EffectsofStockingDensityonGrowthandBodyCompositionof*Labeo bata* (Hamilton, 1822) Rearedin EarthenPond

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Certificate

This is to certify that the research study entitled **"Effects of Stocking Density on Growth and Body Composition of *Labeobata* (Hamilton, 1822) Reared in Earthen Pond"** submitted by **Tanvir Ahmed, Roll-712**, has been carried out under my supervision. This is further to certify that it is an original work and suitable in partial fulfillment for the degree of MS in Fisheries, University of Dhaka.

(Supervisor)
Md. Ghulam Mustafa, Ph.D.
Professor
Department of Fisheries
University of Dhaka

(Co-supervisor)
Md. HasanFaruque
Assistant Professor
Department of Fisheries
University of Dhaka

DEDICATED
TO
MY
BELOVED PARENTS

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ABSTRACT

The present study was carried out to the effects of stocking density on growth and body composition of *Labeo bata*(Hamilton, 1822). Fishes were reared in three selected pond of "Maa fish farm", Nawabgonj, Dinajpur, Bangladesh for a period of 60 days wherein 250 fry decimal^{-1}, 500 fry decimal^{-1}, 750 fry decimal^{-1}were set as the different stocking densities demarked as treatment T_1, T_2 and T_3 respectively. Mean initial length and weight of the fries were same in all three treatments. Mean final length and weight of the experimental fish was 10.4 ± 0.095,10.2 ±0.112, 9.9 ± 0.098 cm and 13.1 ± 0.90, 11.37 ± 0.817, 9.87 ± 0.701 g, respectively in T_1, T_2 and T_3.T_1 showed the highest length and weight gain after harvesting ($P<0.05$). The specific growth rate (%) was found highest (4.25 ±0.139) in $T_1$and lowest (3.77±0.144) in T_3, survival rate (%) was found highest 77.92 in T_1 and lowest 67.65 in T_3. The specific growth rate showed significant differences ($P<0.05$) among the treatment. Mean (±SD) moisture content (%) was found highest (79.23±1.57) in T_2 and lowest (75.16±1.04) in T_1. Mean (±SD) crude protein content (%) was found highest (17.14±0.622) in T_1 and lowest (16.75±0.354) in T_2.Mean (±SD) crude lipid content (%) was found 3.94±0.140 in T_1, 4.51±0.180 in T_2, 4.36±0.185 in T_3.The ash content (%) was found highest (2.16±0.076) in T_2 and lowest (1.81±0.110) in T_1. There were no significant variations ($P>0.05$) in the value of crude protein, content among the treatments. Where moisture, crude lipid and ash content showed significant differences ($P<0.05$) in T_1 but were not significant differences ($P>0.05$) in T_2 and T_3. Production of fingerling was 2.512, 4.251, and 5.008 kg decimal^{-1}respectively in T_1, T_2 and T_3. Despite of this, consistentlyhigher net benefits were found in T_2 and lowest in T_1.Therefore, of the threestocking densities, 500 fry decimal^{-1} appear to be most suitable stocking density for nursing and rearing of bata fry andfingerlingswhich could be recommended to adopt. However, more trials are suggested to optimize the stocking density and feeding regime for better production performance.

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbols	Details
℃	Degree Celsius
G	Gram
Cm	Centimeter
%	Percentage
ANOVA	Analysis of variance
SPSS	Statistical package for the social science
SGR	Specific growth rate
FCR	Feed conversion ratio
SR	Survival rate
IUCN	International Union for Conservation of Nature
T_1	Treatment 1
T_2	Treatment 2
T_3	Treatment 3
SD	Standard deviation
DOF	Department of Fisheries
GDP	Gross Domestic Production
Mg/L	Milligram Per Liter
Hrs	Hours

Introduction

1.1 Status and Importance of Fisheries in Bangladesh

Fish is a stapled food item due to its great importance both nutritionally and medically (Ullah et al., 2014;Muhammad et al., 2014).It is also a meat of choice as it is having good taste, high growth upholding values and is easily digestible (Shaikhet al*.,* 2011). Fish has gained high attention due to its effectiveness in cancer, heart ailment; wound healing and prolonging life expectancy (Kulikove, 1978; Bowman, 1980). Fish is influencing all spheres of human life. Nutritionally, it is one of the most important creatures. Fish diet supply vitamins such as A, D and E and macro nutrients, protein, fats, principle minerals such as Sodium, Iron, Calcium, Phosphorus, Magnesium, Iodine and many other elements (Kumar, 1992; Ross et al., 2007). Fish meat is a rich source of protein having several essential amino acids, traces of vitamin B complexes and fats (Andrew, 2001; Moghaddam et al., 2007)

Bangladesh is one of the resourceful countries having a great potential for development of fish and fisheries sector due to having many rivers, canal, ditches, lakes, ponds, estuarine, haor-baors and the Bay of Bengal.

Fish is the second most valuable agricultural crop in Bangladesh and its production contributes to the livelihoods and employment of millions of people. The culture and consumption of fish therefore has important implications for national income and food security. Bangladeshi people are popularly referred to as “Mache BhateBangali” or “fish and rice makes a Bengali”.

The fisheries sector in Bangladesh is broadly divided into four sub-sectors- inland capture, inland culture, mariculture (artisanal fisheries) and marine industrial fisheries. On the basis of fish species number and abundance Bangladeshi fisheries resource is one of the world (Shah, 2003). There are 260 fresh water fish species and 475 marine water fish species are available in the water area of Bangladesh (Rahman, 1989; Hussain and Hossain, 1999).

According to Department of Fisheries (DOF, 2014) the total inland aquatic resources of Bangladesh consisting of 4699387 hectares which includes pond and ditches (371309 ha). Oxbow lake (5488 ha), shrimp farm (275274 ha), river and estuaries (853863

ha),beel (114161 ha), kaptai lake (68800 ha), flood plain (2702304 ha). These water bodies are highly potential resources for aquaculture development.

Fisheries and aquaculture sector have emerged as the second most important contributors in export earnings of Bangladesh. It is the second largest export industry in Bangladesh and produces 2.5 percent of the global production of shrimp. Though rice is the most widely produced agricultural crop in Bangladesh, fisheries has a unique feature for its role in providing an important source of animal protein and essential elements for the population. Fisheries sector is contributing 2.01% of the total export earnings and 4.39% to the GDP (DOF, 2014). About 12 million people are directly or indirectly involved in this sector.

Bangladesh has some 130 deep-sea fishing trawlers, 22000 mechanized fishing boats, and 25000 non mechanized fishing boats. Currently there are 133 fish processing plants in Bangladesh which are mostly located in port cities (Khulna and Chittagong) of which 74 processing plants are EU approved (Ghose, 2014). Though the country is endowed with enormous fishery resources which are vital to the livelihood of millions of people and national food and nutrition security, the sector is facing major constraints including climate change, poor fisheries infrastructure, resource mismanagement, water and environmental population, natural disasters such as recurrent flood and cyclones, and lack of knowledge among farmers. Bangladesh is working with close collaboration with Department for International Development (DFID), World Fish Center and other international organization to develop the sector by building research partnerships and increasing investment. Community based management of fisheries is proving its potential to avert the longstanding political challenges farmers have been facing. The country, however, faces urgent imperatives to strengthen environmental laws to curb pollution which is significantly compromising the performance of the fisheries sector.

1.2 Status and potential of culture fisheries in Bangladesh

The fish culture in Bangladesh has a long history since time immemorial. However, as an agriculture activity the practice started from the beginning of the last century. In the past, people were used to culture fish, mainly for their own consumption and game purpose. In the face of rapid population growth with simultaneous decline in captures fisheries aquaculture emerged as a viable option for increasing production in our country. Freshwater fish culture mainly pond based and to some extent It is done in oxbow lakes.

Tremendous efforts have been given to the development of appropriate culture and seed production of different species. Successfully breeding techniques and culture method are now available for a number of species. Unfortunately, these are mainly centered on large indigenous carps (rohu, catla, mrigal, kalibaus etc.) and exotic fish species (silver carp, grass carp, big head carp, Thai pungus, African catfish, Vieatnamse koi etc.)

Fish production has been increased to 34.10 lakhs MT in 2012-2013, which was 32.62 lakhs MT in 2011-2012 and 25.63 lakhs MT in 2007-08 (DOF, 2014). This has been possible due to generation adoption of new and appropriate technologies. The high demand for fry/fingerling for aquaculture resulted in the development of infrastructure facilities both in public sector are engaged in fish seed production.

In spite of phenomenon achievement in culture fisheries sector, fisheries experts believe that it is possible to double the current value of fish production by shifting from traditional extensive and semi-extensive culture to intensive culture. The present level of per acre production in lower than neighboring countries, because the productive water bodies of Bangladesh have not been utilized properly for scientific fish culture. On the other hand, there is need for diversification of the culture species by bringing new species under culture. Indigenous species, which have great potential for aquaculture, are neglected. Large fishes require large and permanent water bodies as their appropriate habitat. Therefore, sometimes culture of large fishes remains beyond the reach of poor people. Again, exotic fishes may adverse effects on our natives fish species. Therefore, culture of natives fish species, small fish in particular, would be the viable means for increasing fish production in the country through which the common rural people can be benefited.

A substantial number of derelict and marshy water bodies, approximately 18.37% of total ponds, are available in the country, which is not suitable for culture of carps. In addition to an estimated 1.3 million perennial ponds, there are hundreds of thousands of shallow seasonal ponds and ditches, borrow pits etc. in rural areas. Proper aquaculture as a whole and high density fish culture using supplementary formulated feed in particular is no very popular in Bangladesh. However, there is increasing interest in hardly fishes particularly those air breathing fish farming in Bangladesh. Among various production inputs, the choice of fast growing species with desirable aquaculture traits is a pre-

requisite for augmenting fish production in culture based fisheries. Natural food based culture of major carp is still in practice in Bangladesh.

1.3Bata (*Labeo bata)* A potential candidate for Aquaculture

The bata, *Labeo bata* (Hamilton, 1822) is one of the most important species of minor carps under cyprinidae family Bangladesh with great demand as table fish due to its deliciousness, flavor and less spiny structure (Mahfujet al., 2012)

1.3.1 Common name

Bata in Bangladesh, Bhagan in India, Bata labeo in Nepal (Rahman, 2005; Nath and Dey, 1989; Shrestha, 2008).

1.3.2 Conservation status

Endangered in Bangladesh (IUCN Bangladesh, 2000), least concern (Devi and Ali, 2013), lower risk inWestern Ghats and lower risk near threatened in Telangana state, India (CAMP, 1998).

1.3.3 Identification

Body is elongated and dorsal profile more convex than the ventral. Snout slightly projecting beyond mouth.A pair of minute maxillary barbels present and not easily perceptible.Dorsal fin inserted nearer to snout tip. Pelvic and anal fins dark with orange red tips; other fins with fine black dots (Tal- war and Jhingran, 1991). Fin formula: D.11 (2/9); P1. 16 -17; P2. 9 (1/8): A.7 (2/5) (Rahman, 2005). Scales moderate, lateral line with 37 to 40 scales. Lateral transverse scale-rows 5 or 5.5 between lateral line and pelvic fin base; predorsal scales 10 to 13 (Talwar and Jhingran, 1991).

1.3.4 Importance

Minor carp,*Labeo bata*is a freshwater subtropical species which is commonly known as ‘BangonBata’. This fish is commercially important and target species for commercial small and large scale fishers in Bangladesh, India and Pakistan. It is also used by both culture and capture fisheries nowadays.*L. bata*is in great demand in the market because of its high nutritional value and good taste (Bhuiyan, 1964). This fish contains about 15.42% of protein and 3.73% of lipid (Ahmed et al., 2012).

1.3.5 Distribution

L. bata is distributed throughout Indian subcontinent including Bangladesh, India, Nepal, Myanmar and also Pakistan (Talwar and Jhingran, 1991;Devi and Ali, 2013).

1.3.6 Abundance

It is a non-migratory fish and remains in one habitat through-out its life (Mathur, 1973). Earlier, the fish was widely available throughout the rivers, haors, baors, beels, jheels, canals and ponds of Bangladesh, but has been seriously declining in the main streams (Hafizuddin et al., 1989; Rahman, 2005; Dahanukar et al., 2004; Rahman et al., 2012).

1.3.7 Habitatandecology

L. bata is afreshwater fish in Bangladesh. It lives in small rivers, canals, haors, baors, ponds and ditches. This species is known as the mid-feeder with a habit of a benthopelagic andpotamodromous fish. Also, it is an herbivorous column feeder (Devi and Ali, 2013).

1.3.8Reproduction

Size at first sexual maturity is 14.12 and 14.60 cm in total length for male and female *L. bata*, respectively (Hossen et al., 2014). Spawning season varies from June to October (Rahman, 2005). In an earlier study, spawning season ranged from July to August and average fecundity was 192785 (Siddique et al., 1976).

1.3.9 Threats

Loss of habitat and overexploitation, indiscriminate killing of fry and fingerlings, pollution, siltation and other ecological changes are local threats to wild populations of *L. bata* (Hossain et al., 2009a; Devi and Ali, 2013; Hossain, 2014).

Stocking density is an important aspect to take into account when ranking families or progeny groups for growth performance. Fish density is a key factor affecting growth and maturation of wild and cultured fish besides food supply and its quality, genetics and environmental conditions (Smith et al., 1978). In many cultured species, growth is inversely related to stocking density and this can be attributed to social interactions (Haylor., 1991; Miao., 1992)

Rearing fish at inappropriate stocking densities may impair growth and reduce immune competence due to factors such as social interactions and deterioration of water quality, which can affect both feed intake and conversion efficiency of the fish (Ellis et al., 2002). Stocking densities and management measures practiced by pond operators in Pakistan are not based on scientific knowledge, thus resulting in poor growth and survival offry. Growth and survival of fry and fingerlings in earthen ponds depend on the density of stocking, type and quality of fertilizer applied and supplementary feed provided. To obtain maximum economic return it would be necessary to stock the ponds at optimum stocking densities for desired growth and survival of fry. However, there is no any report are available on the effects of stocking density on the growth and production of *L.bata* in our country.

1.4Body composition

Body composition of any edible animal, including fish, is a key indicator of its biological and functional condition. Measuring body composition is the key factor for evaluating the physiological condition, but is a time consuming process (Ali et al., 2005). Proximate analysis for quantifying body composition of a fish is done through gaging different ingredients such as protein, fat, moisture content, ash content, fiber and organic contents of that fish (Jakhar et al., 2012). On account of the presence in negligible amount carbohydrate and non-protein compounds present are typically ignored (Cui. 1988).

A lot of work is being carried out all around the world on body composition of different fish species such as rainbow trout (Shearer., 1984), Tilapia (Soltan et al., 2008) European Seabass (Kaushik et al., 2008), northern pike (Salam., 1994), herring fish (Iles., 1965), carps (Pongmaneerat et al., 1993), yellowtail (Shimeno et al., 1993), socheye salmon (Brett et al., 1969), *Clariasbatrachus* (Sina and pal., 1990), and*Labeorohita* (Sarkar et al., 2008).

1.5Fish nutrients

Fish and sea foods are valuation in the diet because they supply a good quantity (usually 17% or more) of protein of high biological value, particularly sulfur containing amino acid (Borgstom, 1962). Fish varies in fat content and fish liver oils are being exceptionally good source of the fat soluble vitamins. Fish also considered being the potential source of micronutrients, such as vitamins and mineral. Fish have some unusual

compositional feature that is not applicable to many other foods (Netteleon, 1985). Firstly, most fish do not have appreciable amount of carbohydrates. For the estimation of caloric value of fishes are based only on the fat and protein content. Secondly, a few species have their fat predominantly in the form of wax esters instead of triglycerides. This wax ester is believed to be resistant to digestion by human system so that the fat content would not contribute considerably to the calorie value of the fish (Netteleon, 1985).The biochemical composition of fish flesh especially lipid profile may very within the same species of fish depending upon season, sex, and habitat (Srivastaba, 1985).

1.5.1 Protein

Fish are important source of good quality protein. The amino acid compositions of the proteins in most fish are very similar, having most all essential amino acids, so that nominal amount can fulfill the daily body requirement of protein. In diets based manly on cerals, a supplement of fish can complement the law level of lysine and sulfur containing amino acids (Methionine and cysteine), as a can raise the biological value significantly (Huss, 1988). The most excellent feature of fish is that it is highly digestible to the people of all ages (Netteleon, 1985).

1.5.2. Fats

Most fishes are relatively low in total fat and relatively high in its proportions of poly unsaturated fatty acids (PUFA). This feature gives fish a clear health advantage (Netteleon, 1985). Fat content of fish varies with the species with in individual in a species(Exler, 1975). Variation also may be caused by such factors as feeding, size, age, and season, Physiological status and Spawning, diet of the fish, Geographical location (Stansby, 1969A). Fat content may vary from as high as 30% during intense feeding to as low as 1-2% following spawning (Stansby, 1969B). The amount and nature of fat obtained from different parts of the fish varies enormously. In most species, relatively little fat is found in the muscle and much of that present is in the form of phospholipids as part of cell membrane (Thampson, 1969). Fat deposition may be found just below the skin, after along the lateral line and around the belly wall.

1.6 Objectives

The overall objective was to find out the effects of stocking density on growth and body composition of *L. bata* reared in earthen pond with following specific objectives:

1. to investigate the growth performance of *L. bata* under three different densities.
2. to find out a suitable stocking rate for pond culture *L. bata*
3. to analyze the nutrient content of the *L. bata*

Materials and Methods

2.1 Experimental fish

The experimental fish was*Labeo bata.*

2.2Taxonomic position of experimental fish

Kingdom: Animalia

Phylum:Chordata

Class:Actinopterygii

Order:Cypriniformes

Family:Cyprinidae

Genus: *Labeo*

Species:*Labeobata*

Figure 1: *Labeo bata,* Hamilton, 1822

2.3 Place of the study area

The present experiment was conducted at "Maa fish farm",Nawabgonj, Dinajpur, Bangladesh. Proximate composition of culture fish species was analysis in Fish Nutrition Laboratory, Department of Fisheries, University of Dhaka.

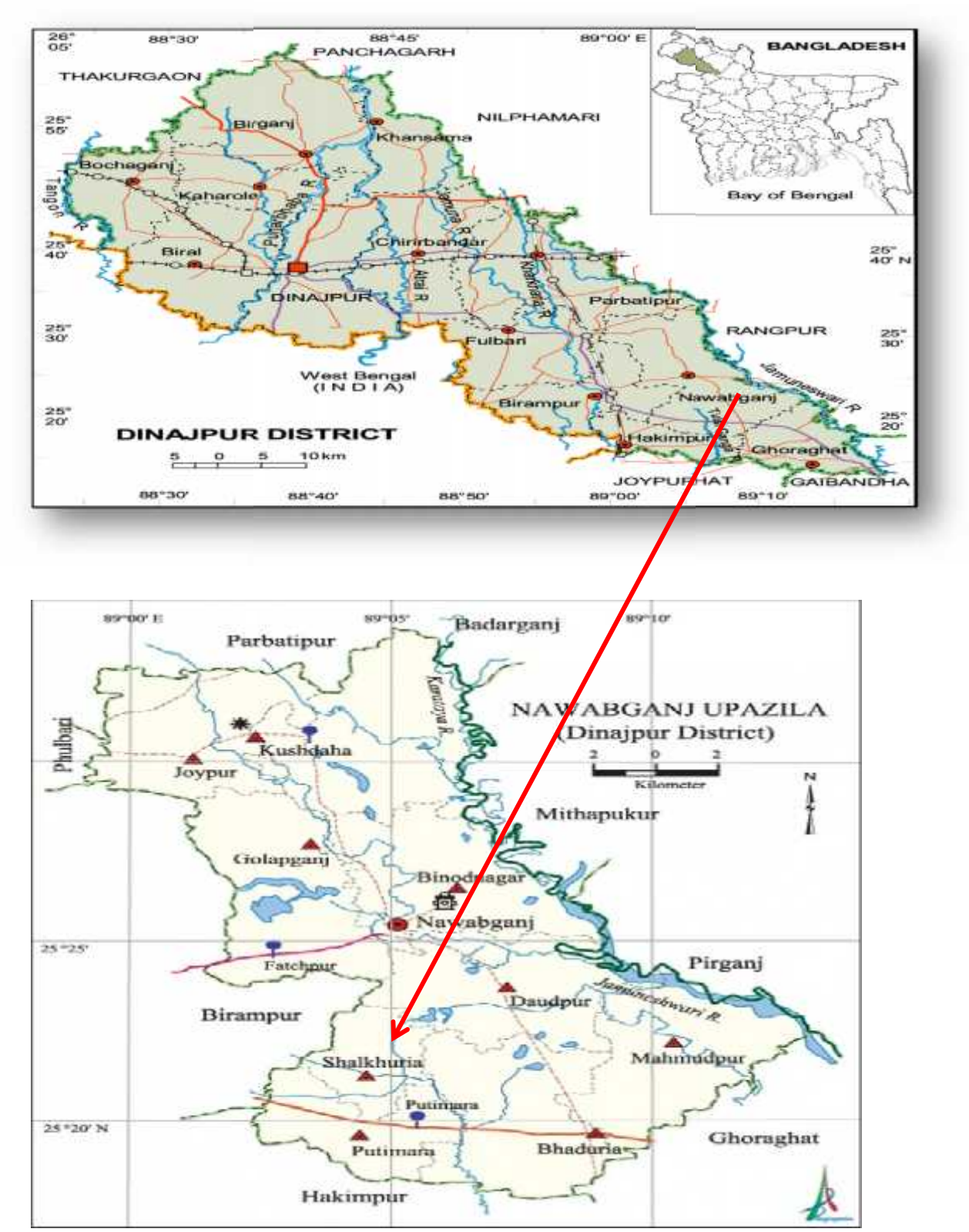

Figure 2: Geographical map of the study area.

2.4Pond selection and preparation

Three nurseryponds were selected each with 10 decimal and an average depth of 1.5 m. Field trial was carried out for a period of 60 days. Before starting the experiment, the pond, fully exposed to prevailing sunlight, was cleaned of aquatic vegetation. Liming ($CaCO_3$)was done at a rate of 1 kg decimal^{-1} to disinfect and improve water quality.

2.5Experimental Design

Three different stocking densities of *Labeo bata* in pond were tested as T_1, T_2 and T_3 in the experiment.

2.6Fry Stocking

Fries were collected from a government hatchery named "fish seed multiplication farm" from Parbotipur, Dinajpur. The initial mean sizes of fry were 3.42 ± 0.068 cm. The average initial weight of individual fry was 1.02 ± 0.064 g.

2.7Fertilization

After stocking fry, all the ponds were fertilized with cow dung at the rate of 1kg decimal^{-1}, Urea 120 g decimal^{-1} and TSP 100 g decimal^{-1} at weekly intervals to stimulate the primary productivity of the ponds throughout the experimental period.

2.8Supplementary feeding

Commercial pellet feed (Aftab feed) for carp fry and fingerlings in accordance with the age and sizes of the fries were used for feeding purpose. Fishes were fed twice a day at 9 am and 4 pm with two equal split of the ration. According to company the nutrient content of fish feed was 30%, 6%, 12%, and 5% respectively protein, lipid, moisture, fiber.Regular monitoring of the stocked fish was carried out during feed supply. In addition random sampling was carried out from each pond on fortnightly basis to check the health condition of fishes.

Table 1: Feeding regime followed during nursing period of*L. bata*

Average weight of fish (g)	Types of feed	Amount of feed supplied (% BW)
1-3	Nursery	10
3-7	Nursery	08
7-10	Nursery	07
>10	Nursery	06

2.9.Water Quality Parameters

Portable digital equipments were used for collectingdata on different water quality parameters. Water temperature (°C) was measured using portable digital thermometer at 10.00 am weekly. Determination of water pH and dissolved oxygen was carried out portable pH meter and DO meter respectively. Transparency was measured using secchi disk.

2.10Growth and Feed Utilization

Length of the fry/fish was measured using steel made centimeter scale at the beginning and end of the experiment. Weights of fry/fish 0.01 g precision portable electric balance at the same time. Weight of the supplied feed was recorded strictly every day for calculation of FCR, PER etc. A total of 20 randomly selected individuals were used for taking all length and weight related data. At the end of the period all harvested live fish were counted and weighed to determine survival rate and yield.

2.11Fish growth performance

Fish were weighted to the gram using an electronic balance. Fish fed with experimental diets. All fish growth parameters were calculated on performance such as mean final fish weight, daily weight gain (g/f/d), percentage of weight gain (%) and specific growth rate, SGR (% day^{-1}).

The procedure of calculation as follows:

$$\text{Mean daily weight gain (g/f/d)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Culture period (days)}}$$

$$\text{Percentage of weight gain (\%)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Mean initial weight}} \times 100$$

$$\text{Specific growth rate (\%day}^{-1}\text{)} = 100 \times \frac{(\ln[\text{final body weight}] - \ln[\text{initial body weight}])}{\text{No.of days}}$$

2.12Feed utilization

Food conversion ratio (FCR) was calculated as follows:

$$\text{Food conversion ratio (FCR)} = \frac{\text{Total weight of feed given (g)}}{\text{Total weight gained by fish (g)}}$$

2.13Chemical analysis

The percentage of proximate composition of fish was determined by conventional method of AOAC (2000). Triplicate determinations were carried out on each chemical analysis.

2.13.1 Determination of moisture

The initial weight of the sample was taken then samples were dried in an oven at about 105℃ for about 8 to 10 h until constant weight was reached and the samples were mince in an electric grinder. Moisture content determined as loss of weight.

Weight of the foil = W_0

Weight of the foil + Wet sample =W_1

Weight of the foil + Dry sample = W_2

$$\text{\% of moisture} = \frac{(W_1 - W_0) - (W_2 - W_0)}{(W_1 - W_0)} \times 100$$

$$\text{Moisture factor} = \frac{(100 - moisture)}{100}$$

2.14.2 Determination of protein content

The total nitrogen (crude protein) was determined using the Kjeldahlmethod. About 0.5 g of the fish sample was weighed on a Nitrogen-free paper. The paper was wrapped round the sample and dropped at the bottom of the Kjeldahl digestion flask together with 6-8 glass beads, 4-5 spatulas full of granular mixture of $CuSO_4$ and K_2SO_4 as catalyst and 20

ml of concentrated H_2SO_4 was carefully added. The flask was gently heated on a Gerhardt heating mantle in an inclined position in a fume cupboard until full digestion was achieved (when the liquid changed from brown to colorless). The contents of the flask were then transferred to a clean 100 ml volumetric flask, and 25 ml aliquot was used for the distillation and total nitrogen was determined calorimetrically.

The percentage of nitrogen in the sample was calculated by using the following formula:

$$\% \text{ of nitrogen} = \frac{(S-B)\times A\times C\times 100}{Weight\ of\ sample\ \times 100}$$

Where,

S= Titration reading for sample

B=Titration reading for blank

A= Strength of 0.01N HCL (0.01)

C= Digest taken for distillation factor ≅ 20

% Crude protein =N_2×6.25×moisture factor

2.14.3 Determination of lipid content

The percentage lipid content in the muscles was determined using the soxhlet extraction method (Bolawa, et. al., 2011). An empty extraction thimble was weighed and noted as W_1, about 5 g of the ground muscle was measured into the empty thimble, the weight of the extraction thimble plus the sample was recorded as W_2.

The percentage lipid was calculated as follows:

$$\% \text{ lipid content} = \left(\frac{W_3-W_2}{W_1}\times 100\right) \times \text{moisture factor}$$

Where;

W_1 = Weight of empty extraction thimble

W_2 = Weight of extraction thimble plus sample extraction

W_3 = Weight of extraction thimble plus sample residue after extraction.

2.14.4 Determination of Ash content

Ash content of fish samples was determined by incineration in a carbolated Sheffield LMF3 muffle furnace at 5000 ℃ (AOAC. 2000). The difference in weight of the fish samples before and after heating was taken as the ash content, the formula is as follows;

% Ash content = $\left(\frac{W_2 - W_0}{W_1 - W_0} \times 100\right)$× moisture factor

Where;

W_0 = Empty crucible,

W_1 = Dry sample; and

W_2 = Ash sample

2.14 Statistical analysis

The data were analyzed through one way Analysis of variance (ANOVA) using SPSS (ver. 20) followed by Tukey HSD to find out whether any significant difference existed among treatment means. Standard deviation in each parameter and treatment was calculated and expressed as mean (± SD). The level of significance was set at 5% ($P>0.05$).

Results

3.1 Water Quality Parameter

A favorable physico-chemical condition of water is the major pre-requisite for healthy aquatic environment and better production. In the present experiment, significant variation in major water quality parameters under investigation indicated apart from natural factors, influence of stocking density and feeding practices played pivotal role in maintaining a water quality. Mean levels of physico-chemical parameters over the 60 daysrearing of fry and fingerlings are presented in Table 2.

Table 2: Physico-chemical characters of water in the earthen ponds during the experimental period.

Parameter	Treatment		
	T_1	T_2	T_3
Dissolved oxygen ($mg\ L^{-1}$)	5.50 ± 0.274^a (5.2-5.9)	5.20 ± 0.360^a (4.7-5.8)	5.10 ± 0.442^a (4.5-5.8)
PH	7.28 ± 0.323^a (6.8-7.8)	7.20 ± 0.430^a (6.7-8.1)	7.16 ± 0.462^a (6.6-8.0)
Temperature (°C)	28.66 ± 1.42^a (27.2-30.1)	28.5 ± 1.4^a (27.1-30.04)	28.48 ± 1.37^a (27.05-30.0)
Transparency (cm)	29.73 ± 2.52^a (27-33.46)	35.5 ± 2.58^b (32.54-39.11)	43.34 ± 3.38^c (38.1-47.66)

Values in the same row having the same superscript are not significantly different ($P>0.05$).

Dissolved oxygen (DO), pH,Temperature, and Transparency were analyzed at weekly intervalsduring the experimental period in rearing pond throughout a culture period of 60 days.

The DO content in the experimental pond water ranged from 5.20 to 5.90, 4.70 to 5.80, and 4.50 to 5.80 with the mean value of 5.50, 5.20 and 5.10 mg L^{-1} respectively in T_1,

$T_2$and T_3.There were no significant variations (P>0.05) in the value of dissolved oxygen among the treatments

The Mean (±SD) pH value was 7.28±0.323,7.20±0.430, 7.16±0.462respectively in T_1, T_2 and T_3.The pH values were not statistically significant (P>0.05) among the treatments.

Average temperature in the experimental pond water ranged from28.66±1.42, 28.5±1.4, 28.48±1.37°Crespectively in T_1, T_2 and T_3.There were no significant variations (P>0.05) in the value of water temperatures among the treatments.

Highest mean (±SD) transparency was observed in T_3than in $T_2$and T_1. And the value was 29.73±2.52, 35.5±2.58, 43.34±3.38respectively in T_1, T_2 and T_3. Mean transparency differed significantly (P<0.05) increasing from T_1 to T_3.

3.2 Growth performance of *L. bata*

Details of growth parameter, survival rate and feed utilization parameters (FCR, PER, SGR) under different stocking densities are shown in Table 3. The mean initial length and weight was same in three different treatments.

The range of final length was found vary from 10.28-10.52, 10.08-10.36, 9.76-10.06 respectively in T_1, T_2, and T_3 during the experimental period. The Mean (±SD) values were 10.4 ± 0.095 in T_1, 10.2 ±0.112 in T_2, 9.9 ± 0.098 in T_3. On the basis of increase in body length, T_1 showed the highest value whereas T_3 resulted in the lowest. Mean length gains in three different treatments were found to be significantly different (P<0.05).

On the basis of final body weight attained at harvest, the growth results obtained on the basis of body weight from the experiment indicated that the growth rate varied in different stocking densities. On the basis of final growth attained at harvest under T_1, T_2 and T_3 were 13.10±0.90, 10.34-12.41 and 9.87± 0.701 g. The range of final weight was found vary from 11.86-14.2, 10.08-10.36, 8.79-10.86g respectively in T_1, T_2, and T_3 during the experimental period. The highest harvesting weight was obtained in T_1 and lowest in T_3. The harvesting mean weight showed significant differences (P<0.05).

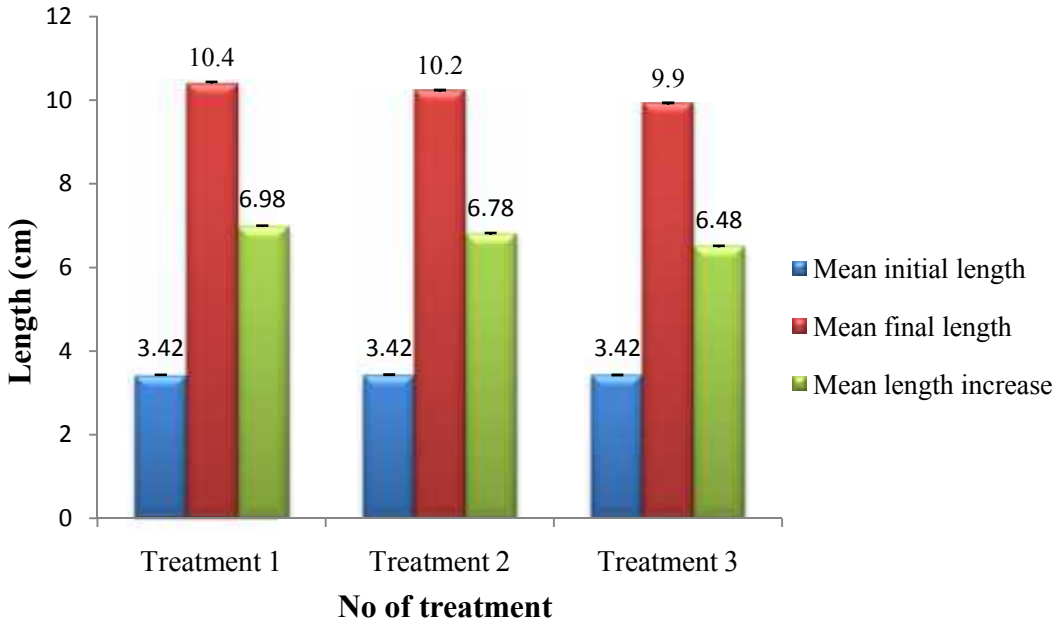

Figure 3: Mean (±SD) initial body length, final body length and net length gain amongthe treatment

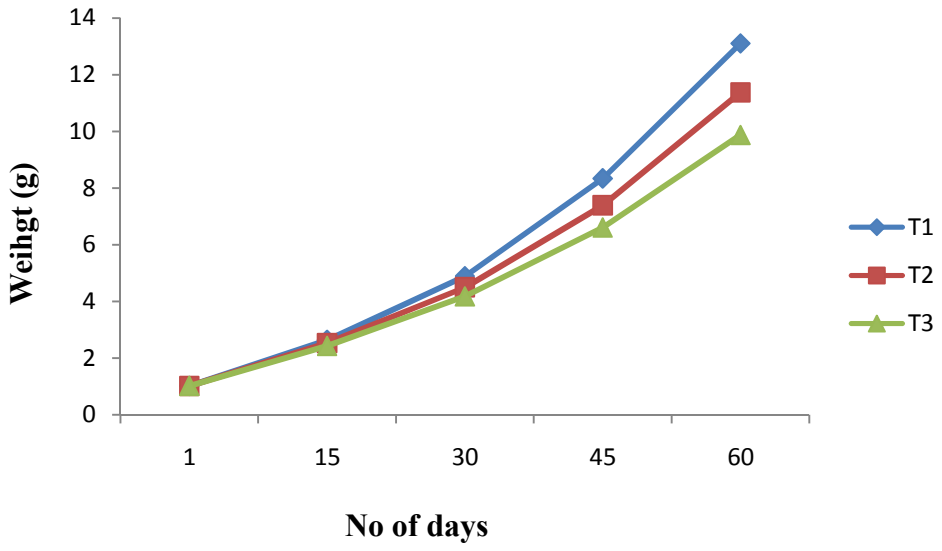

Figure 4: Mean body weight (g) changes of *L. bata* among different treatment at 15 days interval

Mean (±SD) net weight gain of *L.bata* was found 12.08 ± 0.91, 11.37 ± 0.817, 9.87 ± 0.701 respectively in T_1, T_2, and T_3. There were significant different ($P<0.05$) in the value of mean net weight gains among the treatments.

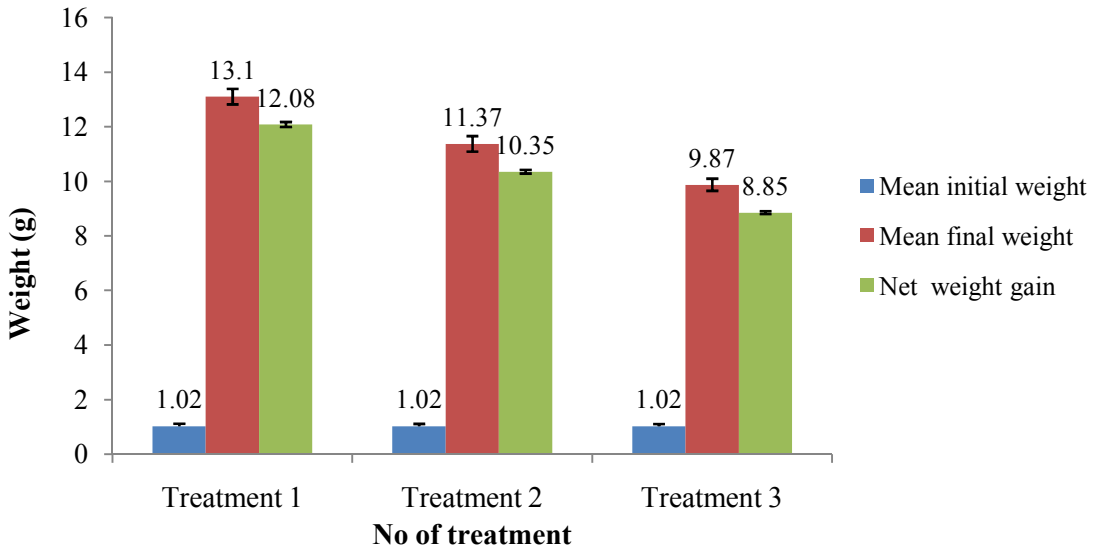

Figure 5: Mean (±SD) initial body weight, final body weight and net weight gain *L. bata* at the end of experiment period in response to different treatment.

The range of specific growth rate (% per day) was found vary from 4.09-4.39, 3.85-4.16, 3.59-3.95 respectively in T_1, T_2, and T_3 during the experimental period. The Mean (±SD) values were 4.25 ±0.139 in T_1, 4.02±0.125 in T_2 and 3.77±0.144 in T_3. The specific growth rate showed significant differences ($P<0.05$) among the treatments.

FCR was lower in T_1 (1.76) than in T_2 (1.93) and T_3 (2.14). Therefore, SGR and FCR were best for fish in T_1 where 250 fingerlings decimal^{-1} were stocked initially.The highest survival rate was also observed in T_1 (77.92%) and the lowest in T_3 (67.65%).

3.3 Proximate composition

The proximate composition of experimental fish of each treatment was determined at the final stage of the experiment.

The Mean (±SD) moisture content of fish at the end of experiment was 75.16±1.04, 79.23±1.57, 76.82±1.50 respectively in T_1, T_2, and T_3.The highest value of moisture content was found in T_2 and lowest in T_1.Moisture content showed significant differences ($P<0.05$) in T_1, where T_2 and T_3 were not statistically significant ($P>0.05$).

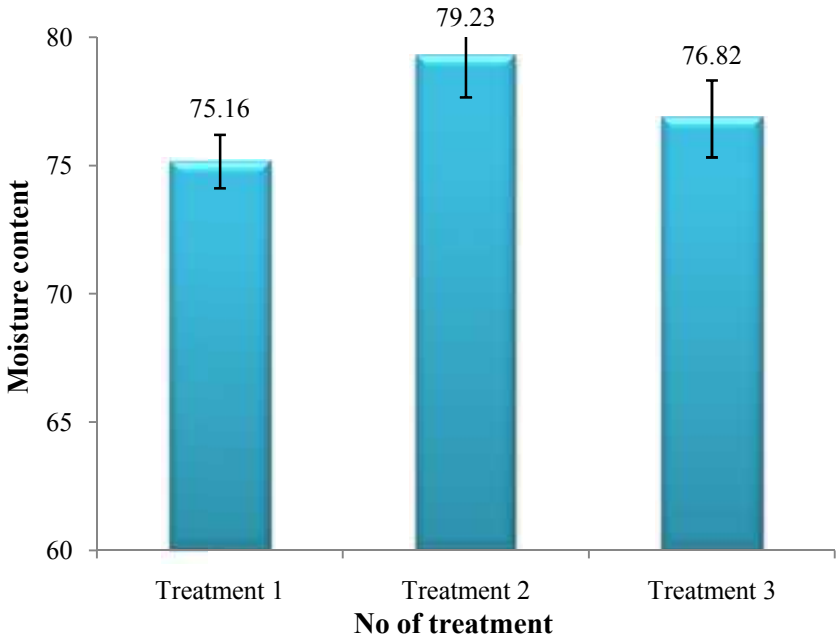

Figure 6: Mean (±SD) moisture content of *L. bata.*

The Mean (±SD) crude protein content of fish at the end of experiment was 17.14±0.622 in T_1, 16.75±0.354 in T_2 and 16.93±0.240 in T_3.There were no significant variations (P>0.05) in the value of crude protein content among the treatments.

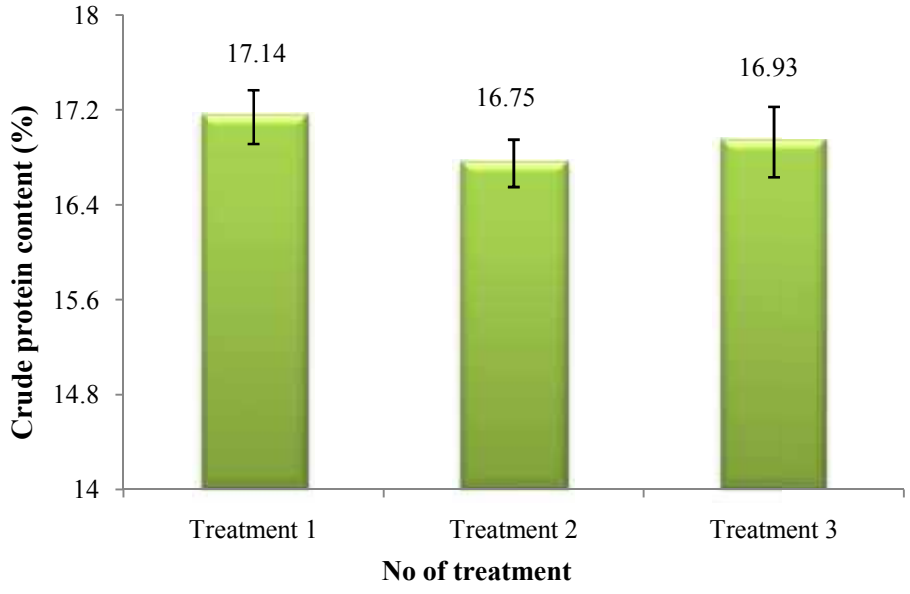

Figure 7: Mean (±SD) crude protein content of *L. bata.*

The Mean (±SD) crude lipid content was 3.94±0.140, 4.51±0.180, 4.36±0.185 respectively in T_1, T_2, and T_3. There were no significant variations ($P>0.05$) in the value of crude lipid content in T_2 and T_3, where T_1showed significant differences ($P<0.05$).

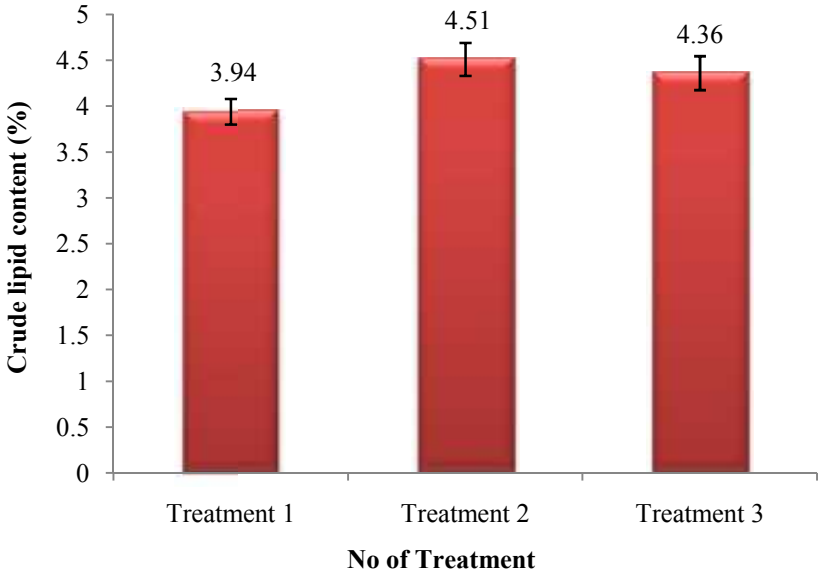

Figure 8: Mean (±SD) crude lipid content of *L. bata.*

The Mean (±SD)ash content of experimental fish was 1.81±0.110, 2.16±0.076, 1.98±0.053 respectively in T_1, T_2, and T_3. The highest value of ash content was found in T_2 and lowest in T_1. Ash content showed significant differences ($P<0.05$) in T_1, where T_2 and T_3 were not statistically significant ($P>0.05$).

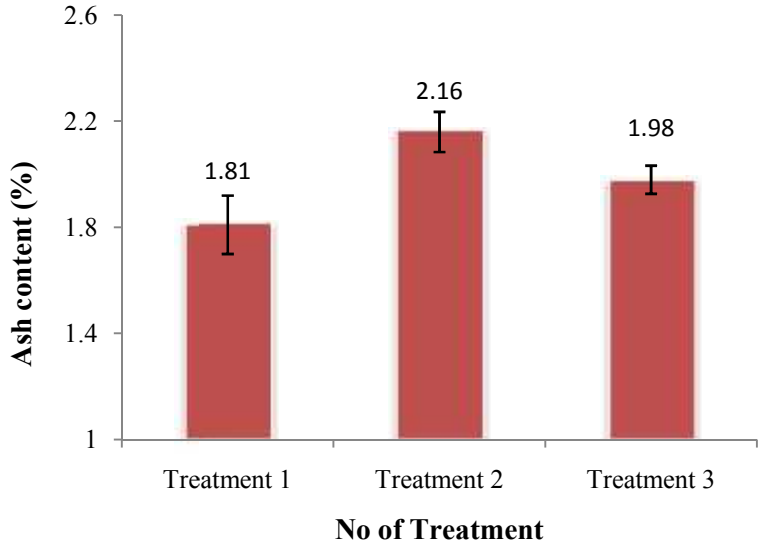

Figure 9: Mean (±SD) ash content of *L. bata.*

3.4 Cost-benefit analysis:

The mean productions (Kg decimal^{-1}) of fingerlings were 2.511, 4.251, and 5.008 in treatment T_1, T_2 and T_3, respectively. Production was higher in treatment T_3 and lowest in treatment T_1. On the other hand, cost of production (for 1 acre pond) in treatment T_2 was consistently lower than those of treatments T_3 and T_1 (Table 4). Highest net benefit was obtained in treatment T_2 (18496 tk) followed by T_3 (15889 tk) and T_1 (8250 tk) in that order (Table 4).

Table 3. Growth performance and nutrient utilization of *L.bata* fry or fingerlings after 60 days of rearing; Mean (±S.D) with ranges in parentheses

Variables	Treatment$_1$	Treatment$_2$	Treatment$_3$
Mean initial length (cm)	3.42 ± .068 (3.3-3.5)	3.42 ± .068 (3.3-3.5)	3.42 ± .068 (3.3-3.5)
Mean final length (cm)	10.4 ± 0.095^a (10.28-10.52)	10.2 ± 0.112^b (10.08-10.36)	9.9 ± 0.098^c (9.76-10.06)
Mean length increase (cm)	6.98 ± 0.058^a (7.06-6.9)	6.78 ± 0.127^b (6.93-6.63)	6.48 ± 0.110^c (6.36-6.6)
Mean initial weight (g)	1.02 ± 0.064	1.02 ± 0.064	1.02 ± 0.064
Mean final weight (g)	13.1 ± 0.90^a (11.86-14.2)	11.37 ± 0.817^b (10.34-12.41)	9.87 ± 0.701^c (8.79-10.86)
Net weight gain (g)	12.08 ± 0.91^a	10.35 ± 0.89^b	8.85 ± 0.701^c
SGR (% day^{-1})	4.25 ± 0.139^a (4.09-4.39)	4.02 ± 0.125^b (3.85-4.16)	3.77 ± 0.144^c (3.59-3.95)
Survival rate (%)	77.92	74.78	67.65
FCR	1.76	1.93	2.14
Production (Kg decimal^{-1})	2.512	4.251	5.008

Values in the same row having the different superscript are significantly different ($P<0.05$). Values in the parenthesis indicate the range.

Table 4: Cost and benefits from the nursing of bata, *L. bata* fingerlings in 1 acre earthen ponds for a nursing period of 60 days.

Item		Amount TK acre^{-1}		
		Treatment$_1$	Treatment$_2$	Treatment$_3$
a. Variable cost :				
1	Price of fry	6875	13750	20625
2	Feed (Tk. 35.00 kg^{-1})	15750	28700	37450
3	Fertilizer and Chemicals	1500	1500	1500
4	Human labour cost (Tk. 100.00 day^{-1})	6000	6000	6000
5	Miscellaneous	500	500	500
Total variable cost (TVC)		30625	50480	66075
b. Fixed cost				
1.	Pond rental value	4500	4500	4500
2.	Interest of operating capital (10% interest according to BKB, Bangladesh)	585	916	1176
Total fixed cost (TFC)		5085	5416	5676
Total cost (TC=TVC+TFC)		35710	55896	71751
Total return (TR)		43960	74392	87640
Gross margin (GM=TR−TVC)		13335	23912	21565
Net return (TR−TC)		8250	18496	15889

BKB=Bangladesh Krishi (Agricultural) Bank.

Sale price fingerlings Tk. 175 kg^{-1}

Discussion

For successful culture of any fish suitable stocking rate is one of the most important prerequisites. Fishes were reared in three selected pond of "Maa fish farm", Nawabgonj, Dinajpur, Bangladesh for a period of 60 days wherein 250 fry decimal^{-1}, 500 fry decimal^{-1}, 750 fry decimal^{-1}were set as the different stocking densities demarked as treatment T_1, T_2 and T_3 respectively.

Water quality was widely acknowledge to be one of the most important rearing conditions that could be managed to reduce diseases exposure and stress in intensive fish culture (Wedemeyer, 1996). Lawson (1995) reported that physical, chemical and biological environmental parameters were interrelated in a complicated series of physiochemical reactions that affected every aspect of fish culture (survival, growth and reproduction).

The temperature of the experimental ponds was within the acceptable range for rearing ponds that agrees well with the findings of Haque et al. (1993, 1994) and Kohinoor et al. (1994). Transparency was consistently higher in T_3, possibly due to the reduction of the plankton population by higher density of fish (Haque et al., 1993, 1994). The pH values agree well with the findings of Kohinoor et al. (1994), Chakraborty et al. (2003) and Rahman and Rahman (2003). The dissolved oxygen in the morning was low in ponds stocked with a high density of fish compared to ponds stocked with a low density. Similar results were observed by Saha et al. (1988) and Rahman and Rahman (2003). Fluctuation of dissolved oxygen concentration might be attributed to photosynthetic activity and variation in the rate of oxygen consumption by fish and other aquatic organisms (Boyd, 1982). However the level of dissolved oxygen (DO) was within the acceptable range in all the experimental ponds. The pH values agree well with the findings of Kohinoor et al. (1994); Chakraborty et al. (2003); Rahman and Rahman (2003).

In this experiment, crude protein levels (30% dry weight) in supplementary feeds are very near the dietary protein of 31% for the optimal growth of *Labeo rohita* (De Silva and Gunasekera, 1991). Growth in terms of length, weight, weight gain and SGR of fingerlings of *L. bata* was significantly higher in T_1 where the stocking density was low compared to those of T_2 and T_3 although the same food was supplied in all the treatments

at an equal ratio. The low growth rate of fry and fingerling in treatment T_2 and T_3 appeared to be related with higher densities and increased competition for food and space (Haque et al., 1994; Islam et al., 1999, 2002; Islam, 2002; Rahman and Rahman, 2003; Chakraborty et al., 2006). High density of fingerlings in combination with increased concentration of food in the rearing system might have produced a stressful situation and toxic substance which could be the probable cause for poor growth in treatment T_2 and T_3 (Haque et al., 1994; Rahman and Rahman, 2003). The FCR values of T_1 were significantly lower than those T_2 and T_3, respectively. The FCR values are lower than the values reported by Das and Ray (1989), Islam (2002) and Islam et al. (2002). De Silva and Davy (1992) stated that digestibility plays an important role in lowering the FCR value by efficient utilization of food. Digestibility, in turn, depends on daily feeding rate, frequency of feeding, and type of food used (Chiu et al., 1987).

However the lower FCR value in the present study indicates better food utilization efficiency, despite the values increased with increasing stocking densities. Fingerlings of *L. bata* had significantly higher survival in T_1, where, the stocking density was lower than T_2 and T_3. The reason for reduced survival rate in these treatments was probably due to higher stocking density of fry as well as competition for food and space in the experimental ponds. Similar results were obtained by Tripathi et al. (1979), Uddin et al. (1988), Haque et al. (1994), Kohinoor et al. (1994), Hossain (2001), Rahman and Rahman (2003) and Chakraborty et al. (2003) for fry and fingerlings of various carp and barb species. Highest growth, survival and lowest FCR of fingerlings were obtained at a density of 250 fry decimal^{-1}. Production of fingerling was 2.512, 4.251, and 5.008 kg decimal^{-1}respectively in T_1, T_2 and T_3. Despite of this, consistentlyhigher net benefits were found in T_2 and lowest in T_1.

In the present investigation, the amount of supplementary feeds given in different treatments was based on the weight of fry stocked and amount of feed provided per fry was kept at the same level. Hence, the observed low growth at higher stocking densities could be due to less availability of natural food and some variations in environmental parameters. Incorporation of food at a higher prsituation in the pond environment which might be accounted for poor growth in *L. bata* fingerlings (Kohinoor et al., 1997). The results in the present experiment are very similar to those of Saha et al. (1988), Kohinoor et al. (1994), Hossain (2001), Rahman and Rahman (2003) and Chakraborty et al. (2003, 2006). Finally, it can be concluded that the survival, growth, and production of *L.*

*bata*fingerlings were inversely related to the stocking densities of fry. Therefore, of the threestocking densities, 500 fry decimal^{-1} appear to be most suitable stocking density for nursing and rearing of bata fry andfingerlingswhich could be recommended to adopt. However, more trials are suggested to optimize the stocking density and feeding regime for better production performance. Production of adequate quality seeds through application of our present findings might be extremely helpful towards the protection of *L. bata* from extinction as well as for its conservation and rehabilitation.

From the present study it has been found that the mean (±SD) moisture content of fish was 75.16±1.04, 79.23±1.57, 76.82±1.50 respectively in T_1, T_2, and T_3. Moisture content showed significant differences ($P<0.05$) in T_1, where T_2 and T_3 were not statistically significant ($P>0.05$). The present study is more or less coincide with the findings of Ali et al. (2005) where he found that the moisture content of some other fish species namely *Labeo rohita, Cyprinus carpio* and *catlacatla* was 74.10, 75.60 and 78.64, respectively.

The average crude protein content of experimental fish was 17.14±0.622, 16.75±0.354 and 16.93±0.240 respectively in T_1, T_2, and T_3 and more or less similar to the findings of with the findings of Nabi and Hossain (1989) in *M. aculeatus* and of Kumar (1992) in *P.gononiotus.*

From the study it has been found that the averages crude lipid content was 3.94±0.140, 4.51±0.180, 4.36±0.185 respectively in T_1, T_2, and T_3. The result is very similar to some other commercial fish in Bangladesh like Gonia (*Labeogonius*) and Rohu (*Labeo rohita*) whose fat content was estimated as 4.02, 4.52 respectively estimated by Murari e al. (1985). There were no significant variations ($P>0.05$) in the value of crude lipid content.

The Mean (±SD) ash content of experimental fish was 1.81±0.110, 2.16±0.076, 1.98±0.053 respectively in T_1, T_2, and T_3. Mazumder et al. (2008) in *Ailiacoila*and in *Amblypharyngodonmola* also find similar ash percentage varied within 1.6-2.52%. The ash content of the fish (*O. rubicundus*) was also more or less similar to that of small indigenous species.

Conclusion

Bata fish (*Labeo bata*) is one of the most important species of Bangladesh with great demand as table fish due to its deliciousness, flavor and less spiny structure. *L. bata* is a freshwater fish and lives in small rivers, canals, haors, baors, ponds and ditches. The overall objective of this experiment was to find out the effects of stocking density on growth and body composition of *L. bata* reared in earthen pond for a period of 60 days where in 250 fry decimal^{-1}, 500 fry decimal^{-1}, 750 fry decimal^{-1} were set as the different stocking densities demarked as treatment T_1, T_2 and T_3 respectively. Different bio parameters, such as survival rate, feed conversion ratio (FCR), specific growth rate (SGR) etc. were used to see the growth performance and feed utilization during the study period. Data were analyzed statistically using ANOVA. Probabilities of 0.05 were considered statistically significant. Mean final length and weight of the experimental fish was 10.4 ± 0.095, 10.2 ±0.112, 9.9 ± 0.098 cm and 13.1 ± 0.90, 11.37 ± 0.817, 9.87 ± 0.701 g, respectively in T_1, T_2 and T_3. T_1 showed the highest length and weight gain after harvesting ($P<0.05$).Production of fingerling was 2.512, 4.251, and 5.008 kg decimal^{-1} respectively in T_1, T_2 and T_3. Despite of this, consistently higher net benefits were found in T_2 and lowest in T_1.Therefore, of the three stocking densities, 500 fry decimal^{-1} appear to be most suitable stocking density for nursing and rearing of bata fry and fingerlings which could be recommended to adopt.

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Appendices

Appendix 1: Statistical analysis for Dissolve oxygen (DO) among the treatment

Descriptives

Treatment	Value	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
T_1	9	5.5000	.27386	.09129	5.2895	5.7105	5.20	5.90
T_2	9	5.2000	.36056	.12019	4.9229	5.4771	4.70	5.80
T_3	9	5.1000	.44159	.14720	4.7606	5.4394	4.50	5.80
Total	27	5.2667	.39125	.07530	5.1119	5.4214	4.50	5.90

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.874	2	24	.430

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.780	2	.390	2.925	.073
Within Groups	3.200	24	.133		
Total	3.980	26			

Appendix 2: Statistical analysis for pH value among the treatment

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
T_1	9	7.2778	.32318	.10773	7.0294	7.5262	6.80	7.80
T_2	9	7.2000	.43012	.14337	6.8694	7.5306	6.70	8.10
T_3	9	7.0889	.46218	.15406	6.7336	7.4442	6.50	8.00
Total	27	7.1889	.40128	.07723	7.0301	7.3476	6.50	8.10

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.249	2	24	.781

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.162	2	.081	.484	.622
Within Groups	4.024	24	.168		
Total	4.187	26			

Appendix 3: Statistical analysis for Temperaturedifference among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	9	28.6556	1.42136	.47379	27.5630	29.7481	26.20	30.10
2.00	9	28.5056	1.39518	.46506	27.4331	29.5780	26.10	30.05
3.00	9	28.4889	1.37154	.45718	27.4346	29.5431	26.10	30.00
Total	27	28.5500	1.34357	.25857	28.0185	29.0815	26.10	30.10

Test of Homogeneity of Variance

Levene Statistic	df1	df2	Sig.
.021	2	24	.979

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.152	2	.076	.039	.962
Within Groups	46.783	24	1.949		
Total	46.935	26			

Appendix 4: Statistical analysis for Transparency difference among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	9	29.7289	2.52290	.84097	27.7896	31.6682	26.10	33.96
2.00	9	35.5011	2.58196	.86065	33.5164	37.4858	32.00	39.11
3.00	9	43.3400	3.37667	1.12556	40.7445	45.9355	38.10	47.66
Total	27	36.1900	6.31102	1.21456	33.6934	38.6866	26.10	47.66

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.794	2	24	.464

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	840.087	2	420.044	51.574	.000
Within Groups	195.467	24	8.144		
Total	1035.555	26			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Transparency

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1.00	2.00	-5.77222*	1.34532	.001	-9.1319	-2.4126
		3.00	-13.61111*	1.34532	.000	-16.9708	-10.2515
	2.00	1.00	5.77222*	1.34532	.001	2.4126	9.1319
		3.00	-7.83889*	1.34532	.000	-11.1985	-4.4792
	3.00	1.00	13.61111*	1.34532	.000	10.2515	16.9708
		2.00	7.83889*	1.34532	.000	4.4792	11.1985
LSD	1.00	2.00	-5.77222*	1.34532	.000	-8.5488	-2.9956
		3.00	-13.61111*	1.34532	.000	-16.3877	-10.8345
	2.00	1.00	5.77222*	1.34532	.000	2.9956	8.5488
		3.00	-7.83889*	1.34532	.000	-10.6155	-5.0623
	3.00	1.00	13.61111*	1.34532	.000	10.8345	16.3877
		2.00	7.83889*	1.34532	.000	5.0623	10.6155

*. The mean difference is significant at the 0.05 level.

Appendix 5: Statistical analysis for moisture content among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	3	75.1600	1.04058	.60078	72.5751	77.7449	74.14	76.22
2.00	3	79.2300	1.57420	.90886	75.3195	83.1405	78.18	81.04
3.00	3	76.8200	1.50453	.86864	73.0825	80.5575	75.12	77.98
Total	9	77.0700	2.14411	.71470	75.4219	78.7181	74.14	81.04

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.680	2	6	.542

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25.129	2	12.564	6.471	.032
Within Groups	11.649	6	1.942		
Total	36.778	8			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Moisture

Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-4.07000*	1.13769	.027	-7.5607	-.5793
	3.00	-1.66000	1.13769	.373	-5.1507	1.8307
2.00	1.00	4.07000*	1.13769	.027	.5793	7.5607
	3.00	2.41000	1.13769	.166	-1.0807	5.9007
3.00	1.00	1.66000	1.13769	.373	-1.8307	5.1507
	2.00	-2.41000	1.13769	.166	-5.9007	1.0807

*. The mean difference is significant at the 0.05 level.

Appendix 6: Statistical analysis for protein content among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	3	17.140	.22716	.13115	16.5757	17.7043	16.98	17.40
2.00	3	16.750	.20000	.11547	16.2532	17.2468	16.55	16.95
3.00	3	16.930	.29715	.17156	16.1918	17.6682	16.59	17.14
Total	9	16.940	.27120	.09040	16.7315	17.1485	16.55	17.40

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.635	2	6	.562

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.229	2	.114	1.906	.229
Within Groups	.360	6	.060		
Total	.588	8			

Appendix 7: Statistical analysis for lipid content among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	3	3.9400	.14000	.08083	3.5922	4.2878	3.80	4.08
2.00	3	4.5100	.18083	.10440	4.0608	4.9592	4.34	4.70
3.00	3	4.3600	.18520	.10693	3.8999	4.8201	4.17	4.54
Total	9	4.2700	.29517	.09839	4.0431	4.4969	3.80	4.70

Test of Homogeneity of Variances of Lipid

Levene Statistic	df1	df2	Sig.
.131	2	6	.879

ANOVA of Lipid

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.524	2	.262	9.073	.015
Within Groups	.173	6	.029		
Total	.697	8			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Lipid

Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.57000*	.13872	.015	-.9956	-.1444
	3.00	-.42000	.13872	.053	-.8456	.0056
2.00	1.00	.57000*	.13872	.015	.1444	.9956
	3.00	.15000	.13872	.559	-.2756	.5756
3.00	1.00	.42000	.13872	.053	-.0056	.8456
	2.00	-.15000	.13872	.559	-.5756	.2756

*. The mean difference is significant at the 0.05 level.

Appendix 8: Statistical analysis for ash content among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	3	1.8133	.11015	.06360	1.5397	2.0870	1.70	1.92
2.00	3	2.1633	.07638	.04410	1.9736	2.3531	2.08	2.23
3.00	3	1.9800	.05292	.03055	1.8486	2.1114	1.94	2.04
Total	9	1.9856	.16786	.05595	1.8565	2.1146	1.70	2.23

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.553	2	6	.602

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.184	2	.092	13.283	.006
Within Groups	.042	6	.007		
Total	.225	8			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Ash

Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.35000*	.06793	.005	-.5584	-.1416
	3.00	-.16667	.06793	.108	-.3751	.0418
2.00	1.00	.35000*	.06793	.005	.1416	.5584
	3.00	.18333	.06793	.079	-.0251	.3918
3.00	1.00	.16667	.06793	.108	-.0418	.3751
	2.00	-.18333	.06793	.079	-.3918	.0251

*. The mean difference is significant at the 0.05 level.

Appendix 9: Statistical analysis for Final Length increase among the treatment

Descriptives

Treatmen	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
250/d	6	10.4000	.09550	.03899	10.2998	10.5002	10.28	10.52
500/d	6	10.2000	.11100	.04531	10.0835	10.3165	10.08	10.36
750/d	6	9.9000	.09818	.04008	9.7970	10.0030	9.76	10.00
Total	18	10.1667	.23205	.05469	10.0513	10.2821	9.76	10.52

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.760	2	.380	36.680	.000
Within Groups	.155	15	.010		
Total	.915	17			

Post Hoc Tests of Final length

Multiple Comparisons

Dependent Variable: Final length

Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
250/d	500/d	.20000*	.05877	.010	.0474	.3526
	750/d	.50000*	.05877	.000	.3474	.6526
500/d	250/d	-.20000*	.05877	.010	-.3526	-.0474
	750/d	.30000*	.05877	.000	.1474	.4526
750/d	250/d	-.50000*	.05877	.000	-.6526	-.3474
	500/d	-.30000*	.05877	.000	-.4526	-.1474

* The mean difference is significant at the 0.05 level.

Appendix 10: Statistical analysis for Length gain among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
250/d	6	6.9800	.05215	.02129	6.9253	7.0347	6.90	7.06
500/d	6	6.7800	.11402	.04655	6.6603	6.8997	6.63	6.93
750/d	6	6.4800	.09879	.04033	6.3763	6.5837	6.36	6.60
Total	18	6.7467	.22847	.05385	6.6330	6.8603	6.36	7.06

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.760	2	.380	44.741	.000
Within Groups	.127	15	.008		
Total	.887	17			

Post Hoc Tests

Multiple Comparisons

Dependent Variable:Length gain

Tukey HSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
250/d	500/d	.20000*	.05321	.005	.0618	.3382
	750/d	.50000*	.05321	.000	.3618	.6382
500/d	250/d	-.20000*	.05321	.005	-.3382	-.0618
	750/d	.30000*	.05321	.000	.1618	.4382
750/d	250/d	-.50000*	.05321	.000	-.6382	-.3618
	500/d	-.30000*	.05321	.000	-.4382	-.1618

*. The mean difference is significant at the 0.05 level.

Appendix 11: Statistical analysis for Final weight among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	10	13.1000	.90475	.28611	12.4528	13.7472	11.86	14.20
2.00	10	11.2700	.81635	.25815	10.6860	11.8540	10.30	12.45
3.00	10	9.8700	.70117	.22173	9.3684	10.3716	8.80	10.90
Total	30	11.4133	1.55655	.28419	10.8321	11.9946	8.80	14.20

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	52.473	2	26.236	39.820	.000
Within Groups	17.790	27	.659		
Total	70.262	29			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Final weight

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1.00	2.00	1.83000*	.36301	.000	.9299	2.7301
		3.00	3.23000*	.36301	.000	2.3299	4.1301
	2.00	1.00	-1.83000*	.36301	.000	-2.7301	-.9299
		3.00	1.40000*	.36301	.002	.4999	2.3001
	3.00	1.00	-3.23000*	.36301	.000	-4.1301	-2.3299
		2.00	-1.40000*	.36301	.002	-2.3001	-.4999
LSD	1.00	2.00	1.83000*	.36301	.000	1.0852	2.5748
		3.00	3.23000*	.36301	.000	2.4852	3.9748
	2.00	1.00	-1.83000*	.36301	.000	-2.5748	-1.0852
		3.00	1.40000*	.36301	.001	.6552	2.1448
	3.00	1.00	-3.23000*	.36301	.000	-3.9748	-2.4852
		2.00	-1.40000*	.36301	.001	-2.1448	-.6552

*. The mean difference is significant at the 0.05 level.

Appendix 12: Statistical analysis for weight gain among the treatment

Descriptives

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	10	12.080	.90475	.28611	11.4328	12.7272	10.84	13.18
2.00	10	10.346	.88649	.28033	9.7118	10.9802	9.28	11.39
3.00	10	8.848	.70130	.22177	8.3463	9.3497	7.77	9.88
Total	30	10.424	1.56677	.28605	9.8396	11.0097	7.77	13.18

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
1.793	2	27	.186

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	52.322	2	26.161	37.439	.000
Within Groups	18.866	27	.699		
Total	71.188	29			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: weight gain

	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1.00	2.00	1.73400*	.37383	.000	.8071	2.6609
		3.00	3.23200*	.37383	.000	2.3051	4.1589
	2.00	1.00	-1.73400*	.37383	.000	-2.6609	-.8071
		3.00	1.49800*	.37383	.001	.5711	2.4249
	3.00	1.00	-3.23200*	.37383	.000	-4.1589	-2.3051
		2.00	-1.49800*	.37383	.001	-2.4249	-.5711
LSD	1.00	2.00	1.73400*	.37383	.000	.9670	2.5010
		3.00	3.23200*	.37383	.000	2.4650	3.9990
	2.00	1.00	-1.73400*	.37383	.000	-2.5010	-.9670
		3.00	1.49800*	.37383	.000	.7310	2.2650
	3.00	1.00	-3.23200*	.37383	.000	-3.9990	-2.4650

*. The mean difference is significant at the 0.05 level.

Appendix 13: Whole body proximate composition of *L.bata* at different treatment (% fresh weight basis, mean ± SD)

Nutrient content	Treatment 1	Treatment 2	Treatment 3
Moisture	75.16^{a}±1.04	79.23^{b}±1.57	76.82^{ab}±1.50
Crude protein	17.14^{a}±0.622	16.75^{a}±0.354	16.93^{a}±0.240
Crude lipid	3.94^{a}±0.140	4.51^{b}±0.180	4.36^{ab}±0.185
Ash	1.81^{a}±0.110	2.16^{b}±0.076	1.98^{ab}±0.053

Values in the same row having the same superscript are not significantly different (P>0.05). Values in the parenthesis indicate the range

Appendix 14: Photos of experimental pond

Treatment Pond 1

Treatment Pond 2

Treatment Pond 3 Measuring Length

Appendix 15a:Photos for proximate analysis

Fish Fresh Homonising Weighing Fish Muscle

Burning Fish Muscle Ash of the Sample in Crucibles

Appendix 15b: Photos for proximate analysis

Muffle furnace

Oven for the moisture contents

Distillation and digestive chamber

Muscle for drying

Lipid extraction by Soxhlet Method

Titration