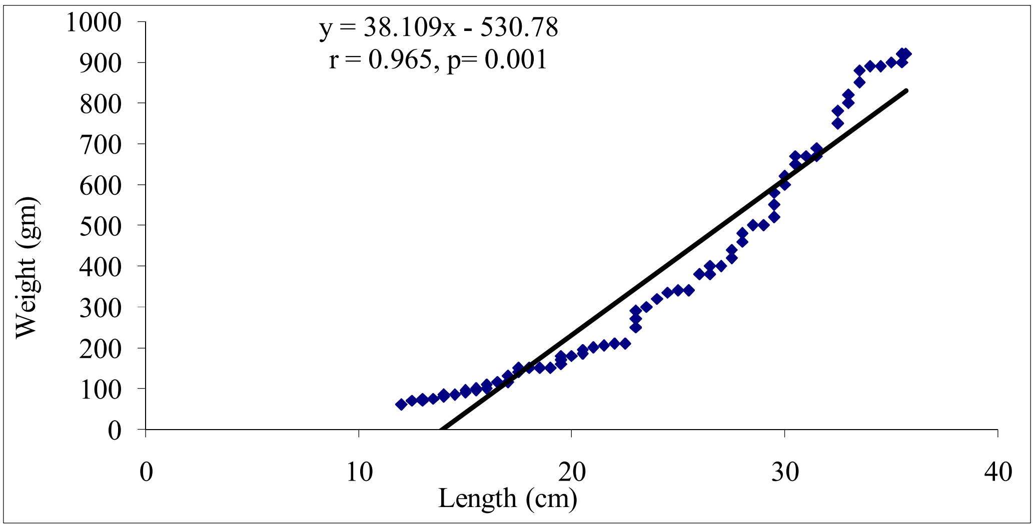

Fig. 8. Showing positive correlation (r=0.965; p=0.001) between length and weight with *Catla catla* in treatment II.

The regression parameters for length-weight relationships, coefficient of determination (r^2), 95% confidence interval of *a* and *b,* total length and body weight range in *Cirrhinus mrigala* is shown in the linear regressions of different feeding group were highly significant (*P*<0,001). The regression correlation value r^2 was 0.940 in treatment I and 0.948 in treatment II. The regression coefficient of LWRs of two different feeding regimes showed positive allometric growth. Both the groups exhibited positively allometric growth irrespective feed differences (Fig. 9 and 10).

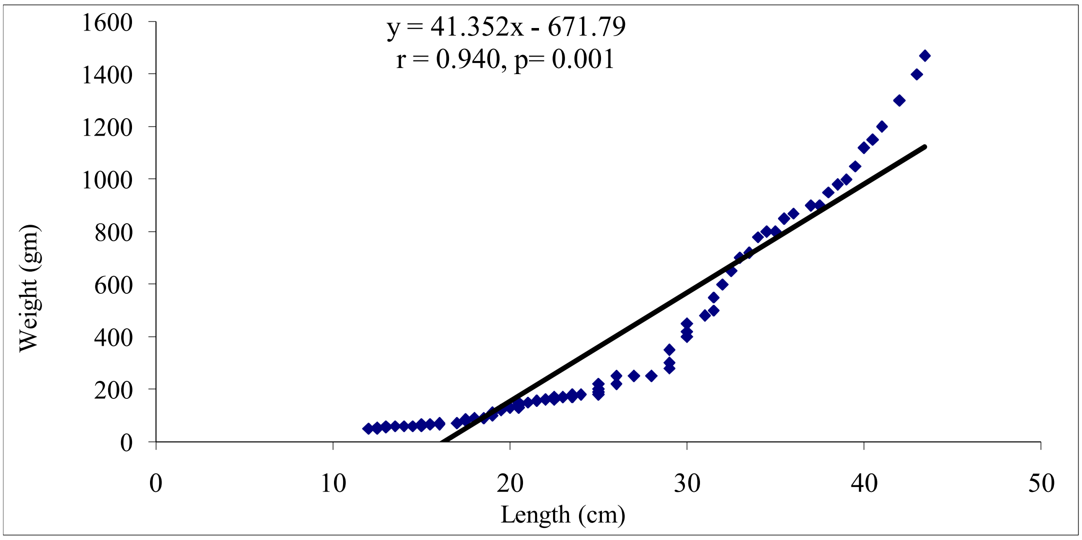

Fig. 9. Showing positive correlation (r=0.940; p=0.001) between length and weight with *Cirrhinus mrigala* in treatment I

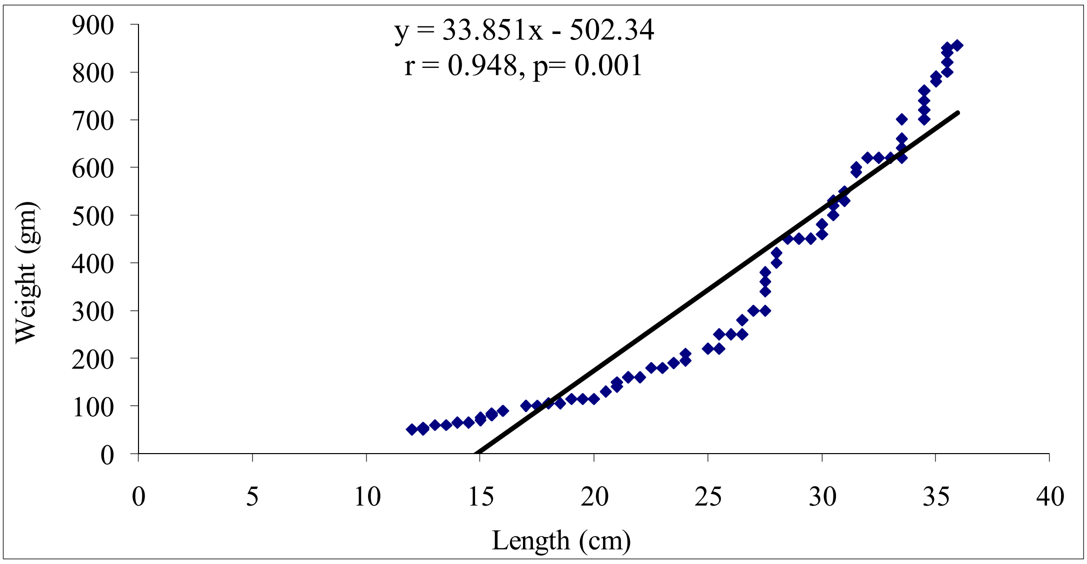

Fig. 10. Showing positive correlation (r=0.948; p=0.001) between length and weight with *Cirrhinus mrigala* in treatment II.

4.4.8. Contribution of different species to the total yield

The study showed that *C. catla* made the highest contribution to the total yield in two treatments. Contribution of *L. rohita* was about 32.84% in treatment I and 34.74% in treatment II. *C. catla* Contributed 35.83% in treatment I and 33.77% in treatment II. *C. mrigala* was found to contribute 31.31% in treatment I and 31.47% in treatment II (Table 10).

Table 10. Contribution of the individual species to the yield of the treatment I and II

Name of fish	**Percent contribution to different treatment**			
	Treatment I		Treatment II	
	n	**%**	**n**	**%**
Labeo rohita	18	32.84%	18	34.74%
Catla catla	18	35.83%	18	33.77%
Cirrhinus mrigala	18	31.31%	18	31.47%

4.4.9. Production of Indian major carps

During the period of this study, different rates of production were found in different treatment practices, which summarized in table (11). Gross production of individual species of fish was calculated from the average final weight multiplied by the actual numbers of fish harvested.

In treatment I, net weight was calculated 407.56 kg, 490.14 kg and 372.21 kg in *L. rohita, C. catla* and *C. mrigala* and 198.15 kg, 204.06 kg and 181.39 kg in *L. rohita, C. catla* and *C. mrigala* in treatment II. It is obtained from the present investigation that total production of treatment I and treatment II were 1269.91 kg. and 583.60. Unpaired t-value at 0.001 levels indicate final production of *L. rohita, C. catla* and *C. mrigala* of two groups in feed feeding system are positively correlated without influence of feed (Fig. 11).

Table 11. Average final production and total production and net production of *Labeo rohita, Catla catla* and *Chirrhinus mrigala* in Treatment I and Treatment II.

	Treatment I		Treatment II		P value
	n	Mean±SD	n	Mean±SD	
Final production (gm)					
Labeo rohita	10	1520.7±0.87	10	870.6±0.45	0.001^{s}
Catla catla	10	1860.7±0.74	10	920.2±0.39	0.001^{s}
Cirrhinus mrigala	10	1470.8±0.27	10	855.5±0.41	0.001^{s}
Final gross production (kg)					
Labeo rohita	10	422.56	10	213.15	0.001^{s}
Catla catla	10	509.64	10	223.56	0.001^{s}
Cirrhinus mrigala	10	386.61	10	195.79	0.001^{s}
Net weight (kg)					
Labeo rohita	278	407.56	245	198.15	0.001^{s}
Catla catla	274	490.14	243	204.06	0.001^{s}
Cirrhinus mrigala	263	372.21	229	181.39	0.001^{s}
Total production (kg)	815	1269.91	717	583.6	

s= significant
P value reached from unpaired t-test

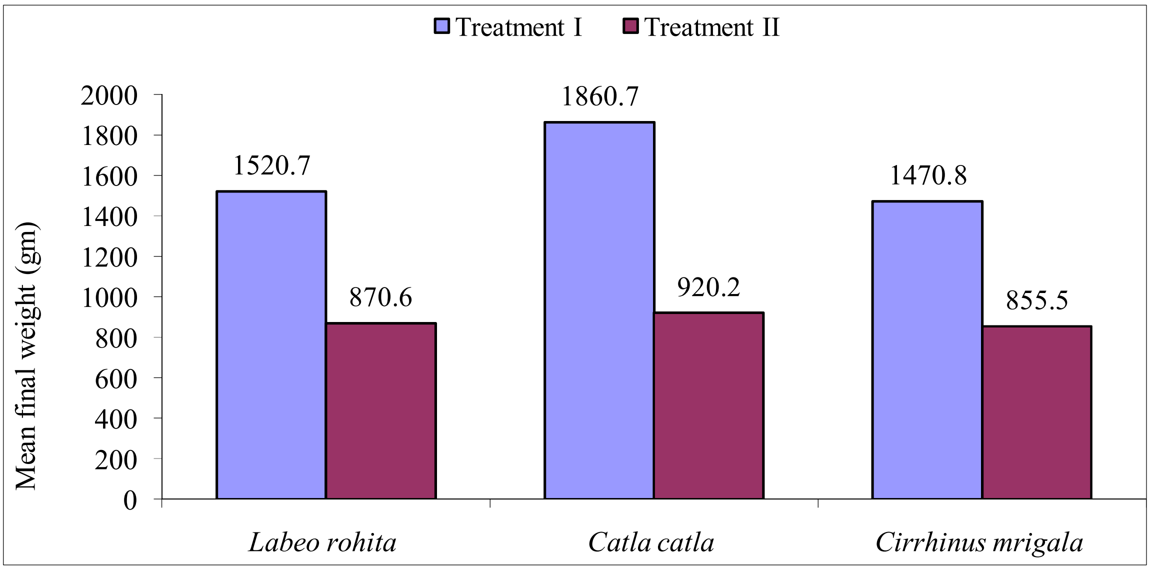

Fig. 11. Mean final weight of Indian major carps in treatment I and II.

4.4.10. Food conversion ratio (FCR)

The ratio showed that *L. rohita* and *C. mrigala* among the three species under both the treatments showed faster growing rate followed by *C. catla* at treatment I and treatment II, respectively. In the month of December 2014, only Urea and T.S.P. were given both of the treatments and other supplementary food was not given. Therefore, food conversation ratio was shown lowest both of the treatment. In treatment I, food conversation ratio was highest 41.28 g in March 2014 and lowest 10.04 in January 2015 in *L. rohita*. The highest pick 42.31 g was shown in the month of March 2014 and lowest 10.39 g was shown in *C. mrigala*. The maximum 36.44 was found in April 2014 and the minimum in 7.42 g in the month of January 2015 in *C. catla*, which indicate better conversion of food into, flash and followed by *L. rohita* and *C. mrigala* at treatment I (Fig. 12).

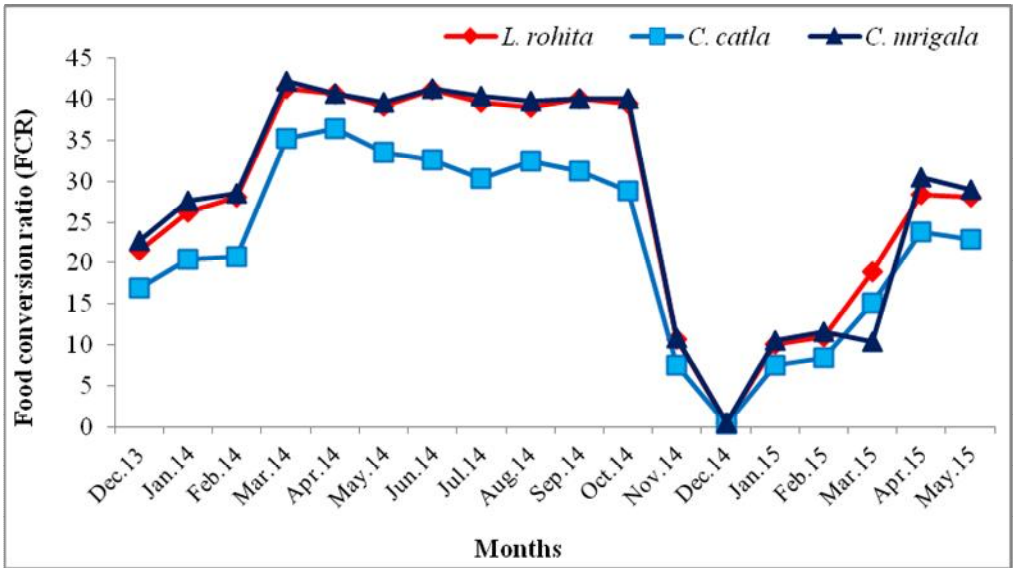

Fig.12. Food conversion ratio of treatment I.

In treatment II, food conversation ratio was the maximum 549.69 g in *C. mrigala*. The second pick was found 535.05 g in *L. rohita* and the lowest was 410.28 g in *C. catla.* The highest pick was found in the month of December 2013 both in *L. rohita* and *in C. mrigala* 41.28 gm and 42.31 gm in the month of March 2014 and the lowest in *C. catla* were found (Fig. 13).

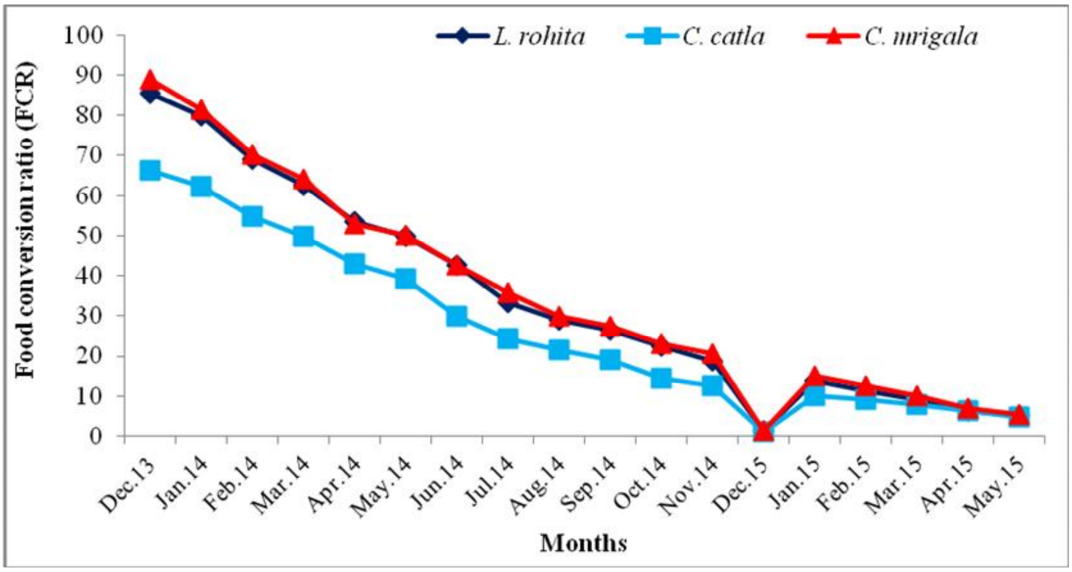

Fig. 13. Food conversion ratio of treatment II.

GROWTH EFFECTORS

5.1. Introduction

The health and subsequent growth of fish are directly related to the quality of water in which the fish are raised. In general, factors affecting fish growth and production in freshwater aquatic systems can be classified as physical, chemical, biological, or a combination. Water quality is one of the most important physical and chemical factors affecting fish growth and production. Tolerance to changes in water quality constituents may result in decrease in metabolism and immunological response. Consequently, decreased growth and in some cases, mortalities, may result, depending on the magnitude of the deviation from the optimum water quality variables.

5.1.1. Fertilizer

In present fish culture practices both organic and inorganic fertilizers are used to enhance plankton production .Efficiency of fertilization varies from type and nature of fertilizer which ultimately affects plankton density and their nutritional value for fish. This variation in fertilizers and their subsequent effects has bearing on fish health and production. Therefore to improve the pond environment and to get maximum yield it is imperative to fertilize the pond water with quality as well as organic fertilizer. Manure input and fish yield are directly related with each other and excessive application of organic manure and nitrogen fertilizer can increased the microbial activity, nitrates and phosphates ultimately plankton productivity. More than the optimum dosage of manure reduces the plankton population, fish biomass, specific growth rate and induces high mortality (Ling and Chen 1967).

Qualitative and quantitative applications of fertilizers and frequency of applications manipulate water quality parameters. Inorganic fertilizers are more effective in improving plankton productivity, dissolved oxygen, pH than organic ones. Nitrogen, phosphorus and occasionally carbon are the limiting nutrients for phytoplankton production in natural waters and also in fish ponds. The doses and frequencies of fertilizer use influence water quality parameters significantly, often reaching ‘critical limits exerting considerable stress on the rearing species. Growth of fish is dramatically influenced by the pond soil and the pond management practices such as stocking density, fertilization strategy and supplemental feeding, upon mineralization, together influence the water quality (Hickling 1962, Ray and David 1969).

5.1.2. Physico-chemical parameters

The physical and chemical properties of fresh water bodies are characterized by the geochemical, climatic, geomorphologic and pollution condition (Chaurasia and Pandey 2007). In order to utilize fresh water bodies successfully for aquatic life and fish production and human consumption, it is very important to study the physico-chemical factors, which influence the biological productivity of the water body (Kaushik *et.al.* 2009). The external controls and internal interactions combine to produce a certain ecosystem structure and the species develop certain pattern of abundance, seasonality, biomass and stratification (Sewell 1927). Physical and chemical factors can influence the levels of the primary productivity and thus influence ecological structure and total biomass throughout the aquatic food web (Wetzel, 1975).

Quality of water generally refers to the change in components of water, which are to be present at the optimum level for suitable growth of plants and animals. These components play an important role for the growth of plants and animals in the water body. A continuous monitoring of water quality is very essential to determine the state of pollution of water. This information is important to be communicated to the general public and the government in order to develop policies for the conservation of the precious fresh water resources (Mehedi *et al.* 1999).

5.1.3. Feed

The objective of feeding fish is to provide the nutritional requirements for good health, optimum growth, optimum yield and minimum waste within reasonable cost so as to optimize profits. Every farmer should be particular about the quality of feed fed to the fish because it is the feed that determines the:

(i) Nutrient loading (and ultimately carrying capacity) in the pond, hence water quality within the culture system

(ii) Fish growth rate,

(iii) Economic viability of the enterprise. 60%-70% of variable production costs in a normal production cycle are due to feed.

Fish need the right and correct kind of food in the right quantities if they are to give high yields. The quality and quantity of feed given an animal is directly affects outputs and returns.

5.1.4. Biological parameters

5.1.4.1. Plankton

The plankton, which lives in all the aquatic habitats, plays a significant role in the overall biological productivity of natural waters, as they serve food to most of the fishes (Mozumder *et al.*2014). The knowledge of planktonic organism is essential because the biological potentiality of any aquatic habitat depend on these. Planktons are free-floating animals and plant organism whose intrinsic power of locomotion, almost at the Mercy of Current and waves (Welch 1952).

Phytoplankton is the chief primary producer of the aquatic environment which fixes solar energy by process of photosynthesis, assimilating carbon dioxide and water to produce carbohydrates. Phytoplanktonic species have different physiological requirements and thus show diverse responses to physical and chemical parameters such as light, temperature and nutrient regime. Their sensitivity and variations in species composition are often a reflection of significant alteration in ambient condition within an ecosystem (Devassy and Goes, 1988, 1989).

The phytoplankton in a reservoir is an important biological indicator of the water quality. Phytoplankton's are important primary producers and the base of the food chain in open water (Whitton and Potts 2000).

Zooplankton plays an important food item of omnivorous and carnivorous fishes (Alam *et al.,* 1987). The larvae of carps feed mostly on zooplankton, because zooplankton provide the necessary amount of protein requires for the rapid growth and development of different organs specially the ground of fishes. Brood fishes productivity depend on zooplankton as an ideal food source of them (Bardach *et al.* 1972). Zooplankton are the major mode of energy transfer between phytoplankton and fish (Howick and Wilhm 1984). The study of zooplanktonic composition, abundance and seasonal variations is helpful in planning and successful fishery management (Jhingran 1974).

Zooplanktons are the heterotrophic planktonic animals floating in water, which constitute an important food source of many species of aquatic organisms. In addition, they serve as indicator organisms of water type, fish yield and total biological production (Goldman and Horne 1983).

5.1.4.2. Parasite

Along with carps all the freshwater species found more or less to suffer with different types of diseases while 15%-20% are associated with parasite infestation (Chowdhury 1998). The parasitic infestations are reportedly playing a major role in disease occurrences (78%) in freshwater aquaculture (Lakra *et al.* 2006). The ectoparasitic diseases are the main problem in freshwater fish farms which caused an annual loss of US$ 1 million due to disease-induced mortality and impaired growth (Mohan and Bhatta 2002). Indian major carps are highly susceptible to disease in comparison to Chinese and European carps (Lilley *et al.* 1992).

In cultured fish population, the parasites involve in the serious outbreak of disease (Kayis *et al.* 2009). They have been receiving considerable scientific attention due to serious damage to fishery resources by them (Ravichandram *et al.* 2009). In the high stocking conditions, particularly if the fishes are stressed, the parasites multiply rapidly. The temperature and slow water flow rate also increase the parasitic infestation (Bednarska *et al.*2009). The incidence and intensity of parasite also varied with season (Bichi and Bawaki 2010). Young fishes are more prone to infection than older one (Ozturk 2005). The stoking density and water quality parameters correlate with the incidence of fish parasites (Bhuiyan *et al.*2008). In order to increase profitability, health care based on the knowledge of organisms, their ecology, and application of the knowledge in the control of diseases is essential (Snieszko 1983, Kaur *et al.* 2012). Therefore, contribution to the knowledge of fish parasites is a pre-requisite for the rapid and correct diagnosis of the disease. Early diagnosis can lead to preventive measures which is the best way to reduce outbreak of disease (Kaur e*t al.* 2012, Abdel 2012, Morsy e*t al.* 2012).

5.2. Objectives

- to investigate the role of growth effectors of water qualities viz, fertilizer, feed.
- to establish an optimal method under a certain condition for the culture of major carps by comparing the growth pattern as affected by different feeding habits (poultry waste and supplemental prepared feed) in separate twin pond of same environmental area.
- to investigate change in growth of bioenergetics with addition to physico chemical and biological variables.

5.3. Results

During the present eighteen months study period climate of the study area, physico-chemical variables and biological variables were observed. The results of this study have been presented under the following headings:

5.3.1. Climatic Parameters

The data on different climatic parameters of experimental site were collected from December 2013 to May 2015, represented in figure 14, 15, 16 and 17 and table 12.

Table 12. Showing the monthly variation of climatic parameters of Sukundi, Gazipur during the period of December 2013 to May 2015

Months	Air temperature (°C)			Relative Humidity (%)	Total Rainfall (mm)	Average Sunshine
	Maximum	Minimum	Average			
Dec. '13	25.5	14.1	19.8	77.65	0	8.75
Jan.'14	26.6	13.0	19.8	79.61	0	7.88
Feb.'14	29.0	15.1	22.1	64.77	10.2	4.1
Mar.'14	33.2	20.0	26.6	62.67	93.5	9.19
Apr.'14	34.6	21.7	28.2	68.17	197.1	9.52
May.'14	35.2	24.5	29.9	72.66	782.8	6.75
Jun.'14	33.0	26.0	29.5	73. 55	859.4	4.51
Jul.'14	32.0	26.0	29.0	81.78	776.7	2.83
Aug.'14	31.0	26.0	28.5	79.50	746.2	4.22
Sep.'14	32.0	25.2	28.6	82.88	485.6	4.32
Oct.'14	31.4	22.5	26.9	78.50	48.0	6.77
Nov.14	28.5	17.4	22.9	76.61	0	7.62
Dec.'14	26.2	13.8	20.0	78.11	1.1	9.13
Jan.'15	26.6	13.0	19.8	75.78	0	7.98
Feb.'15	30.4	15.1	22.8	66.42	22.1	5.88
Mar.'15	33.1	20.0	26.6	59.87	87.4	9.54
Apr.'15	35.0	23.4	29.2	65.35	189.7	9.43
May.'15	35.3	23.7	29.9	72.16	265.3	6.12
Mean	**31.03**	**20.07**	**25.56**	**73.08**	**253.62**	**6.92**
Sd	**3.28**	**4.94**	**3.94**	**7.21**	**32.120**	**2.19**

5.3.1.1. Air temperature

During the study period, the monthly variation of air temperature ranged from 35.3°C-13.0°C. The highest (35.3°C) temperature was recorded in the month of May' 2015 and lowest (13.0°C) was in the month of January' 2014 (Fig. 14).

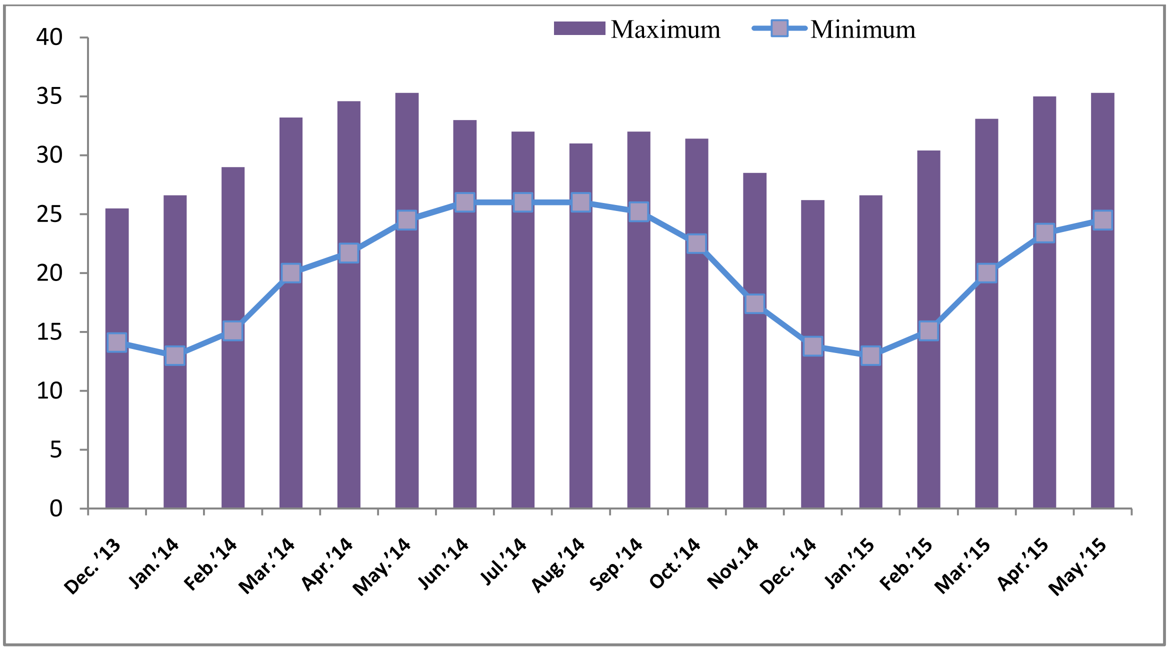

Fig. 14. Monthly variation of air temperature from the study period

5.3.1.2. Relative Humidity

The maximum humidity was recorded in September 2014 and the percentage was 82.88% minimum in March 2015, which was 59.87% (Fig. 15).

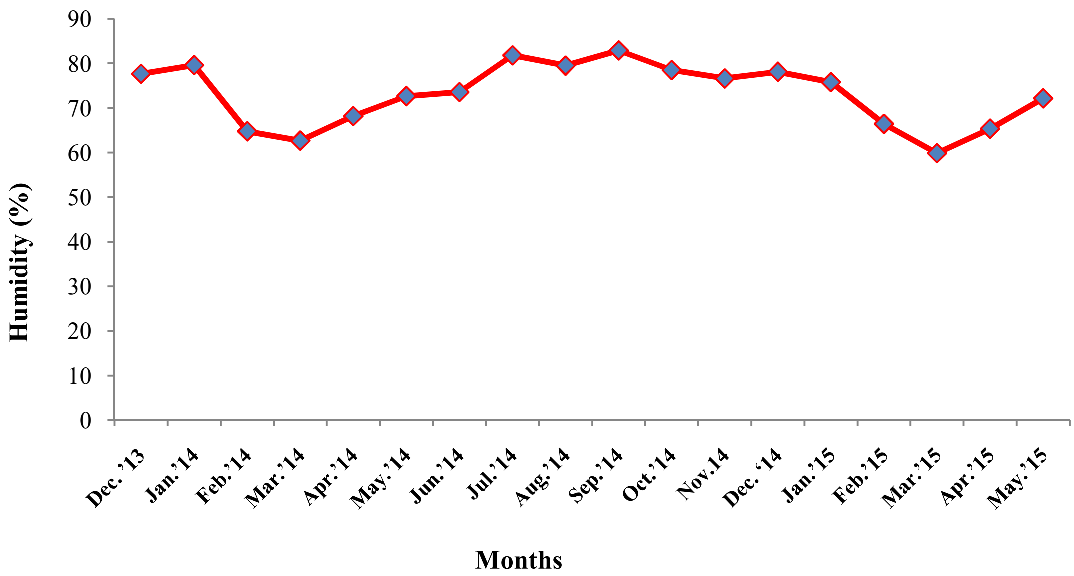

Fig. 15. Monthly mean humidity from the Study area

5.3.1.3. Total Rainfall

Monthly total rainfall has been presented in figure 16, where clean seasonality in occurrence of rainfall was seen during the period of investigation. Highest rainfall occurred in June 2014, it was 859.4 mm and lowest in December 2014, and lowest value was 1.1 mm. But no rainfall was observed in the month of December 2013, January and November 2014 and January 2015.

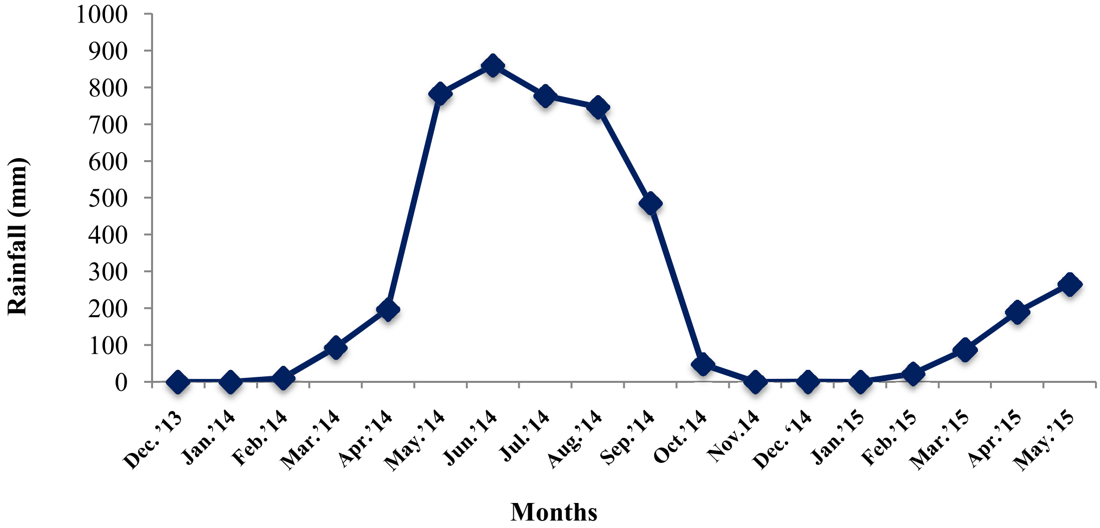

Fig. 16. Monthly total rainfall at the study area

5.3.1.4. Average Sunshine

The average sunshine was observed highest in the dry season than the wet season. The highest sunshine hour 9.52 was observed in the month of March 2015 and the shortest 2.83 hour observed in the month of July 2014 (Fig.17).

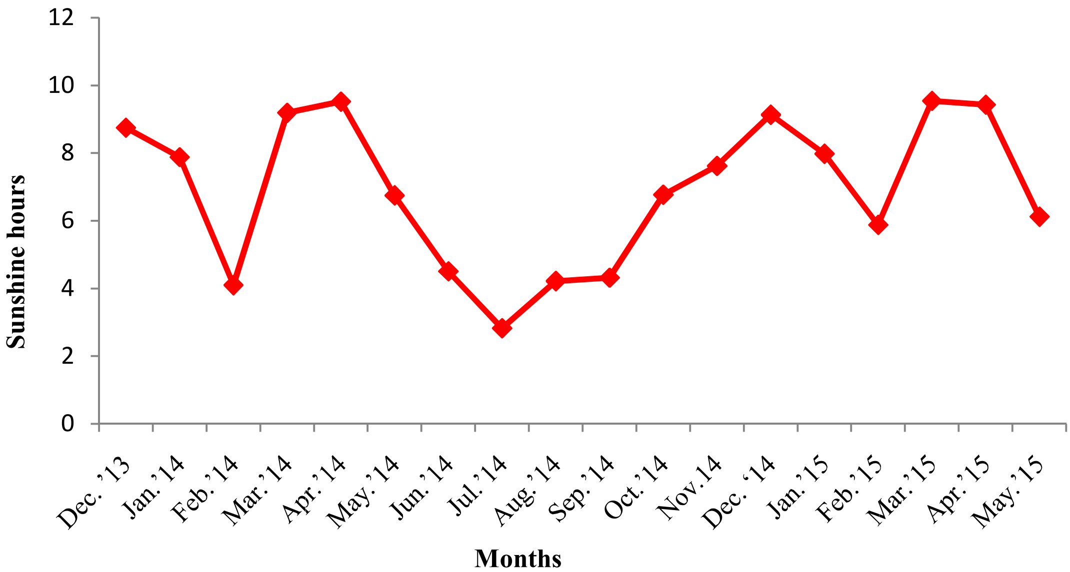

Fig. 17. Monthly mean sunshine hours from the Study area

5.3.2. Physical parameters

The data on different physical parameters of water of experimental site were collected from December 2013 to May 2015 and graphically shown in figure 18, 19, 20 and 21.

5.3.2.1. Air temperature

In treatment I, the highest air temperature was 29.9°C in month of May 2015 and the lowest was 19.8°C in month of December 2013. On the other hand in treatment II the highest air temperature was 29.90°C in the month of May 2014 and the lowest was 19.8°C in month of December 2013. During the study period, the monthly variation of air temperature ranged from 19.8°C to 29.9°C (Fig. 18 and 19).

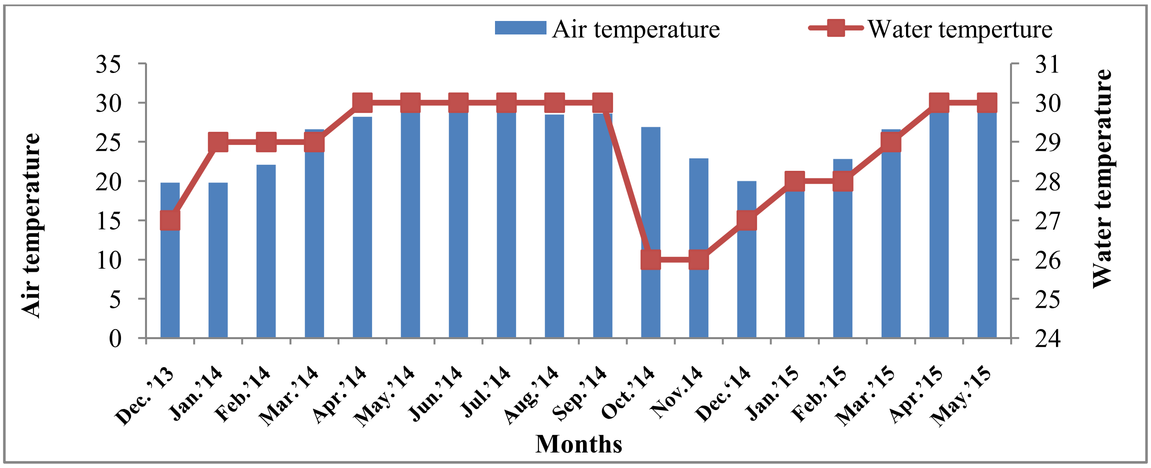

Fig. 18. Showing the monthly fluctuations of air and water temperature in treatment I

5.3.2.2. Water temperature

In treatment I, the highest Water temperature was 30°C in month of April 2014, September 2014 and May 2015 and the lowest was 26°C in month of October and November 2014.

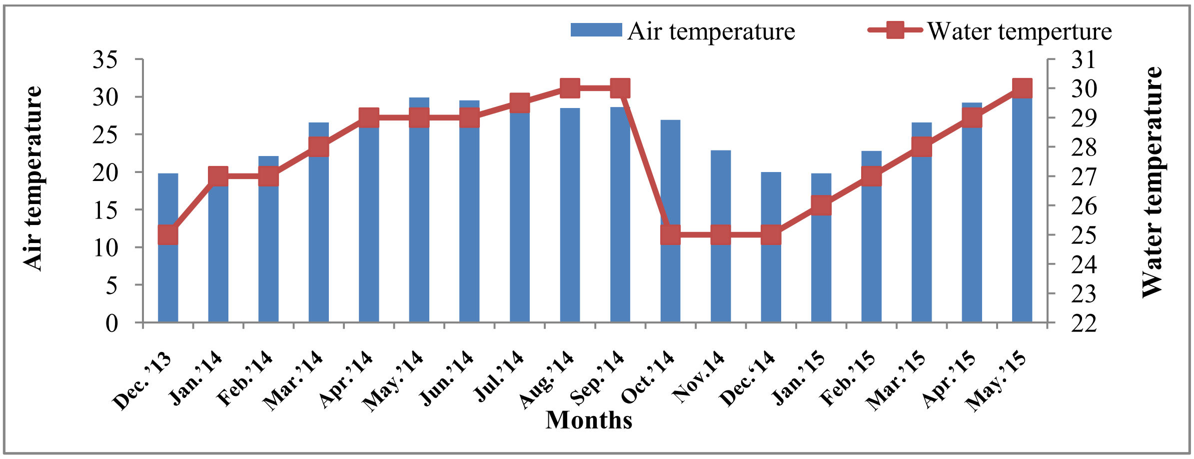

Fig. 19. Showing the monthly fluctuations of air and water temperature in treatment II

On the other hand, in treatment II the highest water temperature was 30°C in the month of August and September 2014 and the lowest was 25°C in the month of December 2013. During the study period, the monthly variation of water temperature ranged from 25°C to 30°C (Fig. 18 and 19).

5.3.2.3. Water depth

There were clear variations of water depth of different treatments in different months. The highest depth was recorded, 6.13 feet in treatment II in August 2014 and the lowest was 2.34 feet in December 2013 in treatment I (Fig. 20).

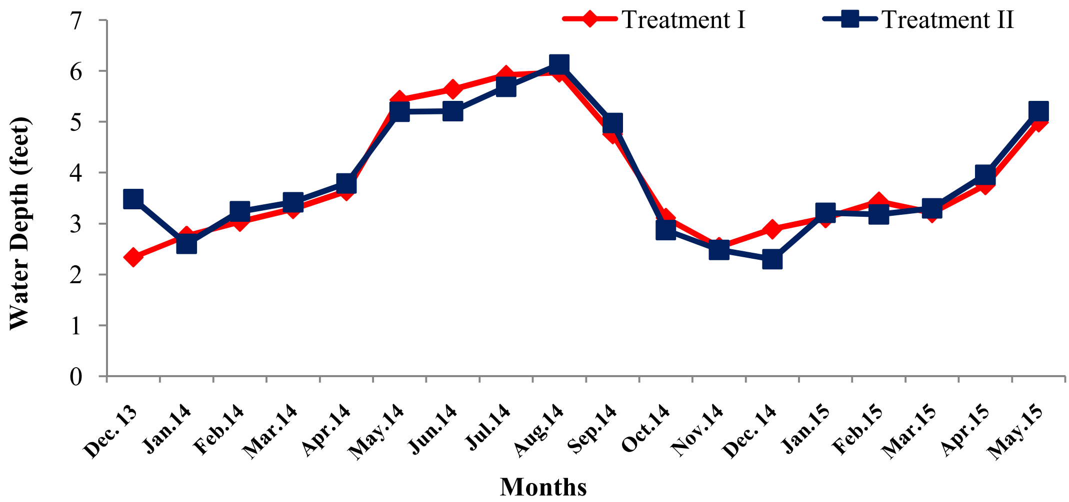

Fig. 20. Showing the monthly fluctuations of water depth (feet) in treatment I and II

5.3.2.4. Transparency

The Secchi depth or the light penetration level of water in the treatments was found to fluctuate from maximum 63 cm in the month of March 2015 in the treatment I and the minimum 25 cm in treatment II. The transparency showed an apparent direct relationship with the water depth. Therefore, it was observed that the water transparency of treatment II was always lower than treatment I (Fig. 21).

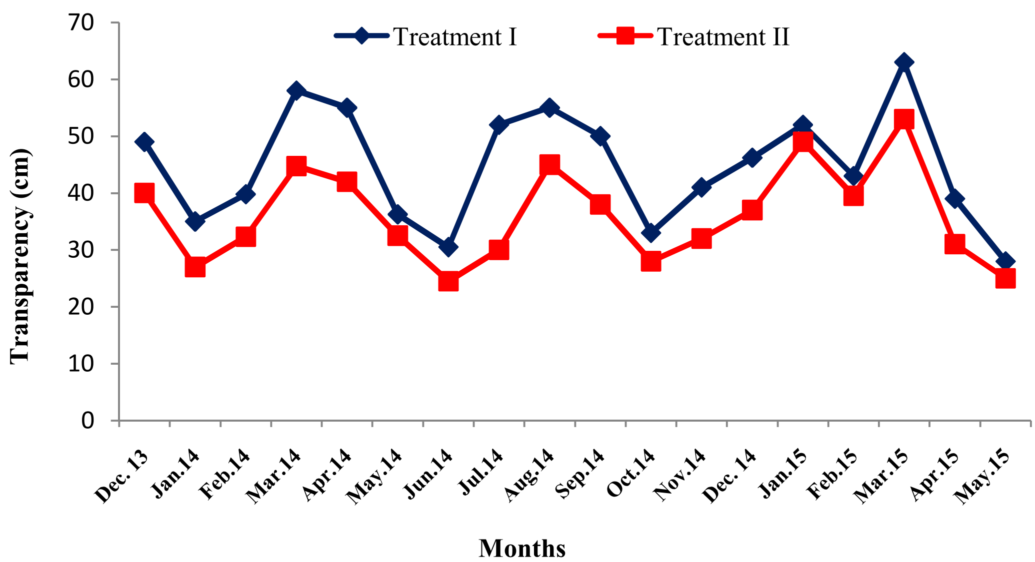

Fig. 21. Showing the monthly fluctuations of transparency (cm) in treatment I and II

5.3.3. Chemical parameters

Monthly variations of pH, dissolved oxygen (DO), free carbon dioxide (CO_2), total alkalinity, hardness and Ammonia of water were recorded regularly throughout the whole study period.

5.3.3.1. Dissolved oxygen (mg/L)

Dissolved oxygen concentration in different treatments was found to be more or less similar and very close at both the ponds. During the study period, the dissolved oxygen (DO) contents of the water were found throughout vary from 4.5 to 5.00 mg/L in both the ponds. The mean values of dissolved oxygen content obtained at were 4.95±0.15 and 5.00±00 respectively. Static 5.00 mg/L dissolved oxygen content was the remarkable observation during the investigation period in both study ponds except March 2014 and 2015 at treatment I and treatment II (Fig. 22 and table 13).

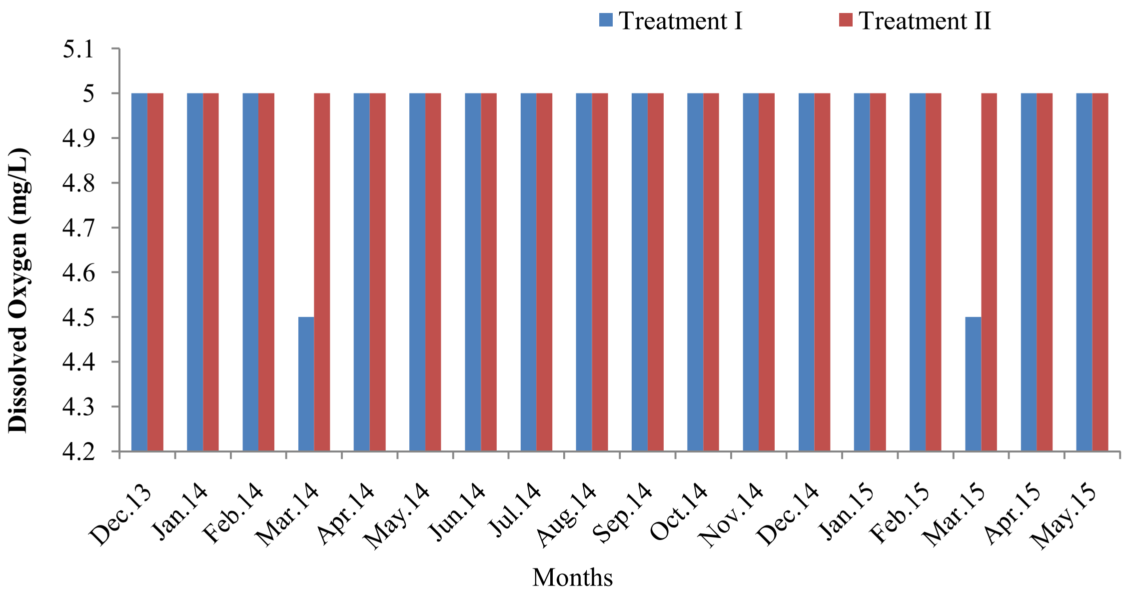

Fig. 22. Showing the monthly fluctuation of Dissolved Oxygen (mg/l) at treatment I and treatment II

5.3.3.2. Free Carbon dioxide (CO_2)

Free carbon dioxide, highly soluble gas in water, main source of carbon pathway in the nature, is contributed by the respiratory activity of animals and can exist in water as bicarbonate or carbonates. CO_2 ranged between 6±0.04 mg/l to 4±0.01 mg/l. The highest (6±0.04 mg/l) CO_2 content was recorded in the month of October 2014 in treatment I and lowest (4±0.01 mg/l) was in the month of December 2013 in treatment II (Table 13 and Fig. 23). The pond water showed little variation in the free CO_2 concentration in overall study period are significantly different (P=0.2748<05) in between the treatment I and II.

Table 13. Showing the monthly fluctuation in chemical parameters of water in Treatment I and Treatment II

Months	Treatment I						Treatment II					
	DO (mg/L)	CO_2 (mg/L)	pH	Hardness	Alkalinity (mg/L)	NH_3 (mg/L)	DO (mg/L)	CO_2 (mg/L)	pH	Hardness	Alkalinity (Mg/L)	NH_3 (mg/L)
Dec. 13	5±0.02	6±0.02	7±0.02	110±0.9	150±0.9	0.025±0.02	5±0.04	4±0.01	6.7±0.02	100±0.9	140±0.07	0.02±0.02
Jan. 14	5±0.04	5±0.00	6.9±0.03	115±0.8	145±0.8	0.02±0.04	5±0.05	5±0.03	6.9±0.03	105±1.0	145±0.98	0.02±0.01
Feb. 14	5±0.05	5±0.03	6.8±0.01	110±0.6	150±0.5	0.025±0.05	5±0.02	5±0.2	6.8±0.04	105±0.98	140±1.00	0.025±0.00
Mar. 14	4.5±0.06	5±0.02	7±0.02	110±0.4	150±0.6	0.025±0.00	5±0.09	5±0.04	7±0.02	110±1.09	150±0.5	0.025±0.03
Apr. 14	5±0.02	5±0.04	7±0.01	110±0.1	150±0.9	0.022±0.01	5±0.01	5±0.2	7±0.01	110±1.5	150±0.76	0.025±0.02
May. 14	5±0.01	5±0.02	7±0.04	115±1.0	150±0.8	0.02±0.00	5±0.05	5±0.03	7±0.03	110±2.00	150±1.5	0.025±0.04
Jun. 14	5±0.03	5±0.00	7±0.03	110±2.10	150±0.5	0.025±0.02	5±0.06	4.5±0.01	6.9±0.04	110±1.8	145±0.9	0.025±0.01
Jul. 14	5±0.04	5±0.01	7±0.03	110±0.8	150±0.9	0.025±0.03	5±0.03	5±0.02	7±0.05	110±0.97	150±0.4	0.02±0.02
Aug. 14	5±0.02	5±0.02	6±0.04	140±0.6	150±1.2	0.025±0.01	5±0.04	5±0.02	7±0.03	110±0.9	150±0.98	0.025±0.04
Sep. 14	5±0.00	5±0.03	6±0.02	110±0.5	150±1.4	0.025±0.00	5±0.02	5±0.01	7±0.02	115±1.02	150±1.5	0.025±0.03
Oct. 14	5±0.01	6±0.04	6.9±0.02	110±0.9	140±1.6	0.025±0.03	5±0.03	4±0.03	6.8±0.04	110±1.04	140±1.8	0.020±0.02
Nov. 14	5±0.03	6±0.02	6.8±0.03	110±0.7	145±0.9	0.022±0.04	5±0.05	5±0.02	6.9±0.03	115±1.32	145±1.5	0.022±0.06
Dec. 14	5±0.02	6±0.01	7±0.04	110±0.1	150±1.6	0.024±0.00	5±0.05	4±0.04	6.7±0.02	110±0.94	140±1.7	0.020±0.02
Jan. 15	5±0.05	5±0.03	6.9±0.01	115±1.4	145±1.02	0.020±0.01	5±0.06	5±0.03	6.9±0.03	105±0.8	145±2.03	0.020±0.01
Feb. 15	5±0.03	5±0.04	6.8±0.02	110±0.9	150±1.9	0.025±0.00	5±0.03	5±0.02	6.8±0.01	105±1.02	140±0.9	0.025±0.02
Mar. 15	4.5±0.02	5±0.02	7±0.03	110±1.2	150±1.7	0.025±0.02	5±0.02	5±0.03	7±0.02	110±0.91	150±0.98	0.025±0.03
Apr. 15	5±0.04	5±0.00	7±0.04	110±1.3	150±1.5	0.022±0.03	5±0.03	5±0.04	7±0.03	110±2.3	150±1.90	0.025±0.04
May. 15	5±0.01	5±0.05	7±0.02	115±1.09	150±0.9	0.020±0.00	5±0.01	5±0.02	7±0.04	115±1.90	155±1.87	0.025±0.02

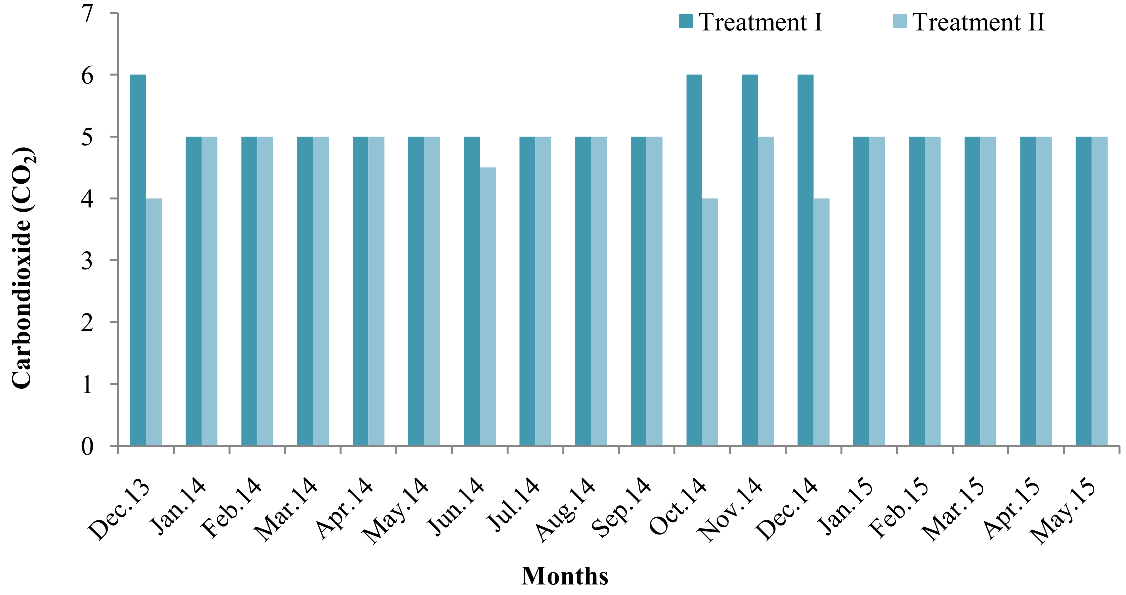

Fig. 23. Showing the monthly fluctuation of free CO_2 (mg/l) at treatment I and treatment II

5.3.3.3. Hydrogen ion concentration (pH)

The pH value of the experimental area was slightly alkaline. PH of the water ranged from 6±0.02 to 7±0.05 in both the treatments. The highest value of pH was 7±0.05 July 2014 in treatment II and lowest was 6±0.02 in the month of September 2014 in treatment I (Table 13 and Fig. 24). There was significant difference of pH between the two treatments ($P= 0.293<0.05$).

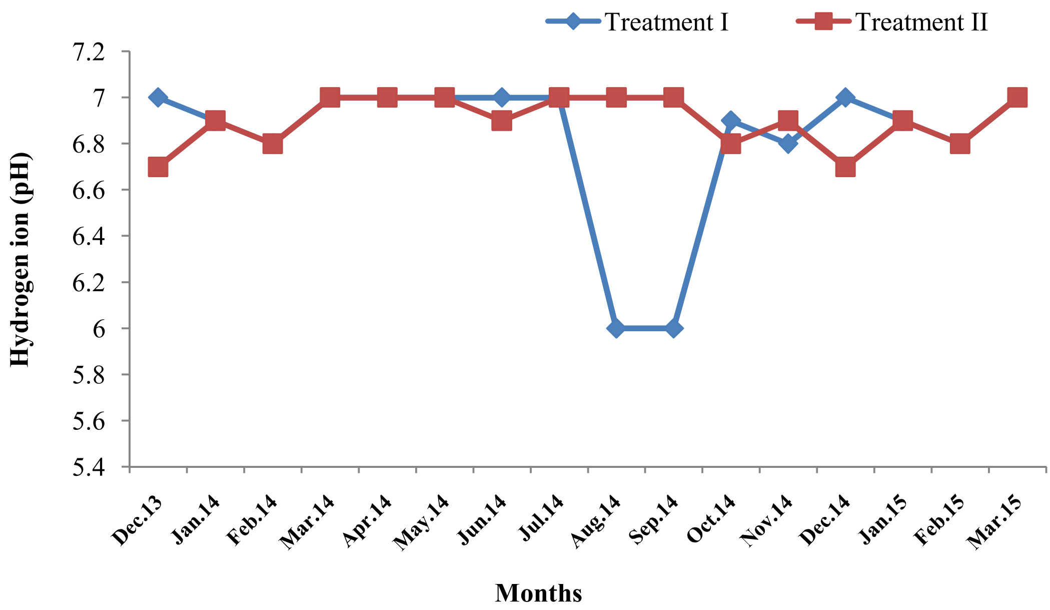

Fig. 24. Showing the monthly fluctuation of pH at treatment I and treatment II

5.3.3.4. Hardness

Hardness range varied from 140±0.6 mg/l to 100±0.9 mg/l. The maximum hardness value observed in the month of August 2014 in treatment I and the lowest value was in the month of December 2013 treatment II (Table 13 and fig. 25). There was significant difference between the two treatments. (P= 0.111<05).

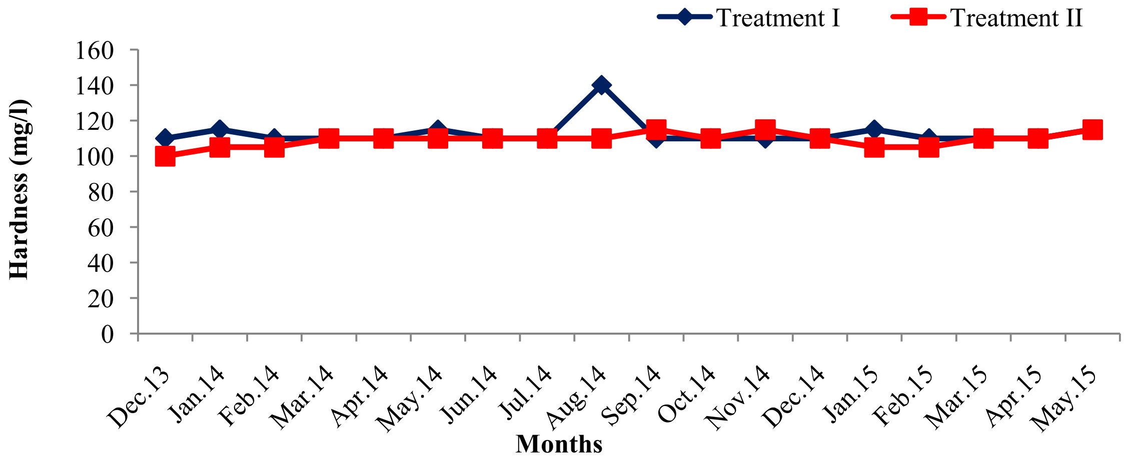

Fig. 25. Showing the monthly fluctuation of hardness (mg/l) at treatment I and treatment II

5.3.3.5. Alkalinity

Alkalinity is the water's ability to resist changes in pH and is a measure of the total concentration of bases in pond water. The maximum alkalinity observed 155±1.87 mg/l in the month of May 2015 in treatment II and the lowest 140±1.00 mg/l was in the month of December 2013 treatment II (Table 13 and figure 26). The difference was significant (P=0.096<0.05) between the treatments.

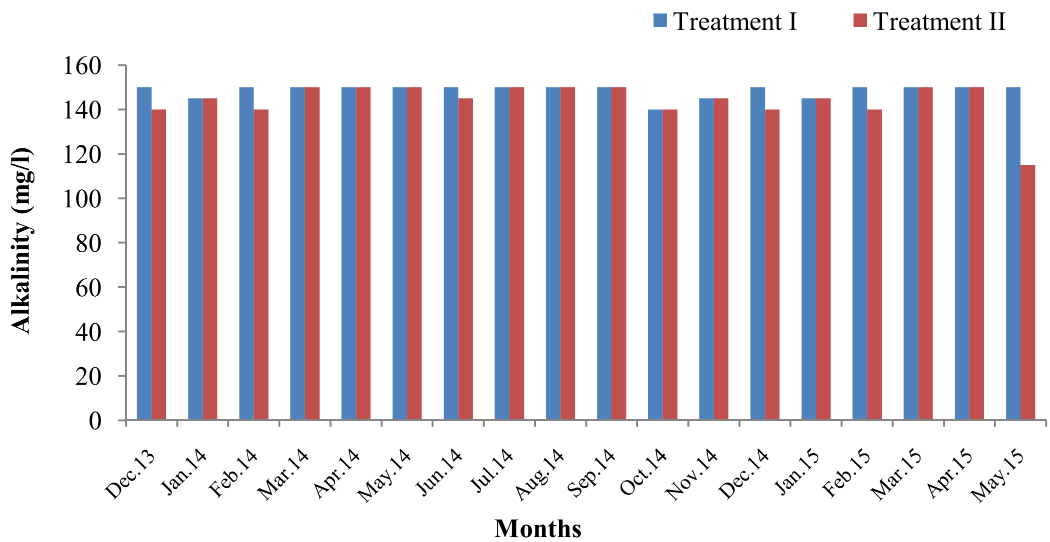

Fig. 26. Showing the monthly fluctuation of alkalinity (mg/l) at treatment I and II

5.3.3.6. Ammonia (NH_3)

The maximum NH_3 observed 0.025±0.04 mg/l in the month of May 2014, August 2014 and April 2015 in treatment II and the lowest 0.02±0.00 mg/l was in the month of May 2014 treatment II (Table 13 and fig. 27).

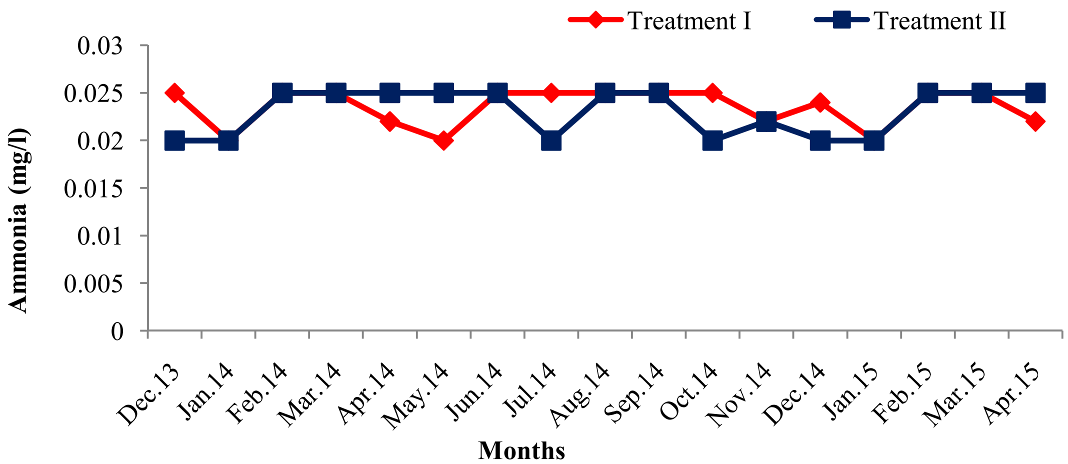

Fig. 27. Showing the monthly fluctuation of NH_3 (mg/l) at treatment I and treatment II

Table 14. Regression analysis for physico-chemical effectors (fertilizer, feed and water quality) of length (*Labeo rohita*) in group I

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.892[a]	0.796	0.505	6.60185

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	P value
Regression	1190.632	10	119.063	2.732	0.098[b]
Residual	305.091	7	43.584		
Total	1495.723	17			

a. Dependent Variable: Length (*Labeo rohita*)

b. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	P value
	B	Std. Error	Beta		
(Constant)	-171.151	177.486		-0.964	0.367
Temperature C°	2.353	9.908	0.361	0.238	0.819
DO mg/L	0.405	8.132	0.014	0.05	0.962
CO2 mg/L	10.428	25.13	0.476	0.415	0.691
pH	-0.705	10.843	-0.031	-0.065	0.950
Hardness	0.097	0.349	0.073	0.276	0.790
Alkalinity mg/L	0.371	2.333	0.114	0.159	0.878
NH3 mg/L	233.126	1701.577	0.053	0.137	0.895
Rice polish (kg)	-0.011	0.048	-0.229	-0.228	0.826
Premix vitamin (kg)	0.325	0.877	0.518	0.371	0.722
Fishmeal (kg)	6.987	8.852	0.652	0.789	0.456

Excluded Variables[a]

Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
					Tolerance
Oil Cake (kg)	242.284[b]	9.474	0.000	0.968	3.257E-006

a. Dependent Variable: Length (*Labeo rohita*)

b. Predictors in the Model: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

Table 15. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of length (*Labeo rohita*) in group II

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.541[a]	.293	-.132	7.51198

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.541[a]	.293	-.132	7.51198

a. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	233.408	6	38.901	.689	.664[a]
	Residual	564.298	10	56.430		
	Total	797.706	16			

a. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

b. Dependent Variable: Length (*Labeo rohita*)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	165.366	292.795		.565	.585
	Temperature C°	-.779	2.340	-.196	-.333	.746
	CO2 mg/L	4.258	6.602	.237	.645	.533
	pH	-59.811	68.139	-.822	-.878	.401
	Hardness	.861	.706	.493	1.220	.251
	Alkalinity mg/L	1.166	1.263	.769	.923	.378
	NH_3 mg/L	295.091	1180.490	.098	.250	.808

a. Dependent Variable: Length (*Labeo rohita*)

All independent variables viz. Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg) explain 79.6% of the variance in length of *Labeo rohita* effect, which is not significant as indicated by ANOVA test with F=2.732 and of P=0.098[b] (Table 14) of the treatment I.

Independent variables viz. Temperature °C, CO2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L an explain 29.3% of the variance in length (*Labeo rohita*) effect, which is not significant as indicated by ANOVA test with F=0.689 and P=.664[a] (table 15).

Table 16. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of length (*Catla catla*) in group I

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.900[a]	.810	.539	7.25805

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1575.605	10	157.561	2.991	.080[b]
	Residual	368.755	7	52.679		
	Total	1944.360	17			

a. Dependent Variable: Length (*Catla catla*)
b. Predictors: (Constant): Temperature °C, DO mg/L, CO2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-172.282	194.945		-0.884	0.406
	Temperature C°	2.016	10.883	0.271	0.185	0.858
	DO mg/L	0.046	8.932	0.001	0.005	0.996
	CO_2 mg/L	10.611	27.602	0.424	0.384	0.712
	pH	-0.873	11.909	-0.034	-0.073	0.944
	Hardness	0.085	0.384	0.057	0.222	0.831
	Alkalinity mg/L	0.466	2.562	0.125	0.182	0.861
	NH_3 mg/L	201.998	1868.955	0.04	0.108	0.917
	Rice polish (kg)	-0.016	0.053	-0.29	-0.299	0.773
	Premix vitamin (kg)	0.521	0.963	0.728	0.541	0.605
	Fishmeal (kg)	6.002	9.723	0.491	0.617	0.557

a. Dependent Variable: Length (*Catla catla*)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Oil Cake (kg)	-237.513[b]	-13.217	.000	-.983	3.250E-006

a. Dependent Variable: Length (*Catla catla*)

b. Predictors in the Model: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

Table 17. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of length (*Catla catla*) in group II

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.544[a]	.296	-.126	7.47880

a. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	235.213	6	39.202	.701	.656[a]
	Residual	559.324	10	55.932		
	Total	794.537	16			

a. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

b. Dependent Variable: Length (*Catla catla*)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	153.376	291.501		.526	.610
	Temperature C°	-.564	2.330	-.142	-.242	.814
	CO2 mg/L	4.420	6.573	.246	.673	.516
	pH	-55.608	67.838	-.766	-.820	.431
	Hardness	.983	.703	.564	1.398	.192
	Alkalinity mg/L	.938	1.257	.620	.746	.473
	NH3 mg/L	154.344	1175.275	.051	.131	.898

a. Dependent Variable: Length (*Catla catla*)

All independent variables viz. Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg) explain 81.0% of the variance in length of (*Catla catla*) effect, which is not significant as indicated by ANOVA test with F=2.991 and P=.080[b] (Table-16) Independent variables viz. Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L an explain 29.3% of the variance in length (*Labeo rohita*) effect, which is not significant as indicated by ANOVA test with F=2.991 and P=.080[b] (table- 16). All independent variable explain 29.6% of the variance in length (*Catla catla*) effect, which is not significant as indicated by ANOVA test with F=0.701 P=.656[a] (Table-17) Standardize correlation *P*-value indicates that none of the independent variable contributes the prediction of length development in case of but explains a non-significant combined influence of predication on the length development of *Catla catla* in both the treatment I and II.

Table 18. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of length (*Cirrhinus mrigala*) in group I

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.898[a]	.806	.528	6.48926

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1222.454	10	122.245	2.903	.085[b]
	Residual	294.773	7	42.110		
	Total	1517.227	17			

a. Dependent Variable: Length (Mrigala)
b. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-170.651	174.295		-.979	.360
	Temperature C°	2.107	9.730	.321	.217	.835
	DO mg/L	.482	7.986	.017	.060	.954
	CO_2 mg/L	9.583	24.678	.434	.388	.709
	pH	-.383	10.648	-.017	-.036	.972
	Hardness	.086	.343	.065	.251	.809
	Alkalinity mg/L	.437	2.291	.133	.191	.854
	NH_3 mg/L	217.687	1670.990	.049	.130	.900
	Rice polish (kg)	-.011	.047	-.223	-.228	.826
	Premix vitamin (kg)	.337	.861	.533	.392	.707
	Fishmeal (kg)	6.934	8.693	.642	.798	.451

a. Dependent Variable: Length (Mrigal)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Oil Cake (kg)	-239.350[b]	-11.758	.000	-.979	3.250E-006

a. Dependent Variable: Length (Mrigal)
b. Predictors in the Model: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

Table 19. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of length (*Cirrhinus mrigala*) in group II

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.541[a]	.293	-.132	7.51198

a. Predictors: (Constant): Temperature C°, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	233.408	6	38.901	.689	.664[a]
	Residual	564.298	10	56.430		
	Total	797.706	16			

a. Predictors: (Constant): Temperature C°, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

b. Dependent Variable: Length (*Cirrhinus mrigala*)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	165.366	292.795		.565	.585
	Temperature C°	-.779	2.340	-.196	-.333	.746
	CO_2 mg/L	4.258	6.602	.237	.645	.533
	pH	-59.811	68.139	-.822	-.878	.401
	Hardness	.861	.706	.493	1.220	.251
	Alkalinity mg/L	1.166	1.263	.769	.923	.378
	NH_3 mg/L	295.091	1180.490	.098	.250	.808

a. Dependent Variable: Length (Mrigala)

All independent variables viz. Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg) an explain 80.6% of the variance in length (*Cirrhinus mrigala*) effect, which is not significant as indicated by ANOVA test with F=2.903 and P=.085[b] (Table-18). In treatment II all independent variable explain 29.3% of the variance of length development in *Cirrhinus mrigala*, which is not significant as indicated by ANOVA test with F=.689 and P=.664[a] (Table- 19) .Temperature °C, CO2 mg/L, pH, Hardness, Alkalinity mg/L, NH3 mg/L were equally influenced the weight (*Catla catla*) in group II, no significance influence was observed in weight *Catla catla* development in group II. Standardized correlation *P*= value indicates that none of the independent variable viz. Temperature C°, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L contributes the prediction of *Cirrhinus mrigala* length development. Those were equally having no significance influence on the length development of *Cirrhinus mrigala* group I treatment and group II treatment.

Table 20. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of weight (*Labeo rohita*) in group I

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945[a]	.892	.738	251.46113

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3658931.191	10	365893.119	5.786	.015[a]
	Residual	442628.884	7	63232.698		
	Total	4101560.075	17			

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).
b. Dependent Variable: Weight (*Labeo rohita*)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2858.993	6754.016		-.423	.685
	Temperature C°	-51.624	377.052	-.151	-.137	.895
	DO mg/L	-75.803	309.447	-.050	-.245	.814
	CO_2 mg/L	232.120	956.288	.202	.243	.815
	pH	-153.469	412.607	-.130	-.372	.721
	Hardness	-1.315	13.299	-.019	-.099	.924
	Alkalinity mg/L	34.864	88.775	.204	.393	.706
	NH_3 mg/L	-14774.155	64751.510	-.064	-.228	.826
	Rice polish (kg)	.128	1.822	.051	.070	.946
	Premix vitamin (kg)	27.736	33.379	.843	.831	.433
	Fishmeal (kg)	24.364	336.867	.043	.072	.944

a. Dependent Variable: Weight (*Labeo rohita*)

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Oil Cake (kg)	-181.016[a]	-21.239	.000	-.993	3.250E-6

a. Predictors in the Model: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).
b. Dependent Variable: Weight (*Labeo rohita*)

Table 21. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of weight (*Labeo rohita*) in group II

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.616[a]	.380	.008	238.33972

a. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	347846.884	6	57974.481	1.021	.465[b]
Residual	568058.212	10	56805.821		
Total	915905.096	16			

a. Dependent Variable: Weight (*Labeo rohita*)

b. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	10181.696	9289.778		1.096	.299
Temperature C°	-34.055	74.241	-.253	-.459	.656
CO_2 mg/L	156.946	209.460	.258	.749	.471
pH	-3320.500	2161.924	-1.346	-1.536	.156
Hardness	15.698	22.405	.265	.701	.499
Alkalinity mg/L	74.856	40.074	1.457	1.868	.091
NH_3 mg/L	23427.473	37454.522	.229	.625	.546

a. Dependent Variable: Weight (*Labeo rohita*)

All independent variables viz. Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg) an explain 89.2% of the variance in weight of *Labeo rohita* effect, which is not significant as indicated by ANOVA test with F=5.786 and P=.015[a] (Table- 20). Standardized correlation *P*= value indicates that none of the independent variable contributes the prediction of weight development of *Labeo rohita* but were equally influenced the weight development in group I treatment and group II treatments, respectively.

All independent variable like Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L in treatment II explain 38.0% of the variance in weight development of *Labeo rohita* effect, which is not significant as indicated by ANOVA test with F=1.021and P=.465[b] (Table- 21) Standardized correlation *P* indicates that no independent variable contributes the prediction of weight development but equally apply a not significant influence on weight development of *Labeo rohita* in two feeding regimes.

Table 22. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of weight (*Catla catla*) in group I

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.936[a]	.876	.698	344.23500

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5836598.766	10	583659.877	4.925	.023[a]
	Residual	829484.171	7	118497.739		
	Total	6666082.937	17			

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

b. Dependent Variable: Weight (*Catla catla*)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2804.137	9245.838		-.303	.770
	Temperature C°	-62.612	516.161	-.144	-.121	.907
	DO mg/L	-98.045	423.613	-.051	-.231	.824
	CO_2 mg/L	363.588	1309.100	.248	.278	.789
	pH	-234.778	564.833	-.156	-.416	.690
	Hardness	-3.173	18.206	-.036	-.174	.867
	Alkalinity mg/L	38.874	121.528	.178	.320	.758
	NH_3 mg/L	-18730.113	88640.884	-.064	-.211	.839
	Rice polish (kg)	-.009	2.495	-.003	-.004	.997
	Premix vitamin (kg)	34.311	45.694	.818	.751	.477
	Fishmeal (kg)	65.322	461.151	.091	.142	.891

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.936[a]	.876	.698	344.23500

a. Dependent Variable: Weight (*Catla catla*)

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Oil Cake (kg)	-195.184[a]	-34.955	.000	-.998	3.250E-6

a. Predictors in the Model: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

b. Dependent Variable: Weight (*Catla catla*)

Table 23. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of weight (*Catla catla*) in group II

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.586[a]	.343	-.051	258.01288

a. Predictors: (Constant): Temperature C°, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	347762.907	6	57960.485	.871	.548[b]
	Residual	665706.470	10	66570.647		
	Total	1013469.377	16			

a. Dependent Variable: Weight (*Catla catla*)

c. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9767.269	10056.579		.971	.354
	Temperature C°	-43.259	80.369	-.305	-.538	.602
	CO2 mg/L	173.435	226.749	.271	.765	.462
	pH	-3212.145	2340.374	-1.238	-1.372	.200
	Hardness	22.336	24.254	.359	.921	.379
	Alkalinity mg/L	69.665	43.382	1.289	1.606	.139
	NH3 mg/L	20568.189	40546.113	.192	.507	.623

a. Dependent Variable: Weight (*Catla catla*)

All independent variables viz. Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg) an explain 87.6% of the variance in effect in weight development of *Catla catla*, which is not significant as indicated by ANOVA test with F=4.925 and P=.023[a] (Table- 22).

All independent variable like Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L in treatment II, explain 38.0% of the variance in weight development of *Catla catla* effect, which is not significant as indicated by ANOVA test with F=.871 and P=.548[b] (Table- 23)

Table 24. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of weight (*Cirrhinus mrigala*) in group I

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945[a]	.892	.739	238.91115

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3312587.228	10	331258.723	5.804	.015[a]
	Residual	399549.749	7	57078.536		
	Total	3712136.976	17			

a. Predictors: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945[a]	.892	.739	238.91115

b. Dependent Variable: Weight (*C. mrigala*)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2705.927	6416.935		-.422	.686
	Temperature C°	-46.010	358.234	-.142	-.128	.901
	DO mg/L	-72.366	294.003	-.050	-.246	.813
	CO_2 mg/L	243.585	908.561	.223	.268	.796
	pH	-162.814	392.014	-.145	-.415	.690
	Hardness	-1.573	12.635	-.024	-.124	.904
	Alkalinity mg/L	32.947	84.344	.203	.391	.708
	NH_3 mg/L	-15454.446	61519.877	-.071	-.251	.809
	Rice polish (kg)	.187	1.731	.079	.108	.917
	Premix vitamin (kg)	25.416	31.713	.812	.801	.449
	Fishmeal (kg)	25.562	320.055	.048	.080	.939

a. Dependent Variable: Weight (Mrigala)

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Oil Cake (kg)	-181.173[a]	-25.994	.000	-.996	3.250E-6

a. Predictors in the Model: (Constant): Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg).

b. Dependent Variable: Weight (*Cirrhinus mrigala)*

Table 25. Regression analysis for physico-chemical effectors (fertilizer, water quality and feed) of weight (*Cirrhinus mrigala*) in group II

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.644[a]	.415	.063	217.48167

a. Predictors: (Constant): Temperature C°, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	334960.724	6	55826.787	1.180	.389[b]
	Residual	472982.787	10	47298.279		
	Total	807943.510	16			

a. Dependent Variable: Weight (*C.mrigala*)

b. Predictors: (Constant): Temperature °C, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10481.487	8476.793		1.236	.245
	Temperature C°	-27.810	67.744	-.220	-.411	.690
	CO_2 mg/L	147.087	191.129	.257	.770	.459
	pH	-3371.006	1972.725	-1.455	-1.709	.118
	Hardness	16.466	20.444	.296	.805	.439
	Alkalinity Mg/L	74.141	36.567	1.537	2.028	.070
	NH_3 mg/L	20445.439	34176.730	.213	.598	.563

a. Dependent Variable: Weight (*C.mrigala*)

All independent variables viz. Temperature °C, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg) an explain 89.2% of the variance in weight of *Cirrhinus mrigala* effect, which is not significant as indicated by ANOVA test with F=5.804, p=0.015[a] (Table 24) All independent variable of group II group explain 34.3% of the variance in weight (prediction of *Cirrhinus mrigala* effect, which is not significant as indicated by ANOVA test with F=1.180 and P=0.389[b] (Table 25) indicates that no independent variable contributes the prediction of weight prediction of *Cirrhinus mrigala*. Temperature, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L were equally influenced the weight prediction of *Cirrhinus mrigala* in group II.

5.3.4. Biological parameters

5.3.4.1. Plankton

Plankton population was studied during the investigation period from December 2013 to May 2015. Phytoplankton population was mainly composed of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. The zooplankton population included Rotifers, Cladocera, Copepoda, Nauplius and Ostracoda. A brief description of the pattern of monthly abundance of plankton population of pond water is presented below:

5.3.4.1.1. Phytoplankton

During the time of investigation different phytoplankton taxa were recorded. The highest number of taxa belongs to Chlorophyceae (47.05%), Cyanophyceae (23.52%), Euglenophyceae (17.64%) and Bacillariophyceae (11.76%). The monthly abundance of phytoplankton shown in Table 26, 27 and Fig. 28 and 29.

In treatment I, the average monthly abundance of phytoplankton was about 627.44/l. The highest density was recorded as 2000/l in March 2014 and the lowest 60/l in January 2015. The second pick of phytoplankton was found in May 2015. The average monthly abundance of phytoplankton was about 908.38/l in treatment II. The highest density was recorded as 1780/l in May 2015 and the lowest 510/l in September 2014 (Fig. 28).

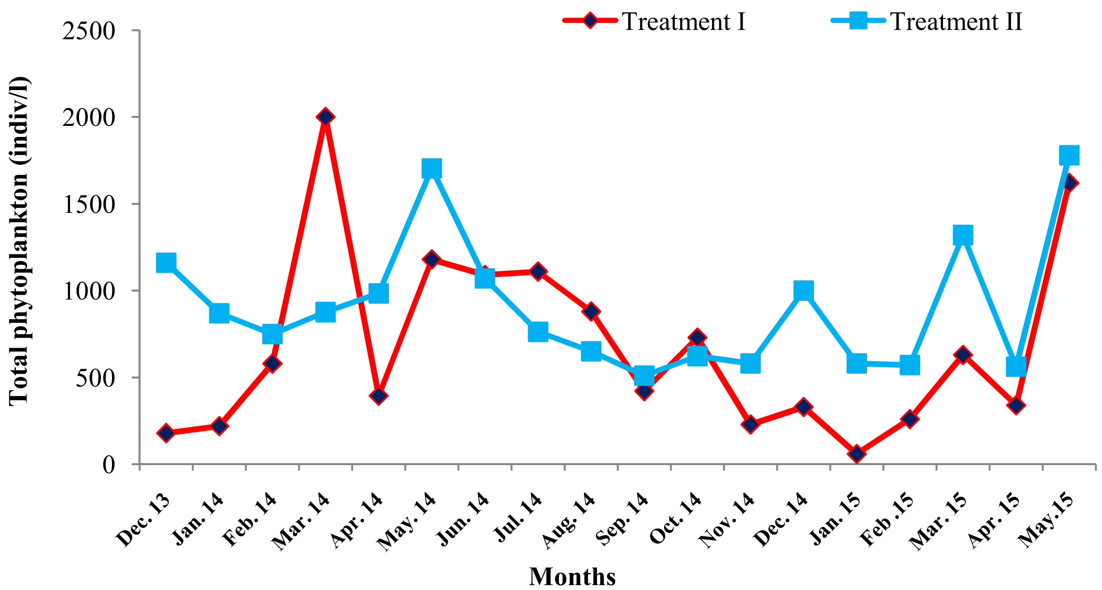

Fig. 28. Monthly abundance of total phytoplankton (indiv/l) in treatment I and treatment II

5.3.4.1.1.a. Chlorophyceae

The Chlorophyceae were the most dominating group among the phytoplankton which occupied 47.05% of total phytoplankton. In treatment I, the maximum number of Chlorophyceae (680/l) found in March 2014 which accounted for 34.00% of the monthly production. The minimum number (10/l) was recording in April 2015, which was 2.94% of the monthly production (Table 26 and Fig. 29). In treatment II, the maximum number of

Chlorophyceae was 900/l found in May 2014 which accounted for 52.82% of the monthly production. The minimum number 80/l was recording in April 2015, which was 10.48% of the monthly production (Table 27 and Fig. 30).

5.3.4.1.1.b. Cyanophyceae

The Cyanophyceae constituted the second dominant group which was 23.53% of the total phytoplankton. The peak (500/l) was found in March 2014 which was 25.00% of the monthly production while the lowest number was to be 20/l (July 2014) and it was 13.61% of the monthly production (Table 26 and Fig 29), respectively in treatment I. In treatment II, the maximum number 690/l was found in May 2015 and it was the 38.76% of the monthly production. The minimum number of Cyanophyceae was 40/l in the month of December 2014 and January 2015 which was 4.00% and 6.89% of the monthly production (Fig. 29, 30 and Table 26).

Table 26. Showing the percentage composition of different phytoplankton group in treatment I

Months	Groups				Total
	Chlorophyceae	Cyanophyceae	Euglenophyceae	Bacillariophyceae	
Dec. ’13	55.56	0	44.44	0	100
Jan.’14	50.00	22.73	27.27	0	100
Feb.’14	6.89	6.89	44.83	41.38	100
Mar.’14	34.00	25.00	18.00	23.00	100
Apr.’14	50.63	12.66	15.19	21.52	100
May.’14	33.05	38.98	27.97	0	100
Jun.’14	28.44	9.17	27.52	34.86	100
Jul.’14	0	13.61	13.61	72.79	100
Aug.’14	25.00	9.09	0	65.91	100
Sep.’14	16.59	52.61	21.32	9.47	100
Oct.’14	4.11	10.96	4.11	80.82	100
Nov. ’14	30.43	52.17	13.04	4.35	100
Dec. ’14	33.33	21.21	42.44	3.03	100
Jan.’15	66.66	0	33.33	0	100
Feb.’15	30.78	38.46	30.78	0	100
Mar.’15	20.63	0	79.37	0	100
Apr.’15	2.94	30.88	66.18	0	100
May.’15	25.93	29.01	30.25	14.81	100
Mean	25.52	20.74	29.98	20.66	
Sd	18.62	16.81	21.01	27.38	

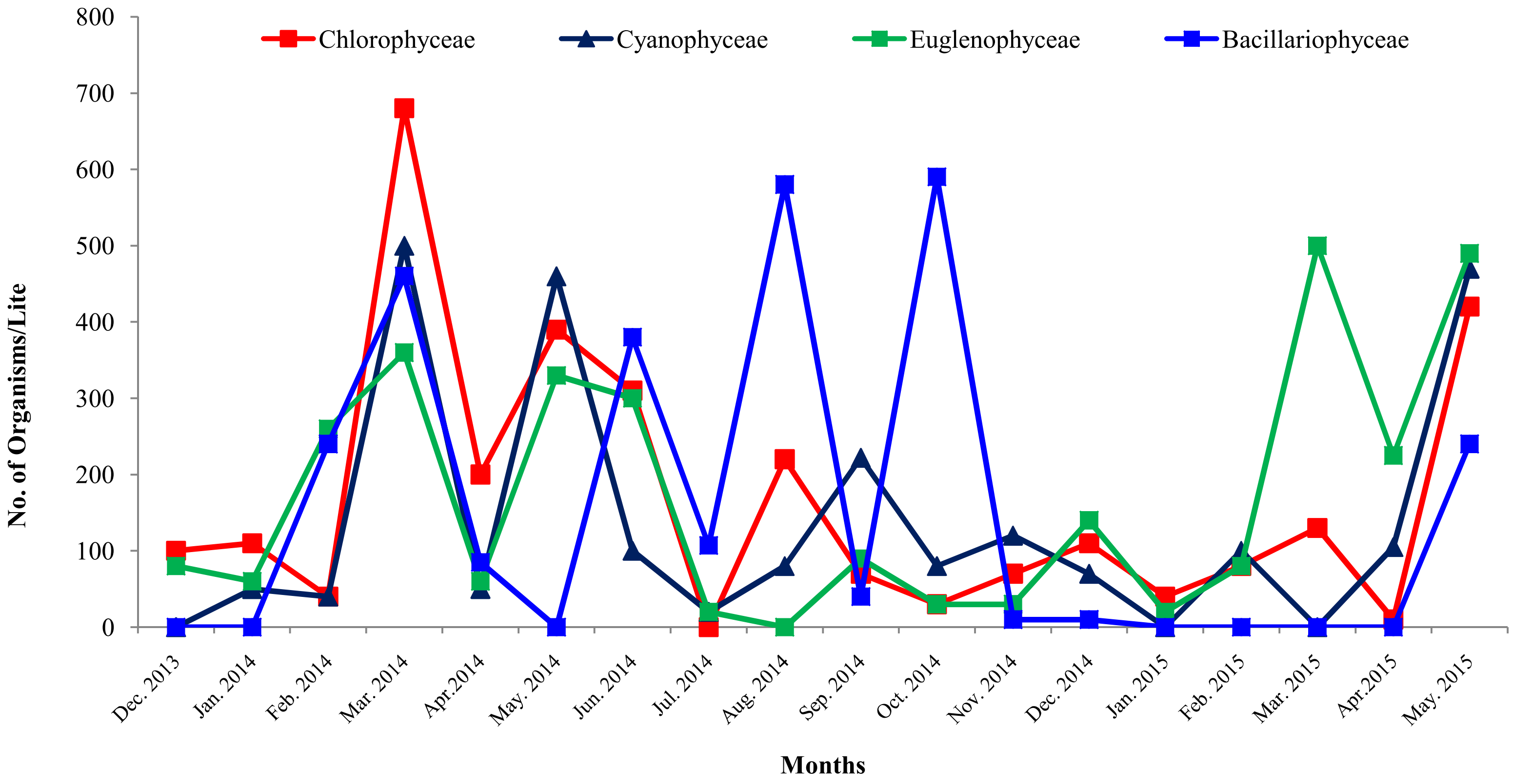

Fig. 29. Showing the monthly abundance (indi/l) of different phytoplankton in treatment I

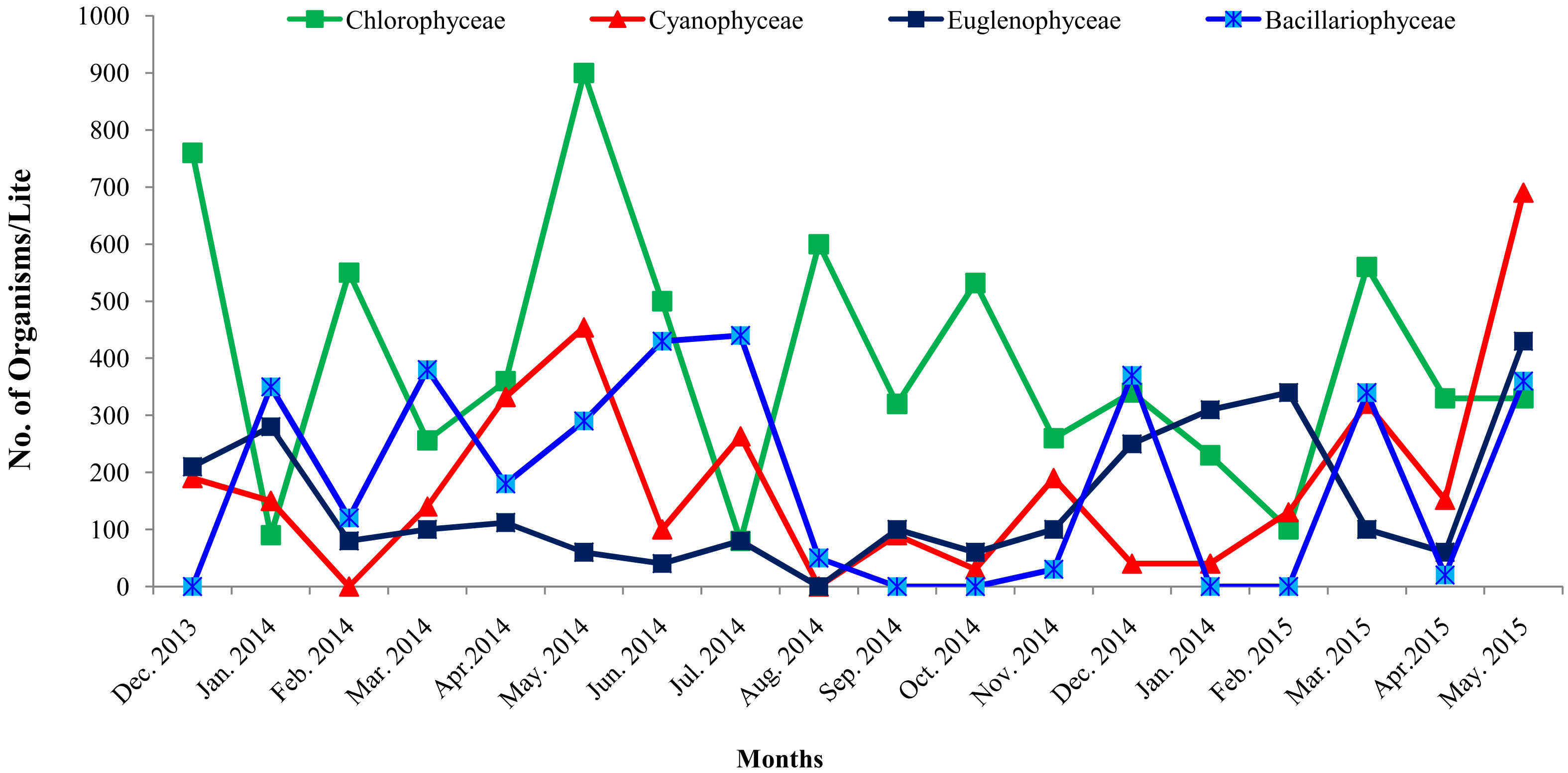

Fig. 30. Showing the monthly abundance (indi/l) of different phytoplankton group in treatment II

5.3.4.1.1.c. Euglenophyceae

This was the third dominating group which 11.76% of the total phytoplankton. The pick was found in October 2014 (590/l) which was 79.37% of the monthly production. The lowest numbers were recorded during July 2014 and January 2015 and occupied 13.61% and 33.33% of the monthly production (Table 26 and Fig. 29) in treatment I. In treatment II, the maximum number (430/l) was found during May 2015 which was 24.16% of the monthly production. The minimum number (40/l) was found in June 2014 which was 3.74% of the monthly production.

Table 27. Showing the percentage composition of different phytoplankton group in treatment II

Months	Groups				Total
	Chlorophyceae	Cyanophyceae	Euglenophyceae	Bacillariophyceae	
Dec. ’13	65.52	16.38	18.10	0	100
Jan.’14	10.34	17.24	22.18	40.23	100
Feb.’14	73.33	0	10.66	16	100
Mar.’14	29.22	15.98	11.42	43.38	100
Apr.’14	36.59	33.74	11.38	18.29	100
May.’14	52.82	26.64	3.52	17.02	100
Jun.’14	46.73	9.35	3.74	40.19	100
Jul.’14	10.48	34.47	10.48	57.67	100
Aug.’14	92.31	0	0	7.69	100
Sep.’14	62.75	17.65	19.61	0	100
Oct.’14	85.53	4.82	9.65	0	100
Nov. ’14	44.83	32.76	17.24	5.17	100
Dec. ’14	34.00	4.00	25.00	37	100
Jan.’15	39.66	6.89	53.44	0	100
Feb.’15	17.54	22.81	59.65	0	100
Mar.’15	42.42	24.24	7.58	25.76	100
Apr.’15	58.72	27.05	10.68	3.56	100
May.’15	18.53	38.76	24.16	20.22	100
Mean	**45.62**	**18.48**	**17.69**	**18.45**	**-**
Sd	**24.23**	**12.38**	**15.83**	**18.36**	**-**

5.3.4.1.1.d. Bacillariophyceae

This was the fourth dominating group which 17.65%of the total phytoplankton. The pick was found in March 2015 (500/l) which was 80.82% of the monthly production. The lowest numbers were recorded in November and December 2014 and occupied 4.35% and 3.03% of the monthly production (Table 26 and Fig. 29) in treatment I. The maximum number (440/l) was found during July 2014 which was 57.67% of the monthly production. The minimum number (20/l) was found in April 2015 which was 3.56% of the monthly production (Table 27 and Fig. 30).

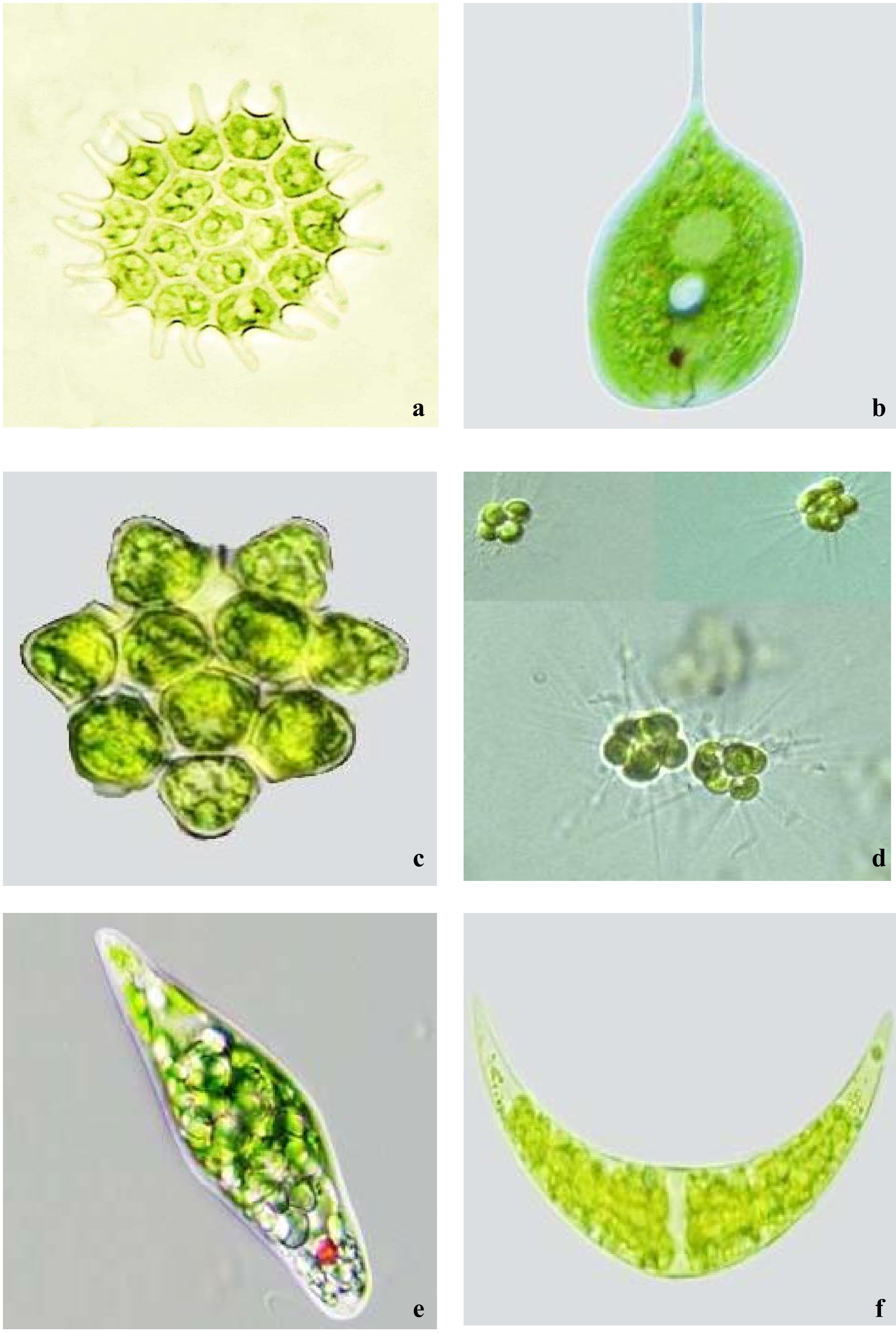

Plate 21. Photographs of *Pediastrum* sp. (a), *Phacus* sp. (b), *Coelastrum* sp. (c), *Micractinium* sp. (d), *Euglena* sp. (e) and *Clasterium* sp. (f)

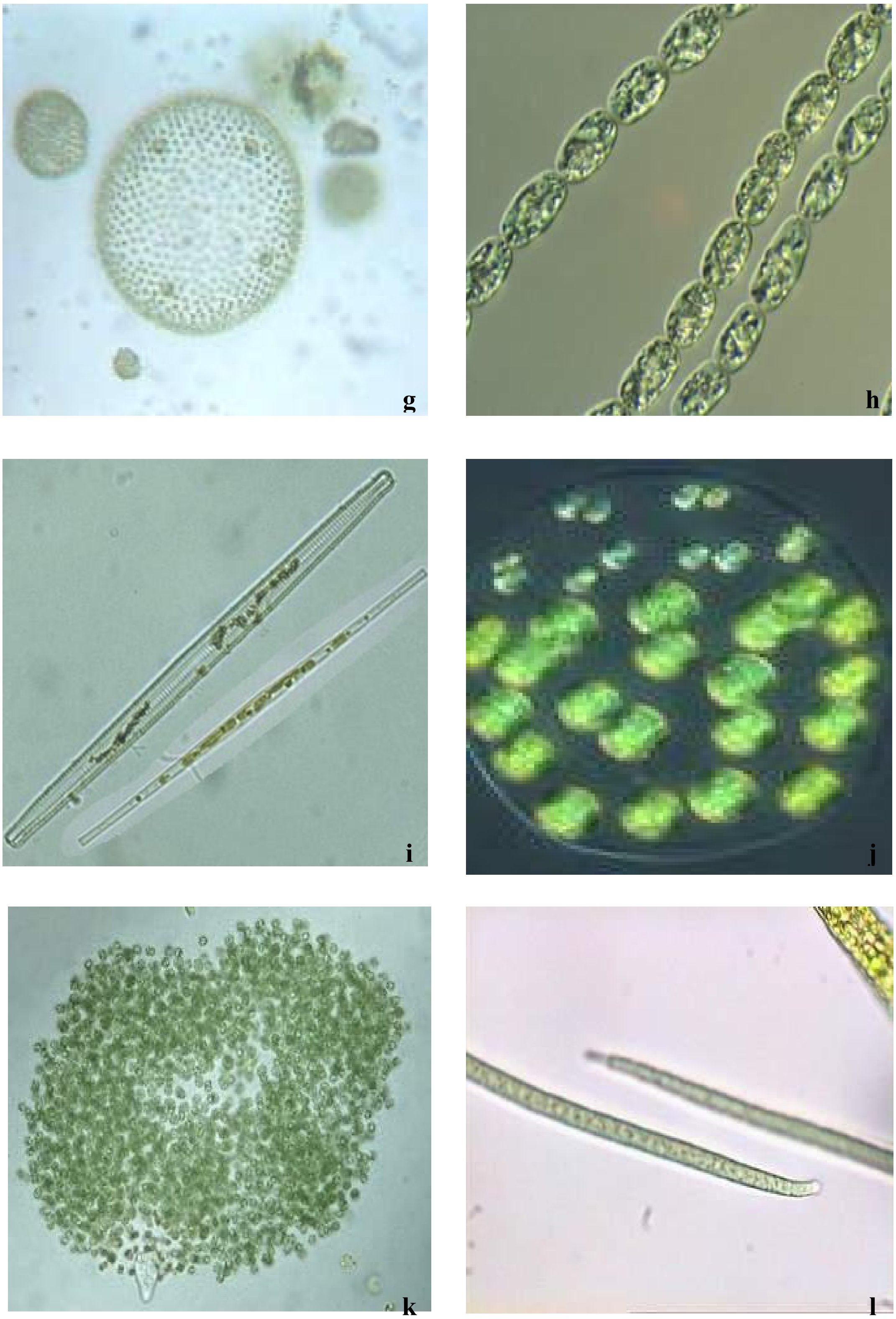

Plate 22. Photographs of *Volvox* sp. (g), *Melosira* sp. (h), *Synedra* sp. (i), *Pleodorina* sp. (j), *Microcystis* sp. (k) and *Oscilla* sp. (l)

5.3.4.1.2. Zooplankton

In the present study monthly abundance of zooplankton and their qualitative and quantitative observation were made. The zooplankton abundance was shown in Table 28, 29 and Fig. 31 and 32 while Fig. 28 and 29 provide data on percent contribution on different groups of zooplankton in the total zooplankton community in every month.

In treatment I, the average monthly abundance of zooplankton was about 556.19/l. The highest density was recorded as 668.7/l in April 2014 and the lowest 390/l in June 2014. The second pick of zooplankton was found 666/l in December 2014. The average monthly abundance of zooplankton was about 671.75/l in treatment II. The highest density was recorded as 907.2/l in October 2014 and the lowest 374.7/l in July 2014 (Fig. 33). The major groups of zooplankton are represented by Rotifers, Cladocera, Copepoda, Ostracoda and Nauplius. The detailed results are described below.

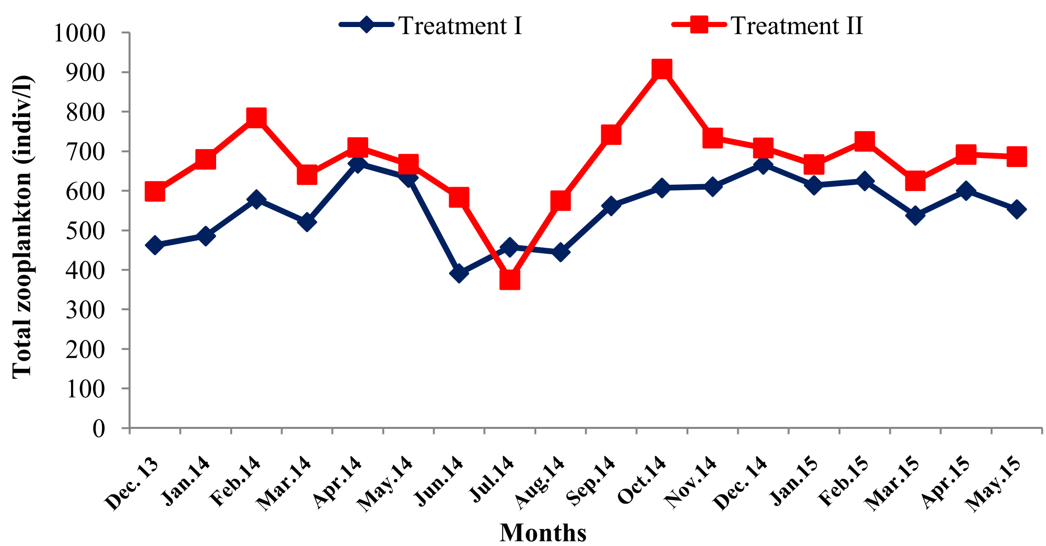

Fig. 31. Monthly abundance of total zooplankton (indiv/l) in treatment I and treatment II

5.3.4.1.2.a. Rotifers

The Rotifers were the most dominating group among the zooplankton which occupied 40% of total phytoplankton (Fig. 31). In treatment I, the maximum number of Rotifers (309.6/l) found in November 2014 which accounted for 50.75% of the monthly production. The minimum number (96.2/l) was recording in July 2014, which was 21.05% of the monthly production (Table 28 and Fig. 32). In treatment II, the maximum number of Rotifers was 349.9/l found in November 2014 which accounted for 47.74% of the monthly production. The minimum number 91.6/l was recording in July 2014, which was 24.45% of the monthly production (Table 29 and Fig. 33).

5.3.4.1.2.b. Cladocera

The Cladocera constituted the second dominant group which was 26.67% of the total zooplankton (Fig 31). The peak (309/l) was found in November 2014 which was 25.00% of the monthly production while the lowest number was to be 40.5/l (June 2014) and it was 10.36% of the monthly production (Table 28 and Fig 32), respectively in treatment I. In treatment II, the maximum number 120.1/l was found in December 2013 and it was the 20.09% of the monthly production. The minimum number of Cladocera was 42.9/l in the month of July 2014 which was 6.65% of the monthly production (Table 29 and Fig. 33).

Table 28. Showing the percentage composition of different zooplankton group in treatment I

Months	Rotifers	Cladocera	Copepoda	Ostracoda	Nauplius	Total
Dec. 13	33.35	21.93	23.70	9.26	11.75	100
Jan.14	39.57	16.63	25.76	4.51	13.42	100
Feb.14	30.81	11.81	20.62	23.25	13.51	100
Mar.14	29.71	9.68	25.98	28.44	11.95	100
Apr.14	43.64	13.65	20.88	9.57	12.26	100
May.14	31.34	17.64	21.27	20.57	8.91	100
Jun.14	26.74	10.36	37.33	5.81	19.75	100
Jul.14	21.05	25.59	29.63	4.92	18.80	100
Aug.14	30.27	24.12	26.17	3.74	15.71	100
Sep.14	36.71	25.25	24.97	3.40	9.58	100
Oct.14	28.25	18.17	16.02	6.16	11.40	100
Nov.14	50.75	11.62	17.28	12.89	7.46	100
Dec. 14	31.53	24.04	19.16	16.24	8.99	100
Jan.15	39.36	12.75	23.23	19.54	11.21	100
Feb.15	32.28	11.03	19.79	24.02	12.87	100
Mar.15	27.98	14.99	25.95	19.25	11.82	100
Apr.15	34.76	11.54	24.24	16.37	13.09	100
May.15	23.64	21.31	23.36	20.95	10.73	100
Mean	**32.87**	**16.78**	**23.63**	**13.82**	**12.40**	
Sd	**7.17**	**6.71**	**4.46**	**8.10**	**3.17**	

5.3.4.1.2.c. Copepoda

This was the third dominating group which 13.33% of the total zooplankton (Fig 31). The pick was found in June 2014 (145.9/l) which was 37.33% of the monthly production. The lowest number 97.2 was recorded during October 2014 and occupied 16.02% of the monthly production (Table 28 and Fig. 32) in treatment I. In treatment II, the maximum number (1258.3/l) was found during June 2014 which was 44.25% of the monthly production. The minimum numbers (75.00/l) were found in November 2014 and January 2015 which was 10.59% and 11.26% of the monthly production (Table 29 and Fig. 33).

5.3.4.1.2.d. Ostracoda

This was also the third dominating group which 13.33%of the total zooplankton (Fig 31). The pick was found in February 2015 (150.00/l) which was 24.02% of the monthly production. The maximum number (161.3/l) was found during February 2014 which was 20.58% of the monthly production. The minimum number (22.5/l) was found in December 2013 which was 3.76% of the monthly production (Table 29 and Fig. 33).

Table 29. Showing the percentage composition of different zooplankton group in treatment II

Months	Rotifers	Cladocera	Copepoda	Ostracoda	Nauplius	Total
Dec. 13	30.48	20.09	26.83	3.76	18.83	**100**
Jan.14	35.45	14.05	14.99	16.19	19.31	**100**
Feb.14	32.51	11.49	14.31	20.58	21.10	**100**
Mar.14	26.72	12.55	16.46	24.13	20.14	**100**
Apr.14	42.59	14.30	16.34	11.02	15.19	**100**
May.14	30.17	18.41	21.11	16.52	13.78	**100**
Jun.14	24.27	11.42	44.25	4.29	15.71	**100**
Jul.14	24.45	6.64	37.79	0	13.12	**100**
Aug.14	21.73	21.73	28.99	0	27.54	**100**
Sep.14	35.94	17.94	26.98	0	19.10	**100**
Oct.14	36.71	12.84	23.87	2.75	23.87	**100**
Nov.14	47.74	12.48	12.49	6.81	20.46	**100**
Dec. 14	41.15	21.19	10.59	11.77	15.30	**100**
Jan.15	38.78	13.76	11.26	17.42	18.77	**100**
Feb.15	37.92	12.64	8.03	19.54	21.85	**100**
Mar.15	30.67	15.98	5.99	21.34	16.01	**100**
Apr.15	45.37	13.25	14.43	10.83	18.08	**100**
May.15	25.98	19.42	27.85	14.58	12.15	**100**
Mean	**33.81**	**15.01**	**20.14**	**11.19**	**18.35**	
Sd	**7.62**	**4.01**	**10.38**	**8.04**	**3.93**	

5.3.4.1.2.e. Nauplius

The Nauplius constituted the fourth dominant group which was 6.67% of the total zooplankton (Fig 31). The peak (85.9/l) was found in July 2014 which was 18.80% of the monthly production while the lowest number was to be 45.5/l (November 2014) and it was

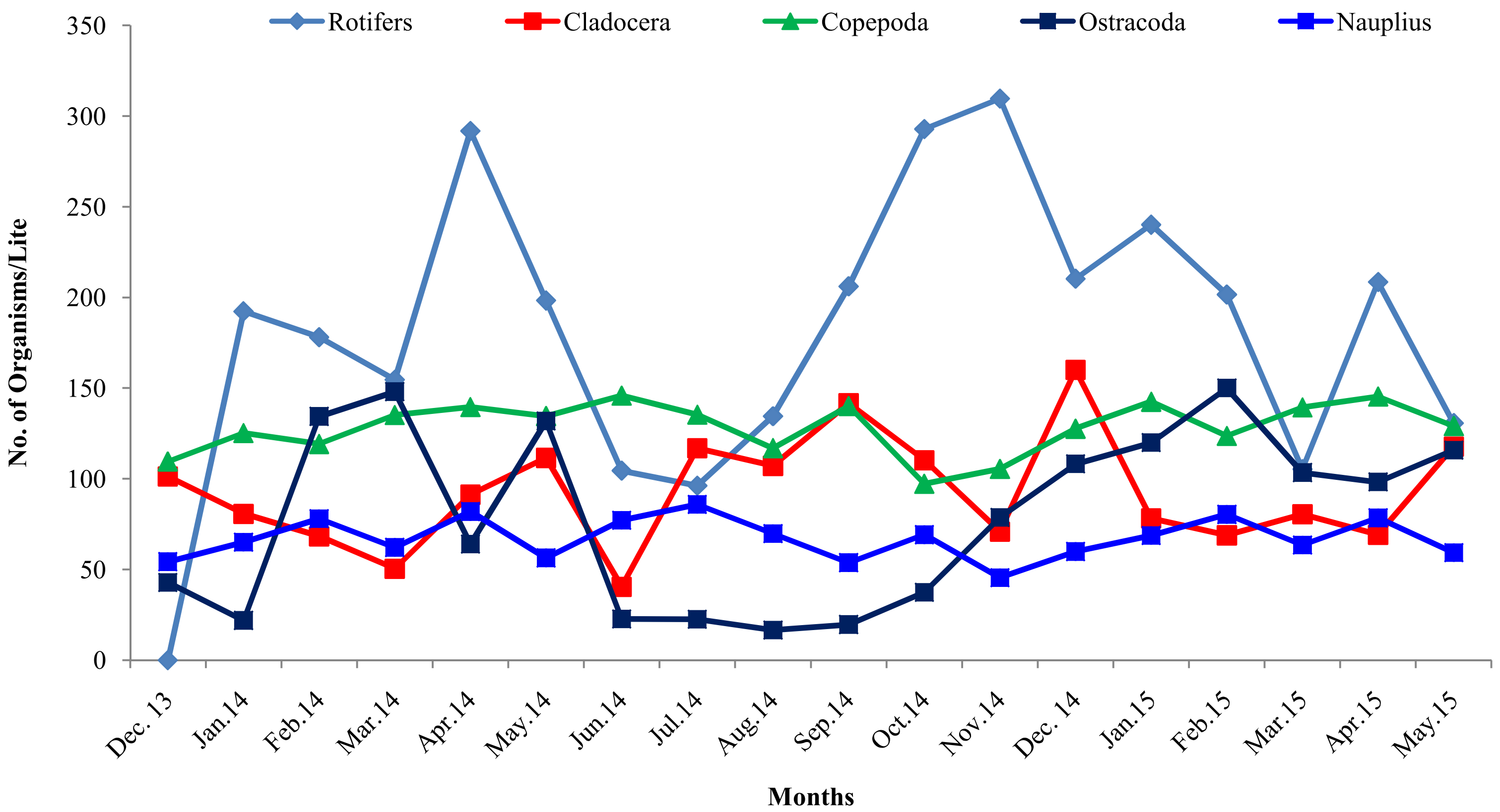

Fig. 32. Showing the monthly abundance (indi/l) of different zooplankton group in treatment I

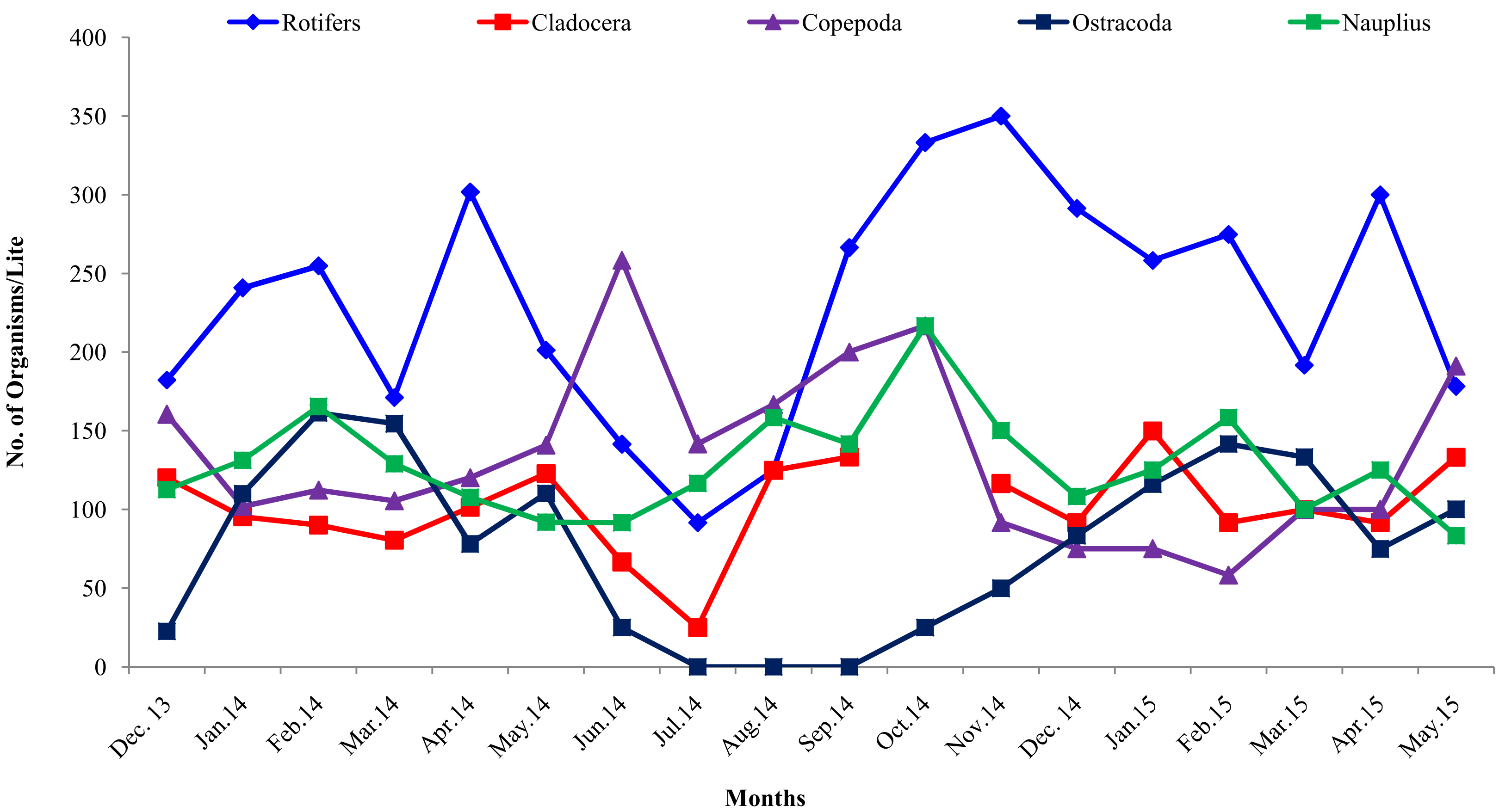

Fig. 33. Showing the monthly abundance (indi/l) of different zooplankton group in treatment II

7.46% of the monthly production (Table 28 and Fig 32) in treatment I. The maximum number 216.6/l was found in October 2014 and it was the 23.87% of the monthly production. The minimum number of Nauplius was 83.3/l in the month of May 2015 which was 12.15% of the monthly production in treatment II (Table 29 and Fig. 33).

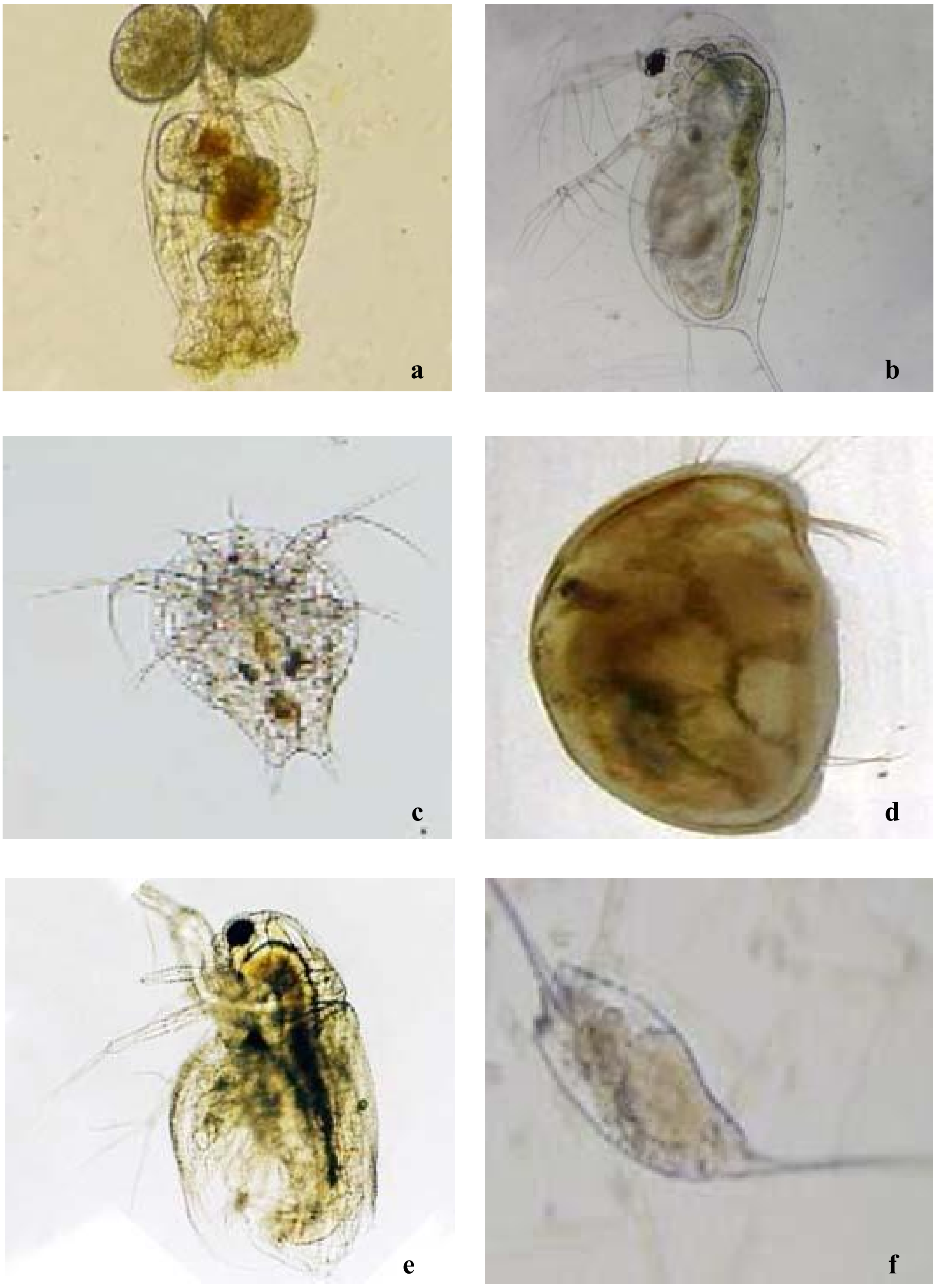

Plate 23. Photographs of *Brachionus* sp. (a), *Keratella* sp. (b), *Nauplis* sp. (c), *Heterocypris* sp. (d), *Moina* sp. (e) and *Filinia* sp. (f)

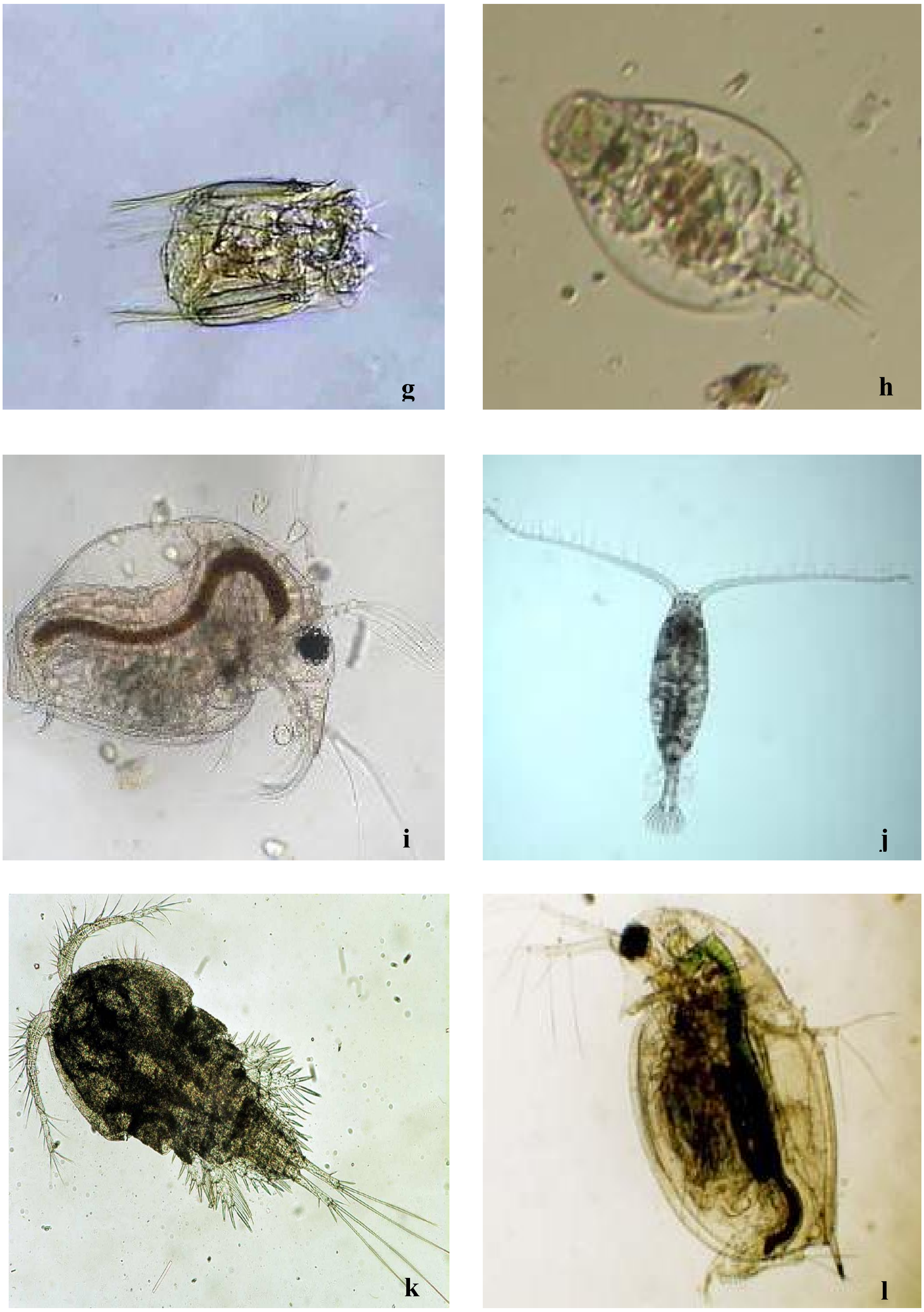

Plate 24. Photographs of *Polyarthra* sp. (g), *Synedra* sp. (h), *Bosmina* sp. (i), *Diaptomus* sp. (j), *Cyclops* sp. (k) and *Daphnia* sp. (l)

Table 30. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of length (*Labeo rohita*) in group I

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.636[a]	.404	-.192	10.55344

a. predictors: (constant): Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

ANOVA

model		the sum of squares	df	mean square	F	P
1	regression	603.875	8	75.484	.678	.702[b]
	residual	891.000	8	111.375		
	total	1494.875	16			

a. dependent variable: length (*Labeo rohita*)

b. predictors: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant)	-991.516	663.902		-1.493	.174
	chlorophyceae	-.221	.192	-.409	-1.151	.283
	cyanophyceae	-.021	.240	-.037	-.087	.933
	euglenophyceae	-.122	.221	-.257	-.552	.596
	rotifers	10.267	6.673	7.966	1.539	.162
	cladocera	10.230	6.504	5.826	1.573	.154
	Copepoda	11.328	7.497	5.565	1.511	.169
	ostracoda	10.832	6.969	8.528	1.554	.159
	nauplius	8.191	5.917	2.413	1.384	.204

a. dependent variable: length (*Labeo rohita*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	bacillariophyceae	.[b]	.	.	.	.000

a. dependent variable: length (*Labeo rohita*)

b. predictors in the model: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 40.4% of the variance in length (*Labeo rohita*) effect, which is not significant as indicated by ANOVA test with F=.678 an examination of p=.702[b] (Table- 30) indicates that no independent Biological Effectors contributes the prediction of length (*Labeo rohita*). Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda, and nauplius have equally influenced the length (*Labeo rohita*) in group I, no significance influence was observed in length (*Labeo rohita*) development in group I and Bacillariophyceae had no influence CST= .000, where the variable was excluded from the model.

Table 31. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of length (*Labeo rohita*) in group II

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.716[a]	.513	-.044	7.54347

a. predictors: (constant): Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

anova[a]

model		the sum of squares	df	mean square	F	p
1	regression	419.567	8	52.446	.922	.550[b]
	residual	398.328	7	56.904		
	total	817.895	15			

a. dependent variable: length (*Labeo rohita*)

b. predictors: (constant):

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant) *******	-1842.059	1720.795		-1.070	.320
	cyanophyceae	.166	.204	.267	.814	.442
	euglenophyceae	.164	.157	.368	1.048	.330
	bacillariophyceae	-.099	.140	-.240	-.710	.501
	rotifers	18.963	17.380	18.769	1.091	.311
	cladocera	18.501	17.054	10.621	1.085	.314
	Copepoda	18.929	17.235	23.888	1.098	.308
	ostracoda	18.740	17.197	17.265	1.090	.312
	nauplius	17.580	17.007	8.784	1.034	.336

a. dependent variable: length (*Labeo rohita*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	chlorophyceae	91.030[b]	.681	.521	.268	4.215e-006

a. dependent variable: length (*Labeo rohita*)

b. predictors in the model: (constant): cyanophyceae, euglenophyceae, bacillariophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 51.3% of the variance in length (*Labeo rohita*) effect, which is no significant as indicated by ANOVA test with F=.922 and P=.550[b] (Table- 31) indicates that no independent Biological Effectors contributes the prediction of length (*Labeo rohita*). (constant): Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, ostracoda, and nauplius were equally influenced the length (*Labeo rohita*) in group II.

Table 32. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of length (*Catla catla*) in group I

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.637[a]	.405	-.189	12.00443

a. predictors: (constant): Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

anova[a]

model		the sum of squares	df	mean square	f	sig.
1	regression	785.928	8	98.241	.682	.700[b]
	residual	1152.850	8	144.106		
	total	1938.778	16			

a. dependent variable: length (*Catla catla*)

b. predictors: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant)	-1083.960	755.182		-1.435	.189
	chlorophyceae	-.218	.218	-.354	-.999	.347
	cyanophyceae	-.005	.274	-.007	-.017	.987
	euglenophyceae	-.085	.251	-.157	-.337	.744
	rotifers	11.178	7.591	7.616	1.473	.179
	cladocera	11.126	7.398	5.564	1.504	.171
	Copepoda	12.227	8.527	5.274	1.434	.190
	ostracoda	11.828	7.927	8.177	1.492	.174
	nauplius	9.057	6.730	2.343	1.346	.215

a. dependent variable: length (*Catla catla*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	bacillariophyceae	.[b]	.	.	.	.000

a. dependent variable: length (*Catla catla*)

b. predictors in the model: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 40.5% of the variance in length (*Catla catla*) effect, which is not significant as indicated by ANOVA test with F=.682 an examination of p=.700[b] (Table- 32) indicates that no independent Biological Effectors contributes the prediction of length (*Catla catla*). Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influenced the length (*Catla catla*) in group I.

Table 33. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of length (*Catla catla*) in group II

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.705[a]	.497	-.079	7.63192

a. predictors: (constant): Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

anova[a]

model		the sum of squares	df	mean square	f	sig.
1	regression	402.374	8	50.297	.864	.583[b]
	residual	407.724	7	58.246		
	total	810.098	15			

a. dependent variable: length (*Catla catla*)
b. predictors: (constant): cyanophyceae, euglenophyceae, bacillariophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant) *********	-1926.945	1740.972		-1.107	.305
	cyanophyceae	.157	.206	.254	.762	.471
	euglenophyceae	.174	.159	.391	1.095	.310
	bacillariophyceae	-.090	.141	-.217	-.634	.546
	rotifers	19.835	17.584	19.726	1.128	.296
	cladocera	19.343	17.254	11.157	1.121	.299
	Copepoda	19.758	17.437	25.052	1.133	.294
	ostracoda	19.541	17.399	18.090	1.123	.298
	nauplius	18.453	17.206	9.264	1.072	.319

a. dependent variable: length (*Catla catla*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	chlorophyceae	84.949[b]	.621	.557	.246	4.215e-006

a. dependent variable: length (*Catla catla*)

b. predictors in the model: (constant): cyanophyceae, euglenophyceae, bacillariophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 49.7% of the variance in length (*Catla catla*) effect, which is not significant as indicated by ANOVA test with F=.864 an examination of P=0.583[b] (Table- 33) indicates that no independent Biological Effectors contributes the prediction of length (*Catla catla*) Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influence the length (*Catla catla)* in group II.

Table 34. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of length (*Cirrhinus mrigala*) in group I

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.635[a]	.404	-.193	10.62842

a. predictors: (constant): Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

anova[a]

model		the sum of squares	df	mean square	f	sig.
1	regression	611.802	8	76.475	.677	.703[b]
	residual	903.707	8	112.963		
	total	1515.509	16			

a. dependent variable: length (mrigala)

b. predictors: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant)	-969.868	668.619		-1.451	.185
	chlorophyceae	-.217	.193	-.397	-1.120	.295
	cyanophyceae	-.008	.242	-.015	-.035	.973
	euglenophyceae	-.096	.222	-.202	-.433	.676
	rotifers	10.045	6.721	7.740	1.495	.173
	cladocera	9.990	6.550	5.651	1.525	.166
	Copepoda	11.047	7.550	5.390	1.463	.182
	ostracoda	10.590	7.018	8.280	1.509	.170
	nauplius	8.080	5.959	2.364	1.356	.212

a. dependent variable: length (mrigala)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	bacillariophyceae	.[b]	.	.	.	.000

a. dependent variable: length (mrigala)

b. predictors in the model: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 40.4% of the variance in length (*Cirrhinus mrigala*) effect, which is no significant as indicated by ANOVA test with F=.677 an examination of p=.703[b] (Table- 34) indicates that no independent Biological Effectors contributes the prediction of length of (*Cirrhinus mrigala*) Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, ostracoda, and nauplius were equally influence the length (*Cirrhinus mrigala*) in group I, no significance influence was observed in length (*Cirrhinus mrigala*) development in group I and Bacillariophyceae had no influence CST=.000(Table - 34), where the variable was excluded from the model.

Table 35. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of length (*Cirrhinus mrigala*) in group II

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.715[a]	.512	-.046	7.51454

a. predictors: (constant): Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

anova[a]

model		the sum of squares	df	mean square	f	sig.
1	regression	414.308	8	51.789	.917	.552[b]
	residual	395.278	7	56.468		
	total	809.587	15			

a. dependent variable: length (mrigala)
b. predictors: (constant):

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant) **********	-1800.027	1714.195		-1.050	.329
	cyanophyceae	.161	.203	.261	.794	.453
	euglenophyceae	.163	.156	.368	1.046	.330
	bacillariophyceae	-.101	.139	-.245	-.725	.492
	rotifers	18.539	17.313	18.443	1.071	.320
	cladocera	18.082	16.989	10.433	1.064	.323
	Copepoda	18.502	17.169	23.467	1.078	.317
	ostracoda	18.323	17.131	16.967	1.070	.320
	nauplius	17.167	16.942	8.621	1.013	.345

a. dependent variable: length (mrigala)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	chlorophyceae	88.873[b]	.663	.532	.261	4.215e-006

a. dependent variable: length (*C. mrigala*)

b. predictors in the model: (constant): cyanophyceae, euglenophyceae, bacillariophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 52.1% of the variance in length (*Cirrhinus mrigala*) effect, which is not significant as indicated by ANOVA test with F=.917 an examination of p=.552[b] (Table- 35) indicates that no independent Biological Effectors contributes the prediction of length (*Cirrhinus mrigala*) Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influence the length (*Cirrhinus mrigala*) in group II.

Table 36. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of weight (*Labeo rohita*) in group I

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.654[a]	.427	-.145	533.60193

a. predictors: (constant): Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

anova[a]

model		the sum of squares	df	mean square	F	P
1	regression	1700679.498	8	212584.937	.747	.655[b]
	residual	2277848.162	8	284731.020		
	total	3978527.660	16			

a. dependent variable: weight (*Labeo rohita*)

b. Predictors: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant)	-41499.690	33568.164		-1.236	.251
	chlorophyceae	-8.822	9.708	-.316	-.909	.390
	cyanophyceae	.945	12.159	.033	.078	.940
	euglenophyceae	.419	11.160	.017	.038	.971
	rotifers	422.557	337.413	6.355	1.252	.246
	cladocera	425.117	328.831	4.693	1.293	.232
	Copepoda	452.305	379.045	4.307	1.193	.267
	ostracoda	447.607	352.353	6.831	1.270	.240
	nauplius	346.287	299.158	1.977	1.158	.280

a. dependent variable: weight (*Labeo rohita*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	bacillariophyceae	.[b]	.	.	.	.000

a. dependent variable: weight (*Labeo rohita*)

b. predictors in the model: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 42.7% of the variance in weight (*Labeo rohita*) effect, which is not significant as indicated by ANOVA test with F=.747 an examination of p=.655[b] (Table- 36) indicates that no independent Biological Effectors contributes the prediction of weight (*Labeo rohita*). Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influenced the weight (*Labeo rohita*) in group I, no significance influence was observed in weight (*Labeo rohita*) development in group I and Bacillariophyceae had no influence, where the variable was excluded from the model.

Table 37. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of weight (*Labeo rohita*) in group II

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.778[a]	.605	.155	225.25638

a. predictors: (constant): Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

anova[a]

model		the sum of squares	df	mean square	f	sig.
1	regression	545132.630	8	68141.579	1.343	.355[b]
	residual	355183.049	7	50740.436		
	total	900315.679	15			

a. dependent variable: weight (*Labeo rohita*)

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant) *********	-40701.729	51384.826		-.792	.454
	cyanophyceae	6.009	6.090	.291	.987	.357
	euglenophyceae	5.201	4.681	.352	1.111	.303
	bacillariophyceae	-4.329	4.174	-.315	-1.037	.334
	rotifers	415.357	518.984	12.391	.800	.450
	cladocera	407.888	509.261	7.057	.801	.449
	Copepoda	420.072	514.656	15.978	.816	.441
	ostracoda	418.597	513.534	11.624	.815	.442
	nauplius	375.345	507.848	5.652	.739	.484

a dependent variable: weight (*Labeo rohita*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	chlorophyceae	154.843[b]	1.437	.201	.506	4.215e-006

a. dependent variable: weight (*Labeo rohita*)

b. predictors in the model: (constant): cyanophyceae, euglenophyceae, bacillariophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 60.3% of the variance in weight (*Labeo rohita*) effect, which is not significant as indicated by ANOVA test with F=1.343 an examination of p=0.355[b](Table- 37) indicates that no independent Biological Effectors contributes the prediction of weight gain in (*Labeo rohita*). Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influence the weight gain of *Labeo rohita* in group II.

Table 38. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of weight (*Catla catla*) in group I

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.654[a]	.428	-.145	680.15073

a. predictors: (constant): Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

ANOVA[a]

model		the sum of squares	df	mean square	f	sig.
1	regression	2765788.111	8	345723.514	.747	.655[b]
	residual	3700840.169	8	462605.021		
	total	6466628.280	16			

a. dependent variable: weight (*Catla catla*)

b. predictors: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant)	-54928.794	42787.347		-1.284	.235
	chlorophyceae	-10.983	12.374	-.309	-.888	.401
	cyanophyceae	.365	15.499	.010	.024	.982
	euglenophyceae	-.530	14.225	-.017	-.037	.971
	rotifers	562.035	430.081	6.630	1.307	.228
	cladocera	561.565	419.141	4.863	1.340	.217
	Copepoda	598.414	483.146	4.470	1.239	.251
	ostracoda	592.670	449.124	7.094	1.320	.223
	nauplius	452.914	381.319	2.028	1.188	.269

a. dependent variable: weight (*Catla catla*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	bacillariophyceae	.[b]	.	.	.	.000

a. dependent variable: weight (*Catla catla*)

b. predictors in the model: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 42.8% of the variance in weight (*Catla catla)* effect, which is not significant as indicated by ANOVA test with F=.747 an examination of p=.655[b] (Table- 38) indicates that no independent Biological Effectors contributes the prediction of weight (*Catla catla*) Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influence the weight (*Catla catla*) in group I, no significance influence was observed in weight (*Catla catla*) development in group I.

Table 39. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of weight (*Catla catla)* in group II

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.764[a]	.584	.109	244.42281

a. predictors: Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

ANOVA[a]

model		the sum of squares	df	mean square	F	P
1	regression	587735.184	8	73466.898	1.230	0.399[b]
	residual	418197.573	7	59742.510		
	total	1005932.756	15			

a. dependent variable: weight (*Catla catla*)

b. predictors: Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

coefficients

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant) *********	-57592.904	55757.016		-1.033	.336
	cyanophyceae	6.145	6.608	.282	.930	.383
	euglenophyceae	6.026	5.079	.385	1.186	.274
	bacillariophyceae	-4.211	4.529	-.290	-.930	.383
	rotifers	588.003	563.143	16.595	1.044	.331
	cladocera	575.974	552.592	9.428	1.042	.332
	Copepoda	589.447	558.446	21.210	1.056	.326
	ostracoda	585.783	557.229	15.389	1.051	.328
	nauplius	541.343	551.059	7.712	.982	.359

a. dependent variable: weight (*Catla catla*)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	chlorophyceae	140.632[b]	1.227	.266	.448	4.215e-006

a. dependent variable: weight (*Catla catla*)

b. predictors in the model: Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

All independent variable explain 58.4% of the variance in weight (*Catla catla*) effect, which is no significant as indicated by ANOVA test with F=1.230 an examination of p=0.355[b] (Table- 39) indicates that no independent Biological Effectors contributes the prediction of weight (*Catla catla*). Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influenced the weight (*Catla catla*) in group II,

Table 40. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of weight (*Cirrhinus mrigala*) in group I

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.655[a]	.429	-.143	507.16562

a. predictors: (constant): Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, Ostracoda, nauplius.

ANOVA[a]

model		the sum of squares	df	mean square	f	sig.
1	regression	1543347.344	8	192918.418	.750	.653[b]
	residual	2057735.752	8	257216.969		
	total	3601083.096	16			

a. dependent variable: weight (mrigala)
b. predictors: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

coefficients[a]

Model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
1	(constant)	-40309.411	31905.092		-1.263	.242
	chlorophyceae	-8.723	9.227	-.328	-.945	.372
	cyanophyceae	.736	11.557	.027	.064	.951
	euglenophyceae	-.336	10.607	-.014	-.032	.975
	rotifers	410.648	320.697	6.492	1.280	.236
	cladocera	413.606	312.539	4.799	1.323	.222
	Copepoda	440.877	360.266	4.413	1.224	.256
	ostracoda	434.837	334.897	6.975	1.298	.230
	nauplius	333.942	284.337	2.004	1.174	.274

a. dependent variable: weight (mrigala)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	bacillariophyceae	.[b]	.	.	.	.000

a. dependent variable: weight (mrigala)
b. predictors in the model: (constant): chlorophyceae, cyanophyceae, euglenophyceae, rotifers, cladocera, Copepoda, ostracoda, nauplius.

All independent variable explain 42.9% of the variance in weight (*Cirrhinus mrigala*) effect, which is not significant as indicated by ANOVA test with F=.750 an examination of p=.653[b] (Table- 40) indicates that no independent Biological Effectors contributes the prediction of weight (*Cirrhinus mrigala*). Chlorophyceae, Cyanophyceae, Euglenophyceae, rotifers, cladocerans, Copepoda, ostracoda, and nauplius were equally influenced the weight (*Cirrhinus mrigala*) in group I.

Table 41. Regression analysis for Biological Effectors of growth (Phytoplankton and Zooplankton) of weight (*Cirrhinus mrigala*) in group II

model summary

model	r	r square	adjusted r square	std. error of the estimate
1	.780[a]	.608	.160	210.96192

a. predictors: Cyanophyceae, Euglenophyceae, Bacillariophyceae, Rotifers, Cladocerans, Copepoda, Ostracoda, Nauplius.

ANOVA[a]

model		the sum of squares	df	mean square	F	P
	regression	483543.041	8	60442.880	1.358	.350[b]
1	residual	311534.510	7	44504.930		
	total	795077.551	15			

a. dependent variable: weight (*Cirhinnus mrigala*)

c. predictors:

coefficients[a]

model		unstandardized coefficients		standardized coefficients	t	sig.
		b	std. error	beta		
	(constant) ***********	-39798.518	48124.015		-.827	.436
	cyanophyceae	5.989	5.703	.309	1.050	.329
	euglenophyceae	4.867	4.384	.350	1.110	.304
	bacillariophyceae	-4.043	3.909	-.313	-1.034	.335
1	rotifers	405.345	486.050	12.868	.834	.432
	cladocera	398.798	476.944	7.343	.836	.431
	Copepoda	410.398	481.996	16.611	.851	.423
	ostracoda	408.660	480.946	12.076	.850	.424
	nauplius	368.727	475.621	5.909	.775	.464

dependent variable: weight (mrigala)

excluded variables[a]

model		beta in	t	sig.	partial correlation	collinearity statistics
						tolerance
1	chlorophyceae	176.272[b]	1.736	.133	.578	4.215e-006

a. dependent variable: weight (mrigala)

b. predictors in the model:

All independent variable explain 60.8% of the variance in weight (*Cirrhinus mrigala*) effect, which is no significant as indicated by ANOVA test with F=1.358 an examination of p=0.653 (Table - 41) indicates that no independent Biological Effectors contributes the prediction of weight (*Cirrhinus mrigala*). Cyanophyceae, Euglenophyceae, Bacillariophyceae, rotifers, cladocerans, Copepoda, Ostracoda and nauplius were equally influenced the weight (*Cirrhinus mrigala*) in group I.

The independent variable explains different variation in length and growth development in physico chemical and plankton groups. ANOVA F values and P values indicate no-significant influence on length and growth development. Standardize correlation *P*-value indicates that none of the independent variable contributes the prediction of length and growth development of *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala,* but indicates a non-significant combined influence on predication of IMC length and growth development.

5.3.4.2. Parasites

5.3.4.2.1. Parasites isolated and identified from the investigated carps

The total study period was divided into three seasons; summer (March-June); rainy (July-October) and winter (November-February). A total of 450 fishes 150 from each species of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* were examined for parasite and parasitic infestation. Out of 450 observed fishes a total number of 51 fishes from treatment I and 139 fishes from treatment II were found infected with parasite. During the study period 199 parasites from Indian major carp host in treatment I and 258 parasites from treatment II were identified, isolated and collected. Among the collected parasites 14 species-4 protozoan (*Trichodina* sp., *lchthyophthirius* sp., *Apiosoma* sp. and *Chilodonella* sp. *Ichthyobodo* sp) 2-monogenean (*Gyrodactylus* sp. and *Dactylogyrus* sp.), 2-crustacean (*Argulus* sp. and *Larnaea* sp.), nematoda (*Camallanus* sp.) parasitic species. A total of 480 by these parasites were isolated from body slime, gills and intestine of the infected fishes. Among the isolated parasites *Fellodistomum* sp. was found as the highest and *Chilodonella* sp. was found as the lowest in number. Our results indicate that infection and infestation rate of parasites varied with fish size and season and found to be high in the post-monsoon and winter periods (November-March), when fish are most susceptible to parasites. Were identified of which 10 were ectoparasites and the rest were endoparasites. In *L. rohita* a total number of 7 species were identified.

Table 42. Distribution of parasites in three Indian major carps of treatment I

Host fish species	Type of Parasite	Recovered Parasites	Site of Infestation
		Larnaea sp.	Gill, Fin
		Ichthyobodo sp.	Skin, Fin
Labeo rohita	Ectoparasites	*Argulus sp.*	Skin, Fin
		Ichthyophthirius sp.	Skin
		Chilodonella sp.	Gill, Skin
		Gyrodactylus sp.	Skin
Catla catla	Ectoparasites	*Trichodina* sp.	Gill
		Dactylogyrus sp.	Gill, Skin
		Trichodina sp.	Gill
	Ectoparasites	*Ichthyophthirius* sp.	Skin
		Apiosoma sp.	Skin, Fin
Chirrhinus mrigala		*Ichthyobodo* sp.	Skin, Fin
	Endoparasites	*Eucreadium* sp.	Intestine
		Cammalanus sp.	Intestine

From both of the treatment of which 6 were ectoparasites and the rest was endoparasites. In *C. catla* a total number of 3 species were identified of which 3 were ectoparasites and no endoparasites were found. In *C. mrigala* a total number of 8 species were identified of which 4 were ectoparasites and the rest were endoparasites (Table 42 and 43).

The numbers of parasites collection from the different organs of Indian major carp, *L. rohita, C. catla* and *C. mrigala* were studied in the treatment I and treatment II from December 2013 to May 2015. The highest numbers of parasites were collected from the gill (33) of *C. catla* and lowest numbers were recorded from the fin (6) of *C. mrigala.* The maximum parasites

Table 43. Distribution of parasites in three Indian major carps of treatment II

Host fish species	Type of Parasite	Recovered Parasites	Site of Infestation
Labeo rohita	Ectoparasites	*Larnaea sp.*	Gill, Fin
		Ichthyobodo sp.	Skin, Fin
		Argulus sp.	Skin, Fin
		Ichthyophthirius sp.	Skin
		Chilodonella sp.	Gill, Skin
	Endoparasites	*Cammalanus sp.*	Intestine
Catla catla	Ectoparasites	*Gyrodactylus sp.*	Skin
		Trichodina sp.	Gill
		Dactylogyrus sp.	Gill
Chirrhinus mrigala	Ectoparasites	*Trichodina sp.*	Gill
		Ichthyophthirius sp.	Skin
		Apiosoma sp.	Skin, Fin
		Ichthyobodo sp.	Skin, Fin
	Endoparasites	*Cammalanus*	Intestine
		Eucreadium sp.	Intestine
		Pallisentis sp.	Intestine

found in fin (31) and average numbers were recorded in gill (11) and skin (15). But no parasite was found in intestine at *L. rohita*. On the other hand, at *C. catla* the maximum parasites were found in gill (33) and average in fin (12) and skin (19). No parasites were found in intestine at treatment I during the study period. At *C. mrigala* maximum parasites in gill (26) and minimum in fin (6) were observed. But the average numbers of parasites were recorded in skin and Intestine (Fig. 34).

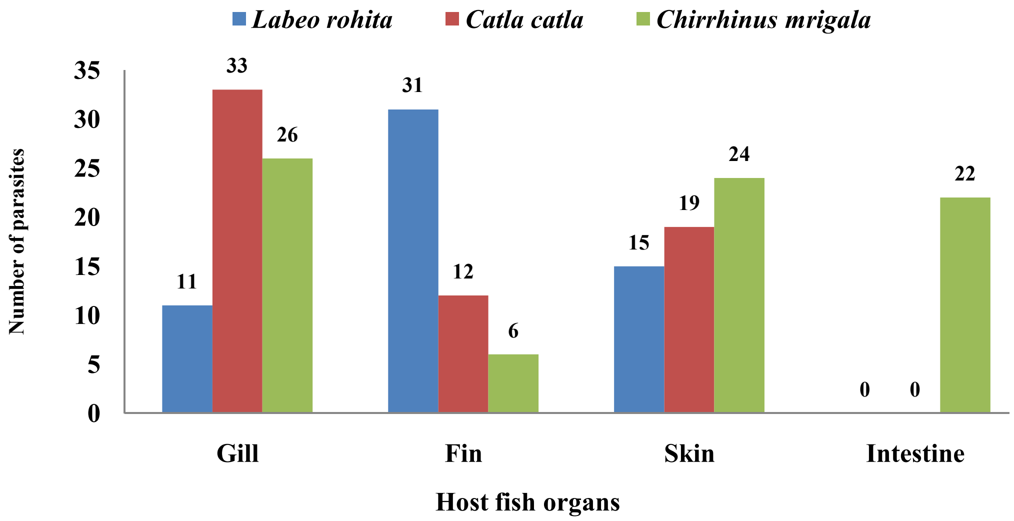

Fig. 34. Number of parasite recovered from the different organs of Indian major carp, *L. rohita, C. catla* and *C. mrigala* at treatment I.

During the study period, the highest numbers of parasites were collected from the gill (46) of *C. catla* and lowest numbers were recorded from the intestine (33) of *C. mrigala*. The maximum parasites found in fin (36) and minimum in intestine (2) and the average numbers were recorded in gill (14) and skin (22) at *L. rohita*. The highest numbers of parasites were collected from gill (46) and lowest numbers were observed in fin. The average found in skin (24) but no parasites were found in intestine at *C. catla*. At *C. mrigala* maximum parasites were collected from fin (39) and minimum numbers of parasites were observed in gill (7). But the average numbers of parasites were recorded from skin (17). Among them, second peak value (33) was from the intestine (Fig. 35).

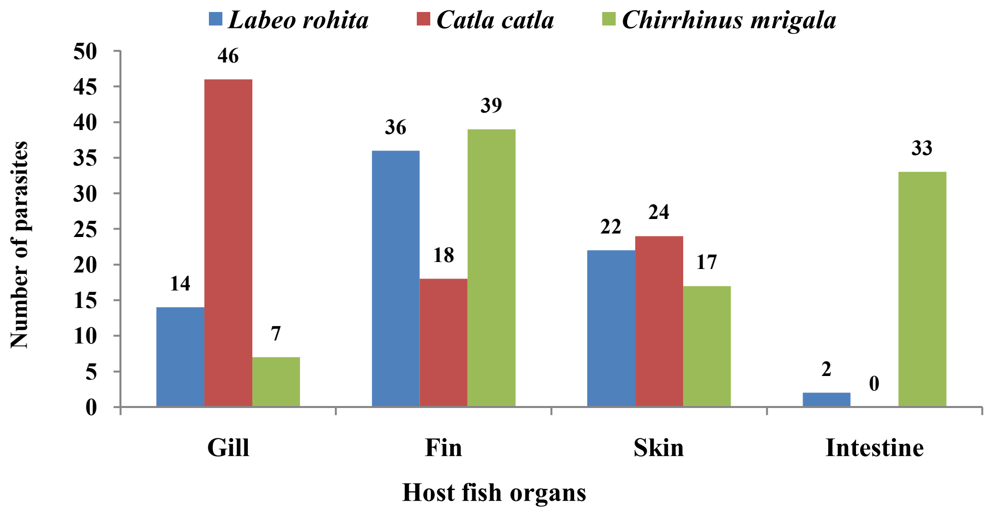

Fig. 35. Number of parasite recovered from the different organs of Indian major carp, *L. rohita, C. catla* and *C. mrigala* at treatment II

5.3.4.2.2. Comparative infestation of Indian major carps

During the study period the highest (12.67%) Prevalence of parasites was recorded in the host *L. rohita* and lowest value 10.67% was recorded in *C. catla* and *C. mrigala*. The abundance value was ranged from 0.38 to 0.49 during the study period. The highest abundance value (0.49) was recorded in the host *C. mrigala* and the lowest (0.38) was recorded in *L. rohita.* The highest mean density of parasites was observed as 4.63 in *C. mrigala* and lowest as 3.00 in *L. rohita* at treatment I (Table 44).

Table 44. Comparative infestations of Indian major carps by different groups of parasites in treatment I

Host fish	No. of host fish		No. of Parasites collected	Prevalence (%)	Abundance	Mean Density
	Examined	Infected				
L. rohita	150	19	57	12.67	0.38	3.00
C. catla	150	16	64	10.67	0.42	4.00
C. mrigala	150	16	74	10.67	0.49	4.63

The highest (34%) Prevalence of parasites was recorded in the host *C. catla* and lowest value 26.67% was recorded in *C. mrigala*. The abundance value was ranged from 0.49 to 0.64 during the study period. The highest abundance value (0.64) was recorded in the host *C. mrigala* and the lowest (0.49) was recorded in *L. rohita.* The highest mean density of parasites was observed as 2.4 in *C. mrigala* and lowest as 1.54 in *L. rohita*. A second peak of mean density was found as 1.73 in *Catla catla* at treatment II (Table 45).

Table 45. Comparative infestations of Indian major carps by different groups of parasites in treatment II

Host fish	No. of host fish		No. of Parasites collected	Prevalence (%)	Abundance	Mean Density
	Examined	Infected				
L. rohita	150	48	74	32	0.49	1.54
C. catla	150	51	88	34	0.59	1.73
C. mrigala	150	40	96	26.67	0.64	2.4

5.3.4.2.3. Comparative Prevalence (%), Abundance and Mean density in different seasons at treatment I and II

The overall prevalence (%), abundance and mean density of the total parasites was observed to fluctuate seasonally during the study period in treatment I and treatment II. The highest prevalence value (18%) was found in *L. rohita* and the lowest value (5%) was in *C. catla.* In winter season, the highest (10%) prevalence value was observed in *C. mrigala* and least prevalence values (6%) was in *C. catla*. But in summer season, *L. rohita* showed the highest (12%) prevalence value while *C. catla* showed lowest prevalence values (5%). In rainy season, the highest (18%) prevalence value was observed in *L. rohita* and least prevalence values (14%) was in *C. mrigala* and *C. catla* (16) was showed the second pick value. The abundance of parasites was fluctuated among these seasons. The highest abundance value was recorded 0.82 in *C. mrigala* and lowest was 0.64 in the host of *L. rohita* during the rainy season. On the other hand, *C. mrigala* showed the highest (0.38) abundance value in summer where *C. catla* showed the lowest value (0.26) in the study area. In winter, the highest abundance value was (0.36) in *C. mrigala* where *C. catla* showed second peak value (0.26) and the lowest (0.22) value was observed in *L. rohita*. The highest mean density (4.33) was recorded in *C. catla* in winter where *L. rohita* showed lowest (2.75). In summer, the highest (4.75) mean density of parasites was also found in *C. mrigala* where as lowest value (2.33) in *L. rohita*. In rainy season, *C. mrigala* showed the highest mean density (5.85) and lowest value was 3.55 in *L. rohita* at treatment I (Table 46).

In winter, *C. catla* showed the highest (30%) prevalence value where *C. mrigala* showed least prevalence values (18%). But in summer, the highest prevalence (34%) was recorded in *L. rohita* and lowest value recorded in *C. mrigala*. The highest abundance value (0.46) was found in *C. mrigala* in winter season where *L. rohita* shows lowest abundance value (0.34). In summer, *C. mrigala shows* the highest (0.44) abundance value where *C. catla* showed second peak value (0.42) and *L. rohita* showed lowest value (0.36). In rainy season, the highest abundance value (1.02) was in *C. mrigala* and the lowest (0.78) value found in *C. catla*. *C. mrigala* showed the highest mean density (2.56) in winter where *C. catla* showed lowest mean density (1.40). In summer, *C. mrigala showed* the highest (1.69) mean density of parasites where lowest value recoded in *L. rohita* as 1.06. In rainy season, highest mean density recorded in *C. mrigala* as 2.83 and lowest value found in *C. catla* as 2.19 at treatment II (Table 47).

Table 46. Comparative Prevalence (%), Abundance and Mean density of three host fishes in different seasons in Treatment I

Host fish	Prevalence (%)			Abundance			Mean Density		
	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
L. rohita	8	12	18	0.22	0.28	0.64	2.75	2.33	3.55
C. catla	6	5	16	0.26	0.26	0.76	4.33	2.60	4.75
C. mrigala	10	8	14	0.36	0.38	0.82	3.60	4.75	5.85

Table 47. Comparative Prevalence (%), Abundance and Mean density of three host fishes in different seasons in Treatment II

Host fish	Prevalence (%)			Abundance			Mean Density		
	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
L. rohita	24	34	38	0.34	0.36	0.78	1.42	1.06	2.50
C. catla	30	30	42	0.42	0.42	0.92	1.40	1.40	2.19
C. mrigala	18	26	36	0.46	0.44	1.02	2.56	1.69	2.83

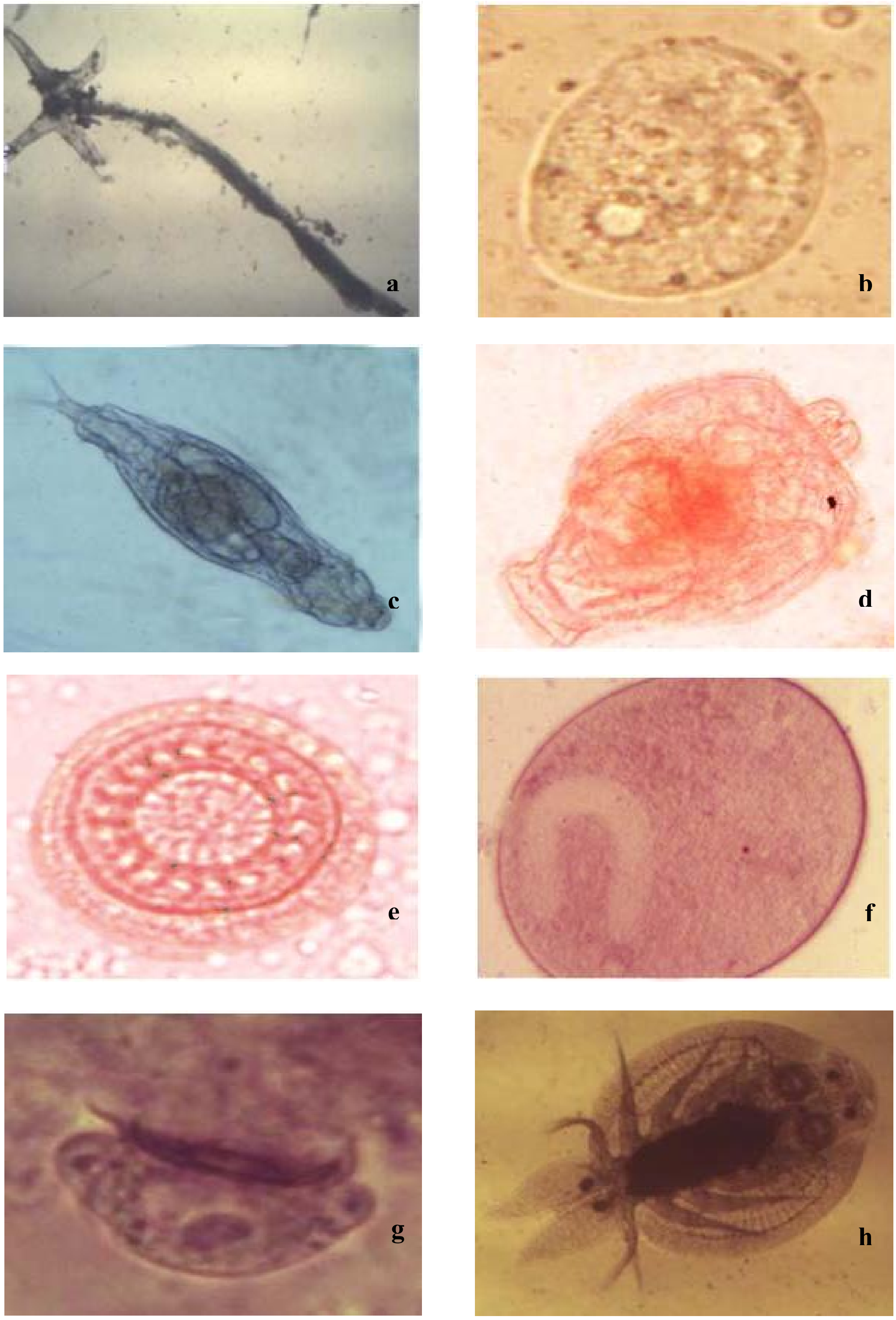

Plate 25. Photographs of *Learnea* sp. (a), *Chilodenella* sp. (b), *Dactylgyrous* sp. (c), *Gyrodactylus* sp. (d), *Trichodina* sp. (e), *Ichthyoptherius* sp. (f), *Trichodina* sp. (g) and *Argulus* sp. (h)

Table 48. Comparison of parasites in Indian major carps in different season of the year 2013-2014 between treatment I and treatment II

	Treatment I (n=50)		Treatment II (n=50)		Z value	P value
	n	%	n	%		
Labeo rohita						
Winter	4	8.0	12	24.0	2.24	<0.05
Summer	6	12.0	17	34.0	2.71	<0.05
Rainy	9	18.0	19	38.0	2.28	<0.05
Catla catla						
Winter	3	6.0	15	30.0	3.29	<0.001
Summer	5	10.0	15	30.0	2.58	<0.05
Rainy	8	16.0	21	42.0	2.99	<0.05
Cirrhinus mrigala						
Winter	5	10.0	9	18.0	1.16	<0.05
Summer	4	8.0	13	26.0	2.47	<0.05
Rainy	7	14.0	18	36.0	2.63	<0.05
Subtotal						
Winter	12	8.0	36	24.0	3.87	<0.001
Summer	15	10.0	45	30.0	4.47	<0.001
Rainy	24	16.0	58	38.7	4.56	<0.001
Grand total	51	11.3	139	30.9	7.42	<0.001

In *Labeo rohita*, 4(8.0%) fish expired during winter season in treatment I and 12(24.0%) in treatment II. Six (12.0%) fish expired during summer season in treatment I and 17(34.0%) in treatment II. Nine (18.0%) fish expired rainy season in treatment I and 19(38.0%) in treatment II. In *Catla catla* 3(6.0%) fish expired winter season in treatment I and 15(30.0%) in treatment II. Five (10.0%) fish expired summer season in treatment I and 15(30.0%) in treatment II. Eight (16.0%) fish expired rainy season in treatment I and 21(42.0%) in treatment II.

In *Cirrhinus mrigala*, 5(10.0%) fish expired during winter season in treatment I and 9(18.0%) in treatment II. Four (8.0%) fish expired summer season in treatment I and 13(26.0%) in treatment II. Seven (14.0%) fish expired rainy season in treatment I and 18(36.0%) in treatment II.

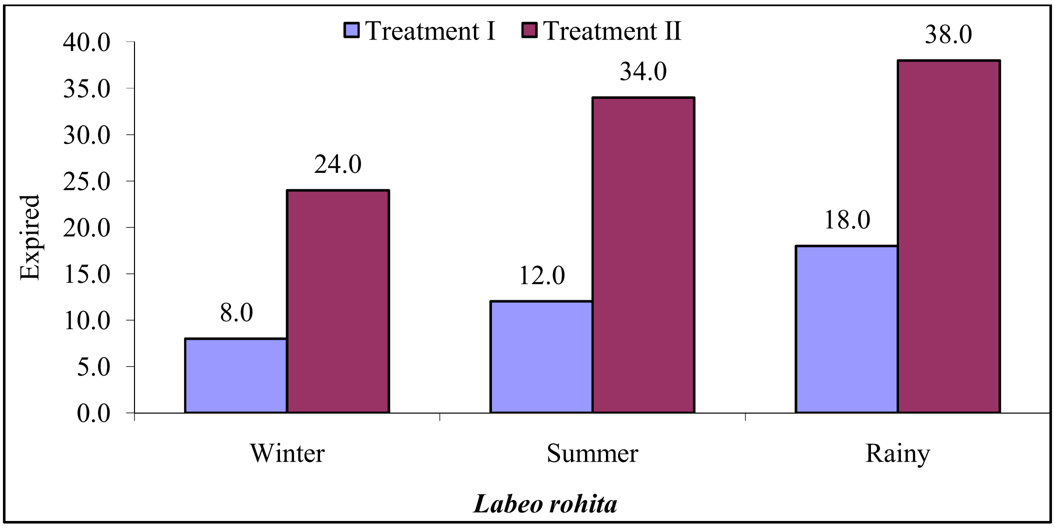

Fig. 36. Showing *Labeo rohita* fish expired in a different season

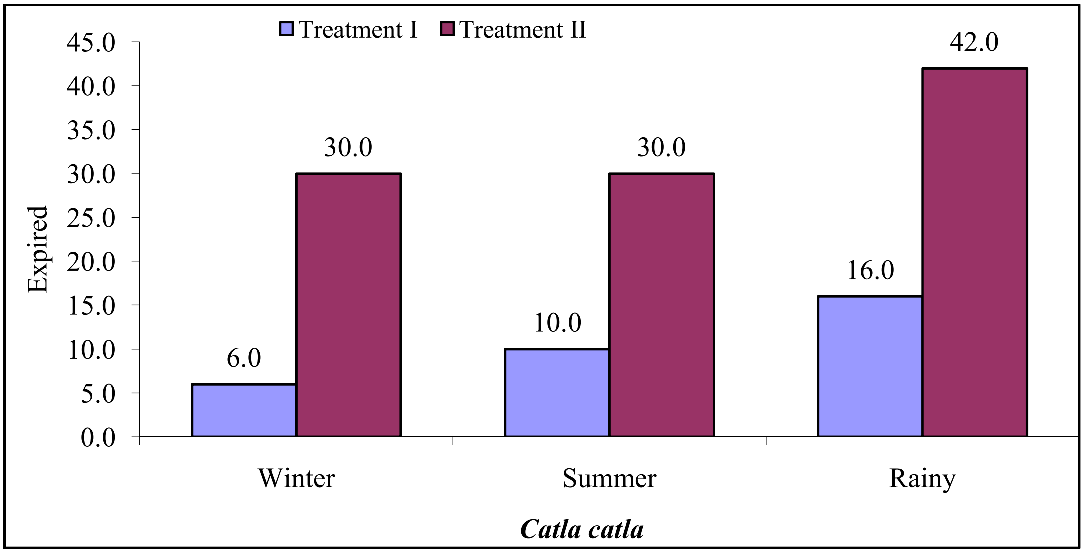

Fig. 37. Showing *Catla catla* fish expired in a different season

Total (*Labeo rohita, Catla catla* and *Cirrhinus mrigala*), 12(8.0%) fish expired during winter season in treatment I and 36(24.0%) in treatment II. Fifeteen (10.0%) fish expired during summer season in treatment I and 45(30.0%) in treatment II. Twenty four (16.0%) fish expired rainy season in treatment I and 58(38.7%) in treatment II. Which were statistically significant ($p<0.05$) between two groups.

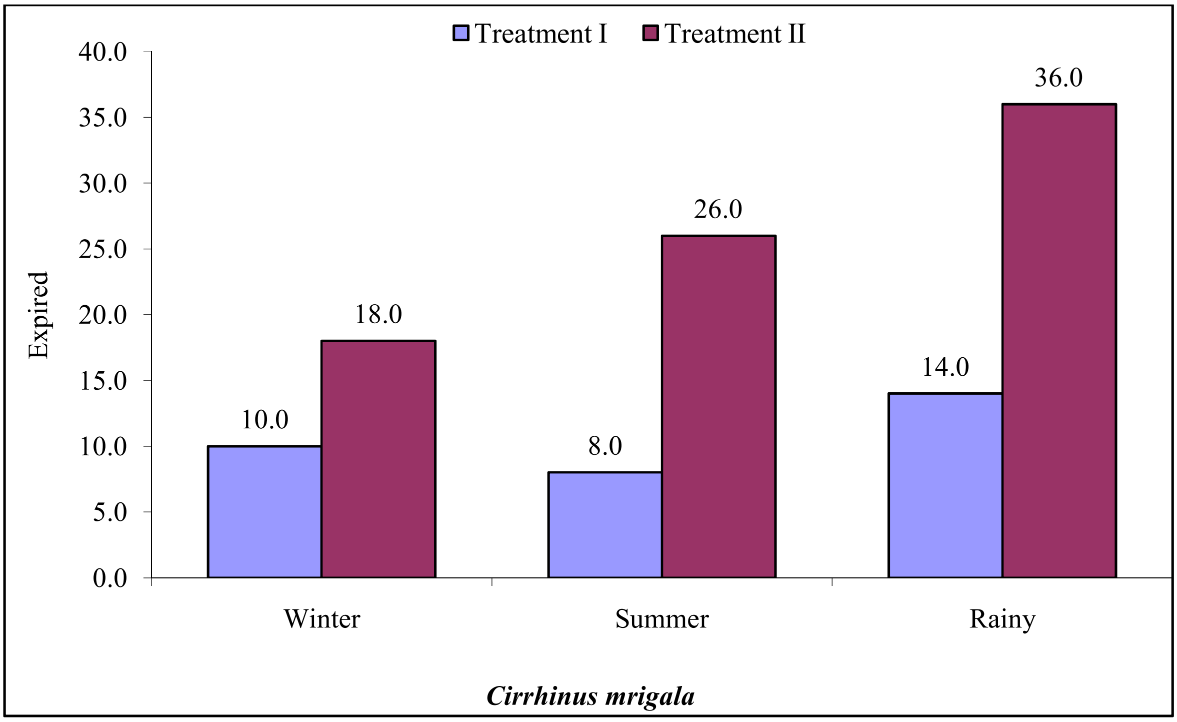

Fig. 38. Showing *Cirrhinus mrigala* fish expired in a different season

This study describes the parasitic infestations of three Indian minor carps from different fresh water bodies of Gazipur, Dhaka district, Bangladesh and indicates that infection and infestation rate of parasites varied with habitat and seasonality. This could be due to stocking density, water depth, temperature along with other physico-chemical parameters and management practices maintained. Nevertheless, more in depth research is needed to be carried out for studying parasites as well as diseases of this three minor carp species and other carp fishes to depict precise and full information of carp fish diseases in Bangladesh.

ECONOMIC AND COST BENEFIT ANALYSIS

6.1. Introduction

Cost–benefit analysis (CBA), sometimes called benefit–cost analysis (BCA), is a systematic approach to estimating the strengths and weaknesses of alternatives for example in transactions, activities, functional business requirements; it is used to determine options that provide the best approach to achieve benefits. It can be explained as a procedure for estimating all costs involved and possible profits to be derived from a production opportunity or proposal. It takes into account both quantitative and qualitative factors for analysis of the value for money for a particular project or investment opportunity. Benefits to costs ratio and other indicators are used to conduct such analysis (Sondhi and Joir 1993).

In order to estimate the costs and benefits of fish-farming operations, the data required about the yields and income obtained from at least one harvest. Production cycle maintained was 18 months, as harvesting was done during a convenient time. The results showed very uneven yields in two feed regimes. Price of table-size fish has been found to be the most important factor of variation in net incomes among fish-farmers. Break even point calculation is essential for to generate a setting price level and its sensitivity.

6.2. Objectives

The objective is to ascertain the soundness of any investment opportunity and provide a basis for making comparisons with other such proposals. All positives and negatives of the study are first quantified in monetary terms and then adjusted for their time-value to obtain correct estimates for conduct of cost-benefit analysis. Most economists also account for opportunity costs of the investment in the study to get the costs involved. The cost-benefit analysis at individual farm level was implemented with the following objectives:

- to cover a sample of production coming from two treatments, in order to assess variations in profitability according to feeding practice.
- to cover the impact of different technical and economic factors on treated pond's profitability (fish prices, types of fish culture, fish feeding methods, length of production cycle.).

6.3. Results

To evaluate the potential of feed management of the treatment I and treatment II cost of the total expenditure are presented (table 50) and prediction of cost benefit differences are presented (table 51). Input costs includes fixed cost viz., cost of pond preparation, fingerlings and variable cost like, cost of fertilizer, cost of feed, cost of labor and transportation costs were recorded and total expenditure are presented table.

No revenue was involved in these treatments. Treatment I, which was loaded with supplemental feeds was higher (75%) than that of treatment II, loaded with poultry manure (25%). Total cost for treatment I was Tk. 2, 16,471.00, whilst it was 39,952.00 for treatment II. The probable net income from treatment I was calculated to be Tk. 1, 79,206.00 and that was for treatment II was Tk. 1, 26,630.00**.**

6.3.1. Variable costs

Fertilizer, feed, labour and others constituted major variable costs in the investigation. Feed constituted the biggest input cost in both the treatments. Range and mean with standard deviation of different input costs of treatment I and treatment II are presented in table 49 and graphically presented in figure 39.

Table 49. Range and mean with standard deviation of different input costs expenditure of treatment I and treatment II

Expenditure item	**Treatment I**		**Treatment II**		**P value**
	Mean	±SD	Mean	±SD	
Cost of Fertilizer (Tk..)	362	±0	362	±0	-
Range (min, max)	362	362	362	362	
Cost of Feed (Tk..)	10219	±9701	568.1	±146.7	0.001^{s}
Range (min, max)	0	31500	0	622	
Cost of Labor (Tk..)	561.1	±230.4	450	±179	0.115^{ns}
Range (min, max)	0	1000	0	1000	
Vehicle and others (Tk..)	255.6	±92.18	211.1	±75.84	0.123^{ns}
Range (min, max)	100	500	100	500	
Total	11398	±9860	1591	±351.5	0.001^{s}
Range (min, max)	462	33062	462	2484	

s=significant; ns=not significant

P value reached from unpaired –test

Table 50. Monthly total expenditure of treatment I and treatment II

Months	Treatment I						Treatment II					
	Fixed cost		Variable cost				Fixed cost		Variable cost			
	Cost of pond preparation (Tk.)	Cost of Fingerlings (Tk.)	Cost of Fertilizer (Tk.)	Cost of Feed (Tk.)	Cost of Labor (Tk.)	Vehicle & others (Tk.)	Cost of pond preparation (Tk.)	Cost of Fingerlings (Tk.)	Cost of Fertilizer (Tk.)	Cost of Feed (Tk.)	Cost of Labor (Tk.)	Vehicle & others (Tk.)
Dec. '13			362	1000	1000	500	**2660**	**8650**	362	622	1000	500
Jan.'14	**2660**	**8650**	362	1190	400	200			362	622	400	200
Feb.'14			362	1388	400	200			362	622	400	200
Mar.'14			362	2854	400	200			362	622	400	200
Apr.'14			362	3783	400	200			362	622	400	200
May.'14			362	4692	400	200			362	622	400	200
Jun.'14			362	5386	400	200			362	622	400	200
Jul.'14			362	7572	400	200			362	622	400	200
Aug.'14			362	14127	600	200			362	622	400	200
Sep.'14			362	20187	600	200			362	622	400	200
Oct.'14			362	23320	700	300			362	622	500	200
Nov.14			362	6990	700	300			362	525	500	200
Dec. '14			362			100			362			100
Jan.'15			362	7677	700	300			362	525	500	200
Feb.'15			362	8223	700	300			362	525	500	200
Mar.'15			362	16770	700	300			362	565	500	200
Apr.'15			362	27286	800	300			362	622	500	200
May.'15			362	31500	800	400			362	622	500	200
Total (Tk.)	**2660**	**8650**	**6516**	**183945**	**10100**	**4600**	**2660**	**8650**	**6516**	**10226**	**8100**	**3800**
Total (Tk.)	**11310**		**205161**				**11310**		**28641**			
GRAND TOTAL	**216471**						**39952**					

Table 49 Shows cost range and mean cost with standard deviation of different variable inputs, Mean cost of feed was found 10219±9701 Tk. in treatment I and 568.1±146.7 Tk. in treatment II, with to 0-31500 Tk. and 0-622 Tk. in treatment I and treatment II, respectively, shows statistically significant ($p<0.05$) difference. Mean cost of labor was found to be 561.1±230.4 Tk. and 450±179 Tk. with treatment I and treatment II, respectively. Mean vehicle and other cost was 255.6±92.18 Tk. in treatment I and 211.1±±75.84 Tk. in treatment II. The mean cost of labor and vehicle and others were not significant ($p>0.05$) between two groups. Total mean variable costs were significantly ($p<0.05$) different in two treatments.

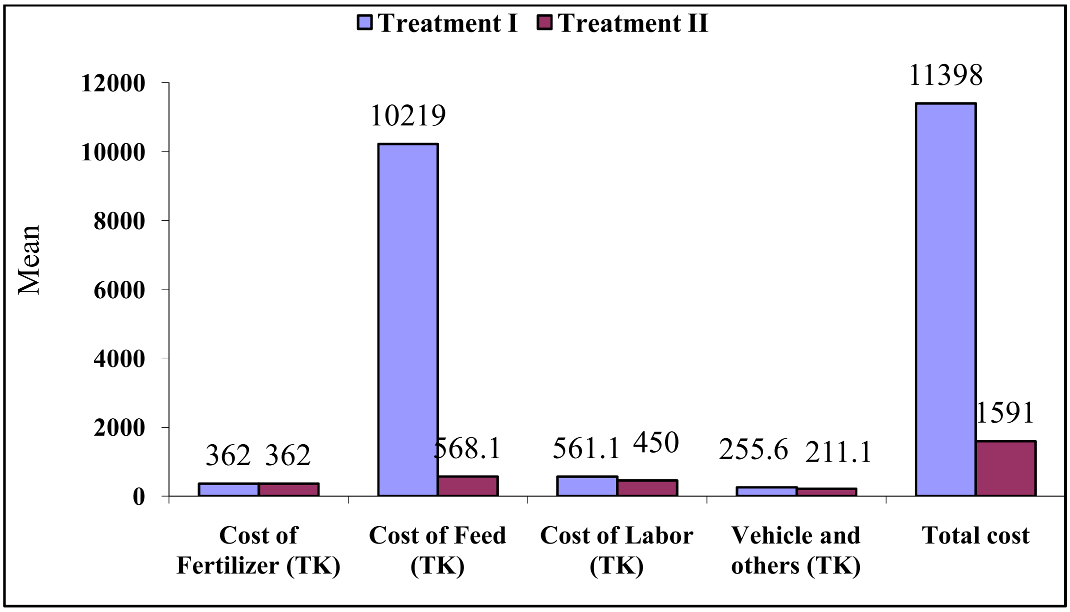

Fig. 39. Showing different expenditure of treatment I and treatment II

6.3.2. Gross return

The average yield of fish was 5255 kg in supplemental feed regime as compared with 5037 kg in poultry manure feeding regime. This was considered a good yield relative to the amount of input provided to the ponds. The fish price being almost constant with an average price of about 270-350Tk./kg. The gross revenue obtained highly differs from each other treatment, due to cost difference. At Treatment I total production was 1318.81 kg. and 632.50 kg. from treatment II only. Return in both systems appeared to beneficial from the stand point of cost strategy .The net returns were slightly higher in the case of supplemental feeding system. The overall net return of Tk. 395677 was however, considered to be a better income as compared to treatment II with lower cost expenditure, table 52.

Table 51 shows key financial and economic indication of two feeding regime ponds. The cost for the production was 2,16,471 Tk., in treatment I and 39,9,52 Tk. in treatment II. Net return was 3,95,677 Tk. and 1,66,582 Tk. in treatment I and treatment II respectively. Calculated total net return of profit was 1,79,206 Tk. in treatment I and 1,26,630 Tk. in treatment II. Percentage of profit was 83 % in treatment I and 317% in treatment II. Cost and benefit ratio was 121:100 in treatment I and 32: 100 in treatment II. Cost profit ratio and benefit cost ratio were positively significant (p=0.05 and p=0.001).

Table 51. Key financial and economic indication of two feeding process

Key financial	**Treatment I**	**Treatment II**	**P value**
Total Costs	216471	39952	
Net return	395677	166582	
Profit	179206	126630	
Cost and profit ratio	121:100	32:100	0.001^{s}
Percentage of profit (%)	83	317	
Benefit cost ratio	1.82	4.16	0.001^{S}

s=significant
P value reached from Chi square test

The effect of the various inputs used in the process of fish production was analyzed. Inputs used in production were classified broadly into material inputs (fingerlings, feed, lime and fertilizer, etc.) and labor. Furthermore, there were some inherent characteristics of pond environment and factors that could affect its production such as pond area, be employed to explain the variation in output of ponds. Accordingly, some crucial inputs were identified and included in the model to explain the variation of productivity of fish in ponds.

Table 52. Key financial and economic indicators of two feeding regimes

Species	Treatment I			Treatment II		
	Net return (Tk.)	Costs (Tk.	Profit (Tk...)	Net retern (Tk.)	Cost. (Tk.)	Profit (Tk..)
L. rohita	122268	**216471**	179206	55482	**39952**	126630
C. catla	161746			61218		
C. mrigala	111663			49882		
Total	395677	**216471**	179206	166582	**39952**	126630

A benefit-cost ratio (BCR) is an indicator, used in the formal discipline of cost-benefit analysis that attempts to summarize the overall value for money. A BCR is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms. All benefits and costs should be expressed in discounted present values.

Cost benefit ratio (BCR) takes into account the amount of monetary gain realized by performing a project versus the amount it costs to execute the project. General rule of thumb is that if the benefit is higher than the cost the project is a good investment.

The present study clearly shows that carp farming practices in Bangladesh were profitable. Though the production level was slightly higher in treatment I (1318.81kg) as compared to treatment II (632.5 kg), but in terms of food conversion ratio, the system proved to be better, which is important from the environmental point of view. Even the benefit-cost ratio showed the benefits of treatment II farming (121:100) as compared to treatment I (32:100). The results of the study thus indicate that there is an opportunity to improve the food conversion ratio and profitability by employing the improved method of pond fertilization, available local feed and better management practices.

The survival rate was 51 percent. This was largely due to the small size of the fish stocked. The size of fish at harvest was small (300g–500g) as there was a strong demand for this size of fish. The overall profitability of the farmers was better in treatment I system with the use of pellet feed as compared to the treatment II. The overall net returns were found to be 3,95,677Tk. and 1,66,582 Tk. and this level of profit with low labour requirement was found to be better than all other agricultural activities prevalent in the area. The profit function analysis clearly showed that the production and profitability of the system can be increased further by judicious application of fertilizer and feed. Other variables like labour showed negative returns and hence farmers have to carefully manage labour inputs. With the availability of the large amount of feed ingredients in Bangladesh, significant improvements in fish production can be achieved. It is likely that the current level of profitability would encourage more land to be converted to aquaculture, particularly by using the vast amount of waste land available in Bangladesh.

It was suggested that technology could be developed for the culture of alternative species, such as catfish, which could have a higher demand in the local market. In addition, promoting fish as a health food would bring more revenue to farmers, assuming that demand will increase within and outside of Bangladesh. Fish culture systems are recognized as users of a valuable water resource, even though they are more efficient than the prevailing crops like rice and wheat cultivation.

However, in view of the declining water tables in the region as a whole, it is suggested that ground water exploitation should be reduced and efficient use of water should be planned. Aquaculture is recognized by the farmers in Bangladesh as a profitable alternate cropping system that can generate an assured level of income. In view of the positive impact, there is opportunity to expand fish farming and help poor farmers to derive the benefits from the new exotic organic resource management for natural food for fish production

DISCUSSION

7. DISCUSSION

During the study period survival rate, growth rate, monthly length increase and weight gain, length-weight relationship, role of growth effectors, yield and production and cost benefit analysis of treatment I and treatment II were observed. The results after observations discussed as following.

A total of 900+900 (300 from each species) fingerlings of same batch of Indian major carps *Labeo rohita, Catla catla* and *Cirrhinus mrigala* were stocked in two ponds of same locality for investigation of their survival rate, growth rate, monthly length and weight increase, length-weight relationship, role of growth effectors, yield and production and cost benefit analysis, named as treatment I loaded with supplemental feed and treatment II loaded with organic poultry waste .

7.1. Growth performance of fish

The average survival rate of different species was found satisfactory and comparatively higher. SGR in *L. rohita, C. Catla* and *C. mrigala* was 92.04±75.38, 98.06±93.79 and 79.41±75.51 in treatment I and 45.96±58.19 in *L. rohita*, 47.61±52.09 in *C. catla* and 61.94±97.07 in *C. mrigala* in treatment II but this result were better than the result reported by Saha *et al*. (1988). No significant relation was observed in growth rates between two treatments. Monthly growth rates fluctuate according to months. Higher growth was recorded during the summer months, which might be the result of abundance of preferred food and more feeding intensity of fish. Slow growth was observed in all the three species during winter months. This might be due to less feeding activity in low temperatures, which was in support with Davis *et al.* (1983), Mustafa (1984) who also found the same results during fish growth study.

The initial average weight (g) of *L. rohita, C. catla* and *C. mrigala* was 50±4.56 g, 65±3.57 g and 48±3.40 g while the final average weight (g) was 1520.7±0.87 g, 1860.7±0.74 g and 1470.8±0.45 g, respectively. The monthly average growth of *C. catla* was always higher than those of *L. rohita* and *C. mrigala* during the entire experimental period. The monthly average growth of *L. rohita* and *C. mrigala* was observed very close to each other and significantly different during the last few months of the experiment.

The net production of *L. rohita, C. catla* and *C. mrigala* in treatment I were recorded as 407.56 kg, 490.14 kg and 372.21 kg, respectively. On the other hand net production of *L. rohita, C. catla* and *C. mrigala* in treatmentII were recorded as 198.15 kg, 204.06 kg and 181.39 kg, respectively.The survival rate of *L. rohita* was higher than *C. catla* and *C. mrigala* but the highest net production was *C.catla* higher in treatment I and II.

During the 18 months study period mean with standard deviation the length increase *L. rohita* , *C. Catla* and *C. mrigala* were higher in treatment I than that of treatment II. The highest length increase observed in *C. catla* 29.76±10.70cm. followed by both *L. rohita* and *C. mrigala* (29.59±9.4cm.) and in treatment I and in treatment II again *C. catla* was the higher length increaser 22.76±6.9 followed by *L. rohita* 22.50±6.9 and *C. mrigala* (22.29±6.9). The co-efficient of correlation of three species *L. rohita, C. catla* and *C. mrigala* showed the mean total length of two treatments possessed highly significant (P=0.015, 0.027 and 0.012) correlation (Table 8 and Figure 3).

During the 18 months study period mean with standard deviation the total weight gain by *L. rohita, C. catla* and *C. mrigala* were higher in treatment I than treatment II (Fig. 4). The highest weight gain was observed in *C. catla* 774.36±626.20g followed by both *L. Rohita* 601.41±491.20g and *C. mrigala* 579.28±467.30g treatment I and in the treatment II *C. catla* was the highest gainer with 308.14±245.30g, followed by *L. rohita* with 250.23±232.30g and *C. mrigala* 234.70±218.10g.

The study showed that *C. catla* made the highest contribution to the total yield in two treatments. Contribution of *L. rohita* was about 32.84% in treatment I and 34.74% in treatment II. *C. catla* Contributed 35.83% in treatment I and 33.77% in treatment II. *C. mrigala* was found to contribute 31.31% in treatment I and 31.47% in treatment II.

Manure input and fish yield are directly related with each other and excessive application of organic manure and nitrogen fertilizer can increased the microbial activity, nitrates and phosphates ultimately plankton productivity. More than the optimum dosage of manure reduces the plankton population, fish biomass, specific growth rate and induces high mortality (Ling and Chen 1967).

The co-efficient of correlation of three species *L. rohita, C. catla* and *C. mrigala* showed the mean total weight of two treatments possessed highly significant (P=0.006, 0.015 and 0.012) correlation (Tabl 8 and figure 9).

The regression parameters for length-weight relationships, coefficient of determination (r^2), 95% confidence interval of *a* and *b,* total length and body weight range in *Catla catla* is shown in Table 14. The linear regressions of different feeding group were highly significant (P<0,001). The regression correlation value r^2 was 0.967 in treatment I and 0.965 in treatment II. The regression coefficient of LWRs of two different feeding regimes showed positive allometric growth. Both the groups exhibited positively allometric growth irrespective feed differences (Fig. 7 and 8).

The regression parameters for length-weight relationships, coefficient of determination (r^2), 95% confidence interval of *a* and *b,* total length and body weight range in *C.mrigala* is shown in Table 25. The linear regressions of different feeding group were highly significant (P<0,001). The regression correlation value r^2 was 0.940 in treatment I and 0.948 in treatment II. The regression coefficient of LWRs of two different feeding regimes showed positive allometric growth. Both the groups exhibited positively allometric growth irrespective feed differences.

The study showed that *C. catla* made the highest contribution to the total yield in two treatments. Contribution of *L. rohita* was about 32.84% in treatment I and 34.74% in treatment II. *C. catla* Contributed 35.83% in treatment I and 33.77% in treatment II. *C. mrigala* was found to contribute 31.31% in treatment I and 31.47% in treatment II (Table 10).

7.2. Growth effecter

Quality of water generally refers to the change in components of water, which are to be present at the optimum level for suitable growth of plants and animals. These components play an important role for the growth of plants and animals in the water body. Continuous and sustainable management techniques are to be need for increased production from ponds. This information is important to be communicated to the general public and the government in order develop policies for the conservation of the precious fresh water resources (Mehedi *et al.* 1999).

High price of chemical fertilizers and artificial feed are the main problems of culture of fish in ponds. So in order to solve these problems the present investigation was earned out to find out some ways in aquaculture using low-cost organic wastes (e.g. poultry waste). From the last several decades animal manures have been used in fish ponds as a source of soluble phosphorus, nitrogen and carbon to maximize the algal growth and natural food production (Ameen *et al.* 1990). In present fish culture practices both organic and inorganic fertilizers are used to enhance plankton production. (Table 26 and 27)

The success of fish culture depends on the understanding of various climatic factors such as air temperature, relative humidity (%), rainfall (mm) and sunshine of the surrounding of culture area, which have great effect on water body (Rahman 1992). In the present investigation air temperaure ranged from 35.3°C-13.0° C. The general trend of air temperature was fluctuation in water ecosystem of Bangladesh like starting from a higher value in the March to October, which gradually decline until late January and then rise again. Zaman *et al.* (1993) and Ali *et al.* (1985) have made similar observations. As fish is cold-blooded animal, its body temperature changes according to that of environment affecting its metabolism and physiology and ultimately affecting the production. Higher temperature increases the rate of bio-chemical activity of the micro biota, plant respiratory rate, and so increase in oxygen demand. According to Delince (1992) 30º-35°C is tolerable to fish, Bhatnagar *et al.* (2004) suggested the levels of temperature as 28ºC-32°C good for tropical major carps according to Santhosh and Singh (2007) suitable water temperature for carp culture is between 24ºC -30°C.

In the present investigation relative humidity ranged from 59.87% - 82.88%. A highest value 82.88% was in the month September 2014 and minimum 59.87% in the month of March 2015, which gradually fluctuate through the year. Zaman *et al.* (1993) and Ali *et al.* (1985) have made similar observations. In case of rainfall, it has been seen in the May 2014, June 2014, July 2014 and August 2014 782.8 mm, 859.4 mm, 776.7mm and 746.2 mm respectively. This enormous rainfall actually created sufficient dilution of chemical parameters of the ponds. Zaman *et al*. (1993) and Ali *et al.* (1985) have made similar observations. The monthly mean sunshine hours during the period of present investigation was relatively higher. This might have affected autotrophic organisms through enhanced primary production. The secondary effect of higher sunshine hours increasing temperature might increase plankton bloom formation. It was observed that neither a long sunshine hours nor high temperature is favourable for all phytoplankton. Temperature ranged between 35.3°C-13.0°C and average sunshine hours between 9.52 to 12.83 hours were found to be best for the growth of phytoplankton (Epsteen 1993) has made similar observations.

Various physical factors such as water temperature, water depth and transparency have great effect on water body (Rahman 1992) which controls biological activities of fish such as growth, food intake, reproduction etc. Temperature has different relations with other factors, especially dissolved oxygen count (Rahman 1992). Bacterial decomposition of a water body, which is a vital phenomenon, is also related with temperature. The lower the pond water temperature, the less food fish the fish will consume and the slower their growth rate will be.

It was observed that during the present study period that the water temperature of the ponds was closely related to air temperature. Similar observations have been made by Chacko and Ganapati (1949), Rao (1955), Oppenheimer *et al.* (1978), Chowdhury and Majumder (1981), Miah *et al.* (1981), Rahman (1983), Ali *et al.* (1985), Naser *et al.* (1990). The water temperature in two ponds was more or less similar round the year, which reflected the results obtained by various investigators mentioned above. The highest temperature was 30°C in and lowest was 26°C to 25°C in January 2014 in treatment I and treatment II. The recorded minimum temperature in winter and maximum in summer reflected the same results obtained by Rao (1955), Banerjee (1967), Lakshmanan *et al.* (1971), Dewan (1973) and Ali *et al.* (1989).

In the two ponds, the rainfall was the main source of water supply. Hence, it was observed that the depth of water had a direct relationship with rainfall. The water depth was found to be the lowest 2.34 feet in December 2013 in treatment I and highest 6.13 feet in August 2014. The figure 7 also showed that the depth of water of all ponds was nearly similar throughout the year. The increasing trend of water depth of the pond towards the peak was perhaps due to monsoon. This result was similar to those of Michael (1969), Dewan (1973) and Latif *et al.* (1986). The lowest water depth was found in winter (dry season) which was also similar to the results of Islam (1995).

Water transparency was always high in treatment I and treatment II during this study period (Fig 21). The highest value 63 cm was recorded in March 2015 in treatment I. Water transparency was always low in treatment II due to high plankton growth because these pond was feed by poultry wastage. The lowest value was 25 cm in May 2015 in treatment II. Latif *et al.* (1986) gave the similar opinions. Transparency of water was also affected by rainfall. Naser *et al.* (1990) made similar observation.

Dissolved oxygen affects the growth, survival, distribution, behavior and physiology of fishes and other aquatic organisms (Solis 1988). The principal source of oxygen in water is atmospheric air and photosynthetic planktons. Oxygen depletion in water leads to poor feeding of fish starvation, reduced growth and more fish mortality, either directly or indirectly (Bhatnagar and Garg 2000). Oxygen is one of the most important factors in any living ecosystem. Dissolved oxygen at levels of 4.5 mg/l or lower should be regarded as hazardous or lethal 5 mg/l or more dissolved oxygen should be considered as favourable for freshwater fishes (Ellis 1937).The dissolved oxygen content of the treatment water was found maximum 5 mg/L during January'15 and minimum in March'14 4.5 mg/L. This finding is very similar to that of Roy (1955), who noted maximum dissolved concentration of oxygen in winter. Welch (1952), Reid (1961), Chowdhury and Mazumder (1981), Swale (1964), Ferrari (1976), Chakrabarty *et al.* (1959), Pahwa and Mehrotra (1966) and Miah *et al.* (1981) also reported maximum oxygen content in winter months and minimum in summer probably because winter months get longer photosynthesis periods than summer. Dissolved oxygen has direct relationship with water temperature, increase of temperature caused a decrease in oxygen decrease oxygen content of water Boyd (1982), Ali *et al.* (1982) also showed similar relationship. Dissolved oxygen showed an inverse relationship with *p*H and carbon dioxide of waters similar observations were made by Chowdhury and Mazumder (1981). The pH levels also fluctuate in a similar fashion to dissolved oxygen.

The highest concentration of free carbon dioxide was noted in summer. These findings do not agree with that of Lakshinarayan (1965), Dewan (1973), Chowdhury and Mazumder (1981) and Miah *et al.* (1981). During the present investigation content was found lower in winter season. Similar observations were also made by Islam and Mendes (1976), Patra and Azadi (1987) and Miah *et al.* (1983) in Bangladesh.

The pH value of the ponds water are showed alkaline in nature with small variations and varied between 7±0.05 to 6±0.02 during the present investigation period. High pH values were recorded during winter months. The high p*H* value during winter months was possibly due to the low free CO_2, low water temperature, high alkalinity, high dissolved oxygen, low water volume, high photosynthesis and low rainfall.

The low pH values were recorded during in August 2014 and September 2014, which may be due to the high temperature, rainfall, CO_2 content, low photosynthesis, and low dissolved oxygen. The high rate of organic decomposition may also be the cause of low pH in hot days. Ameen *et al.* (1986) also showed this cause of low pH, dissolved oxygen and water temperature. Boyd (1982) also recorded similar observations. These findings more or less agree with Chowdhury and Mazumder (1981), but disagree with Sarker and Rai (1964). In the present study, the pH showed a direct relationship with free $C0_2$, which contradicts Boyd (1982), Mollah and Haque (1978). This might be due to the presence of organic masses at the bottom of the beel and increase in $C0_2$ content resulted the decrease in pH value and probably caused due to the formation of carbonic acid ($CO_2 + H_2O = H_2CO_3$)**.**

Hardness of water is directly related to the biological productivity. A hardness level as 170-22 mg/1 is termed as good quality water (Khan *et al.* 1990). In the present study hardness content varied from 110±0.8 to 140±0.6 mg/1. The highest amount of hardness was recorded in

August'14 month. This finding do not agree with Michael (1969) and Jana (1973) and Chowdhury and Mazumder (1981). During the present investigation hardness content was found lower in December'13 and January'14 months. Khan *et al.* (1990) observed sharp fall in total hardness during monsoon a clue to the heavy rainfall resulting in dilution of water. Total hardness might be related to increasing photosynthesis activities as observed by Clark (1954). In present study the range of hardness observed agree with the other observation made for Bangladesh waters (Khan *et al.* 1990, Mustafa e*t al.* 1994).

The changes in alkalinity values occurred with the changes in hardness levels. Alkalinity and hardness are not same but both are expressed as $CaCO_3$. According to Aalkunhi (1957), the highly productive water bodies should have more than 100 ppm total alkalinity. Total alkalinity in the ponds water varied between 140±0.07 mg/1 to 155±1.87. The suitable range of total alkalinity is 100-200 ppm (Islam 1996). The relatively higher values were observed in the winter. These findings are in agreement with Chowdhury and Mazumder (1981), Ali *et al.* (1980) and George (1966). Ali and Islam (1981) showed a wide range of fluctuations in the value of alkalinity. The low alkalinity was recorded during summer months and is supported by the findings of George (1966).

The high alkalinity during winter was possibly due to the low free CO_2, low temperature and rainfall, evaporation of water, which can cause a gradual increase in alkalinity (Michael 1969), low volume of water and high pH. On the other hand, low alkalinity during summer months was possibly due to the heavy rainfall, which diluted the alkalinity, furthermore production of free Co_2 enhanced by high temperature, and agrees with that of Michael (1969) and Verma (1969).

Ammonia is toxic to fish. In the present study, the values of ammonia varied from 0.02±0.00 mg/1 to 0.025±0.04 mg/l. relatively lower values were observed in the winter and higher values in summer. The high values of ammonia in spring and summer may be due to the high rate of organic decomposition. Welch (1952) also showed such relationship for surface water. The toxicity of ammonia to aquatic animals and plants is of great practical importance (Goldman and Horne 1983). Sub lethal concentrations of ammonia caused pathological changes in fish organs and tissues. Un-ionized ammonia (NH_3) is toxic to fish, while the ammonia ion (NH_4) is not toxic except at extremely high levels (Trussell 1971 and Emerson *et. al.* 1975).

Aquaculture yields productivity and consequently returns are directly related to the quality and quantity of food given to the fish and is the input with the greatest influence on water quality during production. Feed is also the input whose expenditure line is the largest during the course of production, so its performance alone, can therefore single handily make or break one's production target. Therefore, it is extremely important to closely monitor the performance of feeding during the course of production, in feed-based systems.

Phytoplankton studies and monitoring are useful for control of the physico-chemical and biological conditions of the water. Therefore, certain divisions of phytoplankton can degraded recreationally value of surface water, particularly thick surface scum, which reduces the use of amenities for contact large concentrations which causes deoxygenating of the water leading to fish death (Whitton and Patts 2000). In treatment I, highest density was recorded as 2000/l in March'14 and the lowest 60/l in January'15. A second pick of phytoplankton was observed in May'15. In treatment II the highest density was recorded as 1780/l in May'15 and the lowest 510/l in September'14 Hassan *et al.* (2010), Laskar and Gupta (2009) reported minimum density of phytoplankton during monsoon and maximum during summer which was similar with the treatment I, but differ in treatment II.

The Chlorophyceae were the most dominating group among the phytoplankton which occupied 47.05% of total phytoplankton. In treatment I the monthly production was 34.00%, which accounted for 52.82% of the monthly production in treatment II. Ganai *et al.* 2010 also reported a single chlorophyce and peak in summer. Hegde and Bharati 1985 concluded that chlorophyceae do not show similar peak.

The Cyanophyceae constituted the second dominant group which was 23.53% of the total phytoplankton. In treatment II the monthly production was the 38.76%. A similar finding was recorded by Altaf and Parveen 2013, Nabila and Hussein 2012. According to them the dominance of Cyanophyceae during warmer periods and peak density autumn.

Euglenophyceaewas the third dominating group which 11.76% of the total phytoplankton in treatment I. In treatment II, total production Naik *et al*. 2005, Nandan and Aher, 2005, Zargar and Ghosh 2006 also observed similar results.

This was the fourth dominating group which 17.65% of the total phytoplankton. The pick was found in March 2015 (500/l) which was 80.82% of the monthly production. The lowest numbers were recorded in November and December 2014 and occupied 4.35% and 3.03% of the monthly production (Table 26 and Fig. 29) in treatment I. The maximum number (440/l) was found during July 2014 which was 57.67% of the monthly production. The minimum number (20/l) was found in April 2015 which was 3.56% of the monthly production (Table 27 and Fig. 30). The findings are in conformity with the findings of Munawar (1974) and Ganai *et al.* (2010). Similar findings were also made Hosmani *et al*. (1999) and Ying and Oxyang (2005).

Zooplankton was collected from two ponds (treatment I and treatment II) included representatives of the rotifers, copepods, nauplius, cladocerans and ostracods. Each plankton is directly or indirectly subjected to the complex of influences which changes with seasons and some effects might be made, some of which result in the quantitative changes, i.e. increases or decreases of size of the population. Such variation in population may be due to the variation in nutrients and other favourable conditions of water during plankton production (Welch 1952). During the present study a distinct fluctuation of zooplankton population in different months was observed. The zooplankton population showed high peak in April'14 (668.7 ind./l). Hossain *et. al.* (1998) observed similar peaks in zooplankton abundance in Bangladesh in May. Das and Srivastava (1956) observed similar peaks of zooplankton in April. Patra and Azadi (1987) found the peak in August. Whereas, Habib and Mohsinuzzaman (1986) found zooplankton abundance to be the highest in November. But Ehsan *et. al.* (1997) showed two peaks of zooplankton first peak in October and second peak in January. So, zooplankton shows variation in peak formation, probably zooplankton peak may depend on nutrition, phosphorous and nitrogen from decomposition.

Rotifers in treatment I and II, showed highest peak during November'14, similar peak was also observed by Khan and Siddiqui (1974). During the present study, the lower numbers of rotifers were found in the month of July 2014 in treatment I. In treatment II minimum number was recording in July '14. These findings were in agreement with the findings of Jhingran (1991), Banik (1995) and Patnaik (1973). However, Jana *et. al.* (1980) did not find any definite trend of seasonal abundance of planktonic rotifers.

The cladocerans showed highest peak during November'14. Similar findings were also reported by Patra and Azadi (1987), Chowdhury *et al.* (1989) from Bangladesh and Krishnamurthy and Khan (1966), Khan and Siddiqui (1974) from India. Whereas, Habib *et al.* (1984b) stated that cladocera was the highest in December. In the present study the lowest number of Cladocera were found in June 2014. This finding is in agreement with that of Patra and Azadi (1987), Chowdhury *et. al.* (1989) and Habib *et al.* (1984), but does not agree with that of Ehsan *et al.*(1997) But George (1966) from India found no definite peak.

Copepods showed highest peak during June'14 and October'14 in treatment I. In treatment II the maximum numbers were found during June'14 and the minimum numbers were found in November'14 and January'15. Patra and Azadi (1987) made similar observations in Haldarivers. Ehsan *et al*. (1997) also observed summer peak in Chandabeel. In the present study a second peak of copepod was found in January'15 in treatment I Krishnamurthy and Khan (1966) observed two peaks, but one in spring and another in summer.

During the present study the highest density of ostracods were recorded during February'15 and missing in the month of October'14 in treatment I. Patra and Azadi (1987) also made similar observation. Chowdhury *et. al*. (1989) recorded the highest peak of ostracods in the month of April and thus disagrees with the present result.

Nauplius was the fourth dominant group of the zooplanktons. Similar results were also found by Hossain *et al.* (1998). However, Ehsan *et al*. (1997) stated that nauplius was second dominant group among zooplankton. During the present study, the peak was found in July'14 in nauplius population and second highest in the month of February'15 in treatment I. In treatment II the maximum number was found in October'14 and, Patra and Azadi (1987) found the high density of nauplius in the month of October, May, June and September, whereas, Chowdhury *et al.* (1989) stated that nauplius abundance was highest in April.

Statistical analysis explains the role of physico-chemical and biological effects on growth performance All independent aquatic variables viz. Temperature ºC, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Premix vitamin (kg), Fishmeal (kg) explained 79.6%, 81.0% and 80.6% of the variance in Indian major carps *Labeo rohita, Catla catla* and *Cirrhinus mrigala* length development effect, which is not significant as indicated by ANOVA test with F=2.732 and of P=0.098[b], F=2.991 and P=.080[b] and F=2.903 and P=.085[b] respectively of treatment I . Oil Cake (kg) the variable was excluded from the model as it showed no influence. On the other hand in treatment II, Temperature ºC, CO2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L explained 29.3%, 29.6% and 29.3% of the variance in length in three Indian major carp's length development effect, which is not significant as indicated by ANOVA test values with F=0.689 and P=.664[a], F=0.701, and P=0.656[a] and F=2.903 and P=.085[b], respectively.

***Some of the variables like Oil cake in treatment I and DO in treatment II were excluded from the model as they showed static value during the investigation period.**

All independent aquatic physico-chemical variables viz. Temperature ºC, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Premix vitamin (kg), Fishmeal (kg) explained 89.20%, 87.60% and 89.20 % of relation with weight the variance in Indian major carps *Labeo rohita, Catla catla* and *Cirrhinus mrigala* length development effect which are showed no significant correlations as indicated by ANOVA test values F=5.786 and P=.015[a], in F=5.786 and P=.015[a] and F=5.804 an examination of p=.015[a] in treatment I . In treatment II independent variable like Temperature ºC, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L explained 38.00%, 38.00% and 34.3% of variance in weight development of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* effect, which showed no significant correlation as indicated by ANOVA test values F=1.021 and P=.465[b], F=1.021 and P=.46 and F=1.180 and P=0.389[b] All independent variables viz. Temperature ºC, DO mg/L, CO_2 mg/L, pH, Hardness, Alkalinity mg/L, NH_3 mg/L, Oil Cake (kg), Premix vitamin (kg), Fishmeal (kg) an explain 89.2% of the variance in weight (*Cirrhinus mrigala*) effect, which is not significant as indicated by ANOVA test with biological

Effectors like Chlorophyceae, Cyanophyceae, Euglenophyceae, Rotifers, Cladocerans, Copepoda, Ostracoda, and Nauplius have equally influenced the length (*Labeo rohita*) in group I, as independent variable explain 42.70%, 42.80% and 42.80% of the variance in length of *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* length increase effect in treatment I group, which is not significant as indicated by ANOVA test with F=0.678 and $P=0.702^{b}$ F=.682 and $P=0.700^{b}$ and F=0.677 and $P=0.703^{b}$.

The same independent variables explain 51.30%, 49.50% and 51. 10%. of the variance in length increase in effect *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*, which is not significant as indicated by ANOVA test values F=0.922 and $P=0.550^{bical\ g}$, F=0.864 and $P=0.583^{b}$ F=0.917 and P=0.552 respectively in treatment group II. A combined influence of biological effecter planktons were predicts the length increase during the study period.

All independent variable explain 42.70%, 42.80% and 42.90% of the variance in weight gain *L. rohita*, *C. catla* and *C. mrigala,* respectively, which are not significant as indicated by ANOVA test with F=0.747and $P=0.655^{b}$, F=0.0.747 and $P=0.655^{b}$ and 0.750 and $P=0.653^{b}$ no independent Biological effectors contributes the prediction of weight gain. Chlorophyceae, Cyanophyceae, Euglenophyceae, Rotifers, Cladocerans, Copepoda, Ostracoda and Nauplius were equally influenced the weight gain in group I.

All independent variable explained 60.30%, 58.40% and 60.80% of the variance in weight gain of *L. rohita*, *C. catla* and *C. mrigala* effect respectively, which is not significant as indicated by ANOVA test values F=1.343 and P= 0.366, F=1.230 and P=0.355 and F= 1.358 and 0.658 respectively. Indicates that no independent biological effector contributes the prediction of weight gain in *L. rohita*, *C. catla* and *C. mrigala*. Cyanophyceae, Euglenophyceae, Bacillariophyceae, Rotifers, Cladocerans, Copepoda, Ostracoda and Nauplius were equally influence the weight gain in group II.

The independent variable explains different variation in length and growth development in physico chemical and plankton groups. ANOVA F values and P values indicate no-significant influence on length and growth development. Standardize correlation *P*-value indicates that none of the independent variable contributes the prediction of length and growth development of *L. rohita*, *C. catla* and *C. mrigala,* but indicates a non-significant combined influence on predication of IMC length and growth development.

The study of fish parasitology is important both from the point of fishery management and control of human and animal diseases for fish caused by fish parasites. In the present study, the highest prevalence of parasites was observed as compared to the research conducted by *C. Idela* among the all examined fish. The difference in these parasitic infestations might be due to different geo-climatic conditions or these experimental fishes had low resistance against parasites. Akhter (2007) examined 5 exotic freshwater carp species, only 793 fish were infected by different ectoparasites and the parasitic prevalence was the highest in *H. Molitrix*by and *Argulus* sp. (20.1%) and the lowest was seen in *C. carpio.* However*,* Delwer (2010) observed that the highest prevalence of parasites among carp fishes was 87.50% and lowest was 77.04% which is more or less agree with the present study. The highest number of parasites was recorded on the gill and lowest number of parasites was found in the fin of the examined carp fishes at treatment I. On the other hand, the highest number of parasites was recorded on the gill and lowest number of parasites was found in the intestine at treatment II. Delwer (2010) also reported that carps fishes are mostly infested by the skin parasites, which indicate the food prevalence and distribution pattern of parasites, it. Moreover, Sanaullah and Ahmed (1980) found similar observation.

The ectoparasite *Ichthyopthirius* sp., *Larnaea sp., Argulus sp., Ichthyobodo sp. Trichodina sp.* were found in the skin, gill and fin of *L. rohita, C. catla* and *C. mrigala and* where as endoparasites *Eucreadium* sp. *Cammalanus sp.* were found only in intestine of *C. mrigala.* Banu and Chowdhury (1993) reported these parasites in some exotic fishes. Rahman and Parveen (2001) and Rahman *e al.* (2007) observed similar parasitic infestation in different freshwater fish species of Bangladesh.

The highest prevalence of parasites (18%) was recorded in the host of *L. rohita* at rainy season and lowest (5%) in *C. catla* during the summer season. On the other hand, the highest abundance and mean density also showed in *C. mrigala* at rainy season. This might be due to *L. rohita* is more susceptible to parasite diseases than *C. Catla* and *C. mrigala*. Khan *et al.* (2003) observed that there exist a direct relation between temperature and parasitic infestation. The results reveal that the parasites infection is more severe during the rainy season than other season. Tak *et al.* (2014) reported that most of the ectoparasitic infection was occurred during the winter. Mohanta 1998 observed that *Puntius* sp. was more infested by parasites in winter than summer season. Many other researchers such as Akhter (1998) have also found similar observations and heavy infections in the particular season of the year. Furthermore, Hossain (1999) has also reported that winter as a period of high susceptibility of fish to pathogens especially ectoparasites. Kabata (1985) revealed that the fishes are susceptible to disease in low temperature and low metabolic activity. This finding clearly indicates that the seasonal mode of parasitic infestation among the host fishes. However, winter had already been identified as a period of high susceptibility of fish.

7.3. Economic and cost benefit analysis

he total production function as inputs was positive and significant at l% level of significance in both treatment I and II. The coefficients of feed cost was positive and significant at l% level of significance in both treatment I and II , which indicated that l percent increase in feed cost, keeping other factors constant, would increase gross return. Similar the case with input labor and vehicle and other cost. The coefficients of fertilizer cost was insignificant, which indicated the over use of these inputs. Cost of fingerlings was a fixed cost and had no significant impact on two different feeding pond fish production system. Miah *et al*. (1996) obtained 3,434.07 kg/ha fish in 10 month by applying cow dung, supplementary feed and 50 kg/ha inorganic fertilizer in carp polyculture system. In traditional polyculture system of carps in Bangladesh the production range was 3,119 to 4067 kg/ha/yr (Uddin *et al*. 1994, Hossain *et al*. 1997 and Mazid *et al*. 1997). Awal *et al.* (1995) stated that a net production of native, exotic and mixed polyculture system were 1196, 1617 and 982 kg/ha per 6 months, respectively. Though the level of fish production in the present study was not similar to the result quoted above, but the production obtained in ten months was encouraging in terms of maximum individual weights attained.

The production of fish in ponds was higher in Treatment I than in Treatment II. The cost was significantly lower in Treatment II than Treatment I. The cost of fish production was minimum but the profit percentage was maximum in Treatment II than Treatment I. The study reveals that the

Benefit-cost ratio was higher in Treatment II than in Treatment I. In the functional analysis, it was found that the some of factors of fish production (fingerlings, fertilizer, feed, labor and vehicles) were positive Treatment II, where as three factors (fingerlings feed and labor) were positive inTreatment I. The results of the study indicate that the pond fish production canbe increased and made more profitable by cost efficient reallocation resources in theproduction process and sustainable effective management technology.

CONCLUSION

In Bangladesh too, some of the farmers have been able to get a production of even up to11 tonnes/ha by following good management practices. Hence, it was observed that by providing good scientific support to farmers, production can be increased further substantially.

The present study clearly show that carp farming practices in Bangladesh were profitable. Though the production level was slightly higher in supplementary feed loaded systems (5255 kg/pond) as compared to poultry waste loaded system (5037 kg/pond) .Even the benefit-cost ratio showed the benefits of in supplemental feed loaded systems (1.82) as compared to poultry waste loaded system (4.16), but the cost benefit ratio results of the study thus indicate that there is an opportunity to profitability by employing the quality feed and better management practices for commercial production. The study also demonstrated that small homestead ponds appear to be better suited for carp culture with low cost available recourses . The indigenous methods to improve production and reduce production costs included improved method of pond fertilization by using slurry combined with inorganic fertilizers, use of various agricultural wastes as feed for carp. Though the stocking more than double the recommended number of 300 pcs fingerlings, the survival rate was 76.30 to 92.70 percent. This was largely due to the small size of the fish stocked. The size of fish at harvest was small 855 gm. as there was a strong demand for this size of fish among the low income group population. The overall profitability of the farmers was better in semi-intensive system with the use of pellet feed as compared to the traditional system. It is likely that the current level of profitability with cost benefit ratio of poultry waste influence natural food would encourage more land to be converted to aquaculture, particularly by using the vast amount of waste land available in the Banladesh and homestead derelict water body. However, it is important to note that local people do prefer carp because of the muscular test. In addition, promoting fish as a health food would bring more revenue to farmers, assuming that demand will increase within and outside the state. Fish culture systems are recognized as users of a valuable water resource, even though they are more efficient than the prevailing crops like rice and wheat cultivation (Sondhi and Joir, 1993). However, in view of the declining water tables in the region as a whole, it is suggested that ground water exploitation should be reduced and efficient use of water should be planned. Aquaculture is recognized by the farmers in Bangladesh has a profitable alternate cropping system that can generate an assured level of income. In view of the positive impact, there is opportunity to expand fish farming and help farmers to derive the benefits from this new activity.

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APPENDIX

Appendix I: Monthly average length gain of *L. rohita* at treatment I and treatment II (December 2013 to May 2015)

Labeo rohita	Monthly mean length gain (cm)			
	Treatment I		Treatment II	
	n	Mean±SD	n	Mean±SD
Dec. ’13	10	1.9±0.15	10	0.76±0.12
Jan.’14	10	1.2±0.7	10	0.63±0.52
Feb.’14	10	1.2±0.51	10	0.63±0.25
Mar.’14	10	1.7±0.17	10	0.7±0.61
Apr.’14	10	1.9±0.20	10	0.63±0.35
May.’14	10	2.5±0.14	10	1.2±0.71
Jun.’14	10	2.5±0.34	10	1.7±0.27
Jul.’14	10	3.09±0.1	10	1.6±0.55
Aug.’14	10	3.04±0.3	10	1.5±0.2
Sep.’14	10	1.2±0.27	10	1.3±0.9
Oct.’14	10	1.5±0.22	10	1.02±0.0
Nov.14	10	1.02±0.3	10	0.7±0.6
Dec. ‘15	10	0.7±0.61	10	0.7±0.6
Jan.’15	10	0.6±0.31	10	1.02±0.0
Feb.’15	10	1.1±0.52	10	1.1±0.4
Mar.’15	10	1.01±0.23	10	2.2±0.9
Apr.’15	10	1.1±0.41	10	2.7±0.9
May.’15	10	3.3±0.12	10	3.2±0.2

Appendix II: Monthly average weight gain *L. rohita* at treatment I and treatment II (December 2013 to May 2015)

Labeo rohita	Monthly mean weight gain (gm)			
	Treatment I		Treatment II	
	n	Mean±SD	n	Mean±SD
Dec. '13	10	5.6±0.12	10	3.2±0.13
Jan.'14	10	5.8±0.04	10	3.1±0.24
Feb.'14	10	12.7±0.24	10	9.3±0.32
Mar.'14	10	21.7±0.16	10	7.2±0.54
Apr.'14	10	37.6±0.09	10	12.4±0.65
May.'14	10	33.4±0.16	10	6.5±0.78
Jun.'14	10	200.2±0.8	10	15.2±0.32
Jul.'14	10	77.5±0.18	10	30.7±0.34
Aug.'14	10	240.4±0.09	10	20.5±0.31
Sep.'14	10	200.1±0.13	10	15.8±0.25
Oct.'14	10	100.2±0.98	10	30.3±0.29
Nov.14	10	50.2±0.56	10	40.2±0.61
Dec. '15	10	50.3±0.34	10	50.2±0.26
Jan.'15	10	60.2±0.25	10	35.7±0.17
Feb.'15	10	90.1±0.56	10	75.1±0.94
Mar.'15	10	130.3±0.21	10	90.2±0.36
Apr.'15	10	160.3±0.28	10	205.8±0.54
May.'15	10	180.1±0.34	10	175.9±0.67

Appendix III: Monthly average length gain of *C. catla* at treatment I and treatment II (December 2013 to May 2015)

Catla catla	Monthly mean length gain (cm)			
	Treatment I		Treatment II	
	n	Mean±SD	n	Mean±SD
Dec. ’13	10	1.2±0.17	10	0.63±0.52
Jan.’14	10	1.2±0.72	10	0.76±0.21
Feb.’14	10	1.2±0.17	10	0.76±0.24
Mar.’14	10	1.6±0.53	10	0.6±0.32
Apr.’14	10	1.6±0.25	10	0.7±0.61
May.’14	10	2.5±0.14	10	1.2±0.74
Jun.’14	10	2.5±0.24	10	2.03±0.23
Jul.’14	10	3.1±0.27	10	1.7±0.71
Aug.’14	10	2.9±0.12	10	1.7±0.74
Sep.’14	10	1.30±0.34	10	1.6±0.52
Oct.’14	10	1.9±0.42	10	0.8±0.9
Nov.14	10	1.01±0.12	10	0.8±0.91
Dec. ‘15	10	1.27±0.21	10	0.8±0.11
Jan.’15	10	1.02±0.42	10	1.04±0.0
Feb.’15	10	1.01±0.52	10	1.02±0.21
Mar.’15	10	1.5±0.31	10	1.02±0.43
Apr.’15	10	2.2±0.85	10	2.2±0.81
May.’15	10	2.6±0.72	10	3.4±0.32

Appendix IV: Monthly average weight gain of *C. catla* at treatment I and treatment II (December 2013 to May 2015)

Catla catla	Monthly mean weight gain (gm)				P value
	Treatment I		Treatment II		
	n	Mean±SD	n	Mean±SD	
Dec. '13	10	5.1±0.43	10	3.54±0.90	0.001^s
Jan.'14	10	7.5±0.90	10	4.24±0.24	0.001^s
Feb.'14	10	21.2±0.35	10	10.5±0.21	0.001^s
Mar.'14	10	12.3±0.23	10	8.21±0.45	0.001^s
Apr.'14	10	35.5±0.12	10	15.2±0.19	0.001^s
May.'14	10	45.1±0.52	10	5.3±0.26	0.001^s
Jun.'14	10	40.5±0.65	10	35.1±0.56	0.001^s
Jul.'14	10	110.3±0.67	10	35.4±0.25	0.001^s
Aug.'14	10	260.2±0.87	10	25.3±0.78	0.001^s
Sep.'14	10	300.1±0.68	10	25.2±0.28	0.001^s
Oct.'14	10	200.5±0.32	10	75.1±0.43	0.001^s
Nov.14	10	100.3±0.12	10	50.8±0.32	0.001^s
Dec. '15	10	50.5±0.21	10	40.8±0.63	0.001^s
Jan.'15	10	50.2±0.31	10	45.7±0.41	0.001^s
Feb.'15	10	80.6±0.32	10	55.6±0.24	0.001^s
Mar.'15	10	100.2±0.23	10	80.5±0.25	0.001^s
Apr.'15	10	120.6±0.26	10	130.1±0.78	0.001^s
May.'15	10	260.4±0.63	10	210.3±0.65	0.001^s

Appendix V: Monthly average length gain of *C. mrigala* at treatment I and treatment II (December 2013 to May 2015)

Cirrhinus mrigala	Monthly mean length gain (cm)				P value
	Treatment I		Treatment II		
	n	Mean±SD	n	Mean±SD	
Dec. ’13	10	1.9±0.05	10	0.63±0.51	0.001^{s}
Jan.’14	10	1.2±0.35	10	0.63±0.53	0.011^{s}
Feb.’14	10	1.2±0.41	10	0.63±0.54	0.016^{s}
Mar.’14	10	1.6±0.5	10	0.5±0.01	0.001^{s}
Apr.’14	10	1.7±0.71	10	0.63±0.5	0.001^{s}
May.’14	10	2.4±0.11	10	1.01±0.12	0.001^{s}
Jun.’14	10	2.5±0.43	10	1.7±0.74	0.009^{s}
Jul.’14	10	2.7±0.9	10	1.6±0.52	0.004^{s}
Aug.’14	10	2.9±0.42	10	1.5±0.25	0.001^{s}
Sep.’14	10	1.5±0.22	10	1.3±0.92	0.512^{ns}
Oct.’14	10	1.2±0.73	10	1.02±0.5	0.528^{ns}
Nov.14	10	1.2±0.71	10	0.8±0.85	0.268^{ns}
Dec. ‘15	10	0.7±0.61	10	0.7±0.73	1.00^{ns}
Jan.’15	10	0.9±0.2	10	1.01±0.23	0.269^{ns}
Feb.’15	10	1.3±0.7	10	1.1±0.51	0.475^{ns}
Mar.’15	10	1.7±0.32	10	2.2±0.85	0.099^{ns}
Apr.’15	10	2.03±0.2	10	3.05±0.12	0.001^{s}
May.’15	10	1.7±0.8	10	2.6±0.72	0.017^{s}

Appendix VI: Monthly average weight gain of *C. mrigala* at treatment I and treatment II (December 2013 to May 2015)

Cirrhinus mrigala	Monthly mean weight gain (gm)				P value
	Treatment I		Treatment II		
	n	Mean±SD	n	Mean±SD	
Dec. '13	10	4.5±0.90	10	2.7±0.70	0.001^{s}
Jan.'14	10	5.6±0.87	10	5.65±0.23	0.863^{ns}
Feb.'14	10	14.2±0.78	10	9.54±0.32	0.001^{s}
Mar.'14	10	20.4±0.21	10	6.43±0.15	0.001^{s}
Apr.'14	10	39.3±0.12	10	15.32±0.54	0.001^{s}
May.'14	10	31.2±0.24	10	5.21±0.78	0.001^{s}
Jun.'14	10	21.3±0.56	10	15.12±0.41	0.001^{s}
Jul.'14	10	73.3±0.80	10	20.45±0.20	0.001^{s}
Aug.'14	10	235.4±0.42	10	25.10±0.76	0.001^{s}
Sep.'14	10	210.6±0.25	10	15.32±0.87	0.001^{s}
Oct.'14	10	90.5±0.89	10	30.9±0.78	0.001^{s}
Nov.14	10	40.4±0.78	10	25.8±0.45	0.001^{s}
Dec. '15	10	40.9±0.56	10	35.6±0.39	0.001^{s}
Jan.'15	10	40.7±0.46	10	45.21±0.31	0.001^{s}
Feb.'15	10	90.3±0.76	10	360.23±0.57	0.001^{s}
Mar.'15	10	110.2±0.34	10	90.6±0.82	0.001^{s}
Apr.'15	10	140.4±0.57	10	170.5±0.79	0.001^{s}
May.'15	10	220.2±0.89	10	235.2±0.63	0.001^{s}

Appendix VII : Monthly total length gain of *L. rohita* at treatment I and treatment II (December 2013 to May 2015)

Labeo rohita	Monthly mean length (cm)			
	Treatment I		Treatment II	
	n	Mean±SD	n	Mean±SD
Dec. '13	10	14.3±0.52	10	13.1±0.77
Jan.'14	10	15.6±0.22	10	13.8±0.05
Feb.'14	10	16.8±0.91	10	14.4±0.37
Mar.'14	10	18.6±0.61	10	15.1±0.93
Apr.'14	10	20.5±0.73	10	15.8±0.23
May.'14	10	23.1±0.14	10	17.0±0.92
Jun.'14	10	25.6±0.52	10	18.8±0.61
Jul.'14	10	28.7±0.09	10	20.5±0.11
Aug.'14	10	31.7±0.52	10	22.0±0.32
Sep.'14	10	33.02±0.3	10	23.4±0.22
Oct.'14	10	34.5±0.41	10	24.4±0.42
Nov.14	10	35.5±0.64	10	25.2±0.03
Dec. '15	10	36.3±0.22	10	25.9±0.61
Jan.'15	10	36.9±0.54	10	26.9±0.82
Feb.'15	10	38.10±0.56	10	28.1±0.23
Mar.'15	10	39.1±0.14	10	30.4±0.13
Apr.'15	10	40.2±0.55	10	33.2±0.04
May.'15	10	43.5±0.63	10	36.4±0.22

Appendix VIII : Monthly total weight gain of *L. rohita* at treatment I and treatment II (December 2013 to May 2015)

Labeo rohita	Monthly mean weight (gm)			
	Treatment I		Treatment II	
	n	Mean±SD	n	Mean±SD
Dec. '13	10	55.12±0.45	10	53.5±0.44
Jan.'14	10	60.2±0.43	10	56.3±0.65
Feb.'14	10	72.3±0.65	10	65.6±0.54
Mar.'14	10	93.7±0.90	10	72.8±0.44
Apr.'14	10	130.7±0.23	10	84.3±0.34
May.'14	10	163.8±0.31	10	90.7±0.65
Jun.'14	10	183.3±0.26	10	105.6±0.80
Jul.'14	10	260.5±0.54	10	135.1±0.32
Aug.'14	10	500.9±0.76	10	155.3±0.24
Sep.'14	10	700.2±0.89	10	170.8±0.54
Oct.'14	10	800.7±0.54	10	200.6±0.65
Nov.14	10	850.8±0.34	10	240.6±0.61
Dec. '15	10	900.9±0.56	10	290.4±0.24
Jan.'15	10	960.4±0.43	10	325.8±0.54
Feb.'15	10	1050.3±0.25	10	400.7±0.65
Mar.'15	10	1180.3±0.35	10	490.5±0.55
Apr.'15	10	1340.6±0.75	10	695.4±0.63
May.'15	10	1520.7±0.87	10	870.6±0.45

Appendix IX : Monthly total length gain of *C. catla* at treatment I and treatment II (December 2013 to May 2015)

Catla catla	Monthly mean length (cm)				P value
	Treatment I		Treatment II		
	n	Mean±SD	n	Mean±SD	
Dec. '13	10	13.5±0.95	10	12.9±0.52	0.097^{ns}
Jan.'14	10	14.8±0.57	10	13.7±0.13	0.001^{s}
Feb.'14	10	16.1±0.23	10	14.4±0.74	0.001^{s}
Mar.'14	10	17.7±0.85	10	15.1±0.17	0.001^{s}
Apr.'14	10	19.1±0.72	10	15.8±0.76	0.001^{s}
May.'14	10	21.7±0.85	10	17.1±0.45	0.001^{s}
Jun.'14	10	24.2±0.52	10	19.1±0.74	0.001^{s}
Jul.'14	10	27.4±0.36	10	20.9±0.53	0.001^{s}
Aug.'14	10	30.3±0.52	10	22.7±0.32	0.001^{s}
Sep.'14	10	31.6±0.25	10	24.3±0.83	0.001^{s}
Oct.'14	10	33.5±0.63	10	25.2±0.75	0.001^{s}
Nov.14	10	36.5±0.72	10	26.1±0.17	0.001^{s}
Dec. '15	10	37.8±0.43	10	26.9±0.27	0.001^{s}
Jan.'15	10	38.8±0.61	10	27.9±0.46	0.001^{s}
Feb.'15	10	39.8±0.73	10	28.9±0.65	0.001^{s}
Mar.'15	10	41.4±0.12	10	29.9±0.83	0.001^{s}
Apr.'15	10	43.6±0.83	10	32.2±0.65	0.001^{s}
May.'15	10	46.3±0.51	10	35.6±0.94	0.001^{s}

Appendix X: Monthly total weight gain of *C. catla* at treatment I and treatment II (December 2013 to May 2015)

Catla catla	Monthly mean weight (gm)			
	Treatment I		Treatment II	
	n	Mean±SD	n	Mean±SD
Dec. '13	10	70.6±0.23	10	68.3±0.24
Jan.'14	10	77.9±0.45	10	72.2±0.55
Feb.'14	10	98.8±0.42	10	82.4±0.64
Mar.'14	10	110.6±0.15	10	90.5±0.76
Apr.'14	10	145.3±0.71	10	105.6±0.25
May.'14	10	190.65±0.49	10	115.7±0.35
Jun.'14	10	230.9±0.78	10	150.3±0.54
Jul.'14	10	340.8±0.34	10	185.8±0.36
Aug.'14	10	600.7±0.41	10	210.2±0.52
Sep.'14	10	900.6±0.32	10	235.5±0.47
Oct.'14	10	1100.3±0.22	10	310.8±0.85
Nov.14	10	1200.8±0.48	10	360.9±0.56
Dec. '15	10	1250.6±0.63	10	400.7±0.79
Jan.'15	10	1300.7±0.23	10	445.4±0.51
Feb.'15	10	1380.3±0.71	10	500.4±0.49
Mar.'15	10	1480.4±0.53	10	580.5±0.71
Apr.'15	10	1600.5±0.65	10	710.6±0.62
May.'15	10	1860.7±0.74	10	920.2±0.39

Appendix XI : Monthly total length gain of *C. mrigala* at treatment I and treatment II (December 2013 to May 2015)

Cirrhinus mrigala	**Monthly mean length (cm)**			
	Treatment I		**Treatment II**	
	n	**Mean±SD**	**n**	**Mean±SD**
Dec. ’13	10	14.4±0.87	10	13.2±0.08
Jan.’14	10	15.7±0.45	10	13.8±0.41
Feb.’14	10	17.0±0.10	10	14.4±0.77
Mar.’14	10	18.6±0.67	10	14.9±0.83
Apr.’14	10	20.5±0.75	10	15.6±0.29
May.’14	10	22.9±0.87	10	16.6±0.31
Jun.’14	10	25.5±0.26	10	18.4±0.09
Jul.’14	10	28.3±0.25	10	20.1±0.91
Aug.’14	10	31.2±0.44	10	21.7±0.19
Sep.’14	10	32.7±0.64	10	23.1±0.17
Oct.’14	10	34.03±0.23	10	24.1±0.35
Nov.14	10	35.3±0.02	10	25.0±0.16
Dec. ‘15	10	36.06±0.23	10	25.7±0.88
Jan.’15	10	36.9±0.83	10	26.7±0.99
Feb.’15	10	38.3±0.53	10	27.9±0.49
Mar.’15	10	39.6±0.25	10	30.2±0.27
Apr.’15	10	41.6±0.53	10	33.2±0.76
May.’15	10	43.4±0.33	10	35.9±0.44

Appendix XII : Monthly total weight gain of *C. mrigala* at treatment I and treatment II (December 2013 to May 2015)

Cirrhinus mrigala	**Monthly mean weight (gm)**			
	Treatment I		**Treatment II**	
	n	**Mean±SD**	**n**	**Mean±SD**
Dec. '13	10	52.8±0.53	10	50.1±0.87
Jan.'14	10	57.5±0.45	10	55.8±0.61
Feb.'14	10	71.7±0.62	10	64.7±0.39
Mar.'14	10	91.3±0.63	10	70.4±0.43
Apr.'14	10	130.5±0.32	10	85.8±0.46
May.'14	10	161.6±0.35	10	90.6±0.36
Jun.'14	10	182.9±0.54	10	105.9±0.72
Jul.'14	10	255.6±0.43	10	125.8±0.82
Aug.'14	10	490.8±0.32	10	150.5±0.63
Sep.'14	10	700.3±0.55	10	165.1±0.33
Oct.'14	10	790.5±0.65	10	195.5±0.44
Nov.14	10	830.6±0.87	10	220.8±0.56
Dec. '15	10	870.43±0.43	10	255.3±0.81
Jan.'15	10	910.6±0.25	10	300.5±0.39
Feb.'15	10	1000.5±0.33	10	360.7±0.84
Mar.'15	10	1110.5±0.43	10	450.6±0.34
Apr.'15	10	1250.5±0.22	10	620.5±0.56
May.'15	10	1470.8±0.27	10	855.5±0.41

Appendix XIII : Average monthly weight gain at treatment I (December 2013 to May 2015)

Months	*Labeo rohita* (g)	*Catla catla* (g)	*Cirrhinus mrigala* (g)
Dec. ’13	0.17	0.16	0.14
Jan.’14	0.16	0.23	0.15
Feb.’14	0.43	0.74	0.50
Mar.’14	0.68	0.37	0.64
Apr.’14	1.21	1.18	1.28
May.’14	1.06	1.44	1.00
Jun.’14	0.66	1.34	0.70
Jul.’14	2.49	3.93	2.35
Aug.’14	7.74	8.38	7.57
Sep.’14	6.67	9.99	7.00
Oct.’14	3.21	6.44	2.90
Nov.14	1.66	3.34	1.34
Dec.‘14	1.62	1.61	1.27
Jan.’15	1.93	1.6	1.28
Feb.’15	3.20	2.87	3.21
Mar.’15	4.19	3.22	3.55
Apr.’15	5.34	4.00	4.65
May.’15	5.81	8.39	7.09

Appendix XIV: Average monthly weight gain at treatment II (December 2013 to May 2015)

Months	***Labeo rohita* (g)**	***Catla catla* (g)**	***Cirrhinus mrigala* (g)**
Dec. ’13	0.11	0.10	0.09
Jan.’14	0.10	0.13	0.15
Feb.’14	0.31	0.36	0.31
Mar.’14	0.22	0.26	0.19
Apr.’14	0.39	0.48	0.50
May.’14	0.20	0.32	0.15
Jun.’14	0.50	1.17	0.51
Jul.’14	0.95	1.12	0.64
Aug.’14	0.64	0.81	0.80
Sep.’14	0.51	0.83	0.49
Oct.’14	0.97	2.43	0.97
Nov.14	1.33	1.69	0.83
Dec.‘14	1.60	1.29	1.13
Jan.’15	1.13	1.44	1.43
Feb.’15	2.67	1.96	2.15
Mar.’15	2.90	2.58	2.88
Apr.’15	6.83	4.33	5.67
May.’15	5.63	6.76	7.57