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Comparative Study of Different Types of Sinking and Floating Feeds Formulations for Culture of Pangasius Sutchi

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COMPARATIVE STUDY OF DIFFERENT TYPES OF SINKING AND FLOATING FEEDS FORMULATIONS FOR CULTURE OF *PANGASIUS SUTCHI*

A

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By

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Dedicated

To

My Beloved Parents

DECLARATION

I do hereby declare that, the research work submitted as a thesis entitled **"COMPARATIVE STUDY OF DIFFERENT TYPES OF SINKING AND FLOATING FEEDS FORMULATIONS FOR CULTURE OF *PANGASIUS SUTCHI*"** in the Department of Fisheries, University of Rajshahi, Bangladesh for the Degree of Doctor of Philosophy is the result of my own investigation. The thesis or part of it has not been submitted to any other University or Institution for any degree.

16.11.2021

Year: 2021

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CERTIFICATE OF RESEARCH

This is to certify that

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Ph.D Fellow, Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi-6205, Bangladesh carried out the investigation on **"COMPARATIVE STUDY OF DIFFERENT TYPES OF SINKING AND FLOATING FEEDS FORMULATIONS FOR CULTURE OF *PANGASIUS SUTCHI*"** under my supervision. He fulfilled all the requirements and regulations relating to the nature and period of research. It is further certified that the entire work presented as a thesis for the degree of **Doctor of Philosophy** is based on the results of author's own investigation.

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The Author

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ABSTRACT

A study was undertaken to know about the existing farming system of Thai pangas (*Pangasius sutchi*) and to develop better quality sinking and floating feed from locally available fish feed ingredients. Data on socio-economic condition and farming practices were collected through direct interviews with the randomly selected pangus farmers. Socio-economic conditions of the pangas farmers were found quite developed while they encountered several problems in their farming practices. Study revealed the average production of pangas was 37.50 t/ha along with carps and tilapia was 3.50 t/ha with a FCR value of commercial feed ranging from 1.96 to 2.20. They also revealed that 83% pangas ponds surveyed had CBR within 1.0-2.0 and only 3% had greater than 2.0. Therefore, the study concluded with remarks of major problems in lack of quality feed and their higher market price. As a consequence, the second experiment, locally available nine raw materials and seven types of feed additives were used to formulate two types of sinking and floating diets with two formulas each. Each of the formula also had starter and grower graded feeds. Sinking pellets were 2.0-3.0 mm in diameter and 4-7 mm in length and the floating pellets were 2.0-3.0 mm in diameter. Production cost of these two types of feeds was evaluated whereas the price of sinking starter was BDT 36.17 and 38.32; the growers were BDT 34.50 and 36.39. Furthermore, production cost of floating starter was BDT 44.24 and 46.01; and the grower was BDT 40.95 and 43.39. Protein content ranged from 27.42 to 30.55% in sinking pellet feed and 27.95 to 30.85% in floating pellet feed. Lipid content was ranged from 9.26 to 9.45% in sinking pellet feed and 9.15 to 9.53% in floating feed. In the performance evaluation trial of formulated feeds, third experiments were conducted for a period of four months in Jikorgacha Upazila of Jessore district. Among the formulation of sinking pellet feed, significantly higher gross production was recorded at treatment T_2 (40.02±0.76 t/ha) and among the formulation of floating pellet feed treatment T_1 (62.89±0.25 t/ha) showed higher gross production. Along with significantly higher feed cost, total cost was also recorded higher at treatment T_3 (BDT 2839109.37) for sinking pellet feed fed feeding trial. However, significantly higher gross return from fish sales was obtained from treatment T_3 (BDT 3802303.80), and therefore, BCR was also recorded higher from treatment T_2 (1.64). On the other hand, in feeding trial two with floating pellet feed, significantly higher total cost was recorded at treatment T_2 (BDT 2999343.90) and the gross return from fish sales from treatment T_1 (5660775.25). Moreover, significantly higher BCR was obtained from treatment T_1 (2.04). Therefore, it is evident that formulation process of floating pellet feed at treatment T_1 provided better economic return compared to its subsequent treatments and sinking pellet feed groups.

Chapter One

Introduction

1.1 Background

Bangladesh has got a large number of ponds scattered all over the country Fishery resources and fishing plays a vital role in improving the socio-economic status, the fight against malnutrition, earn foreign exchange and creating employment opportunities in Bangladesh (Mahfuj et al., 2012). The climate of Bangladesh is also generally favorable and the water area is very wide with a high rainfall make the country a good place for aquatic production. At present there are about 260 freshwater fish are available in this country. Among them, a lot are now produced within the home based system or other aquatic bodies (Rahman et al., 2013). Annual fish production of Bangladesh is increasing every year (Figure 1.1).

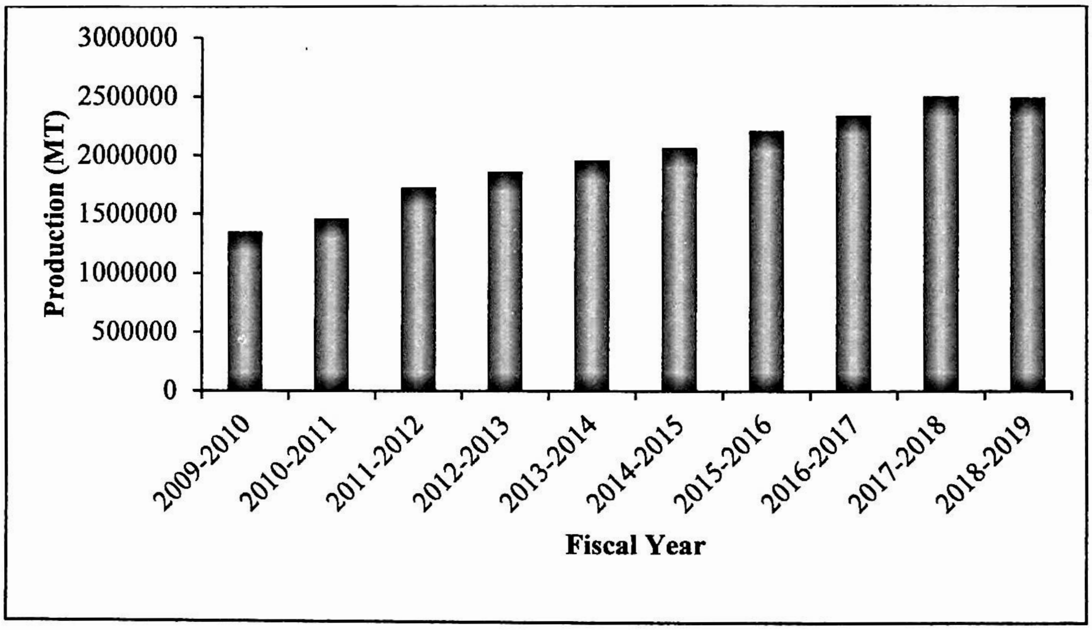

Figure 1.1 Gradual increasing trend of fish production of Bangladesh from the fiscal year 2009-2010 to 2018-2019.

Furthermore, importance of the fisheries sub-sector in the national economy has been demonstrated by their contribution in GDP (3.50%) and the total export earnings (1.23%) (DoF,2020). The total fish production in Bangladesh was estimated at 4384221 mt in 2018-2019 and annually fulfilling 23.00 kg fish per person of which 2488601 MT came from culture system (DoF, 2020). So the country has good potential for freshwater aquaculture. However, this potential cannot be fully utilized for various reasons, because most of them are still rare.

Thai pangas (*Pangasianodon hypophthalmus*) is an economically important species to Bangladeshi aquaculture. Thai pangasius has a range of qualities that make it a suitable candidate for aquaculture. It is particularly important for their fast growth, year round production and high productivity. Consumption of fish and especially oily fish like Thai pangas is essential for an optimal development of the brain and neural system of our children, since omega-3 fatty acids in the form of DHA (docosahexaenoic acid) rather than ALA (α-Linolenic acid) is needed to secure an optimal brain development (Thilsted et al., 2016). This is particularly important during pregnancy and the first two years of life (the 1000-day window). It also exhibits a range of potential advantages in terms of reproductive capacity and resistance to low dissolved oxygen in pond. The fish's relatively low cost, mild flavour and delicate texture have allowed consumption to rise across the world. In the meantime, large-scale production in Bangladesh has led to the marketing of Thai pangasius at low prices. This has significantly contributed to the fish's rapid growth and acceptance on consumers. Thai pangasius culture is spreading to an increasing number of districts and has rapidly evolved into an economically significant activity (Haque, 2009). There is always a demand for fresh fish market, enticing owners of ponds for aquaculture company (Minar et al., 2013) and Thai pangas is a species which can be marketed alive in market. However, further development of aquaculture standards will help the Thai pangasius aquaculture to improve further and secure a sustainable future in Bangladesh. In recent years, economic benefit from this farming is being depleted partly due to increasing feed cost, lack of proper management, unavailability of low cost supplementary feeds and some socio-economic constraints (Akter, 2001). As a result, it was reported that Thai pangasius farmers are gradually losing their interest to invest in Thai pangasius farming in the study area (Wahab et al., 2008).

1.2 Overview of Thai pangas culture in Bangladesh

Pangasius hypophthalmus was introduced in Bangladesh from Thailand in 1989. Over the period of development in culture system, *P. hypophthalmus* is now well accepted by a wide range of people and therefore, it has been a good source of protein and calorie for poor, medium and better-off people in rural as well as urban areas of Bangladesh. It has gained a momentum in Bogra, Jessore, Noakhali, and Dhaka and mainly in Mymensingh district for high growth, high demand and high market price, and over the years Thai pangus production has increased due to its year round breeding and spawning response for fry production, nursing of fingerlings and trading, fish culture and fish trading which ultimately proved itself as a profitable aquaculture enterprise (Monir, 2009). Similarly, successful and sustainable marketing and distribution of this species make it an economically important species in Bangladesh (Alam et al., 2012). In Bangladesh, on the basis of fish production of pond aquaculture, Thai pangas is the dominant culture species contributing 22.64% in total pond production during the fiscal year 2018-2019 (FRSS, 2020). Furthermore, production of Thai pangas is showing gradual increasing trend over the last five years (Figure 1.2). Despite an overall upward trend the industry experiences seasonal and cyclical over and underproduction which create risk in sustainability of this aquaculture system.

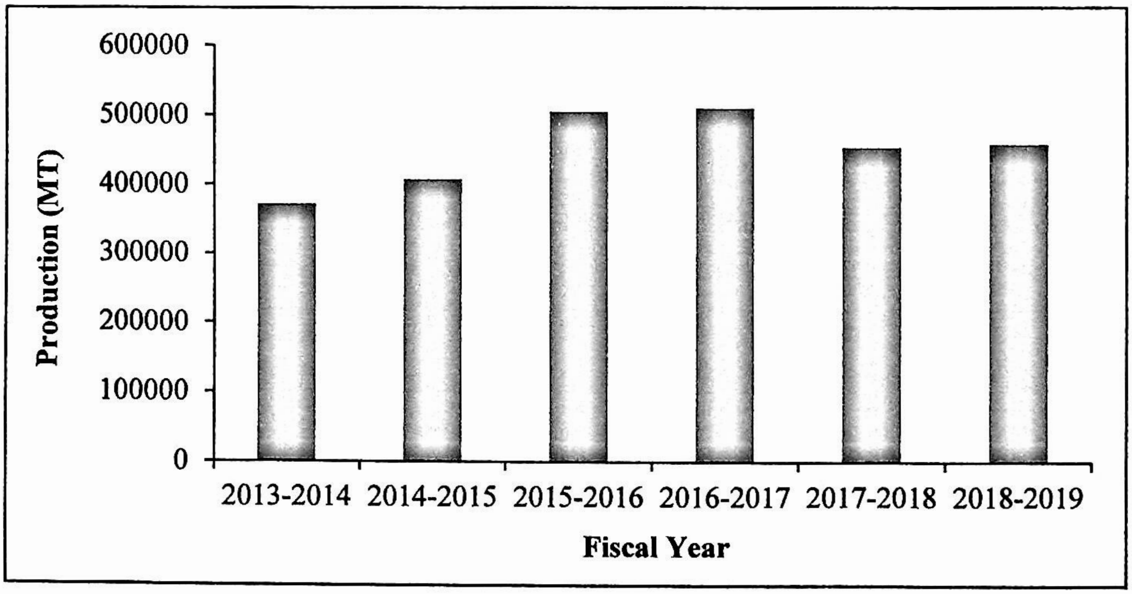

Figure 1.2 Thai pangas production in Bangladesh from the fiscal year 2013-2014 to 2018-2019.

1.3 Present status of aqua feed production in Bangladesh

Use of formulated feeds for fish farming is increasing in Bangladesh, associated with growth and intensification and commercialization of aquaculture. It seems that commercial pelleted feeds are starting to replace 'farm-made' and 'raw' unformulated feeds. As indicated by Figure 1.3, production of commercial feeds has increased at an average rate of 32% per year over the period 2008-2012, and has reached an estimated total of almost 1.07 million tonnes in 2012. Sinking feeds, which accounted for 81% of the total manufactured output, still dominate over extruded floating feed (19%), but growth in the production of floating fish feed has been fastest, averaging 89 per cent over the last four years. Three types of floating feeds are available in Bangladesh: oil coated, non-oil-coated, and vegetable protein based. Non-oil coated feeds account for 95% of total sales. Feed prices increased at a rate of between 9 to 15% per year from 2008 to 2012, due to increases in the price of major raw materials and unavailability. The retail price of 3-4 mm grower feed is currently 35-42 BDT/kg for sinking pellet feed, and 48-54 BDT/kg for extruded floating feed, depending on the species. Using least square demand forecasting and Delphi methods, total feed production is projected to increase to nearly 1.8 million tonnes in 2015 (Figure 1.3).

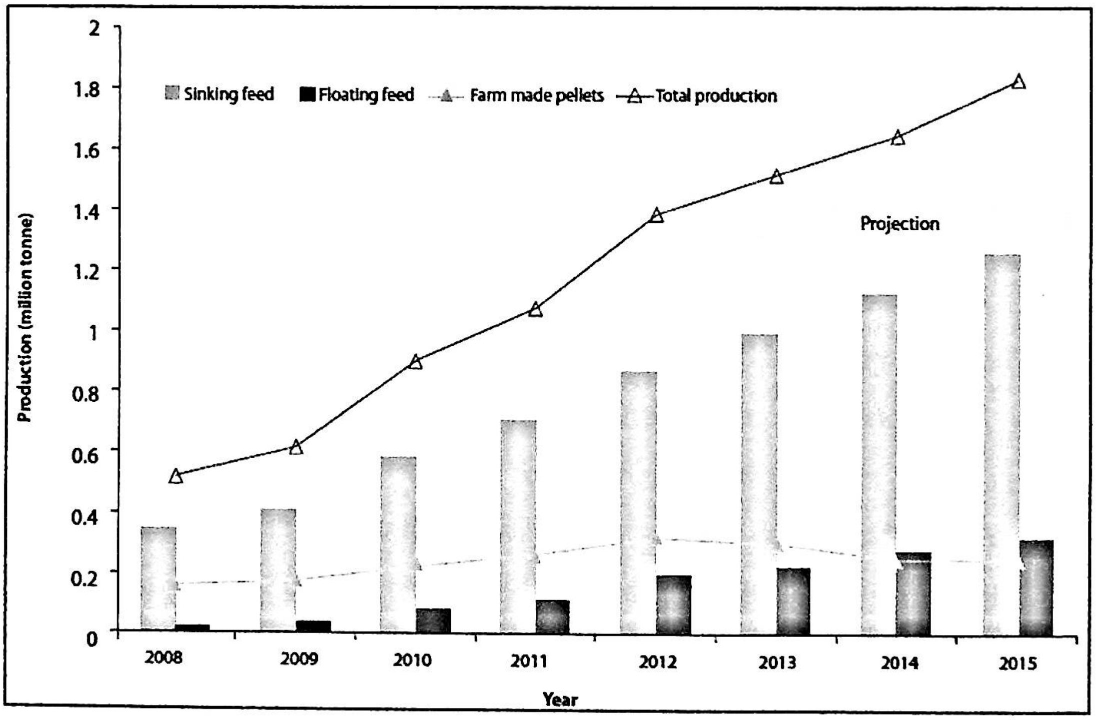

Figure 1.3 Aqua feed production trend in Bangladesh.

Around 100 commercial mills produce aquaculture feeds in Bangladesh. Among these, 8–10 large operators account for 60-70% of market share. During the last two years, horizontal growth (expansion) of feed mill capacity was comparatively higher than in previous years. During the last two years, around 20 companies extended their capacities from 5 to 10 tonnes/hour, and 10 companies have installed extruders for floating fish feed production. The average price of 1% protein in feed is 1.24 ±0.12 BDT. Processing losses in the factory vary from 0.7 to 1.0%. Fuel costs for production of extruded floating feed are higher than those for sinking feed at 2.14 BDT/kg and 0.71 BDT/kg feed, respectively.

1.4 Current problems and constrains of aqua feed production in Bangladesh

Aquaculture is now very much dependent on external feeds provided for cultured species. Sustainability of aqua feeds and the availability and use of feedstuffs are subjects of continuing concern. Although the discussion is centered around fishmeal and fish oil resources (including low-value fish/trash fish), considering past trends and current predictions, sustainability of the aquaculture sector is more likely to be closely linked with the sustained supply of terrestrial animal and plant proteins, oils and carbohydrate sources for aqua feeds (Troell et al., 2014). The aquaculture sector should therefore strive to ensure sustainable supplies of terrestrial and plant feed ingredients. Though Bangladesh has vast water bodies suitable for aquaculture, fish culture is still traditional in nature. Intensive aquaculture is not yet practice and semi-intensive aquaculture is a recent trust. Current problems and constrains in the manufacturing and use of aqua feed in the country can be noted as:

- ✓ Demand for and use of manufactured aqua feeds is very low and not yet conducive to the development of commercial production.
- ✓ Information on the nutrient requirement of the Indian major carps for grow-out fish are available but not for nursery and brood fish. For catfish and other target species, nutritional studies are incomplete and knowledge is insufficient for the formulation and manufacture of feeds.
- ✓ Information on the digestibility of locally available ingredients is not available.

- ✓ Some important ingredients such as good quality fish meal, soybean meal, and growth promoting substances, fungicides and preservatives are not available.
- ✓ Research on the development of suitable aqua feed is incomplete and hence no technology is available to produce good quality aqua feed on a commercial basis.

However, research into replacement of scarce and expensive ingredients, such as fishmeal and fish oil, has increased and the country is producing more or less costly alternatives, as well as making greater use of fishmeal and fish from fish processing wastes. Thus, the use of fisheries resources for feeding fish will not grow as fast as might be expected. However, it is important that the compromise between reducing the cost of feed and the nutritional status of the final produce is carefully balanced. In such a condition, there are a few feed-related issues that the aquaculture industry in Bangladesh needs to address. They are: (i) reducing dependence on fishmeal and fish oil, while maintaining the nutrient quality of farmed aquatic animal products; (ii) ensuring national quality standards for raw materials, feed additives and feeds; (iii) facilitating safe and appropriate use of aqua feeds produced by small-scale manufacturers; (iv) building the capacity of small-scale farmers to make more effective farm-made feeds, and (v) making more efficient use of feed through reduced FCRs.

1.5 Research needed

The commercial viability of any aquaculture venturé hinges on a good understanding of the basic nutritional requirement and culture technique of fish species. Economic performance and environmental sustainability of aquaculture system in ponds are largely depending on reduction of feed cost. Feed and labor comprise the two most important components of the total operating cost for most culture systems in Bangladesh, each accounting for approximately 20 percent and 17 percent, respectively of the total operating costs. One key area which currently restricts the development of Thai pangas culture in Bangladesh is the knowledge on the formulation technology of low cost good quality aqua feed for their better growth performance. To date potentiality of Thai pangas in pond aquaculture system are largely unknown to the huge number of fish farmers. Therefore, the present study was conducted to flourish the potential for the preparation of low cost quality formulated feed for pond culture of Thai pangas.

1.6 This thesis

The general aim of this thesis was to formulate low cost quality feed for Thai pangas culture in Bangladesh. This was achieved by conducting a series of interrelated experiments which determine the formula and ingredients composition for low cost formulated quality feed. In the first experiment at **Chapter 3,** existing Thai pangas farming system in Bangladesh will be studied to find out lacking in the production of low cost quality Thai pangas feed for better economic performance and sustainability. Based on the findings of experiment 1, in experiment 2 at **Chapter 4** different formula for the preparation of sinking and floating Thai pangas feed will be evaluated and the feeds will be prepared accordingly. In **Chapter 5**, different formula will be applied to find out best formula for sinking and floating feed for better growth and economic performance of Thai pangas in pond culture system. Finally, a comparison will be made to choose sinking or floating feed for Thai pangas culture system.

1.7 The specific objectives of the thesis were to:

- To know the existing farming system of Thai pangas in Bangladesh, and subsequent research gaps.
- Study on the water quality parameters of the experimental ponds.
- To know manufacturing technology of floating and sinking feeds
- To formulate nutrient rich low cost quality feed formulae for sinking and floating feeds by using locally available feed ingredients.
- Finally, to evaluate growth, production performance, feed efficiency and economics of commercial culture of Thai pangas.

Chapter Two

Review of Literature

Pangasius feed has developed greatly over the years. One example is industrial feed that can reduce fish diseases and environmental pollution by feed residuals, but industrial feed is more expensive than other alternatives such as homemade feed. Mono farming in respect of several fishes has come into being and has become a common practice, Pangus farming is also gaining in popularity. Commercial fish diets are manufactured as either extruded (floating or buoyant) or pressure-pelleted (sinking) feeds. Both floating and sinking feed can produce satisfactory growth, but some fish species prefer floating, others sinking. Shrimp, for example, will not accept a floating feed, but most fish species can be trained to accept a floating pellet. Extruded feeds are more expensive due to the higher manufacturing costs. Usually, it is advantageous to feed a floating (extruded) feed because the farmer can directly observe the feeding intensity of his fish and adjust feeding rates accordingly. Determining whether feeding rates are too low or too high is important in maximizing fish growth and feed use efficiency. In addition, young fish cannot feed well on homemade feed so industrial feed is often used during the first two months of the grow-out culture system. When the market price for fish drops, farmers tend to apply both industrial and homemade feed. However, a short account of research on pangus culture of Bangladesh and some other parts of the world are as follows:

Aas et al., (2020) revealed the relative feed intake was highest in salmon fed Diet 2 and Diet 3 with no effects of pellet hardness. Growth and feed efficiency ratio were similar among all fish. The apparent digestibility of energy, dry matter, nitrogen and lipid was similar for all feeds, whereas the apparent digestibility of phosphorus and zinc was the lowest in Diet 3. Retention of energy, lipid and nitrogen was also similar for all feeds. Salmon fed Diet 1 and Diet 3 retained more phosphorus than those fed Diet 2. An increased retention of the digested zinc was found in salmon fed Diet 3. This study concludes that physical pellet quality affects feed intake and improve utilization of feed in salmon if optimized properly. Moreover, pellet hardness can be optimized in commercial scale without compromising feed intake as it has no influence on feed intake.

Debnath et al., (2019) conducted the supplementation of 30% protein (F2) and 35% protein feed (F3) compared with conventional rice bran+ mustard oil cake feeding (F1) on the growth responses of endangered Indian butter catfish, *Ompok bimaculatus* (pabda) stocked at 15% with 40% catla, 30% rohu and 15% mrigal in polyculture in stocking density of 4000 fingerlings/ha. Water and soil quality parameters were assessed on monthly intervals which showed normal variation among the treatments. The weight of the pabda during harvest was higher in F2 and F3 than F1; as a result, growth rate was higher in F2 and F3 than F1. Survival was highest in F2. The growth of carps was significantly improved in F2 and F3 except for mrigal in F2. Feed conversion ratio significantly lower in F2 and F3 when compared with F1. Benefit-cost ratio was lowest in F3. Overall, the pabda production was increased by 16.2% with F2 and 19.5% with F3. The study concluded that pabda perform better in polyculture with carps when feed supplemented with 30% protein feed.

Rachmawati et al., (2019) revealed the effect of papain enzyme diet on growth performance of Catfish (*Pangasius hypopthalmus*) through feed efficiency and growth parameters. The research employed a completely randomized design with four treatments and three replicates. Catfish fingerlings with an average weight of 2.23 g/fish were used as samples. The experimental diets were prepared to be iso-nitrogenous (31%) and iso-caloric (252.06 kcal/g). Papain enzyme was added to the feed within various doses; A (0 g/kg feed), B (2 g/kg feed), C (4 g/kg feed), D (6 g/kg feed) and E (8 g/kg feed). The study parameters included apparent digestibility coefficient of protein (ADCP), relative growth rate (RGR), the efficiency of feed utilization (EFU), feed conversion ratio (FCR), protein efficiency ratio (PER), survival rate (SR) and water quality. The results of the study show that the addition of papain enzyme significantly affected ADCp, RGR, EFU, FCR, and PER, but not the SR of catfish. Based on regression analysis, the optimum dose of ADCP and RGR were 4.05 g/kg, RGR was 4 g/kg feed, respectively. The EFU had an optimum dose of 3.93 g/kg feed, meantime the FCR and PER had an optimum dose of 4 g/kg feed each. The diet of papain in the amount of 4 g/kg feed increased the growth performance and nutrient utilization of catfish (*Pangasius hypopthalmus*)

Rahman et al., (2019) Observed the quality changes in fish pickle from Thai Pangus (*Pangasianodon hypophthalmus*) at refrigeration (5°C to 8°C) and freezing (-20°C to -18°C) temperature in kitchen refrigerator. In fish pickle, moisture content (%) decreased from 58.20 ± 0.194 to 48.53 ± 0.345 and 58.67 ± 0.180 to 43.90 ± 0.245 at refrigeration and freezing storage, respectively after twelve months of storage. Likewise, protein content (%) decreased from 22.35 ± 0.385 to 18.85 ± 0.097 and 22.70 ± 0.141 to 14.69 ± 0.137, respectively throughout the storage period. Lipid content (%) increased up to five months of storage and then decreased gradually at refrigeration temperature, whereas at frozen temperature it increased gradually at the whole storage period. Ash content (%) increased from 4.08 ± 0.043 to 7.38 ± 0.081 and 4.83 ± 0.130 to 9.18 ± 0.085, respectively in refrigeration and freezer compartment. pH value decreased from 6.83 ± 0.040 to 4.29 ± 0.045 and from 6.79 ± 0.036 to 4.11 ± 0.045, respectively at refrigeration and frozen storage condition.

Sku et al., (2019) conducted to evaluate effects of two growth promoter aqua drugs, Aquaboost and Megaviton the growth performances of Thai Pangas (*Pangasius sutchi*) in pond environment. Formulated feed with six different doses in per kg feed were used for six different treatments: T_1-Controlled(no dose); T_2-Less than recommended dose (0.66g/kg); T_3-Recommended dose (1g/kg); T_4-More than recommended dose (1.33g/kg); T_5-more than recommended dose (1.40g/kg) and T_6-more than recommended dose (1.50g/ kg). Each pond area was 1 decimal and 50 fishes/decimal were stocked. Average initial body weight of fish was 50g. Aqua drugs mixing feed were fed two times daily at the rate of 10% body weight of fish. Growth performance of the fish was monitored every 15 days interval. The water quality parameters of experimental ponds were recorded and they were within acceptable limit. In case of Aquaboost, the final weight gain in different treatments after 60 days of rearing were: 79±0.85g in control (T_1); 84±0.63g in T_2; 96±1.24g in T_3; 112±1.12gin T_4; 98±1.32g in $T_5$and 96±1.33 in T_6. Best growth performances were evident in treatment T_4 which was more than one step of recommended dose (1.33g/kg feed). The recommended dose of 1g/kg feed was used in T_3 and the growth of 96±1.24g was obtained from this treatment. In case of Megavit, the final weight gain in different treatments after 60 days of rearing were: 77±0.55g in control (T_1); 81±0.66g in T_2; 97±1.44g in T_3; 115±1.05gin T_4; 89±2.02g in T_5 and 92±1.22 in T_6. Best growth performances were evident in treatment T_4 which was more than one step of recommended dose (1.33g/kg feed). The recommended dose of 1g/kg feed was used in T_3 and the growth of 97±1.44g was obtained from this treatment. The highest specific growth rate of 0.005% to 0.006% was observed in feed containing the dose 1.33g/kg in both Aquaboost and Megavit and significantly ($P<0.05$) higher than the control and other doses. The moisture, lipid, crude protein and ash content of feed containing either Aquaboost or Megavit were in the range of 12.36% to 16.24%; 7.70% to 8.90%; 23.10% to 24.68% and 12.02% to 13.72%, respectively.

Akter et al., (2018) stated that the inverse relationship between farm size and productivity have been expanded tremendously but most of the aquaculture farms are small and their productivity is not as high as expected. The relationships among farm size, productivity and efficiency of pangas fish farms has been conducted. Stochastic frontier production function was carried out to estimates the level of technical efficiency and polynomial regression was employed to show the relationship among farm size productivity and efficiency in pangas fish farming. In general, pangas fish farming was found to be profitable, where the large size farms were more profitable than the small. Feed and salt had highly significant and positive effects on productivity, while human labor had negative influences. Larger farms were found to be more productive and technically efficient than the smaller one, and the more productive farms were found to be more efficient. Inefficiency model was used in determining the contribution of socio-economic variables to the technical inefficiency (T_1) of pangas fish farmers. Farm size and productivity relationship is a debatable issue in literatures.

This relationship may positive or negative with respect to certain production factors. The output of local polynomial regression under this study revealed the relationship between farm size and productivity is positive that means productivity increases with the increase of farm sizes. Farm productivity mainly depends on some factors that are enhanced by efficiency. Polynomial regression output indicates a significant positive relationship between the productivity and efficiency. It means that if farms use different inputs efficiently then the productivity will increase. Results indicated that the farmer's age, education and experience were the most socioeconomic determinants of inefficiency. Relationship between productivity and efficiency was also found to be positive that means productive farms are more efficient. All these results indicated that farms productivity and efficiency increases with the increase of farm size.

Ali et al., (2018) stated that feeding and stocking density were the most significant factors influencing fish production. The analysis also showed an increasing return to scale, implying an increase in inputs will more than proportionately increase production. The estimated marginal physical productivity of the inputs suggests that stocking density, feeding and labor should be increased in order to increase farm profitability. However, some inputs were inefficiently used by different farm categories. The amount of feed used ranged between 9.1 and 148 t/ha, with no significant difference ($P \geq 0.05$) observed between farm categories. All farmers applied feed twice per day throughout the production cycle. The feed conversion ratios (FCRs) were 1.70 ± 0.31, 1.73 ± 0.32 and 1.72 ± 0.36 in small, medium and large farm categories.

Bhilave, (2018) stated that formulation of feed is the quality of the feed ingredients and the nutritional parameters in formulated feeds. Soyabean (*Glycine max*) has been selected as the raw material for formulation. It is the most promising alternative protein source for fish meal and widely used as the cost effective alternative for high quality fish meal in feeds for many aquaculture fish species due to its high protein content, excellent amino acid profile, low cost, availability and steady supply as compared to the other plant protein sources. The nutritional quality of feed or ingredients depends upon the availability of nutrients to the fish The analytical result reveals that formulated feed was nutritionally rich as compared to conventional feed-de oiled groundnut cake. Following the above procedure all the feeds were formulated, in the percentage composition of 25% (soyabean meal 25% + groundnut oil cake 75%), 50% (soyabean meal 50% + groundnut oil cake 50%), 75% (soyabean meal 75% + groundnut oil cake 25%), 100% formulated (only of soyabean meal) and 100% conventional (only of groundnut oil cake).

Islam et al., (2018) conducted to determine the growth performance of Thai pangas (*Pangasius hypophthalmus*) in the cage culture system (4.6×1.5×1.4 m^3) of Globe Fisheries Ltd., at Subornachor under Noakhali, Bangladesh for a period of 45 days. The initial weight of *P. hypophthalmus* fry was 0.19±0.007g and stocked the fry in net cage. After acclimatization, the fry fed with formulated diet containing 28% gross protein level twice a day at the rate of 5% body weight. The diet was consisted of fishmeal, mustard oil cake, rice bran, wheat bran, vitamin and salt. The water quality parameters were recorded throughout the study period and temperature, dissolved oxygen and pH were ranged 28.3–32°C, 8.0–8.5 mg/l and 7.4–8.3, respectively. The results showed that the growth performance of *P. hypophthalmus* was found higher in low stocking density after 45 days of rearing. Finally, fish attained 0.2±0.007 g, 0.17±0.007 g, and 0.09±0.06 g in mean weight gain and 1.8±0.04 cm, 1.6±0.07 cm, 1.2±0.14 cm in mean length gain, 0.92±0.006, 0.49±0.005, 0.49±0.003 in specific growth rate, 1.93±0.23, 2.23±0.19, and 3.05±0.13 in food conversion ratio and 95±0.02, 85±0.02, and 81±0.02% in survival rate in the treatment T_1, T_2 andT_3, respectively.

Samad et al., (2017) revealed the impacts of three different low cost diets in monoculture system on the growth and production of indigenous catfish Shingi, *Heteropneustes fossilis* (Bloch, 1794) (*H. fossilis*) in earthen ponds. The higher growth and survival rate of *H. fossilis* was found with 31% protein level of the feed in earthen ponds of Bangladesh. The net weight gain and survival rate were found to be (43.90 ± 0.42) g and (83.21 ± 1.43)% in T_1, (37.50 ± 0.67) g and (79.28 ± 1.36)% in T_2 and (34.30 ± 0.62) g and (78.95 ± 2.53)% in T_3, respectively, which were significantly ($P < 0.05$) different among the treatments. The minimum value [(1.10 ± 0.22)%] of specific growth rate (SGR) was recorded in T_3; whereas the maximum value [(1.35 ± 0.25)%] was recorded in T_1. The values of feed conversion ratio (FCR) of *H. fossilis* were found to be 2.68 ± 0.34, 2.31 ± 0.12, 2.22 ± 0.05 in T_1, T_2 and T_3, respectively. Significantly higher weight gain, SGR and survival rate of *H. fossilis* were found in T_1. The net production (kg/ha) was also found significantly ($P < 0.05$) different among the treatments. Net production in T_1 (2 249.98 ± 10.66) was significantly higher than that in T_2 (1 829.34 ± 4.50) and T_3 (1 652.05 ± 16.69). Cost-benefit ratio (CBR) in treatment T_1 in the present study was higher (1:1.91) than that in the other two treatments.

Vaishnav et al., (2017) revealed the comparative growth performance of *Pangasius sp.* cultured at different stocking density in floating net cages. The experiment was conducted in 05 replications at 3 stocking densities in 15 floating net cages of the size-3.65 x 3.65 x 5.48 m (L x W x D). The stocking densities were-T_1 (2600 fish fingerling/cage), T_2 (2800 fish/cage) and T_3 (3000 fish/cage). During experiment of 60 days, the fingerlings of pangas (*Pangasius hypophthalmus*) were fed on commercial floating pelleted feed given to fish @ 5% of their body weight per day. The fishes were properly maintained for good health by regular feeding schedule and use of prophylactic measures and probiotics. The results indicated that the weight gain (NWG), specific growth rate (SGR), food conversion ratio (FCR) and gross conversion efficiency (GCE) were significantly different ($P<0.05$) in all the treatments. Still, the significantly higher growth performance was observed in T_1. In this treatment NWG, SGR and GCE were the highest 289.570c±0.928g, 1.698c±0.019 and 0.852c±0.002 respectively. The lowest FCR (1.174a±0.004) was also recorded in T_1 compared to all other treatments. The net yield in 60 days was maximum in T_3 (9.080/m3) and per cent increase in biomass was maximum (176.955%) in T_1.The fish growth was maximum at 30-45 days of observation which corresponds with water temperature of 23.68±2.07°C, pH-8.54±0.13 and dissolved oxygen 8.26±0.10 mg/l. The higher Ponderal index was noticed in T_1 i.e. 2.403b±0.057 indicating wellness of fish. Through this study we can recommended that in above conditions 2600 fingerlings of *Pangasius hypophthalmus* stocked in each floating net cage gives maximum growth and per cent increase in fish yield.

Zaman et al., (2017) revealed that almost all of the Pangasius farmers used supplementary feeds in their farms and observed the peak period of harvesting from October to January. 37% of farmers received general aquaculture training from Bangladesh Fisheries Research Institute and Department of Fisheries and some non-government organizations. Various constraints such as, lack of capital and proper technological knowledge, lack of continuous supply of quality fry, high price of the inputs especially feed, adulteration of feed, inbreeding, improper marketing and management problems were prominent. About 46% of the farmers collected fingerlings from the nearby nursery, 43% of the farmers collected fries/fingerlings from the fry traders and 11% from the local private farms or Hatchery. Fingerlings size varies from 1 to 2 inch with price of BDT 0.8-1/fingerling. Commercial fish feeds produced by different Industries (e.g. Mega feed, Fresh feed, Paragon feed, Teer feed, CP feed etc.) feeds used in the farming of the pangus in the studied areas. observed the growth performance of (*P. pangasius*) in obtained at 40% protein level in feed containing cow viscera, mustard oil cake, wheat bran and rice bran. Some farmers use some unethical feeds in their farms. Out of 80 farmers, most of them used chemicals and fertilizers. They used mainly lime, geolite, matrix, salt and TSP. It was found that the highest ammonia, nitrate, phosphorus was respectively 0.89±0.16 mg/l, 0.30±0.06 mg/l, 5.03±0.21 mg/l in three different categories of pangus farm. Very poor number of farmers also used Vitamix F Aqua Premium, timsen, somethion, salt, provt-gel, oxytetracycline, oxy care, copper sulphate, bleaching powder, potash, etc. the peak harvesting season were from June to July and November to December.

Momoh et al., (2016) stated that eight 40% crude protein diets with approximately 3000 KCal/kg metabolizable energy were formulated for juvenile catfish. Four test ingredients (Rice milling, Millet Offal, Wheat offal and Brewer's Dry Grain) were used as binders. The influence of these binders and the inclusion of yeast was tested on the physical characteristics, floatation and water stability of each compounded diet. Diets with yeast generally had significantly higher expansion but less water stability. Diet with wheat offal supports floatation best among the test ingredients while Rice Bran facilitates water stability. Also, the inclusion of yeast enhanced floatation. It was therefore recommended that wheat offal and rice bran can be added in fish feed to enhance floatation and water stability of pellets. Moisture content was generally below 4.0% and crude lipid were high (between 6.00 – 9.54%). The crude fiber was also low while ash and NFE were relatively high. Percentage floatation period varies among diet combinations. The diets fortified with yeast had higher percentage floatation than their corresponding counterparts without yeast within throughout the duration of test. All the diets floated with over 76.67% floatation. Among the ingredients tested, wheat offal holds the highest potential to enhance floatation of pellets, especially when it is fortified with yeast. Rice bran however comes second to wheat offal in terms of floatation and more stable in water after both pellets have sank to the bottom. Diets made of BDG were observed to have been the least water stable despite the fact that they were subjected to similar conditions of processing with diets made of the other test ingredients.

Pham et al., (2016) analyzed the economic feasibility of recirculating aquaculture systems (RAS) in *Pangasius* farming in Vietnam. The study uses a capital budgeting approach and accounts for uncertainty in key parameters. Stochastic simulation was used to simulate the economic performance of medium and large farms operating with a traditional system or RAS. Data were obtained through structured surveys and a workshop in the Mekong River Delta. Results show that for large farms, net present value increases from an average of 589,000 USD/ha to 916,000 USD/ha after implementing RAS. Overall, the probability that RAS is a profitable investment was found to be 99%.

Limbu, (2015) revealed the effect of floating and sinking diets on the growth performance, feed conversion efficiency, condition factor, yield and cost-effectiveness of *C. gariepinus*. Fingerlings of 14.95 ± 0.24 g initial mean weight (± standard error) were reared in triplicate earthen ponds at a stocking density of 10 fish m^2 for eight weeks. The results showed that, feeding *C. gariepinus* using either floating or sinking diets did not significantly affect growth and survival rate ($P > 0.05$). Equally, *C. gariepinus* fed on sinking and floating diets had similar feed conversion efficiency ($P = 0.426$). The fish in both treatments had similar condition factors and were growing isometrically ($P > 0.05$). Rearing *C. gariepinus* either on floating or sinking diets did not affect gross, net and annual yields ($P > 0.05$). However, *C. gariepinus* fed on floating diet had significantly higher incidence cost by 33% more than feeding them on sinking diet ($P = 0.001$). Furthermore, the profit index for *C. gariepinus* fed on the floating diet was significantly lower by 35% less than those fed on the sinking diet ($P = 0.001$). The present study indicates that, *C. gariepinus* farmers can reduce feeding cost up to more than 30% by using sinking diet without affecting the growth performance, survival, nutrient utilization, condition factor and yield of their fish.

Tuan, (2015) stated that approximately 0.5 million mt of marine trash fish was used for livestock, aquaculture and fish meal. Local marine fish meal consisting of protein content from 50 to 68% and catfish byproduct meal containing protein level from 50 to 60% were available. Based on FCR values of 5 major species including catfish, black tiger shrimp, white leg shrimp, Asian seabass, and snake head, aquafeed production was estimated at around 2.5 million mt. Marine fish oil/squid liver oil requirement was from 15.5 to 31 thousand MT. Fish meal demand was from 252 and 430 thousand MT. Almost all fish meal and marine fish oil used in aquafeed were imported. Soybean and other plant ingredients are potential alternative sources to replace fish meal and fish oil. Vietnamese farmers produced 168 thousand MT soybean while soybean demand amounts for aquafeed were from 693 to 1,140 thousand MT.

Malik et al., (2014) conducted the effect of stocking density on growth performance, production and survival of Pangas, *Pangasius hypophthalmus* was evaluated in cemented tanks. Fry of Pangas (1.52 ± 0.03 cm in length and 1.08 ± 0.02 g in weight) respectively were stocked into cemented tanks measuring 15 x 6 x 3 ft. Three treatments with two replicates were used: T_1-100; T_2-150 and T_3-200 fry/ tank. Pangas fry were fed twice daily with formulated feed 35 % protein at 10%, 5%, and 3% body weight for the first, second, and third month, respectively. After 90 days, the highest growth performances (determined in terms of average weight) were recorded in T_1 (27.5±2.5 g) and T_2 (22.4±2.8 g) while T_3 (18.2±3.5g) recorded the smallest growth. Production differed significantly among treatments ($P<0.05$). Feed conversion ratio (FCR) of 1.0, 1.02 and 1.05 in T_1, T_2 and T_3, respectively were not significantly different ($P>0.05$). Survival was significantly different among treatments ($P<0.01$). Highest survival (100%) was attained in T_1 with lower stocking density, followed by T_2 (96%) and T_3 (90%). Survival was greatly influenced by the stocking densities in all treatments.

Shah et al., (2014) recorded that the fry of Pangasius were fed with formulated diet containing 30% gross protein level thrice a day at the rate of 5 % body weight. The diet was consists of fishmeal, mustered oil cake, rice bran, wheat bran, rice protein and wheat flour. During rearing period, fish showed slow growth in weight and length due to new environment adaptation but after 30 days, culture period better growth was observe. The frys of Pangas (*Pangasius hypophthalmus*) grew from mean weight of 0.76 g to 106.5 g during 120 days mean daily weight gain was 0.88 g/day and specific growth rate (SGR) reached 4.1g/day and Food conversion ratio (FCR) was 1.15, survival rate was 85% and condition factor was recorded 2.16. Fish attained 80-140 g in weight and 19.3-23.0 cm in length with Specific growth rate (SGR) 4.1. Feed conversion ratio was estimated 1.15 in 120 days experiment.

Ali et al., (2013) conducted about the present status and characteristics of *pangasius* culture in Bangladesh based on data from a study conducted in Mymensingh district. The mean productivity of *pangasius* was 36.9 MT/ha, where 87.9% of the farms produced between 15 and 65 MT halof *pangasius*. *Pangasius* aquaculture in Bangladesh has improved the economic and social status of a variety of stake-holders in communities where the fish is farmed. Normally, six or seven types of ingredients are used to prepare farm-made feed, including fine rice bran or polish from industrial rice mills, maize meal, wheat flour or wheat bran, dry fish, mustard oil cake, soybean meal and meat and bone meal. The nutritional quality of commercially manufactured feeds, as stated by the manufactures, is highly variable with crude protein (CP) ranging from 23% to 32% (mean: 28.05%). Feeding rates ranged from 1.5% to12% and 1–10% of body weight per day for farm-made feeds and commercial feeds. 62% used sinking pelleted feeds, 25% used floating pelleted feeds and 18% used a combination of both sinking and floating pelleted feeds. Moreover, 21% of farms also used farm made mash feeds (non-pelleted) including rice bran/polish, rice products, wheat products, mustard oilcake, and maize meal. Sixteen percent of small scale farmers applied both commercial and farm-made pelleted feeds, usually opting for commercial feeds during rainy and cloudy weather due to the increased difficulty of preparing and drying farm-made pelleted feeds.

Ali et al., (2013) stated the effect of increased stocking density and of a commercial and formulated feed on *Pangasius* production over six months in ponds with an average salinity of 10 ppt. Fish were stocked at a density of $2/m^2$ and fed a formulated (28% CP, T_1 group) and commercial feed (CP Mega floating feed, 28% CP; T_2 group). In a third treatment (T_3) fish were stocked at $3/m^2$ and fed the commercial feed. Fish were fed at an initial rate of 10% body weight (bw)/day down to 3% bw/day. No significant differences were observed in survival rate, weight gain, SGR, and feed conversion ratio (FCR) among the treatments. Significantly higher production was observed in T_3 (23,264kg/ha) followed by T_1 (15,538kg/ha) and T_2 (15,622kg/ha).Because formulated feed is substantially cheaper than commercial feed net profit was greater in T_1

(US$11,438/ha) than in T_2 (US$8,275/ha). Total cost was higher in T_3 than in T_2 due to higher stocking densities, but net profit was higher in T_3 (US$12,104/ha) than in T_2 (US$8,275/ha). The results indicate for the first time that Pangasius can be grown in salinities as high as 10 ppt. The adoption of formulated feeds rather than commercial pelleted diets or of a higher stocking density of 3 fish/m^2 can provide additional profits of as high as 40%.

Lazu et al., (2013) stated that the collected feed samples were analyzed with a significant variation of mean proximate composition of different farm and factory made feed. In case of farm made (feed, Feed 2, Feed 3, Feed 4, Feed 5, Feed 6, Feed 7 and Feed 8) the significantly highest moisture content was found at Feed 4 followed by Feed 2, Feed 1, Feed 8 but there were no significant variation in case of factory made feed i.e. Feed 9, Feed 10, Feed 11 and Feed 12. Similar observation was also found in case of lipid content. But in case of protein, ash and fiber content the significantly highest value were found at factory made feed compared to farm made feed. No marked changes had been occurred in case of carbohydrate content between factory and farm made feed. But the overall quality of the farm made feed was satisfactory compare to factory made fish feed with some exceptions. The lower value of farm made feed was due to the lack of knowledge of feed composition of farmers. By knowing appropriate feed composition then pangus culture can possible by producing their own feed spending less money rather buying fish feed from companies by more money.

Mamun-Ur-Rashid et al., (2013) revealed the a number of entry points for interventions in the sector, and investments which would improve feed quality and farmer access to better feeds and support the growth of sustainable aquaculture. More than 1 million tonnes of commercially formulated feeds and 0.3-0.4 million tonnes of farm-made feeds were produced in 2012, and sectoral growth was projected to increase substantially over the medium term. Fish feed value chains, market trends, ingredients and formulation systems, farm feeding practices, ancillary services and feed regulations were investigated. The main ingredients used for fish feed production are rice bran (20–50% inclusion), maize

(5–20% inclusion), soybean meal (10–30% inclusion), mustard oil cake (10–25% inclusion), fish meal (5–15% inclusion) and meat and bone meal (10–20% inclusion). Production of commercial feeds has increased at an average rate of 32% per year over the period 2008–2012, and has reached an estimated total of almost 1.07 million tonnes in 2012. Sinking feeds, which accounted for 81% of total manufactured output, still dominate over extruded floating feed (19%), but growth in the production of floating fish feed has been fastest, averaging 89% over the last four years. Three types of floating feeds are available: oil coated, non-oil-coated, and vegetable protein based. Non-oil coated feeds account for 95% of total sales. Meat and bone meal is utilized as a source of cheap protein (48–52% crude protein) and is imported.

Ramakrishna et al., (2013) revealed that mash feed was the most popular and widely used feed type. De-oiled rice bran was used as the principal feed ingredient, followed by groundnut cake and cottonseed cake. All the farmers reported using de-oiled rice bran, while 56 percent used groundnut cake, 40 percent used cottonseed cake, and 30 percent used raw rice bran and other mash feed ingredients. The poor quality of the mash feed ingredients, especially the de-oiled rice bran, groundnut cake, and cottonseed cake was an important issue of concern to the farmers. Commercially manufactured pelleted feeds were used by 33 percent of the farmers to complement their mash feeds, with the majority choosing to use sinking pellets. There has been a marked increase in the use of commercially manufactured aqua feeds, most notably for the large-scale production of the striped catfish *(Pangasianodon hypophthalmus)*.

Amin et al., (2012) revealed that four feeding regimes were evaluated: fed to satiation twice per day (treatment daily feeding); 1-day food deprivationand1-day feeding (treatment 1D-1F), 2-day deprivation and 2-day feeding (treatment 2D-2F) and 5-day deprivation and 5-dayfeeding (treatment 5D-5F). Fingerlings (mean weight 373g, mean total length 182 cm) were stocked in replicated earthen ponds at a density of 25000/ha and cultured for 18 weeks during which commercial diet (33% crude protein) were de-livered to apparent satiation on the feeding day ac-cording to the treatment. Results showed that the daily feeding and 1D-1F treatments resulted in similar individual weight gain (515-536 g) and net fish production (10954-11387 kg/ha) as compared with treatment 2D-2F (weight gain 309 g; net production 6700 kg/ha) or treatment 5D-5F (weight gain 251g; net production 5651 kghal). While fish body protein levels were not affected by food deprivation, lipid contents were lowest in treatments 2D-2F and 5D-5F. The study concluded that sutchi catfish could be cultured in alternate-day feeding regime without any negative effects on production and meat quality of fish resulting in a net profit of USD 2750/ha pond.

Hasan, (2012) stated that the environmental impact assessments on the use of the two feed types suggested that good feed management and overall farming practices, and improving the quality of trash fish/low-value fish or pellets reduce the impacts of feed on the water beneath and around the culture sites. In addition, a good culture site where the carrying capacity is not stressed by aquaculture and non-aquaculture activities will considerably reduce the mortality risks from biotic and abiotic hazards. The pellets were not specifically designed for the cultured species. Diets contained the high levels of crude protein and moderate levels of crude lipid that are generally required by carnivorous marine fish. Ash, fiber, calcium and phosphorous levels all appeared to be within a suitable range for warm water fish.

Udo and Umoren, (2011) conducted to evaluate the proximate composition and the digestibility of nutrients and energy in protein-rich (dried fish, duckweed meal, blood meal, shrimp waste meal) carbohydrate-rich (rice bran, wheat offal, cassava root meal, cocoyam root meal) and in oilseed cake (groundnut cake, soybean cake, sesame cake, cotton seed cake) feedstuffs to improve least-cost diet formulations and to allow effective substitution for fishmeal. The digestibility of various ingredients was measured by using an inert marker in the feed and by using the Guelph faeces collecting system. The Basal diet (B) was formulated to contain 273.84 g/kg protein, 79.06 g/kg lipid and 20.25 MJ/kg DM gross energy. The test diets were composed of the ingredient of interest plus

Cr_2O_3, making up 30% of the dietary Dry Matter (DM) and B making up 70% of the DM. ADC values of the ingredients tested were generally high especially for dried fish. It was found that dried fish (97.48%) among the protein-rich ingredients, cocoyam root meal (89.44%) among carbohydrate-rich ingredient and sesame cake (90.95%) among the oilseeds were the best ingredients tested. The ADC of energy in the test diets was high and ranged from 80.3 to 88.6% (average 83.3%, SD 2.3).

Ahmed et al., (2010) revealed that sutchi catfish farming is profitable irrespective of the level of intensification and in all three instances the cost of feed dominated the variable costs of production. Inputs are inefficiently used in the intensive farming system. Production costs and returns of sutchi catfish (*Pangasianodon hypophthalmus*) aquaculture under three different farming systems in Bangladesh. Based on the production technology, sutchi catfish farming is classified as extensive, semi-intensive and intensive. The average annual production per hectare under intensive farming conditions (13945 kg) was higher than semi-intensive (7705 kg) and extensive (3380 kg) farming mainly due to higher levels of inputs, including seed, feed, fertilizer and labour. Despite the higher production costs per hectare, the average annual net return was higher in intensive farming (US$ 3364), compared with semi intensive (US$ 2048) and extensive (US$ 1099) farming.

Bhosale et al., (2010) revealed that soybean (*Glycine max*) has been selected as the raw material for formulation of fish feed along with ingredients essential for growth, disease resistance and the binding agent to hold the feed for grass carp (*Ctenopharyngodon idella*). Soybean is probably the most promising alternative protein source for fish meal. It is widely used as the cost effective alternative for high quality fish meal in feeds for many aquaculture fish species due to its high protein content, excellent amino acid profile, low cost, availability and steady supply as compared to the other plant protein sources.

Khan et al., (2009) revealed a commercially available pelleted feed was given only for pangasiid catfish with same feeding rate in all treatments but the feeding frequency was different. The feeding rate was 10%, 8%, 7%, 6 %, 5%, 4% which was consecutively adjusted after each fortnightly sampling and 3% for the last 4 weeks of the study period. Feeding frequencies was once a day in T_1, two times a day in T_2 and three times a day in T_3. The average weight gain of pangasiid catfish and silver carp in T_3 (376.69 g and 81.02 g) was significantly higher ($P<0.05$) than those of T_2 (330.25 g and 58.35 g) and T_1 (261.76 g and 42.89 g). The survival rate was 95.2, 96.0 and 96.8% for pangasiid catfish and 83.2, 85.2 and 86.0% for silver carp in T_1, T_2 and T_3, respectively. The net production of fish in T_3 (5,430.64 kg/ha) was significantly higher ($P<0.05$) than those of T_2 (4,584.70 kg/ha) and T_1 (3,562.89 kg/ha). Significantly highest net return (Tk. 68,533.54/ha with benefit cost ratio of 1.36) was achieved from T_3 followed by T_2 (Tk. 40,080.56/ha with benefit cost ratio of 1.22) and T_1 (Tk. 13,786.67/ha with benefit cost ratio of 1.08). The present research findings suggest that an increase of feeding frequency has positive effect on growth and production of pangasiid catfish.

Azmat et al., (2008) revealed the nutritional status of a low value/trash fish which have a low commercial value by virtue of their low consumer preference, low quality and small size. The hazards of environments on low valued fish and survival of trash fish with the importance and significance of minerals and nutrition like sodium, potassium, calcium, moisture, total protein, total fat, ash and calorific value which were determined by standard methods. The highest potential of essential minerals ions and low biochemical profile of trash fish reflects the effects of pollution leads to threat, for life of marine resources and showed that the environmental stress, may be detrimental for survival of commercially important fish species in their initial stages of life cycle with over fishing. The moisture contents varied significantly 3.1 to 9.8 among the species studied, one specie (*Rhabdoscargus sarba*) has moisture content below 5%, whereas the rest of the species have moisture value between 5-10% showed that moisture contents have some bearing of environmental stress. A marked variation were observed in ash contents of reported species which were in the ranged of 11.8 to 18.4. *Otolithus argenteus* showed lowest value of ash content (11.8). Protein contents ranged 42.1% to 62.5%. Only one specie *P. filamentosa* (62.5). Na contents were ranged between 35 to 62 ppm and K contents ranged 24-45 ppm and Ca contents ranged 11-22 ppm. There were highest potential of sodium (Na), potassium (K), calcium (Ca) in all trash fishes. The total fat or lipids also showed a great variation ranged from 11.3 to 22.5%.

Islam et al., (2008) determined growth performance, the highest economic return and suitable species composition in the polyculture of Thai pangus (*Pangasius hypophthalmus*) with carps (*Catla catla* and *Labeo rohita*) and freshwater giant prawn (*Macrobrachium rosenbergii*) using low-cost formulated feed. Three treatments (T_1, T_2 and T_3) were conducted with three replications. The treatment T_1 was designed as a monoculture of pangus with a stocking density of 17 500 individual/ha.

Sayeed et al., (2008) revealed that Growth performance using Hand-made Feed (F1) which was compared with two commercial fish feed in three respective treatments of T_1, T_2 and T_3. All treatments were carried out in triplicate at 24700/ha for Thai pangus. Growth performance was influenced by feed type. Average final weight of Thai pangus and rohu were 820 and 710; 846 and 770; and 872 and 717g with specific growth rate 1.58 and 0.93; 1.59 and 0.95 and 1.60 and 0.93 %/day in T_1, T_2 and T_3 respectively. Feed conversion ratio was estimated 2.3 in T_1, 2.1 in T_2 and 1.96 in T_3. A typical increasing trend of final weight and specific growth rate of Thai pangus along with the increasing of feed protein level. Suitable protein level and quality feed is required for adequate growth of fish.

Chapter Three

Existing farming practices and major constrains of *Pangasius sutchi* farming in Bangladesh

3.1 Introduction

Among the exotic fish species introduced in Bangladesh, Pangas farming constitute a significant role in aquaculture production in Bangladesh. During the fiscal year 2015–2016 pangas production reached 494,357 tonne which accounted for 29% of the total farmed fish supply in the country (DoF, 2017). The preference for pangas over other the exotic fish species for aquaculture is due to its relatively high growth rates, market demand, market price and adaptability to local conditions (Subagja et al., 1999; Hassan et al., 2011). It has also the ability to cope with hypoxia and it is possible to increase its fry production through induced breeding in hatchery (Lefevre et al., 2011a, 2011b). Pangas is highly tolerant to the changes in salinity, pH, dissolved oxygen or even pollution. This fish is omnivorous in nature and takes crustaceans, molluscs, fish, and vegetable wastes as food. Additionally, it can be stocked at a much higher density in ponds together with other aquaculture species (Alam, 2011).

Expanding rapidly pangas industry in Bangladesh crating other linkage industries like hatchery, nursery, fingerlings trading, Pangus farming and trading which providing employment opportunity and enhance livelihood of the involved people through its long backward and forward linkages for a wide range of value chain actors (Ali, 2009; Belton and Azad, 2012).

Nowadays, pangus is becoming popular by rural and urban people and therefore it turns into a good source of protein and calorie. Therefore, it becomes an important fish for national food security in Bangladesh due to both the volumes produced and its popularity among poor consumers in urban areas due to its low market value (Belton et al., 2011). Market price of pangas is low compared with that of the Indian major carps which cost for more than twice as much of pangas (Ahmed, Alam and Hasan 2010; Belton et al. 2011b; Belton, Haque and Little 2012).

However, some worries have been raised regarding the social and environmental sustainability of pangasius aquaculture in Bangladesh. Pangas industry in Bangladesh is experiencing a seasonal and cyclical over and underproduction despite an overall upward trend. In recent years, depleted economic sustainability is being observed by pangas industry partly due to increasing feed cost, lack of proper management, unavailability of low cost supplementary feeds and some socio-economic constraints (Akter, 2001). Over the last 10 years, pangus farming was accelerating smoothly but recently it has been affected negatively by many factors. As a result, pangasius farmers are increasingly losing their interest to devote in pangasius farming (Wahab et al., 2008). Therefore, it is high time to recover the overall conditions of the pangasius farmers. Existing pangas farming now needs an up gradation to achieve sustainability in farming practices through institutional initiatives (Monir et al., 2011).

Recently, researches on pangas farming are now only focusing on productivity and profitability (Kausari, 2001; Akter, 2001), economics (Ali et al., 2018, Ahmed et al., 2010) and cage farming of pangas (Chowdhury et al., 2020). However, studies regarding the solving approaches of factors affecting pangas farming in Bangladesh have received less attention. There appears a good potential for further development of this industry in Bangladesh.

Therefore, the broad objective of the study was to conduct a baseline survey to find out existing pangas farming and management practices followed by the farmers of the study areas. This study was also aimed to find out constrains of pangas farming practices based on the results of research carried out in different districts of Bangladesh.

3.2 Materials and methods

3.2.1 Study locations and study period

The study was conducted at 6 Upazila of 4 districts, namely Jikorgacha and Monirumpur Upazila from Jesore district, Sujanagar and Kashinathpur Upazila from Pabna district, Boura sadar Upazila from Bogura district and Trishal upazila from Mymensing district of Bangladesh (Figure 3.1). Data were collected for a period of six months from July to June 2014.

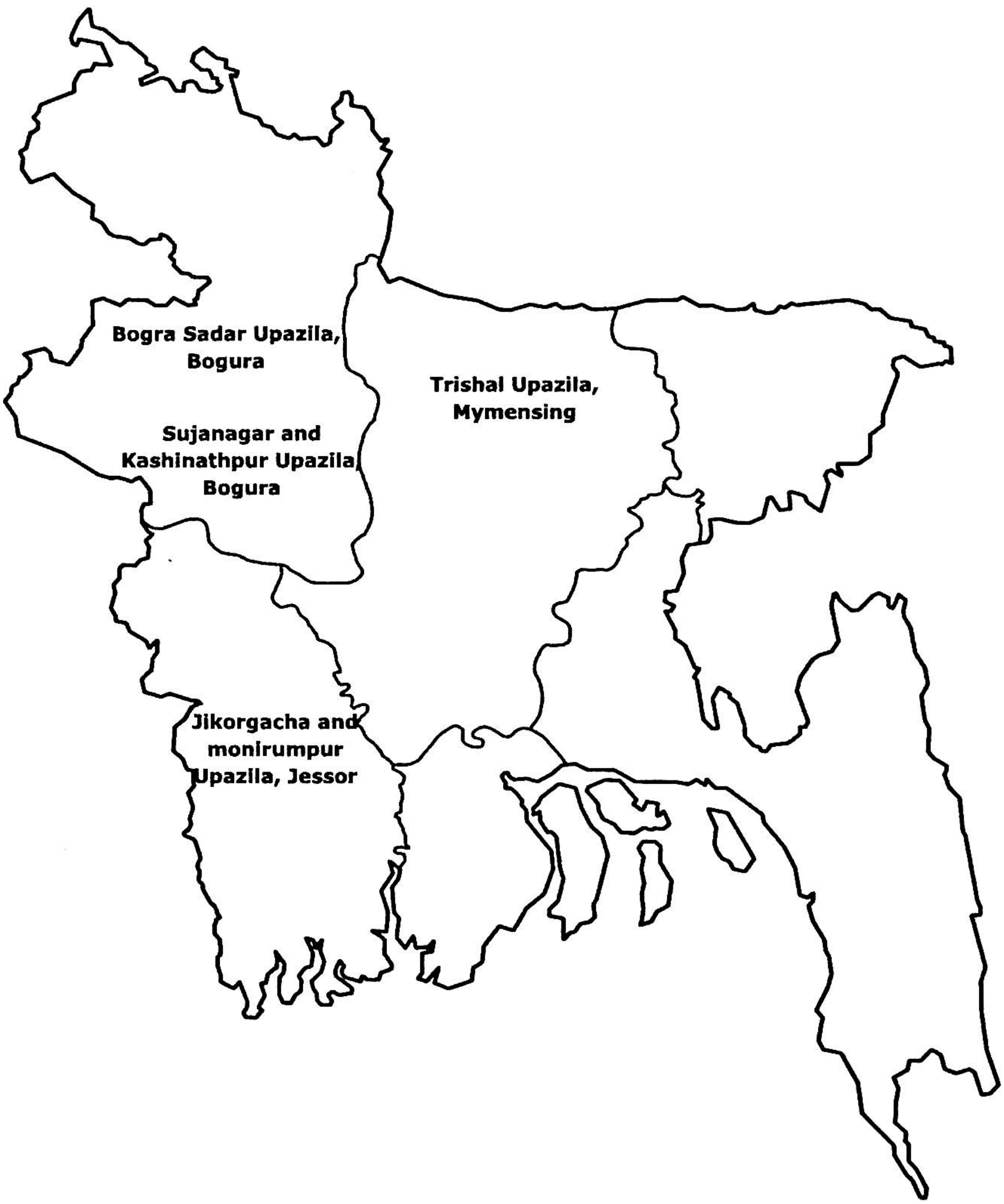

Figure 3.1 Location of study areas for the collection of data

3.2.2 Data collection methods

Information on socio-economic conditions, farming practices and water and sediment quality parameters were collected during the study period. A total of 120 pangas farmers were interviewed during the data collection period. Finally, a combination of the participatory, qualitative and quantitative methods was used for primary data collection. Data on socio-economic condition and farming practices were collected through direct interviews with the randomly selected pangus farmers. Wide ranged data were collected through participatory rural appraisal (PRA) tool focus group discussion (FGD) was conducted with pangas farmers. A total of 10 FGD sessions were conducted where each group size was 20 persons (total 120 people) and the duration of each session was approximately 2 hours. Focus group discussion sessions were held in farmer fish culture pond. Questionnaire interviews were also conducted at the end of pangas farming as well as harvesting season which based on pangas farming systems, productivity, farming constraints, production costs, returns and profitability. Finally, a crosscheck interviews were conducted with key informants such as Upazila Fisheries Officer (UFO), school and college teachers, local leaders and non-government organization (NGO) workers where information was contradictory.

3.2.3 Water quality parameters

Pond water temperature was measured using a Celsius thermometer. Water pH was measured using an electronic pH meter (Jenwary 3020). Dissolved oxygen (DO) was measured using a portable aquaculture kit (Model FF2, HACH, USA). Ammonia-nitrogen (NH_3-N), Nitrate-nitrogen (NO_3-N), phosphate-phosphorus (PO_4-P) concentrations were measured using Hach Kit (DR/2020, a direct reading spectrophotometer) with high range chemicals (Nitra Ver. 5 Nitrate Reagent Powder Pillows for 25 ml sample for NO3-N and Phos. Ver. 3 Phosphate Reagent Powder Pillows for 25 mL sample for PO4-P analysis).

3.2.4 Processing and analysis of data

After collection of data, these were edited and coded. All the collected data were summarized and scrutinized carefully and recorded. Finally relevant tables were prepared in accordance with the objectives of the study. Data were presented in tabular and graphical form because it is simple in calculation, widely used and easy to understand. Then the data were tabulated into a computer. After the entry of data, it was analyzed using Statistical Package for Social Science (SPSS) and Microsoft (MS) Excel.

3.3 Results

3.3.1 Socio-economic characteristics of pangas fish farmers

Knowledge on the socio-economic characteristics of farmers is essential to know the complete picture of productivity and efficiency at different farm size of pangas fish farming. Variations in fish culture system are usually reflected by the characteristics of socio-economic conditions of small and large scale framers (Khan, 2012). Therefore, parameters like the age structure, experience in pangas farming, farm size, education level of pangus farmers, pond ownership pattern, housing conditions and annual income of pangas farmers were considered as the socio-economic characteristics.

3.3.2 Age structure

Potential productive human resources are generally determined by the age structure of farming individuals. Different categories of age groups: Up to 30, 31-40, 41-50, and above 50 was considered to examine the age structure of the respondents. 20 respondents were interviewed from each 6 study locations. Study revealed that most of the pangas farmers were within the age group of 31-40 in all the study locations, whereas percentage contribution of respondents from up to 30 years and above 50 years age groups was lower. However, among the total 120 respondents interviewed, 69.17 % was within the age group of 31-40 followed by 18 % from 41-50 years age group (Table 3.1).

Table 3.1 Age structure of pangas farmer in the study locations

Age groups	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Total (n=120)
Up to 30	2 (10)	1 (5)	2 (10)	1 (5)	1 (5)	2 (10)	9 (7.50)
31-40	14 (70)	12 (50)	13 (65)	15 (75)	15 (75)	14 (70)	83 (69.17)
41-50	2 (10)	6 (30)	2 (10)	2 (10)	2 (10)	4 (20)	18 (15)
Above 50	2 (10)	1 (5)	3 (15)	2 (10)	2 (10)	0 (0)	10 (8.33)

n = number of respondents; Figures in the parentheses indicate percentage

3.3.3 Experience in pangas farming

Among 120 surveyed pangas farmers, majority had the farming experience of 6-10 years (38.33%). However, the number of farmers starting pangas farming in the recent years was increasing and this percentage was 30.84% which had up to 5 years of pangas farming experiences. Moreover, more experienced farmers having 11-20 years of farming constituted 20.83% of the total respondents. Farmers having more than 20 years of farming experience were small and this percentage was 10%. The data revealed in the present study clearly indicated that more profit incurred from pangas farming attract more people converting their lands or ponds into pangus farms (Table 3.2).

Table 3.2 Farming experiences of pangas farmer in the study locations

Groups	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Total (n=120)
Up to 5	4 (20)	7 (35)	3 (15)	6 (30)	10 (50)	7 (35)	37 (30.84)
6-10	10 (50)	8 (40)	12 (60)	10 (50)	5 (25)	1 (5)	46 (38.33)
11-20	4 (20)	5 (25)	3 (15)	2 (10)	3 (15)	8 (40)	25 (20.83)
Above 20	2 (10)	0 (0)	2 (10)	2 (10)	2 (10)	4 (20)	12 (10)

n = number of respondents; Figures in the parentheses indicate percentage

3.3.4 Farm size of pangas farmers

During the study period, small, medium and large farms were defined as <0.5 ha, 0.5-1.0 ha and >1.0 ha area, respectively. Among the pangas farmers, number of large farmers was highest in Sujanagar (25%) and Kashinathpur (25%), whereas number of medium farmers was the highest in Bogura sadar (65%). In the study locations, many farmers adopted small farms and this number was the highest Sujanagar (35%) and Trishal (35%). However, among the 120 pangas farmers, 54.17% were holding the possession of medium farm, whereas 26.67% of small farm and the lowest 19.17% holding large farm area (Figure 3.2).

3.3.5 Education level of pangus farmers

The interviewed pangus farmers were found literate with five levels of education; (I) No education (illiterate) (ii) Primary level i.e., 1 to 5 class, (iii) Secondary level i.e., up to S.S.C level, (iv) Higher secondary level i.e., up to xi and xii class (v) Bachelor i.e., up to degree. Result of the present investigation indicate that total 5% of farmers was illiterate, 25% had primary level of education, 20% had secondary, 38% had higher secondary and only 12% had Bachelor degree (Figure 3.3). Among the study locations, Kashinathpur and Bogura sadar had no illiterate pangas farmers.

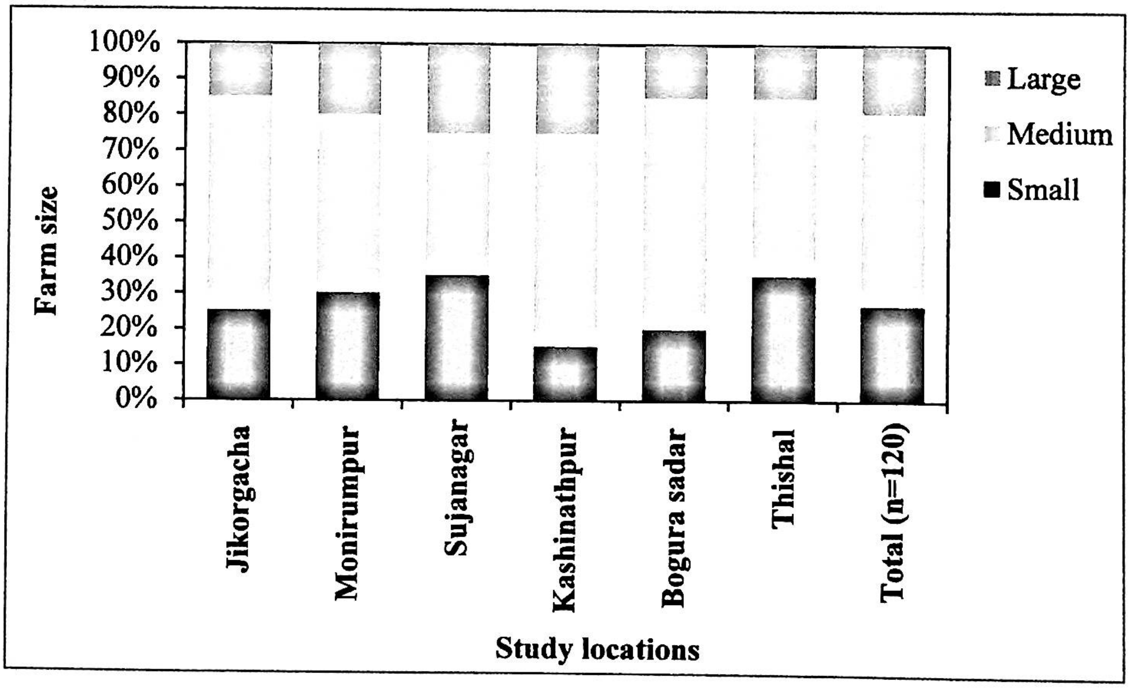

Figure 3.2 Farm size categories of pangas farmers

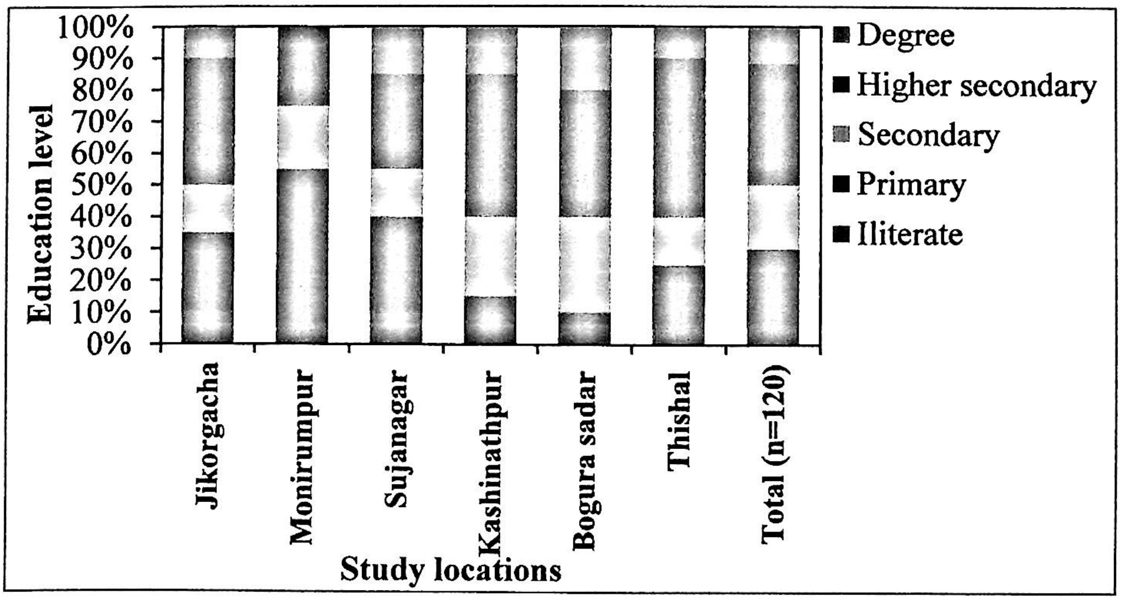

Figure 3.3 Education levels of pangas farmers

3.3.6 Pond ownership

In the study area, it was found that most of the pangas farmer had leased pond to culture fish (48%), while a percentages (22%) of farmers had own ponds. However, the percentage of pangus farms who had combined own and leased pond without partnership was 30%. Farmers of Jikorgacha had the highest percentage of leased pond (15%), Kashinathpur had lower percentage of own ponds and Trishal had the highest percentage (45%) of combined own and leased pond (Figure 3.4).

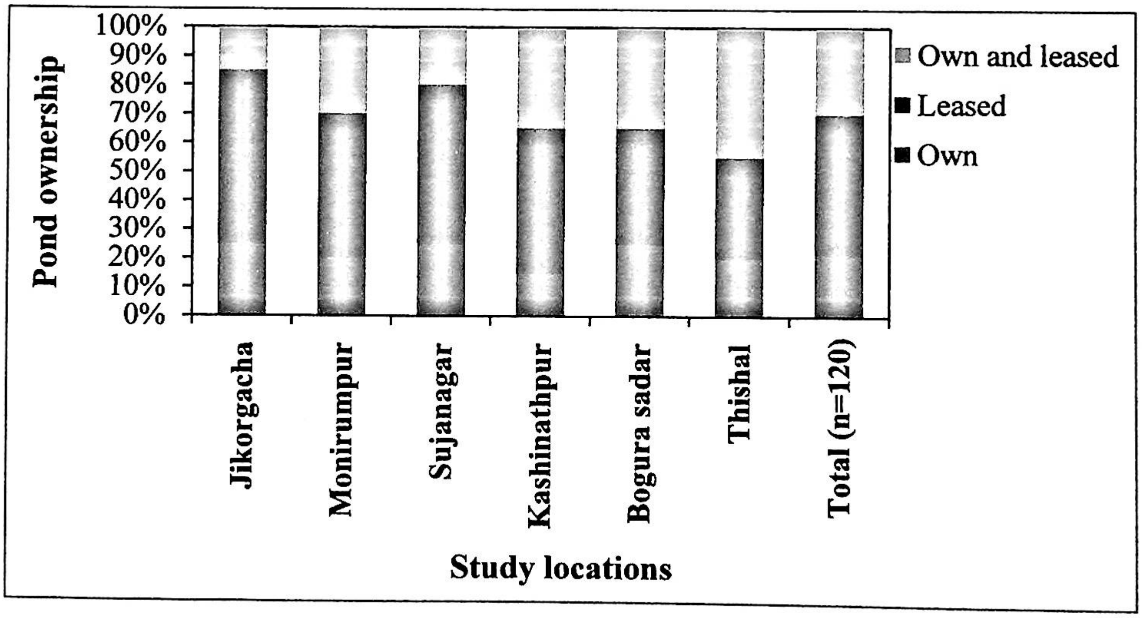

Figure 3.4 Pond ownerships of pangas farmers

3.3.7 Housing conditions

Housing conditions of pangas farmers studied are shown in Table 3.4. Economic status of pangas farmers in the study locations were good enough as there was no any Kacha (houses made with mud as wall and straw as roof) house observed during the survey. A smaller number of farmers also had Tin shed house (house made with tin as wall and roof). However, majority (45%) of the farmers had house made with brick wall and cemented roof (Paka house). Second majority (40%) of farmers were found to holding the possession of Semi-paka (house made with brick wall and tin shed as roof) house. Location wise highest percentage of Paka house was observed in Sujanagar and Semi-paka house in Bogura sadar.

Table 3.3 Housing conditions of pangas farmer in the study locations

Groups	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Total (n=120)
Kacha	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Tin shed	5 (25)	3 (15)	2 (10)	3 (15)	2 (10)	3 (15)	18 (15)
Semi-paka	8 (40)	10 (50)	6 (30)	7 (35)	11 (55)	6 (30)	48 (40)
Paka	7 (35)	7 (35)	12 (60)	10 (50)	7 (35)	11 (55)	54 (45)

n = number of respondents; Figures in the parentheses indicate percentage

3.3.8 Annual income of pangas farmers

Pangas farmer of the study locations had gain stability in pangas farming. Majority of the respondent farmers (78%) had income categories within 25-35 lac per year, while only a lesser percentage were within the income category less than 25 lac. However, 18% of the pangas farmer also had the income level more than 35 lac per year (Figure 3.5). There were no pangas farmers less than 25 lac income per year in Monirumpur and Sujanagar area. Moreover, 30% of the pangas farmer had income more than 35 lac in Sujanagar.

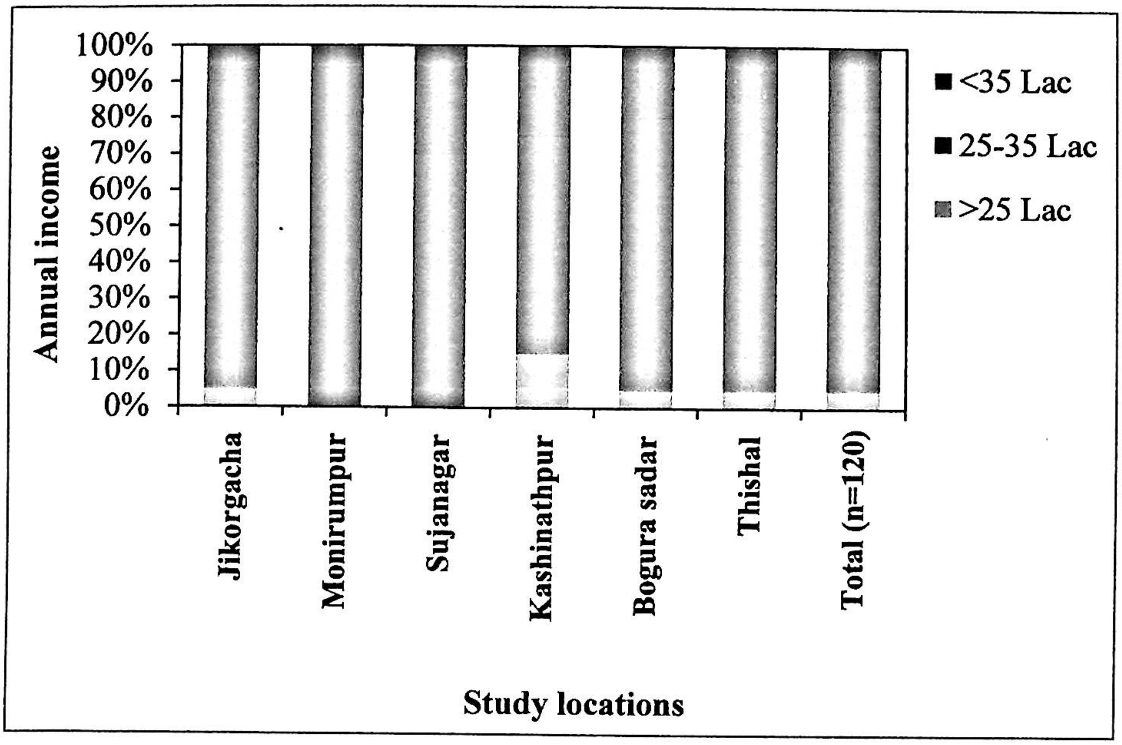

Figure 3.5 Annual income categories of pangas farmers

3.3.9 Characteristics of pangas pond and management aspects

Profitability of pangas farming is depend on water quality parameters, soil quality parameters, pond preparation, suitable stocking density, feeding and disease management of the pond environment. Proper understanding of these parameters can lead to sustainable pangas farming in Bangladesh.

3.3.10 Culture methods of pangas

During the study period, two types of culture methods followed by pangas farmers were observed (Table 3.4). Among the 120 pangas farmer studied, 92% were found to follow polyculture method in their pond, while only 8% were found practicing monoculture of pangas. In the study locations of Sujanagar, Kashinathpur and Bogura sadar, all farmers studied were found to follow polyculture of pangas in pond. However, Jikorgacha had the highest number of pangas farmer following monoculture (25%) in their culture pond among all the study locations.

Table 3.4 Culture methods followed by the farmers in the study locations

Groups	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Total (n=120)
Poly-culture	15 (75)	18 (90)	20 (100)	20 (100)	20 (100)	18 (90)	111 (92)
Mono-culture	5 (25)	2 (10)	0 (0)	0 (0)	0 (0)	2 (10)	9 (8)

n = number of respondents; Figures in the parentheses indicate percentage

3.3.11 Water quality parameters of pangas ponds

Water quality parameters recorded during the study period are shown in Table 3.5. All the water quality parameters were more or less similar in all the study locations. Average temperature of the study locations was 25.52±0.52 °C. pH and DO were comparatively higher in Sujanagar (7.39±0.12) and Bogura sadar (5.41±0.38 mg/l) with the average values of 7.24±0.17 and 5.28±0.19 mg/l, respectively. NH_3-N content was relatively higher in Trishal (0.23±0.02 mg/l) and NO_3-N and PO_4-P in Monirumpur (0.27±0.04 and 1.23±0.02 mg/l, respectively). However, the average values of NH_3-N, NO_3-N and PO_4-P were 0.18±0.04, 0.26±0.03 and 1.09±0.12 mg/l, respectively.

3.3.12 Soil quality parameters of pangas culture ponds

Three different types of soils were observed in the study locations (Table 3.6). Most of the study locations had the loamy soil structure (65%). However, 26% of the ponds had Sandy loamy soil and 9% had silt loamy soil structure. Jikorgacha had the highest number of ponds (75%) with loamy soil, while Kashinathpur had the highest number of ponds (40%) with sand loamy soil.

3.3.13 Average water depth

Average annual water depth of studied ponds is shown in Table 3.7. The water depth of individual ponds was ranged from 1.10 to 3.15 m during the rainy season and 0.51 to 2.70 m in the dry season. However, majority of the ponds had average annual water depth of 1.51-2 m range (68%) followed by 1-1.50 m (28%) and <2 m range (4%). During the study period, not any survey ponds had the water depth less than 1 m.

3.3.14 Use of chemicals and fertilizers

List of chemicals and fertilizers used by the investigated farmers is shown in Table 3.8. Almost all the farmers used all the available chemicals and fertilizers in their ponds. Among all the farmers about 100% farmer use lime for during pond preparation and conditioning, urea and TSP as inorganic fertilizers and rotenone for the removal of unwanted and predatory fishes. 78% use Zeolite to remove gas (e.g. ammonia), 100% use salt and 44% use Potassium permanganate as disinfectant and disease control, 25% use copper sulfate for aquatic weeds removal and 33% use Hydrogen peroxide for providing oxygen when emergency. Farmer also used Oxytetracycline and Vitamin C as growth promoter in their ponds and this percentage was 63% and 78%, respectively.

Table 3.5 Water quality parameters of pangas ponds in the study locations

Parameters	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Average
Temperature (°C)	25.50±0.50	25.50±0.50	25.42±0.63	25.53±0.50	25.50±0.25	25.70±0.75	25.52±0.52
pH	7.12±0.34	7.22±0.20	7.39±0.12	7.25±0.28	7.23±0.03	7.26±0.04	7.24±0.17
DO (mg/l)	5.11±0.22	5.27±0.27	5.27±0.01	5.27±0.03	5.41±0.38	5.35±0.23	5.28±0.19
NH_3-N (mg/l)	0.20±0.04	0.19±0.04	0.15±0.05	0.14±0.01	0.18±0.06	0.23±0.02	0.18±0.04
NO_3-N (mg/l)	0.26±0.03	0.27±0.04	0.25±0.05	0.25±0.02	0.24±0.01	0.25±0.01	0.26±0.03
PO_4-P (mg/l)	1.15±0.13	1.23±0.02	0.97±0.25	1.11±0.13	1.03±0.11	1.04±0.08	1.09±0.12

n = number of respondents

Table 3.6 Soil quality of pangas ponds in the study locations

Parameters	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Total(n=120)
Loamy	15 (75)	14 (70)	12 (60)	11 (55)	12 (60)	14 (70)	78 (65)
Sandy loamy	3 (15)	3 (15)	6 (30)	8 (40)	6 (30)	5 (25)	31 (26)
Silt loamy	2 (10)	3 (15)	2 (10)	1 (5)	2 (10)	1 (5)	11 (9)

n = number of respondents; Figures in the parentheses indicate percentage

Table 3.7 Average water depth of pangas ponds in the study locations

Groups	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Total (n=120)
>1 m	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
1-1.50 m	3 (15)	6 (30)	6 (30)	8 (40)	5 (25)	5 (25)	33 (28)
1.51-2 m	16 (80)	14 (70)	13 (65)	10 (50)	15 (75)	14 (14)	82 (68)
<2 m	1 (5)	0 (0)	1 (5)	2 (10)	0 (0)	1 (5)	5 (4)

n = number of respondents; Figures in the parentheses indicate percentage

Table 3.8 Chemicals and fertilizers used in pangas ponds in the study locations (Percentage of total farmer)

Groups	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)	Total (n=120)
Lime	100	100	100	100	100	100	100
Salt	100	100	100	100	100	100	100
Zeolite	75	50	55	100	85	100	78
Urea	100	100	100	100	100	100	100
TSP	100	100	100	100	100	100	100
Potassium permanganate	60	40	40	55	30	40	44
Copper sulphate	25	15	20	35	20	35	25
Hydrogen peroxide	30	35	25	30	55	25	33
Oxytetracycline	50	60	55	55	90	70	63
Vitamin C	80	75	75	60	80	100	78
Rotenone	100	100	100	100	100	100	100

n = number of respondents; Figures in the parentheses indicate percentage

3.3.15 Stocking density of pangus

In the study area, most of the farmers followed polyculture of pangas with other species. Major fish species stocked with pangas were Monosex Tilapia, Silver carp, Grass carp, common carp, Mrigal, Rui and Catla. In polyculture of pangas, maximum stocking density was observed for pangas and tilapia. Stocking density of pangas ranged between 16952 (Thishal) to 18410 (Kashinathpur), whereas stocking density of mososex tilapia ranged between 9854 (Bogura sadar) to 11285 (Monirumpur) (Table 3.9).

Table 3.9 Stocking density in pangas culture ponds followed by the farmers in the study locations

Groups	Jikorgacha (n=20)	Monirumpur (n=20)	Sujanagar (n=20)	Kashinathpur (n=20)	Bogura sadar (n=20)	Thishal (n=20)
Pangas	17584	18250	17580	18410	17245	16952
Silver carp	1452	1452	1396	1485	1521	1458
Catla	1025	985	1121	1010	988	978
Rui	1110	1100	1025	1078	988	1010
Mrigel	685	745	810	750	685	642
Common carp	642	555	547	516	620	640
Grass carp	702	710	715	741	726	728
Monosex tilapia	10254	11285	10520	10454	9854	10852

n = number of respondents; Figures in the parentheses indicate percentage

3.3.16 Use of feed in pangas culture

Farmer of the study locations are known to use both commercial and home- made feed (Figure 3.6). Majority (65%) of the farmers were found to use commercial feed in all the study locations. However, farmers were also found to use both commercial and home-made feed in their pangas culture ponds (23%). A small percentage of farmer were found to use home-made feed (13%) in their ponds. 75% of the farmer were found to use commercial feed in Monirumpur, 70% in both Sujanagar and Bogura sadar. However, comparatively less amount of commercial feed was used in Kashinathpur (55%) and farmers in this study location were also found to use both commercial and home-made feed (30%).

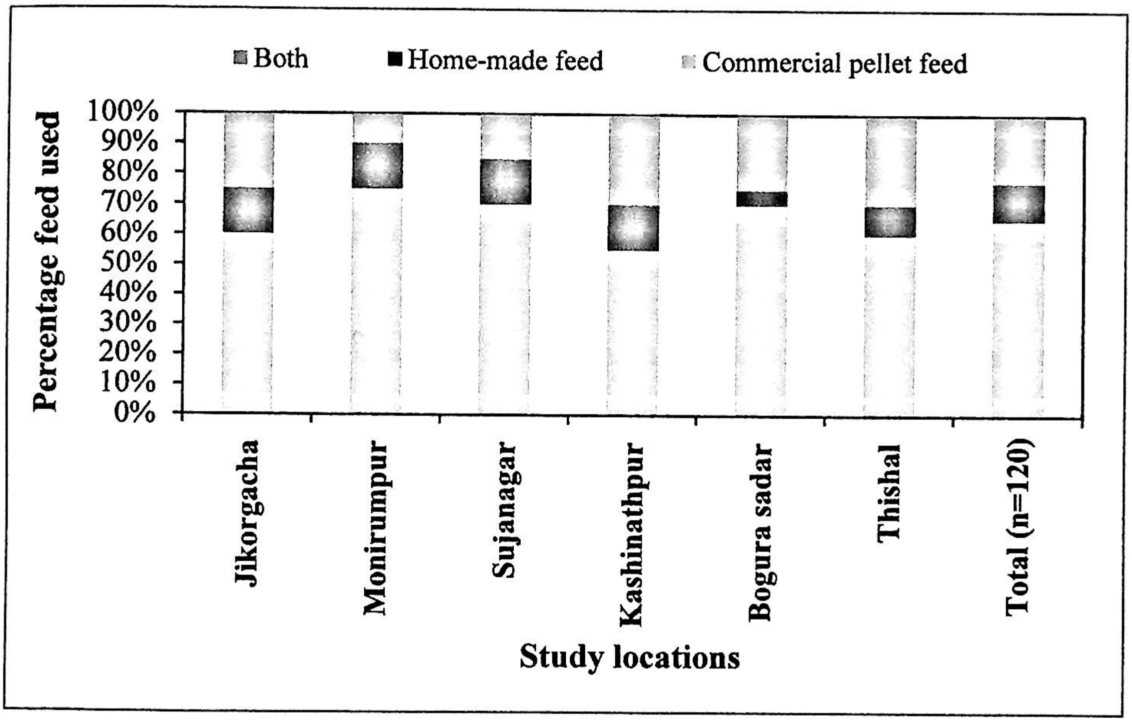

Figure 3.6 Feed used by pangas farmers in the study locations

3.3.17 Production of pangas

During the study period, total production of pangas was found ranged between 32 t/ha (Bogura sadar) to 42 t/ha (Trishal). Together with pangas, carps and tilapia production was found higher at Monirumpur (4 ton/ha) and lower at Bogura sadar (3.21 t/ha). However, average pangas production was 37.50 t/ha and carps and tilapia was 3.50 t/ha (Figure 3.7).

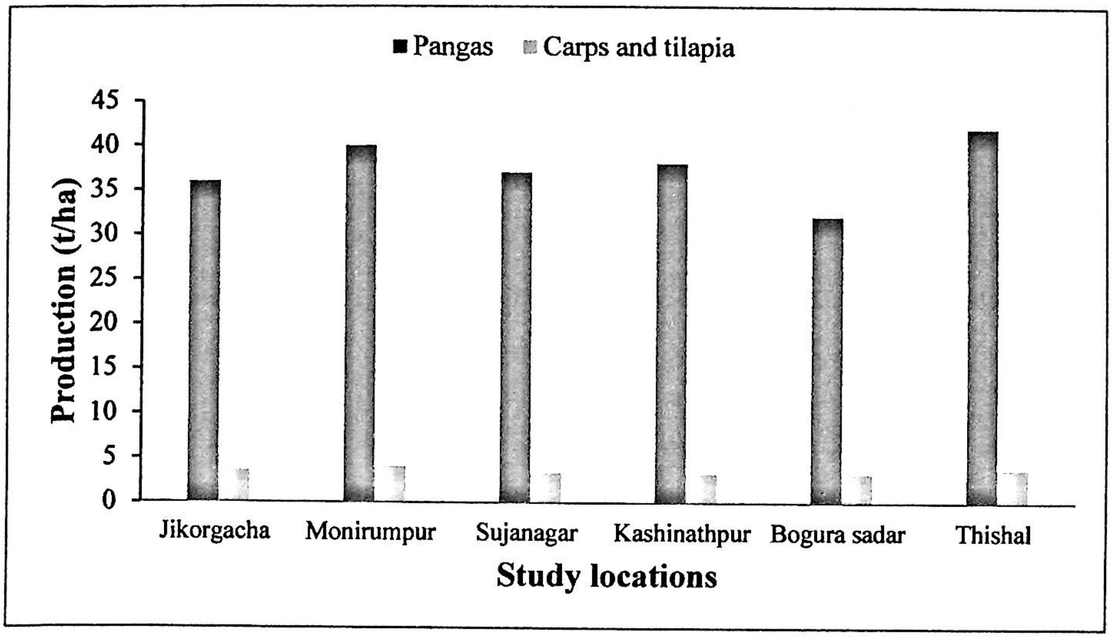

Figure 3.7 Production of pangas at different study locations

3.3.18 Food conversion ratio (FCR)

Food conversion ratio of the surveyed ponds is shown in Figure 3.8. Study showed that FCR of commercial pellet feed was always lower compared to home-made feed. FCR of commercial feed ranged between 1.96 to 2.20, whereas the lowest value was found at Jikorgacha, and the highest at Bogura sadar. However, FCR of home-made feed was higher with the highest value was recorded at Bogura sadar (2.30) and the lowest at Monirumpur (2.20).

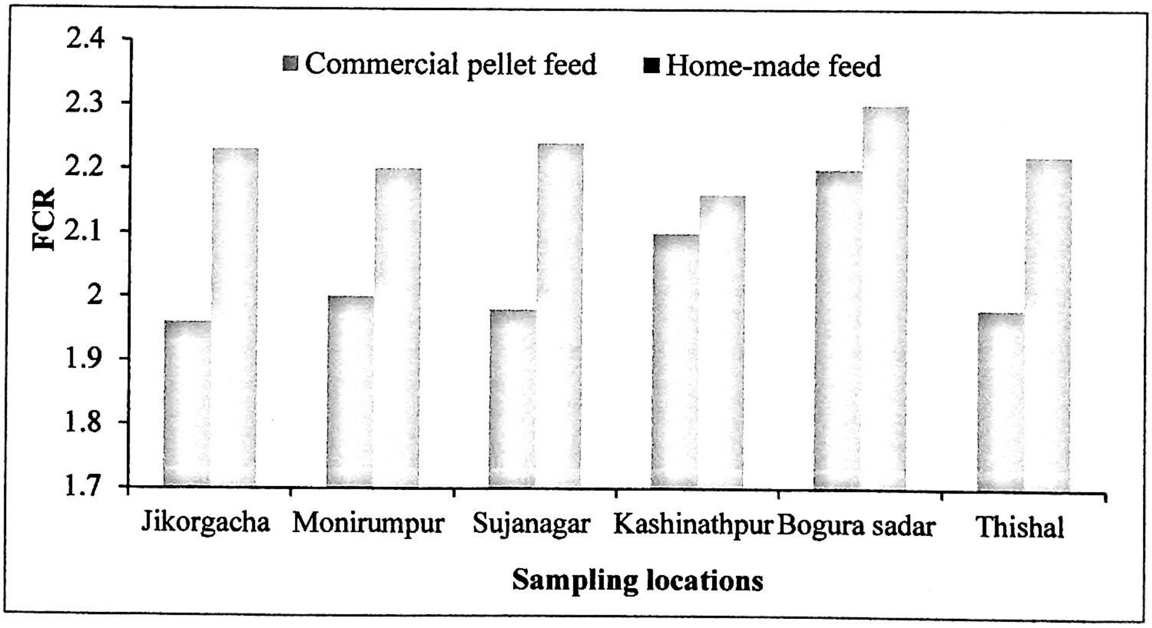

Figure 3.8 FCR of pangas farming ponds at different study locations

3.3.19 Cost-benefit ratio

Cost-benefit ratio (CBR) observed during the study period is shown in Figure 3.9. At Jikorgacha, 90% of the pangas ponds had CBR within 1.0-2.0, and 10% had less than 1.0. At Monirumpur, 5% of the pangas pond had CBR greater than 2.0, while majority 70% had CBR within 1.0-2.0. As Sujanagar, ponds with CBR greater than 2.0 was absent, while 80% ponds had CBR within 1.0-2.0. At Kashinathpur, 30% of the ponds had CBR below 1.0 and 5% had greater than 2.0. At Bogura sadar, all the studied ponds had CBR within 1.0-2.0 and at Trishal, 90% ponds had CBR within 1.0-2.0. Overall, 83% pangas ponds surveyed had CBR within 1.0-2.0, 14% less than 1.0 and only 3% had greater than 2.0 (Figure 3.10).

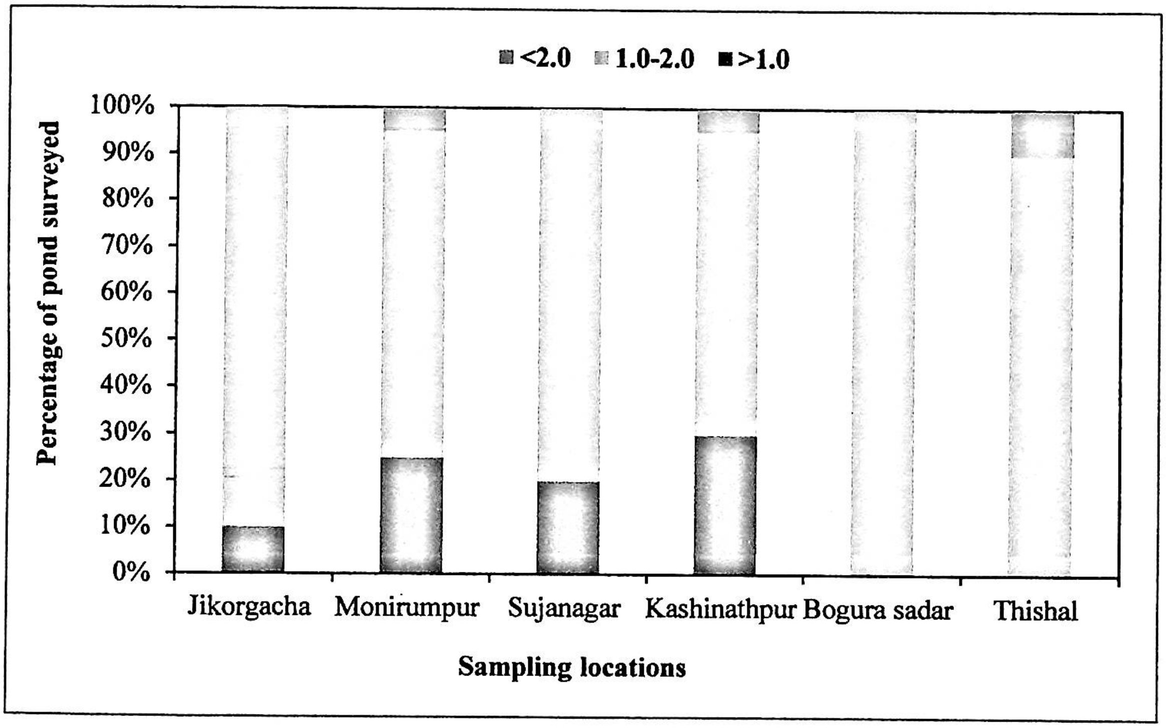

Figure 3.9 Cost-benefit ratios (CBR) of pangas farming ponds at different study locations

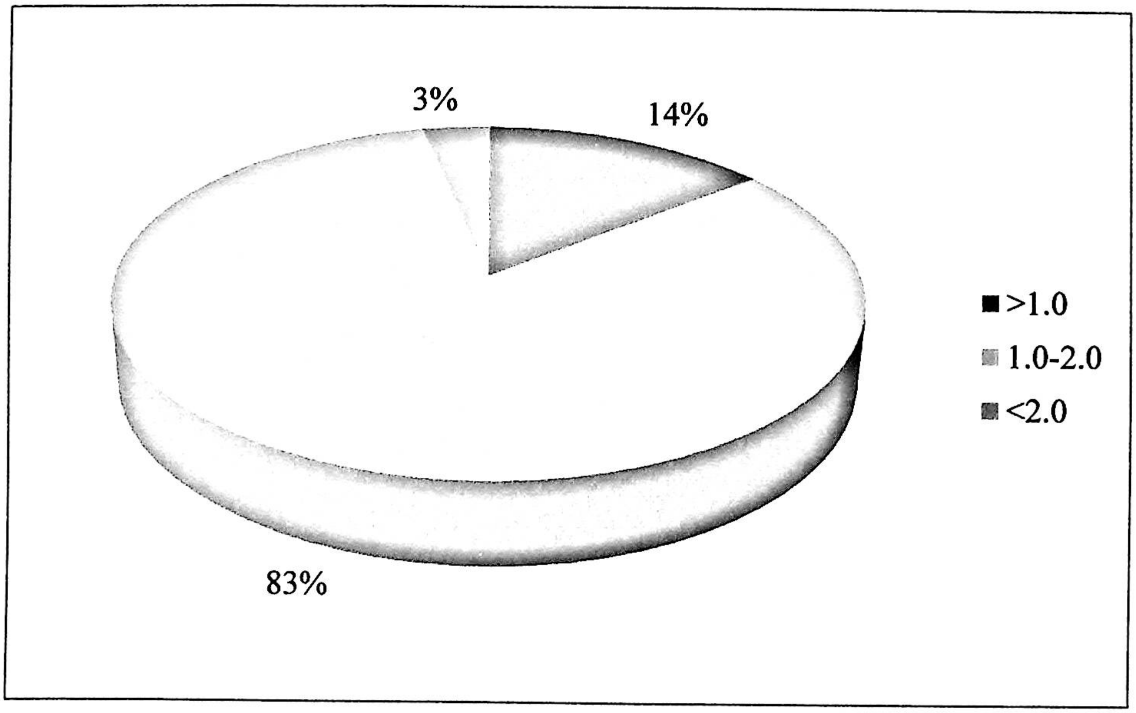

Figure 3.10 Overall cost-benefit ratios (CBR) of pangas farming ponds during the study period

3.3.20 Constraints of pangus farming

It was found that the pangus farmers in the study locations were facing a number of technical and social constraints during pangus farming. The major problems were lack of quality feed and their higher market price, capital to be invest in pangas farming and sometimes marketing problems.

3.4 Discussion

The present study investigated existing pangas farming practices at six selected study locations to find out major concerns and limitations regarding socio-economic status of farmers and their farm level management particulars. This study contributes to find out pangas farmer's livelihood, major constrains in their farming system and possible recommendation to be adopted to overcome this situation. Study on socio-economic status of interviewed pangas farmer's revealed improved social and economic conditions. Therefore, they achieved food security, improved life style and housing condition. As reported by Miah (2001) 85% pangus farmers and related people were economically and socially benefited due to pangus farming. However, pangas farmers of the study area are now wanted to achieve sustainability in the farming system through the proper intervention of scientific knowledge.

During the study period, water and soil quality parameters of the studied locations were found within the acceptable limit of pangas culture which was supported by the recommended level of water quality parameters by Boyd (1998). During the study period, total average production of pangas was 37.50 t/ha and carps and tilapia was 3.50 t/ha, which was similar to the findings of Zaman et al. (2017) and Ali et al. (2013). Study conducted by Akter (2001) and Kausari (2001) also reported average production of pangus was ranged between 20-21 t/ha. Therefore, pangas production in the present study was much more developed than the available literature.

However, the major constraints mentioned by the farmers were lack of quality feed and their higher market price, capital to be invested in pangas farming and sometimes marketing problems. Most of these constrains were directed to higher production cost. The constraints study was conducted by Asif et al. (2014), Yeasmin et al. (2015), Sharif and Asif (2015), Chowdhury et al. (2015) and Razeim et al. (2017), which is more or less similar with the present study.

The present study showed that FCR of commercial pellet feed was always lower compared to home-made feed, which was similar to the findings of Ali et al. (2013). FCR of commercial feed ranged from 1.96 to 2.20, whereas the lowest value was found at Jikorgacha, and the highest at Bogura sadar. However, FCR of home-made feed was higher with the highest value was recorded at Bogura sadar (2.30) and the lowest at Monirumpur (2.20). The FCR using pelleted feeds for cat fish farming in the Mekong Delta ranged from 1.5 to1.7 (Hung et al. 2007), which was much lower than the present findings. Culture practice also has a significant effect on FCR of culture system. Ali et al. (2013) reported that high levels of protein in industrially manufactured pelleted feeds, lower the FCR in pangas farming system, while in extensive farming of pangas with home-made feed can increase the FCR of the culture system. Moreover, Phuong et al. (2007) also reported that manufactured pelleted feeds had a lower FCR for cat fish farming in Vietnam due to the high nutritional value, compared with farm-made feeds. However, manufactured pelleted feed is higher in unit price and higher in total feed cost per hectare farm, and thus, the use of this feed leads to a high level of investment. In that situation, reduction in the use of commercial feed can be beneficial for reducing feed cost in pangas farming system. In contrast, Ahmed et al. (2013) reported lower FCR with prepared feed compared to commercial feed and proved that prepared feed is more suitable when compared with commercial feed. However, the FCR recorded during the study period was more or less comparable with the other findings. Amin et al. (2005) recorded FCR 1.65 for pangus culture with eight earthen ponds, which is lower than the value of the present experiment. Halder and Jahan (2001) observed FCR (2.96-3.09) in 5 months pangus polyculture with carp, which has similarity with the value of the present experiment.

Cost-benefit ratio (CBR) observed during the study period was within the range of 1.0-2.0 and only a fewer number of pangas ponds (14%) showed CBR less than 1.0 and greater than 2.0. CBR implies the profitability index of any farming system which implies that a ratio of 1 means the operation is at a break-even position and CBR greater than 1 indicated positive net benefit. CBR of a culture system is dependent on the faming system. As shown by Ahmed et al. (2010) CBR of extensive farming was 2.12, which was comparable with 1.76 in semi-intensive and 1.64 in intensive farming. They also reported that extensive farmers produced at least cost, with a higher rate of farm income (52%). Conversely, intensive farmers produced at a higher cost, therefore having a lower rate of farm income (39%). Findings of Kaliba et al. (2006) also indicated that producing more fish does not necessarily imply greater profitability. Thus, economic analysis is an important management tool necessary for aquaculture business planning and identifying economically sustainable enterprises.

3.5 Conclusion

Pangus farming is started since 1998 in Bangladesh; however, sustainable aquaculture of pangas remains a challenge for resource poor rural household. Although a higher net return is obtained from intensive pangas farming, it is more sophisticated and needs a high level of capital investment. Therefore, it will be the best option to culture pangas by adopting semi-intensive farming system where there is enough scope to increase productivity by reduced input cost. As feed is appears to be one of the major constraints in achieving the sustainability in pangas farming, the development of low-cost feeds is essential to reduce the dependence on industrially manufactured pelleted feeds which can help to increase farmer's profit margin. Therefore, there is a need for researches and technical support with respect to raw material selection, storage, processing, feed formulation and preparation of farm-made feeds.

Chapter Four

Formulation of diets and manufacturing process for commercial culture of *Pangasius sutchi*

4.1 Introduction

Feed cost is one of the main costs for any successful aquaculture farm which comprise more than 50% of total production cost and therefore feed cost should be considered besides it quality (Craig and Helfrich, 2002). However, quality of the feed is depending on the manufacturing process of the feed industries (Patwary et al., 2013). Fish feed manufacturing involves the processing of mixtures of feedstuffs and feed additives into a usable form. There are several goals and considerations in feed manufacturing, some of which are nutritional and some of which are non-nutritional. However, the primary goal is to increase profits of fish production by maximizing the nutritional value of a feedstuff or a mixture of feedstuffs at minimum cost. The success of fish farming business depends largely on the provision of low cost and good quality fish feed that can guarantee optimum feed conversion ratio. Presently, aquaculture production still frequently experiences low feed conversion efficiency which is mostly linked to feed wastage (Devenport, 2003).

Generally, there are three factors to consider in the choice of feed ingredients for aqua feeds, (i) quality – nutrient composition and presence of any anti-nutrients (substances that interfere directly with the absorption of nutrients or contaminants); (ii) quantity – quantum of availability; and (iii) price of ingredients. Also, the other challenges of fish feed management are feed formulation, feed processing, storage, handling and transport. Floating extruded pellets are in greater demand than sinking pellets; this is because they enable the farmer to observe the feeding activity of the fish thus prevent wastage of feed. They also exhibit superior characters such as greater water stability, digestibility, water protection, zero water pollution and zero wastage of raw materials (Almaraaj, 2010), and in addition supply higher energy than sinking pelleted feed. Most locally produced fish feed are the sinking pelleted type (Orire and Sadiku, 2014).

Success of intensive fish culture depends to a large extent on adequate information on nutrient requirements, especially dietary protein, which is the most expensive component in artificial diets (Tacon et al. 2009, 2011). Commercial feed formulation is intended to meet nutritional requirement with quality product at cheaper prices depending on type of fish species grown. In commercial aquaculture production feed costs can be reduced by developing proper feed management and husbandry strategies to improve fish growth. Best management practices (BMPs) in fish husbandry involve proper stocking densities, nutrient ratios, aeration, and water exchange to reduce metabolites that can deteriorate water quality. Good quality feeds enable farmers to culture this species for high growth and high profits. Good quality sinking and floating feeds are crucial to the development and success of a pangas farming industry. Plant proteins that are cheap and locally available are used to supplement animal protein at lower cost. Feeds consisting of soybean, wheat and corn meal, canola meal, and extruded pea seed meal, supplemented with methionine have been used for formulation of diets for carps, tilapia, and catfish without influencing growth performance.

Fish diet production begins with ingredient selection and feed formulation (Adeparusi and Famurewa, 2011). To formulate a diet that meets a target fish requirement, information on its nutrient requirement, the nutrient composition of individual ingredients as well as their antinutrient compositions is required (Craig and Helfrich, 2009). Selection of ingredients can be done from a wide range of choices; therefore it is often necessary to consider the locally availability and cost of the ingredients. However, information about proximate composition of local feed ingredient for farm made fish feed is usually limited and not reliable. Farmers depend on the existing information about the feed composition given by different fish feeds manufacturers. Considering the above facts the present study was conducted to formulate quality sinking and floating pellet feed from locally available fish feed ingredients for intensive culture of pangas in pond.

4.2 Materials and methods

4.2.1 Raw materials collection

The feed ingredients were collected from different feed value chain actors like feed mills, ingredient suppliers, retailers, producers etc. from Mymensingh, Gazipur, Comilla, Bogura, Noakhali, Chittagong, Dhaka, Barisal, Bhola, Khulna and Rajshahi areas of Bangladesh. A total of 17 feed ingredients and feed additives such as dry fish, meat and bone meal, fish meal, fish oil, rapeseed meal, soybean oil cake, maize, rice polish A Gr., wheat flour, de oil rice bran, salt, limestone, vitamin and minerals, growth promoter, binder, methionine and DCP were purchased from local fish feed seller.

4.2.2 Preparation of raw materials

The feed ingredients were collected as bulk quantity from different lots of supplied raw materials. The Sample of each feed ingredient was grounded using an electrical grinder into small particle size and sieved through a sieve of 60 μm mesh size. After sieving the samples were stored in dry and well covered containers until analysis.

4.2.3 Feed formulation

Eight formulas were formulated including the proposed inclusion rate and raw material costs for sinking feeds and floating feeds which included four formulas for sinking feeds and four formulas for floating feeds. Every feeds consist two grades of feeds which naming starter and grower feeds which manufactured by different two formulas. Inclusion rate of each raw material to formulate the feed is shown in Table 4.1. The feeds were prepared in Afil Feeds ltd, Jessore, Bangladesh.

Table 4.1 Inclusion rate of different raw materials in the formulation of diets

Ingredients (%)	Sinking pellet-F1		Sinking pellet-F2		Floating pellet-F1		Floating pellet-F2	
	Starter	Grower	Starter	Grower	Starter	Grower	Starter	Grower
Dry fish	0	0	8	5	0	0	8	5
Meat and bone meal	0	0	10	7	0	0	10	7
Fish meal	0	0	5	3	0	0	0	3
Fish oil	2	2	0	0	2	2	5	0
Rapeseed meal	20	20	20	20	20	20	20	20
Soybean Oil Cake	30	25	12	14	30	25	12	14
Maize	8	10	0	0	8	10	0	0
Rice Polish A Gr.	11	14	13	19	11	14	13	19
Wheat Flour	15	15	14	14	15	15	14	14
De Oil Rice Bran	12	12	15	15	12	12	15	15
Salt	0.70	0.70	0.80	0.80	1.00	0.70	1.00	0.80
Limestone	0.40	0.40	0.80	0.50	0.40	0.40	1.00	0.50
Vitamin and Minerals	0.20	0.20	0.30	0.30	0.20	0.20	0.30	0.30
Growth promoter	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Binder	0.30	0.30	0.40	0.70	0.00	0.60	0.00	0.70
Methionine	0.30	0.30	0.00	0.00	0.30	0.00	0.00	0.00
DCP	0.40	0.40	0.50	0.50	0.40	0.40	0.50	0.50
Total	100	100	100	100	100	100	100	100

4.2.4 Proximate Analysis

The analysis of proximate composition was done in the laboratory of SMS Feeds Limited, Gazipur, Dhaka, Bangladesh. On each chemical analysis, triplicate determinations were carried out. Proximate analysis was carried out for both raw materials (Table 4.2) and finished formulated feed.

4.2.3.1 Determination of moisture

Moisture contents in the raw materials were determined by following Oven method (Lovell, 1975). The percent moisture was calculated using the following formula:

$$\text{Moisture (\%)} = \frac{\text{Original weight of sample} - \text{Dry weight of sample}}{\text{Original weight of sample}} \times 100$$

4.2.3.2 Determination of crude protein

Crude protein was determined followed by Kjeldhal method (Crampton and Harris, 1969; Jacobs, 1973; Perason, 1977) according to the following formula:

$$\text{\% Nitrogen} = \frac{\text{Vol.of H2SO4} \times \text{N.of H2SO4} \times 14}{\text{Wt.of Original sample (wet basis)}} \times 100$$

% Crude Protein = % Nitrogen × conversion factor*

*= Conversion factors for animal and Plant origins ingredients are 6.25 (Silva, 2002)

4.2.3.3 Determination of total ash

Ash content of each feed ingredients was estimated by following incineration method (AOAC, 2005). The total ash content of the sample was determined by the following formula:

$$\text{Total ash} = \frac{\text{Wt.of crucible with original sample} - \text{Wt.of crucible with ashed sample}}{\text{Wt.of original sample (wet basis)}} \times 100$$

4.2.3.4 Determination of crude fiber

Crude fiber was determined by following method of (AOAC, 1980). The crude fiber content of feed ingredients was then determined according to the following formula:

$$\text{Crude fiber (\%)} = \frac{\text{Wt.of crucible with dried residue} - \text{Wt.of crucible with ashed sample}}{\text{Wt.of original sample}} \times 100$$

4.2.3.5 Determination of crude fat

Crude fat was quantified through Soxlet extraction technique (Maynard, 1970; Jacobs, 1973) using hexane (65°C-70°C) as the solvent through the following formula:

$$\text{Crude fat (\%)} = \frac{\text{Corrected weight of fat}}{\text{Weight of original sample}} \times 100$$

4.2.3.6 Determination of nitrogen free extract (NFE)

Nitrogen free extract (NFE) was determined by the difference between the original weight of the sample and sum of the weights of its moisture, crude protein (CP), crude fat (CF), ash and crude fiber as determined by their appropriate analysis followed by Castell and Tiews (1980).

% NFE (wet basis) = 100 - (% moisture+ % CP + % CF + % ash + % CFb)

Table 4.2 Proximate composition of raw materials used for feed formulation

Ingredients (%)	Moisture	Dry matter	Crude protein	Crude fat	Crude fiber	Total Ash	*NFE
Dry fish	15.15	84.63	43.00	6.85	3.42	32.98	2.46
Meat and bone meal	10.96	89.75	51.00	10.36	1.68	27.68	0.83
Fish meal	10.69	89.69	60.00	7.96	3.10	20.63	0.88
Rapeseed meal	12.30	87.66	36.00	0.97	10.40	7.66	29.68
Soybean Oil Cake	12.60	87.20	43.00	1.03	6.10	6.83	27.10
Maize	12.77	87.53	10.50	2.85	2.48	1.79	71.52
Rice Polish A Gr.	12.80	87.13	14.00	12.29	8.67	10.40	41.36
Wheat Flour	12.89	87.52	10.50	1.66	1.87	1.44	70.55
De Oil Rice Bran	12.50	88.12	17.00	1.55	10.59	14.12	43.85

*Nitrogen free extract, determined by subtraction from 100% of other parameters.

4.3 Results

4.3.1 Physical description of formulated feeds

Using nine raw materials and seven feed additives, four diets (8 formulas) were prepared which consist of two types of sinking and two types of floating feeds each having both starter and grower graded feed. Shape and size of different finished feeds are shown in Table 4.3. Sinking pellets were 2.0-3.0 mm in diameter and 4-7 mm in length. Floating pellets were 2.0-3.0 mm in diameter. The diets were prepared for pangas ranged between 100 to 1000 g in weight.

Table 4.3 Physical properties of formulated sinking and floating feeds

Sl. No	Diets Name	Size of Pangas	Shape of feed	Size of feed (mm)
1	Starter	100-150 g	Sinking Pellet	2.0x4-5
2	Grower	150-1000 g	Sinking Pellet	3.0x 5-7
3	Starter	100-150 g	Floating pellets	2.0
4	Grower	150-1000 g	Floating pellets	3.0

4.3.2 Production cost of feed

Production cost of each diet is shown in Table 4.4. Variables considered determining the production costs are material cost, packaging cost, operational cost, management cost, transportation cost, commission agent, and profit of manufacturer. Production cost of floating diets was comparatively higher then sinking diets. Production costs of sinking starter were BDT 36.17 and 38.32; the growers were BDT 34.50 and 36.39. Furthermore, production cost of floating starter was BDT 44.24 and 46.01; and the grower was BDT 40.95 and 43.39. Materials costs were more or less similar for sinking and floating feed. However, major difference was caused by higher operational cost of floating feed.

Table 4.4 Production costs for different formula of sinking and floating diets

Variables (BDT)	Sinking pellet-F1		Sinking pellet-F2		Floating pellet-F1		Floating pellet-F2	
	Starter	Grower	Starter	Grower	Starter	Grower	Starter	Grower
Material cost	28.67	27.10	30.82	28.89	28.29	26.45	30.31	28.89
Packaging cost	0.80	0.80	0.80	0.80	1.50	1.50	1.50	1.50
Operational cost	1.20	1.10	1.20	1.10	6.50	6.00	6.50	6.00
Management cost	1.00	1.00	1.00	1.00	1.50	1.00	1.50	1.00
Transportation cost	1.00	1.00	1.00	1.00	1.20	1.20	1.20	1.20
Commission agent	2.00	2.00	2.00	2.00	3.00	3.00	3.00	3.00
Profit of manufacturer	1.50	1.50	1.50	1.50	2.25	1.80	2.00	1.80
Total cost	**36.17**	**34.50**	**38.32**	**36.29**	**44.24**	**40.95**	**46.01**	**43.39**

4.3.3 Proximate composition

The proximate composition of formulated sinking and floating diets of different formula is shown in Table 4.5. There was not much variation in the proximate composition between the sinking and floating diets. Moisture in sinking pellet feed ranged from 9.15 to 10.20% and in floating feed 8.16 to 10.42%. Protein content ranged from 27.42 to 30.55% in sinking pellet feed and 27.95 to 30.85% in floating pellet feed. Lipid content was ranged from 9.26 to 9.45% in sinking pellet feed and 9.15 to 9.53% in floating feed. Sinking and floating feeds were found to contain 11.24 to 11.30% and 11.34 to 11.75% ash, respectively. Nitrogen free extract was ranged from 33.56 to 37.96% in sinking pellet feed and 34.25 to 38.20% in floating pellet feed.

Table 4.5 Proximate composition of formulated sinking and floating diets

Variables (BDT)	Sinking pellet-F1		Sinking pellet-F2		Floating pellet-F1		Floating pellet-F2	
	Starter	Grower	Starter	Grower	Starter	Grower	Starter	Grower
Moisture (%)	9.32	10.20	9.15	10.11	8.96	10.41	9.12	10.42
Protein (%)	30.55	28.52	30.22	27.42	30.45	27.95	30.85	28.41
Lipid (%)	9.36	9.26	9.45	9.26	9.24	9.22	9.53	9.15
Ash (%)	11.28	11.29	11.30	11.24	11.34	11.75	11.55	11.62
*NFE	33.56	37.85	34.25	37.96	34.25	38.20	34.26	37.75

*Nitrogen free extract, determined by subtraction from 100% of other parameters.

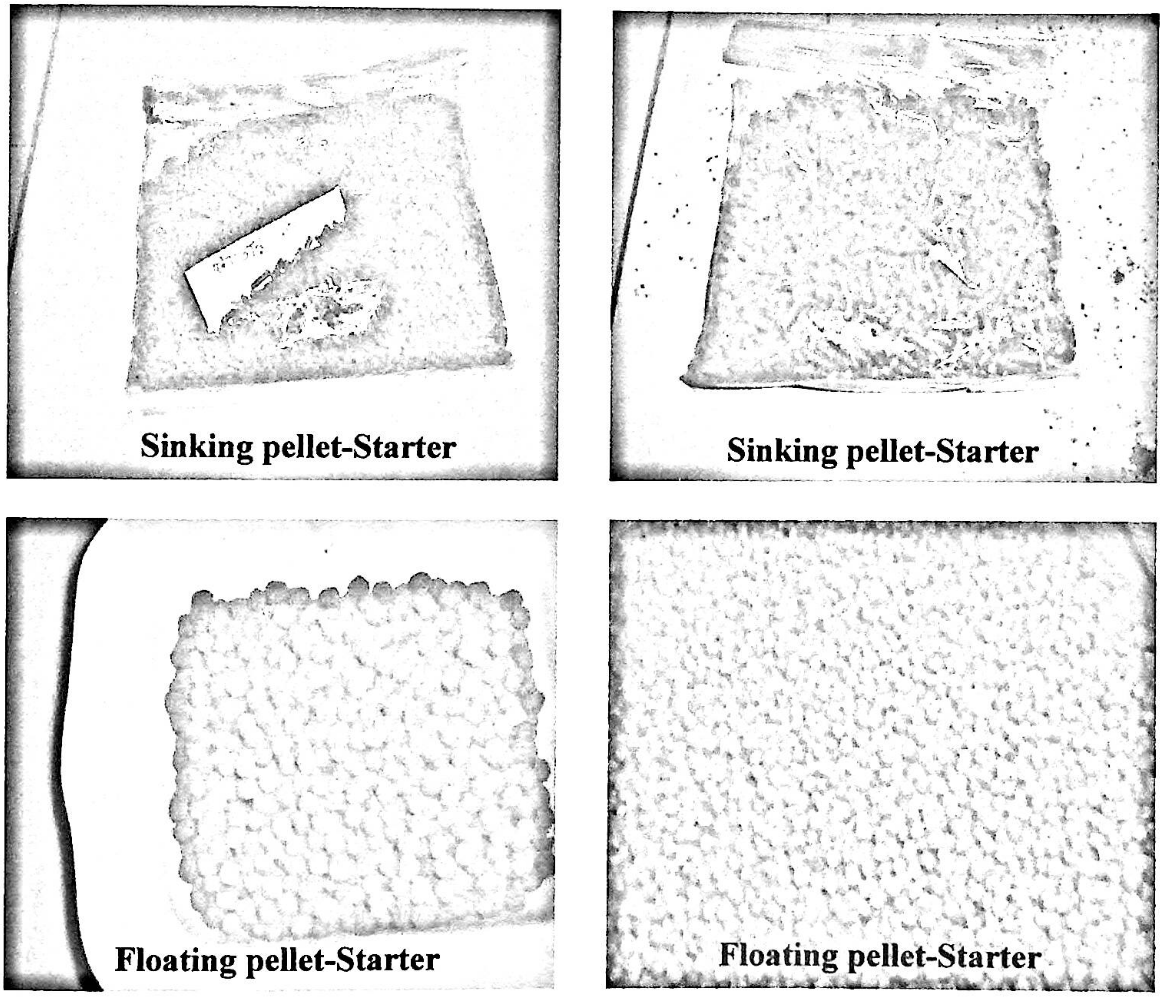

Figure 4.1 Different types of formulated sinking and floating pellet feeds

4.4 Discussion

Pangasius culture is intensive in Bangladesh whereas most farmers (65.6%) are using commercially produced pellet feed purchased from local feed dealers or directly from feed companies. However, 34.4% of farms used farm-made feed (Ali et al., 2013). Of those that used commercially produced feeds, 62% used sinking pelleted feeds, 25% used floating pelleted feeds and 18% used a combination of both sinking and floating pelleted feeds (Ali et al., 2018).

In the present study, 10 feed ingredient and seven feed additives were used for the preparation of sinking and floating pellet feed. Normally, six or seven types of ingredients including fine rice bran or polish from industrial rice mills, maize meal, wheat flour or wheat bran, dry fish, mustard oil cake, soybean meal and meat and bone meal and additives such as vitamins, calcium and feed binders were reported to be used by farmers of Bangladesh to produced farm make pellet feed (Ali et al., 2013).

The main nutritional component of formulated feed was protein, which was ranged from 27.42 to 30.55% in sinking pellet feed and 27.95 to 30.85 % in floating pellet feed, which was within the range reported by Ali et al. (2013) who reported the protein level in commercially manufactured feeds is highly variable and ranging from 23 to 32%. The present protein content of formulated feed were also more or less similar with some other commercial pangas pellet feed available in Bangladesh reported by Kader et al. (2013) who reported the protein content of starter feed ranged from 27.21 to 28.97% and for grower feed 27.07 to 28.38%.

In the present study, per kg cost of finished feed was found to vary from BDT 36.17 to 38.52 for sinking pellet feed and BDT 40.95 to 46.01 for floating feed. However, formulation process also had some effect on feed cost. Feed costs for two formulas of sinking feed were BDT 36.17-34.50 and BDT 36.29-38.32. On the contrary, feed costs for two formulas of floating feed were BDT 40.95-44.24

and BDT 43.39-46.01, which was quite higher than the finding of Ali et al. (2013) who reported production cost for per kg commercial pellet feed was ranging from BDT 26.95 to 29.36 and farm made feed was BDT 22.05 to 25.73. The difference in formulation process and ingredient selection might be responsible for these differences.

4.5 Conclusion

It can be concluded that formula used in the present study to formulate sinking and floating pellet contained the nutrient (moisture, protein, lipid, ash and NFE) recommended for pangas. The production cost of sinking pellet was lower than floating pellet. Protein content ranged from 27.42 to 30.55% in sinking pellet feed and 27.95 to 30.85%. Lipid content ranged from 9.26 to 9.45% in sinking pellet feed and 9.15 to 9.53% in floating feed. In the present study, per kg cost of finished feed was found to vary from BDT 36.17 to 38.52 for sinking pellet feed and BDT 40.95 to 46.01 for floating feed which was more or less similar with the available commercial pellet feed of Bangladesh. The results of the study showed that feed formulated in the present study is of better quality.

Chapter Five

Growth and economics of striped catfish *Pangasius sutchi* farming using cost-effective floating and sinking pellet feed

5.1 Introduction

Thai pangas is the most popular and widely cultured catfish species of Bangladesh which contributing 11.404% (0.42 million MT) of total fish production (FRSS, 2016). It is one of the most popular species in aquaculture compared to other species in our country (Begum et al., 2012). It was introduced for cultivation in Bangladesh in 1989, and after that it remains one of the major culture species contributing to the total fish production of Bangladesh (Sarker, 2000). Successful artificial propagation followed by induced breeding of this species was first accomplished in 1993 and after that fry of this species become available all over the country which created many other linkage industries like hatchery, nursery, fingerlings trading and provided employment opportunity and improved livelihood of the involved people. This fish species has omnivorous feeding habits and takes crustaceans, molluscs, fish, and vegetable wastes as food. It has fast growth, lucrative size, good taste and high market demand and value in Bangladesh (Kader et al., 2003). Fishes are providing 60% of animal protein intake in Bangladesh and pangas is one of the most frequently consumed nutrient rich food fish in Bangladesh (DoF, 2017; Toufique and Belton, 2014). Like other cultivated catfishes, this species is well-known for its easy culture system, high disease resistance and tolerance of a wide range of environmental parameter such as changes in salinity, pH, dissolved oxygen or even pollution. Therefore, pangus is now popular by rural and urban people and therefore it would be a good source of protein and calorie.

Considering the potential of culture and market demand of this species, its production needs to be increased through the targeted application of inputs that are readily available to farmers. In Bangladesh, successful farming of pangas is solely depended on the supply of adequate artificial diet. However, worldwide increasing demand and price of fish meal and other dietary ingredients are causing increased unit price of the feed cost and ultimately increasing the production cost and subsequently decreasing the net return from pangas farming system. Therefore, efforts are needed to minimize the production of fish and maximize the farmers' income for a sustainable aquaculture venture. One of the problems faced by fish farmers is low efficiency of feed utilization and high feed cost (Hugues et al., 2018). Not only the nutrient composition but also the form of the diets is also causing lower growth performance, limited nutrient utilization and finally lower fish yield (Kristiansen and Fernö, 2007).

In Bangladesh, the culture potential of pangas is mostly limited by higher feed cost which constitutes the major cost item in pangasius culture system (Sørensen, 2012). In any fish culture system feed cost is commonly accounts for 40-60% of the operating costs depending on the level of intensification and species (Limbu and Jumanne, 2014). Furthermore, this cost of feeding is usually exacerbated when the cultured species requires higher protein level in the diet. The farming of pangas worldwide normally comprises the purchase or production of on-farm sinking or floating feeds and costing of floating feeds are generally higher as it requires extrusion process as a means of flotation of the feed. Therefore, floating feeds require extra manufacturing cost and the sinking pelleted diets are fairly common and less costly to produce than the floating diets (Adewumi and Olaleye, 2011).

There was no studies have been carried out to explore the feeding habit of pangas in order to recommend the suitable diet between floating and sinking diets. Although majority of the pangas farmers were found to use floating feed in their farming system, they often curse the feed cost as the main barrier in the path of higher net return. Consequently, famers do not know which diet to choose for their culture ponds due to paucity and inexistence of published scientific information on growth and yield when the fish is fed on floating and sinking diets. The present study was therefore undertaken to compare the growth performance, percentage survival, feed conversion efficiency, yield and economics of pangas fed on formulated floating and sinking diets using different composition of ingredients.

5.2 Materials and methods

5.2.1 Study locations and study period

The study was conducted in Jikorgacha Upazila of Jessore district for a period of 4 months from April to July 2016 (Figure 5.1).

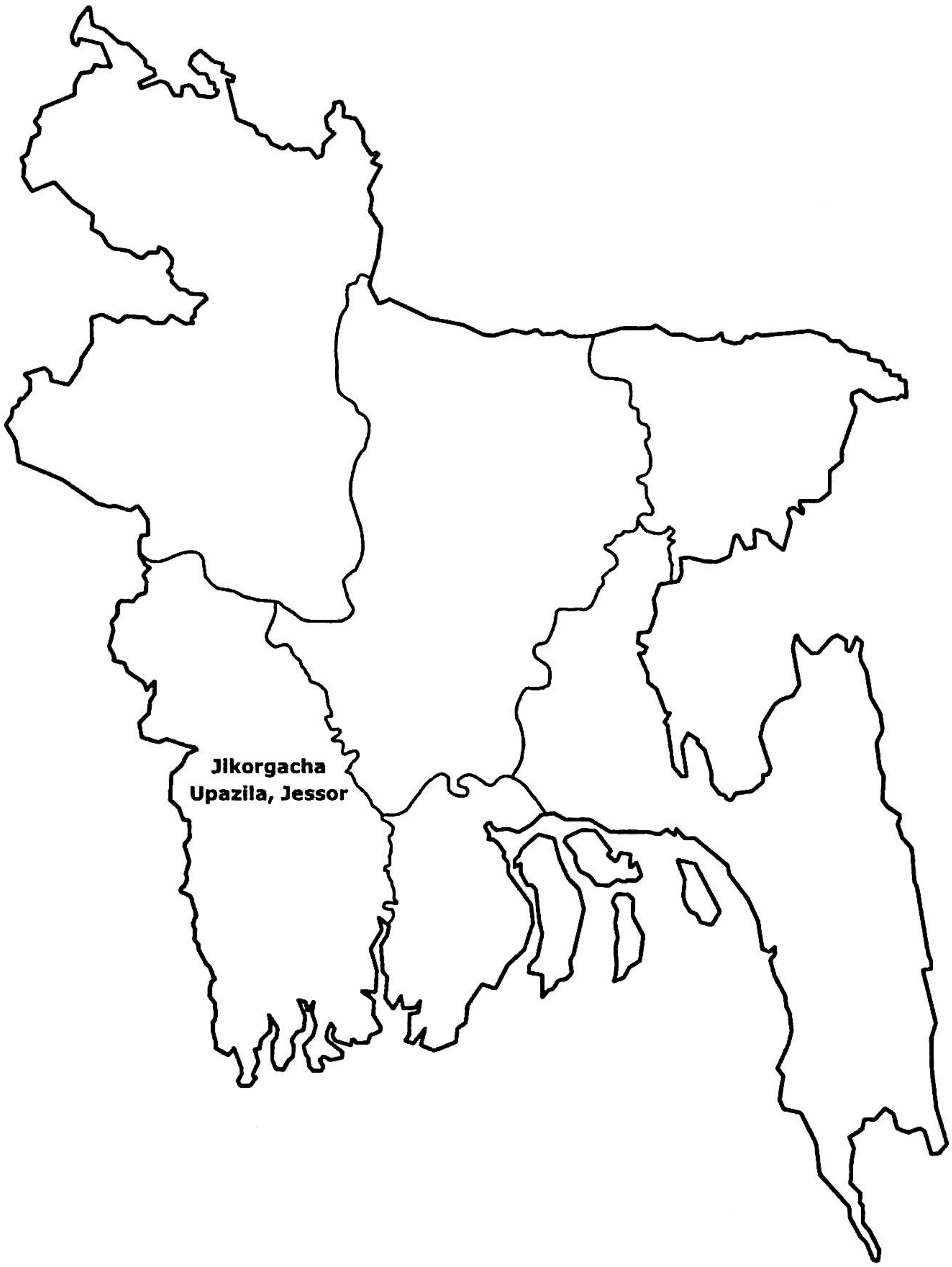

Figure 5.1 Location of study areas for pangas culure

5.2.2 Experimental Design

Two different feeding trials were conducted during the study period. In the first feeding trial, pangas were feed with formulated sinking pellet feed at three treatments with two experimental sinking pellets and one commercial sinking pellet feed which were assigned as treatment T_1, T_2 and T_3, respectively. In the second feeding trial, the fishes were fed with formulated floating pellet feed at three treatments with two experimental floating pellets and one commercial floating pellet feed. Here also the treatments were assigned as T_1, T_2 and T_3, respectively. Finally, the economic performance of these two different feeding trials was compared to evaluate the best form of feed for sustainable culture of pangas in ponds. Stocking density was 150 nos./decimal and remained fixed for all the treatments.

Table 5.1 Experimental design layout

Trials	Feeding trial with sinking pellet			Feeding trial with floating pellet		
	T_1	T_2	T_3	T_1	T_2	T_3
Replication I (R_1)	T_1R_1	T_2R_1	T_3R_1	T_1R_1	T_2R_1	T_3R_1
Replication II (R_2)	T_1R_2	T_2R_2	T_3R_2	T_1R_2	T_2R_2	T_3R_2
Replication III (R_3)	T_1R_3	T_2R_3	T_3R_3	T_1R_3	T_2R_3	T_3R_3

5.2.3 Feed management

The feeding was dependent on manufactured feeds. The Feed applied twice in a day by broad casting system. Different manufactured feeds and commercial feeds were applied on the basis of size of pangas. Fish were fed starter for 30 days and remaining 90 days grower feeds. The below feeding protocol had been maintained for the culture period (Table 5.2).

Table 5.2 Feeding protocols of pangs with formulated feed

Sl. No	Feed grade	Fish weight (g)	Feed applied (%) of body weight	Remarks
2	Starter	100-150	9-6	First 30 days
3	Grower	150-1000	4.5-2	Rest 90 days

5.2.4 Water quality monitoring

Water samples were collected fortnightly (twice in a month) between 10:00 and 11:00 hours for analysis of various physico-chemical parameters using dark bottles. Water temperature and transparency were measured using a Celsius thermometer and a black and white standard colour coded Secchi disc of 30 cm diameter. Water depth was measured with a measuring tape. Water pH was measured using an electronic pH meter (Jenwary, 3020) and dissolved oxygen (DO) was measured directly with a DO meter (Lutron, DO-5509). NH_3 was tested using a HACH water analysis kit (Model FF-2, USA).

5.2.5 Fish sampling, growth parameters and yield analysis

Fish sampling was carried out in the morning between 7:00 and 9:00 am using a net. Fishes were sampled monthly in order to determine weight of fishes. At the final harvest, all fish were weighed, measured and the survival rate and mean weight were determined. To determine the growth response of fish, the following parameters were calculated by following formulas:

Mean weight gain (g) = Mean final weight (g) – Mean initial weight (g)

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

$$\text{Average daily weight gain of weight (ADG)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Culture period}}$$

$$\text{Average daily weight gain of length (ADG)} = \frac{\text{Final length} - \text{Initial length}}{\text{Culture period}}$$

$$\text{SGR of weight } (\% \, bwd^{-1}) = \frac{\ln[\text{Final weight} - \ln[\text{Initial weight}]}{\text{Culture period}} \times 100$$

$$\text{SGR of length } (\% \, bwd^{-1}) = \frac{\ln[\text{Final length} - \ln[\text{Initial length}]}{\text{Culture period}} \times 100$$

$$\text{Survival rate } (\%) = \frac{\text{No. of fish harvested}}{\text{No. of fish stock}} \times 100$$

$$\text{Food conversion ratio} = \frac{\text{Weight of feed fed}}{\text{Fish weight gain}}$$

Gross production (kg/ha) = Fish biomass at harvest

Net production (kg/ha) = Fish biomass at harvest – fish biomass at stock

5.2.6 Economic analysis

At the end of the experiment, an economic analysis was performed to estimate the net return and benefit–cost of the experimental diets used for Thai pangas. The following simple equation was used according to Asaduzzaman et al. (2010):

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

Where, R = net return, I=income from Thai pangas sale, FC = fixed/common costs, VC = variable costs and Ii=interest on inputs

The benefit-cost ratio was determined as:

Benefit cost ratio (BCR) = Total net return/Total input cost

5.2.7 Statistical analysis

Water quality, fish growth and yield parameters and economic performance were analyzed by one-way ANOVA. When a mean effect was significant, the ANOVA was followed by Duncan New Multiple Range Test (Duncan 1955) at 5% level of significance (Gomez and Gomez 1984). The percentages and ratio data were analyzed using arcsine transformed data. All analyses were performed using SPSS (Statistical Package for Social Science) version 20.0 (IBM Corp., Armonk, NY, USA).

5.3 Results

5.3.1 Feeding trial with sinking pellet feed

5.3.1.1 Water quality parameters

Mean fortnight value of water quality parameters are shown in Figure 5.2. Variation in fortnight was not significant for all the water quality parameters. However, water temperature was increased with increasing the culture period and water transparency was decreased. Mean water temperature was the highest during 6th fortnight at treatment T_3 (32.57 °C), and lowest during 1st fortnight at treatment T_2 (27.63 °C). Difference in water transparency was not significant among the fortnight and treatment. However, highest transparency was recorded during 1st fortnight at T_3 (16.73 cm) and lowest during 6th fortnight at T_3 (14.47 cm). Water depth was more or less constant over the study period, while pH showed a decreasing trend. pH was the highest during 6th fortnight at T_3 (7.23) and the lowest during 2nd fortnight at T_2 (6.63). During the study period, dissolved oxygen and NH_3 showed an uneven increasing and decreasing trend over the sampling duration. Highest value of dissolved oxygen was recorded during 4th fortnight at T_2 (6.33 mg/l) and lowest during 1st fortnight at T_1 (3.70 mg/l).

All the water quality parameters recorded during the study period are shown in Table 5.3. Over the study period, the water quality parameters were not varied significantly ($P < 0.05$) among the treatments. However, highest value of temperature was recorded at T_3 (30.47±1.64 °C) and the lowest at T_1 (30.41±1.61 °C). Transparency was ranged between 16.19±1.79 cm (T_3) to 15.72±1.64 cm (T_1). Water depth of the studied ponds was not fluctuated much among the treatments, while the highest water depth was recorded at T_2 (6.65±0.12 ft) and the lowest at T_1 (6.58±0.30 ft). Again the highest value of pH was recorded at T_2 (7.47±0.59) and lowest at T_3 (7.16±0.50). Dissolved oxygen was ranged between 5.86±0.97 mg/l (T_2) to 5.34±0.61 mg/l (T_3). Difference in NH_3 content of water was insignificant among the treatments and the lowest value was obtained at T_3 (0.06±0.01 mg/l).

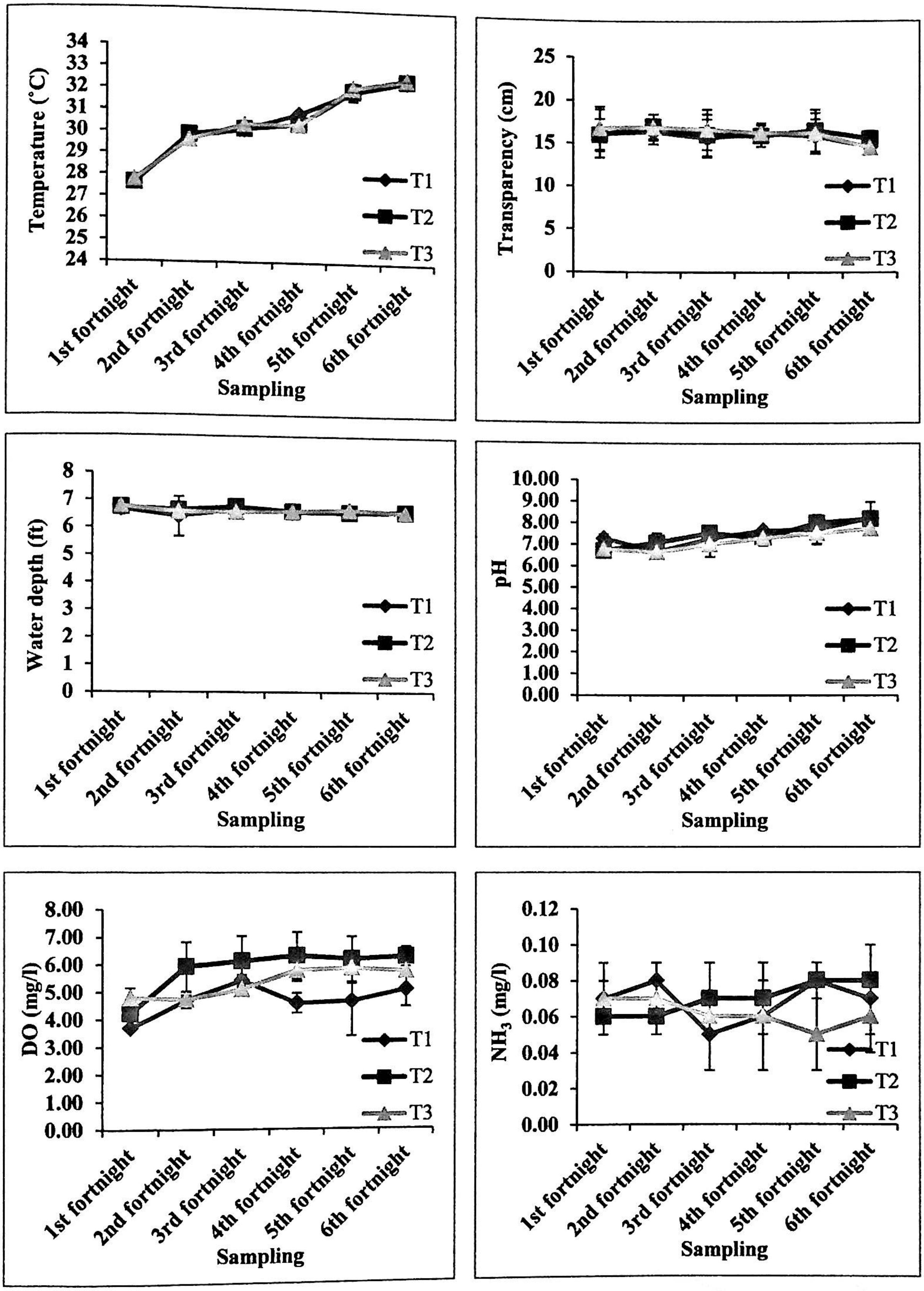

Figure 5.2 Fortnight values of water quality parameters at different treatments using sinking pellet feed

Table 5.3 Water quality parameters of at different experimental treatments using sinking pellet feed

Parameters	Treatments			F-value	P-value
	T_1	T_2	T_3		
Temperature (°C)	30.41±1.61[a]	30.43±1.63[a]	30.47±1.64[a]	0.01	0.99
Transparency (cm)	15.72±1.64[a]	16.15±1.60[a]	16.19±1.79[a]	0.45	0.64
Water depth (ft.)	6.58±0.30[a]	6.65±0.12[a]	6.62±0.16[a]	0.47	0.63
pH	7.44±0.62[a]	7.47±0.59[a]	7.16±0.50[a]	1.57	0.22
DO (mg/l)	5.65±0.77[a]	5.86±0.97[a]	5.34±0.61[a]	10.35	0.10
NH_3 (mg/l)	0.07±0.02[a]	0.07±0.01[a]	0.06±0.01[a]	2.45	0.11

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, DO = Dissolved oxygen, NH_3 = Ammonia, cm = centimeter, ft = feet, mg/l = milligram per litter

5.3.1.2 Growth and production performance

Periodic growth performances of fish at different fortnight sampling date are shown in Table 5.4 to 5.8. During the 1st fortnight there were no significant difference was observed among the treatments (Table 5.4). However, comparatively higher final weight was obtained at T_2 (147.33±14.64 g) followed by T_1 (145.33±10.50 g) and T_3 (124.67±7.51 g). Wight gain was highest at T_1 (43.00±9.17 g) and lowest at T_3 (19.33±8.74 g). Moreover, percent weight gain was highest at T_1 (41.97±8.52%) and lowest at T_3 (18.44±8.69%). Again, ADG and SGR were also highest at T_1 (2.87±0.61 g and 2.33±0.41 %/day) followed by T_2 (2.82±1.24 g and 2.24±0.91 %/day) and T_3 (1.29±0.58 g and 1.11±0.48 %/day). During the 2nd fortnight sampling, significant differences were observed in final weight, weight gain and ADG among the treatments (Table 5.5). Significantly ($P < 0.05$) higher final weight was observed at T_2 (243.33±8.08 g) followed by T_1 (231.00±5.57 g) and T_3 (208.33±7.64 g), respectively. Similarly, weight gain and

ADG were the highest at T_2 (96.00±6.56 and 6.40±0.44 g) followed by T_1 (85.67±5.13 and 5.71±0.34 g) and T_3 (83.67±1.15 and 5.58±0.08 g). At 3rd sampling date, final weight, weight gain and ADG were found to vary significantly ($P < 0.05$) among the treatments (Table 5.6). However, % weight gain and SGR were not varied significantly ($P > 0.05$) among the treatments. Final weight was significantly ($P < 0.05$) higher at treatment T_2 (389.67±5.03 g) followed by T_1 (340.67±14.01 g) and T_3 (319.33±7.02 g). Similarly, ADG was significantly ($P < 0.05$) higher at T_2 (9.75±0.76 g) and the lowest at T_1 (7.31±0.97 g). At 4th sampling date, insignificant ($P > 0.05$) was observed in all the studied growth parameters among the treatments (Table 5.7), while at 5th sampling date significant ($P < 0.05$) difference was only observed in final weight among the treatments (Table 5.8) and the highest value was recorded at T_2 (936.67±5.03 g) followed by T_3 (867.33±28.18 g) and T_1 (849.33±6.43 g). Gradual trend in the variation of fortnight values of final weight of pangas at different treatments is shown in Figure 5.3. It was observed that periodic final weight of pangas was higher at T_2 followed by T_3 and T_1.

Overall growth performances of pangas recorded during the study period are shown in Table 5.9. Fishes were uniform at the start of the study period as their variations in initial weight were insignificant. Variations of the initial length of the studied fishes were also insignificant. However, final weight showed a significant differences among the treatments with the highest value was recorded at treatment T_2 (1137.34±32.11 g) and the lowest at treatment T_1 (1051.29±5.47 g). Again, final length was not varied significantly among the treatments. Furthermore, weight gain showed significant difference among the treatments while length gain, % weight gain and % length gain did not show significant differences among the treatments. ADG of weight was found vary significantly among the treatments whereas the highest value was recorded at treatment T_2 (11.47±0.39 g), and the lowest at T_3 (10.82±0.42 g). However, SGR was not varied significantly among the treatments. During the study period, FCR and survival rate of fishers were not varied significantly among the treatments. However, gross and net production of pangas were significantly higher at treatment T_2 (53365.67±1011.48 and 48178.67±1144.04 kg/ha, respectively).

Table 5.4 Growth performances of fish at different treatment during 1st fortnight sampling fed with sinking pellet feed

Parameters	Treatments				
	T_1	T_2	T_3	F-value	P-value
Initial weight (g)	102.33±2.52^a	105.00±4.36^a	105.33±2.52^a	0.77	0.51
Final weight (g)	145.33±10.50^a	147.33±14.64^a	124.67±7.51^a	3.72	0.09
Weight gain (g)	43.00±9.17^a	42.33±18.58^a	19.33±8.74^a	3.23	0.11
% weight gain	41.97±8.52^a	40.83±19.72^a	18.44±8.69^a	2.95	0.13
ADG (g)	2.87±0.61^a	2.82±1.24^a	1.29±0.58^a	3.25	0.11
SGR (%/day)	2.33±0.41^a	2.24±0.91^a	1.11±0.48^a	3.36	0.11

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.5 Growth performances of fish at different treatment during 2nd fortnight sampling fed with sinking pellet feed

Parameters	Treatments				
	T_1	T_2	T_3	F-value	P-value
Initial weight (g)	145.33±10.50^a	147.33±14.64^a	124.67±7.51^a	3.72	0.09
Final weight (g)	231.00±5.57^a	243.33±8.08^a	208.33±7.64^b	18.34	0.00
Weight gain (g)	85.67±5.13^b	96.00±6.56^a	83.67±1.15^b	5.58	0.04
% weight gain	59.32±7.72^a	65.87±10.80^a	67.27±4.08^a	0.84	0.48
ADG (g)	5.71±0.34^b	6.40±0.44^a	5.58±0.08^b	5.53	0.04
SGR (%/day)	3.10±0.33^a	3.36±0.44^a	3.43±0.16^a	0.83	0.48

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.6 Growth performances of fish at different treatment during 3rd fortnight sampling fed with sinking pellet feed

Parameters	Treatments			F-value	P-value
	T_1	T_2	T_3		
Initial weight (g)	231.00±5.57^{a}	243.33±8.08^{a}	208.33±7.64^{b}	18.34	0.00
Final weight (g)	340.67±14.01^{b}	389.67±5.03^{a}	319.33±7.02^{c}	43.19	0.00
Weight gain (g)	109.67±14.57^{b}	146.33±11.37^{a}	111.00±1.00^{b}	11.36	0.01
% weight gain	47.52±6.77^{b}	60.28±6.58^{a}	53.34±2.34^{ab}	3.88	0.08
ADG (g)	7.31±0.97^{b}	9.75±0.76^{a}	7.40±0.07^{b}	11.33	0.01
SGR (%/day)	2.59±0.31^{b}	3.14±0.27^{a}	2.85±0.10^{b}	3.82	0.09

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.7 Growth performance of fish at different treatment during 4th fortnight sampling sinking pellet feed

Parameters	Treatments			F-value	P-value
	T_1	T_2	T_3		
Initial weight (g)	340.67±14.01^{b}	389.67±5.03^{a}	319.33±7.02^{c}	43.19	0.00
Final weight (g)	629.00±19.31^{b}	693.00±7.21^{a}	615.00±7.00^{b}	32.84	0.00
Weight gain (g)	288.33±31.90^{a}	303.33±7.02^{a}	295.67±8.74^{a}	0.44	0.66
% weight gain	84.98±13.01^{a}	77.86±2.35^{a}	92.64±4.27^{a}	2.55	0.16
ADG (g)	19.22±2.13^{a}	20.22±0.47^{a}	19.71±0.58^{a}	0.44	0.66
SGR (%/day)	4.09±0.46^{a}	3.84±0.09^{a}	4.37±0.15^{a}	2.63	0.15

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.8 Growth performance of fish at different treatment during 5th fortnight sampling fed with sinking pellet feed

Parameters	Treatments			F-value	P-value
	T_1	T_2	T_3		
Initial weight (g)	629.00±19.31[b]	693.00±7.21[a]	615.00±7.00[b]	32.84	0.00
Final weight (g)	849.33±6.43[b]	936.67±5.03[a]	867.33±28.18[b]	22.23	0.00
Weight gain (g)	220.33±14.22[a]	243.67±12.22[a]	252.33±31.77[a]	1.81	0.24
% weight gain	35.09±3.28[a]	35.18±2.14[a]	41.06±5.48[a]	2.32	0.18
ADG (g)	14.69±0.95[a]	16.24±0.81[a]	16.82±2.12[a]	1.82	0.24
SGR (%/day)	2.01±0.16[a]	2.01±0.10[a]	2.29±0.26[a]	2.29	0.18

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

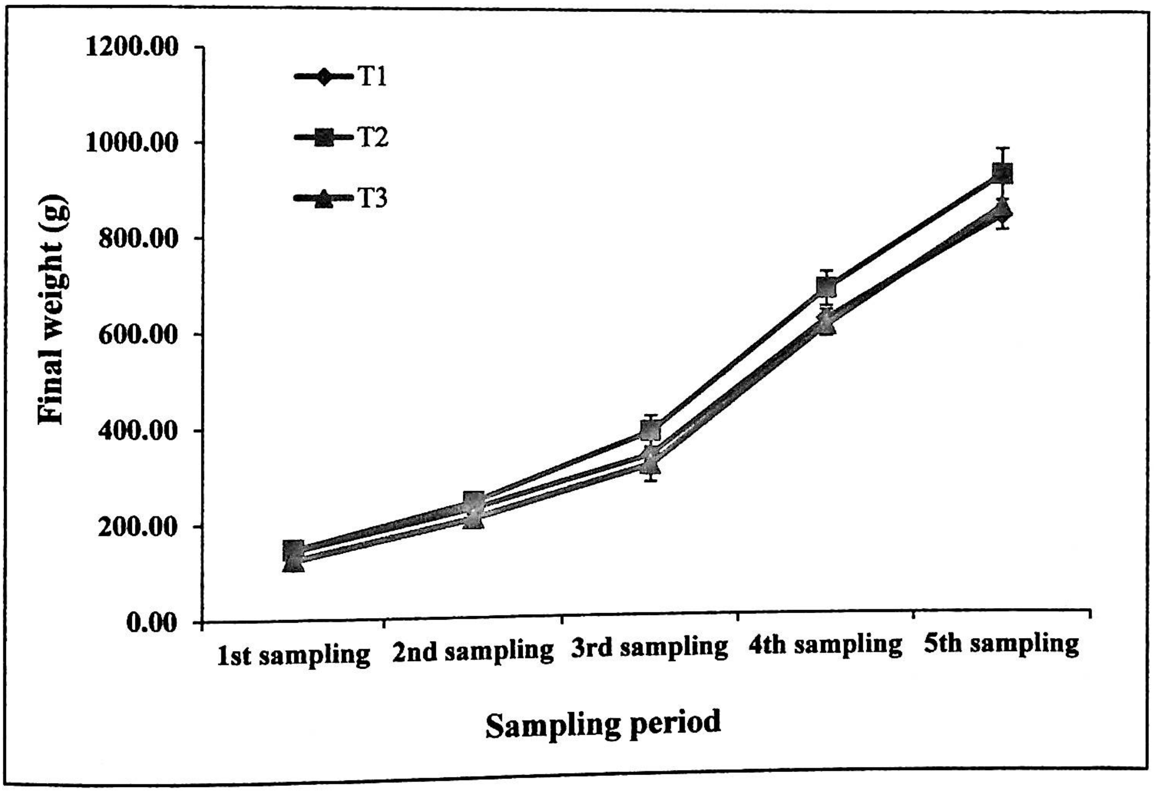

Figure 5.3 Fortnight values of final weight of pangas at different treatments fed with sinking pellet feed

Table 5.9 Growth performance of fish at different treatments fed with sinking pellet feed during the study period

Parameters	Treatment			F-value	P-value
	T_1	T_2	T_3		
Initial weight (g)	102.33±2.52^a	105.00±4.36^a	105.33±2.52^a	0.77	0.51
Final weight (g)	1051.29±5.47^b	1137.34±32.11^a	1079.18±35.69^b	7.43	0.02
Initial length (cm)	11.83±0.76^a	11.00±2.00^a	12.33±0.58^a	0.83	0.48
Final length (cm)	31.67±1.53^a	32.17±0.76^a	30.54±0.47^a	1.98	0.22
Weight gain (g)	948.95±6.65^b	1032.34±35.34^a	973.85±37.82^{ab}	6.06	0.04
Length gain (cm)	19.83±2.25^a	21.17±1.89^a	18.21±1.05^a	2.02	0.21
% Weight gain	927.75±27.33^a	985.07±71.17^a	925.38±56.29^a	1.15	0.38
% Length gain	168.89±30.06^a	198.72±51.94^a	148.12±15.03^a	1.52	0.29
ADG_W (g)	10.54±0.08^b	11.47±0.39^a	10.82±0.42^{ab}	6.10	0.04
ADG_L (g)	0.22±0.03^a	0.23±0.02^a	0.20±0.01^a	1.69	0.26
SGR_W (%/day)	2.59±0.03^a	2.60±0.03^a	2.59±0.06^a	0.09	0.92
SGR_L (%/day)	1.09±0.13^a	1.20±0.20^a	1.01±0.07^a	1.44	0.31
FCR	1.62±0.03^{ab}	1.57±0.06^c	1.70±0.04^a	6.48	0.03
Survival rate (%)	95.00±1.00^a	95.00±1.00^a	93.33±1.53^a	1.92	0.23
Gross production (t/ha)	37.00±0.58^b	40.02±0.76^a	37.31±0.83^b	15.62	0.00

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

5.3.1.3 Economics

Economic analysis of the experiment is shown in Table 5.10. During the study period, lease value, pond preparation, seed cost, harvesting and marketing and labour cost were similar and fixed for all the treatments. However, significant difference was observed in feed cost, total cost, gross return and BCR. At the initial life stages, fishes were feed starter feed which showed significant ($P < 0.05$) difference among the treatments, whereas significantly higher feed cost for starter feed was observed at treatment T_2 (BDT 55947.20), followed by treatment T_3 (BDT 468312.00) and the lowest at treatment T_3 (BDT 411410.24). Cost of grower feed was also varied significantly among the treatments whereas the highest cost was at treatment T_3 (BDT 1970947.37), and the lowest at treatment T_1 (BDT 1622885.59). Finally, total feed cost was significantly higher at T_3 (BDT 2439259.37) and the lowest at T_2 (BDT 1920561.51). Significantly higher total cost was showed at treatment T_3 (BDT 2839109.37) followed by T_1 (BDT 2434145.83) and T_2 (BDT 2320411.51). On the contrary, significantly higher gross return was incurred from treatment T_2 (BDT 3802303.80) and the lowest from treatment T_1 (BDT 3213430.53). Furthermore, significantly higher benefit-cost ratio was obtained from T_2 (1.64) and the lowest from T_3 (1.18).

Table 5.10 Economic analysis of pangas culture with sinking pellet feed

Cost items		Treatment			F-value	P-value
		T_1	T_2	T_3		
[1]Lease value		40000.00	40000.00	40000.00	-	-
[2]Pond preparation		40500.00	40500.00	40500.00	-	-
Seed cost		259350.00	259350.00	259350.00	-	-
Feed cost	Starter	411410.24^b	55947.20^a	468312.00^b	195.62	0.00
	Grower	1622885.59^b	1864614.31^a	1970947.37^a	18.55	0.03
	Total	2034295.83^b	1920561.51^b	2439259.37^a	15.26	0.01
Harvesting and marketing		30000	30000	30000	-	-
Labor cost		30000	30000	30000	-	-
Total cost		2434145.83^b	2320411.51^b	2839109.37^a	46.04	0.00
Gross return (fish sales)		3213430.53^c	3802303.80^a	3357671.77^b	15.79	0.00
Benefit-cost ratio (BCR)		1.32^b	1.64^a	1.18^c	78.06	0.00

[1]Lease value = For 5 months lease period, [2]Pond preparation = pond repairing, Removal of predatory fish, liming, fertilization and disinfection of pond

5.3.2 Feeding trial with floating feed

5.3.2.1 Water quality parameters

Mean fortnight variations of water quality parameters are shown in Figure 5.4. There were no significant variations in the mean values of all the water quality parameters among the fortnight sampling period. Irregular fluctuation was observed in water temperature while gradual increasing trend in transparency was observed from 1^{st} fortnight sampling to 6^{th} fortnight sampling. Gradual increase and decrease in water depth was evident among the sampling fortnights. However, pH was found more or less stable in all the fortnight samplings. Fortnight variation of DO was also stable while gradual ups and downs were observed in NH_3 content of water during the study period.

Mean values of water quality parameters are shown in Table 5.11. Water temperature was not varied significantly among the treatments. However, numerically higher water temperature was recorded at T_3 (30.44±1.63 °C) followed by T_2 (30.44±1.56 °C) and T_1 (30.17±1.09 °C). Water transparency was ranged between 25.92±3.51 cm at the treatment T_3 to 25.12±2.98 cm at the treatment T_1. During the study period water depth of the ponds was not significantly varied among the treatment whereas the highest depth was found at T_2 (6.72±0.19 ft.) and the lowest at T_1 (6.67±0.19 ft.). Variations in pH among the treatments was also insignificant with the highest numeric value recorded at T_1 (7.43±0.40) and the lowest at T_3 (7.25±0.48). Insignificant variation was also observed in DO among the treatments, whereas T_1 (5.86±0.69 mg/l) had the highest DO content and T_2 (5.70±0.75 mg/l) had the lowest. During the study period, significant variations was only observed in NH_3 content of water, whereas significantly higher NH_3 was recorded at treatment T_3 (0.07±0.01 mg/l) and the lowest at treatment T_1 (0.06±0.01 mg/l). Although treatment T_3 had significantly higher NH_3 compared to the treatment T_1 and T_2, difference between treatment T_1 (0.06±0.01 mg/l) and T_2 (0.06±0.01 mg/l) was insignificant.

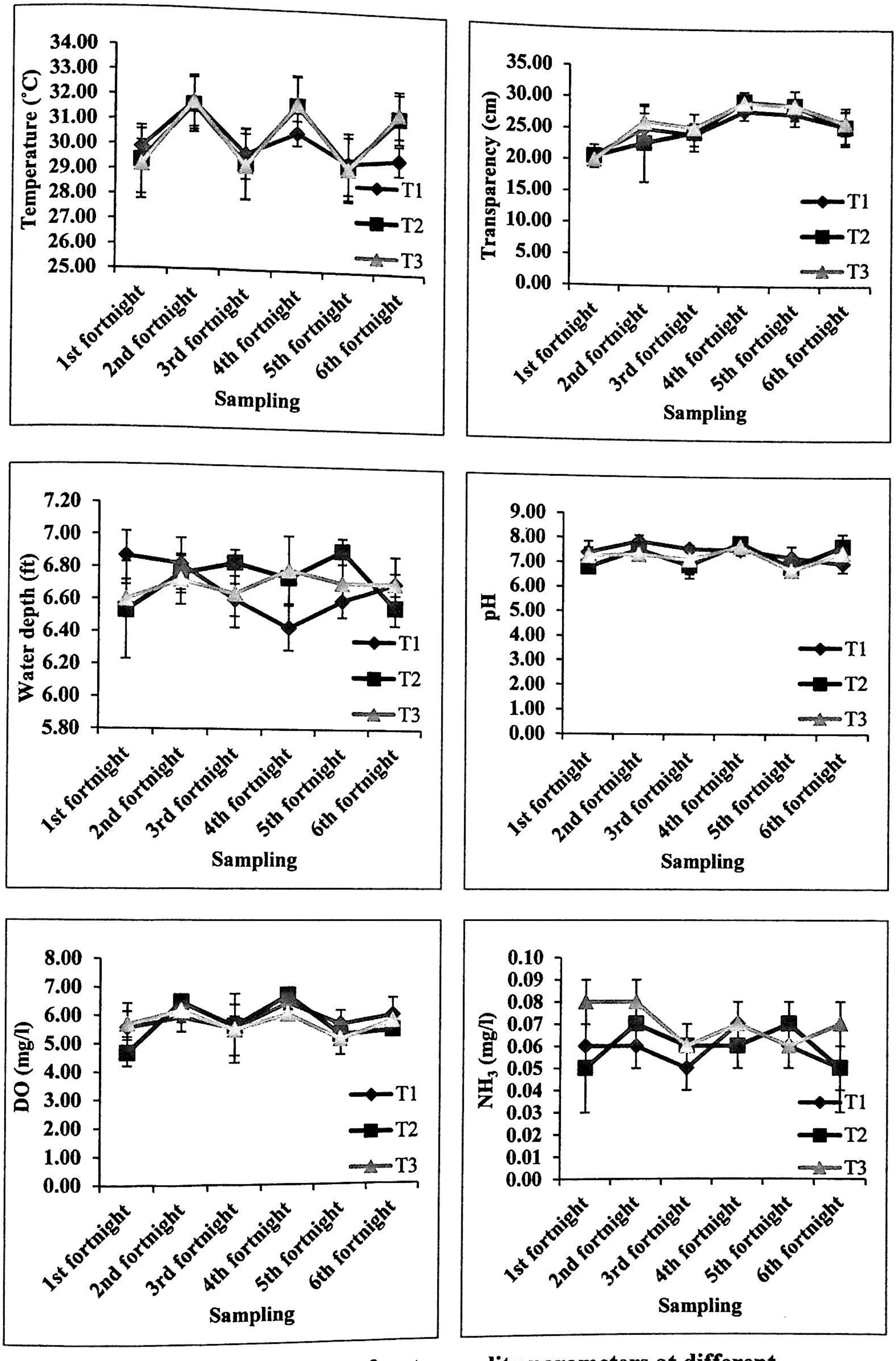

Figure 5.4 Fortnight values of water quality parameters at different treatments using floating pellet feed

Table 5.11 Water quality parameters of at different experimental treatments using floating pellet feed

Parameters	Treatments			F-value	P-value
	T_1	T_2	T_3		
Temperature (°C)	30.17±1.09^a	30.44±1.56^a	30.44±1.63^a	0.22	0.81
Transparency (cm)	25.12±2.98^a	25.26±4.18^a	25.92±3.51^a	0.26	0.77
Water depth (ft.)	6.67±0.19^a	6.72±0.19^a	6.70±0.14^a	0.40	0.67
pH	7.43±0.40^a	7.26±0.49^a	7.25±0.48^a	0.87	0.43
DO (mg/l)	5.86±0.69^a	5.70±0.75^a	5.72±0.56^a	0.29	0.75
NH_3 (mg/l)	0.06±0.01^b	0.06±0.01^b	0.07±0.01^a	7.70	0.00

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, DO = Dissolved oxygen, NH_3 = Ammonia, cm = centimeter, ft = feet, mg/l = milligram per litter

5.3.2.2 Growth and production performance

Fortnight growth performance of pangas fed floating feed of different formulations is shown in Table 5.12 to 5.16. Growth parameters were not varied significantly among the treatments during the 1st fortnight sampling. However, at 2nd fortnight sampling, significantly higher final weight was recorded at T2 (285.33±9.07 g) and the lowest at T_3 (266.00±8.54 g). During the 3rd fortnight sampling all the growth parameters showed significant difference among the treatment. Significantly higher final weight (416.67±13.61 g), weight gain (147.33±17.04 g), % weight gain (54.78±7.19 %), ADG (9.82±1.14 g) and SGR (2.91±0.31 %/day) were recorded at treatment T_1. At 4th fortnight sampling period, significant difference was only observed for final weight, weight gain and ADG, whereas significantly higher final weight (780.67±11.15 g), weight gain (364.00±16.52 g) and ADG (24.26±1.10 g) were recorded at T_1 and the lowest at

T_3 (714.33±9.71 g, 319.00±15.59 g and 21.27±1.04 g, respectively). However, there was insignificant differences in all the growth parameters were observed at 5th fortnight sampling period. Gradual increment in final weight of pangas at different fortnight sampling period is shown in Figure 5.5.

Overall growth performance of pangas feed floating pellet feed at different treatment is shown in Table 5.17. Stocked fish were uniform in initial weight and initial length, as there are no significant differences among the treatments. After the culture period, significant differences were observed among the treatments, whereas the highest final weight and length were recorded at treatment T_1 and the lowest at treatment T_3. Weight gain was also varied significantly among the treatments with the highest value at treatment T_1 and the lowest at treatment T_3. However, variation of length gain among the treatments was insignificant. Furthermore, % weight gain and % length gain were not varied significantly among the treatments. ADG of weight was significantly higher at treatment T_1 and the lowest at treatment T_3, while ADG of length was not varied significantly among the treatments. SGR of weight and length was not varied significantly among the treatments. During the study period, FCR was not varied significantly among the treatments. Fish were found to survive better at treatment T_1 and the highest mortality was recorded at treatment T_3. At the end of the study period, significantly higher gross productions were observed at treatment T_1 (62.89±0.25 t/ha) and the lowest at treatment T_3 (58.38±1.27 t/ha).

Table 5.12 Growth performances of fish at different treatment during 1st fortnight sampling fed with floating pellet feed

Parameters	Treatments T_1	T_2	T_3	F-value	P-value
Initial weight (g)	103.00±1.00^a	104.00±1.00^a	101.33±1.53^a	3.77	0.19
Final weight (g)	175.00±10.00^a	182.67±6.81^a	178.33±12.34^a	0.45	0.66
Weight gain (g)	72.00±11.00^a	78.67±6.11^a	77.00±11.14^a	0.38	0.70
% weight gain	69.97±11.36^a	75.62±5.46^a	75.92±10.07^a	0.39	0.69
ADG (g)	4.80±0.73^a	5.24±0.41^a	5.13±0.74^a	0.39	0.70
SGR (%/day)	3.53±0.45^a	3.75±0.21^a	3.76±0.38^a	0.40	0.69

Figures in the same row having similar superscript letter indicates no significant difference (P > 0.05). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.13 Growth performances of fish at different treatment during 2nd fortnight sampling fed with floating pellet feed

Parameters	Treatments T_1	T_2	T_3	F-value	P-value
Initial weight (g)	175.00±10.00^a	182.67±6.81^a	178.33±12.34^a	0.45	0.66
Final weight (g)	269.33±5.13^b	285.33±9.07^a	266.00±8.54^b	5.29	0.05
Weight gain (g)	94.33±12.50^a	102.67±7.02^a	87.67±4.04^a	2.29	0.18
% weight gain	54.27±9.91^a	56.27±4.55^a	49.41±5.46^a	0.75	0.51
ADG (g)	6.29±0.84^a	6.84±0.47^a	5.84±0.27^a	2.28	0.18
SGR (%/day)	2.88±0.43^a	2.97±0.20^a	2.68±0.24^a	0.73	0.52

Figures in the same row having similar superscript letter indicates no significant difference (P > 0.05). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.14 Growth performances of fish at different treatment during 3rd fortnight sampling fed with floating pellet feed

Parameters	Treatments				
	T_1	T_2	T_3	F-value	P-value
Initial weight (g)	269.33±5.13^{b}	285.33±9.07^{a}	266.00±8.54^{b}	5.29	0.05
Final weight (g)	416.67±13.61^{a}	402.00±12.49^{a}	395.33±7.02^{b}	2.74	0.04
Weight gain (g)	147.33±17.04^{a}	116.67±5.51^{b}	129.33±2.08^{ab}	6.58	0.03
% weight gain	54.78±7.19^{a}	40.90±1.80^{b}	48.67±2.21^{ab}	7.29	0.03
ADG (g)	9.82±1.14^{a}	7.78±0.37^{b}	8.62±0.14^{ab}	6.59	0.03
SGR (%/day)	2.91±0.31^{a}	2.29±0.08^{b}	2.64±0.10^{ab}	8.02	0.02

Figures in the same row having similar superscript letter indicates no significant difference (P > 0.05). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.15 Growth performances of fish at different treatment during 4th fortnight sampling fed with floating pellet feed

Parameters	Treatments				
	T_1	T_2	T_3	F-value	P-value
Initial weight (g)	416.67±13.61^{a}	402.00±12.49^{a}	395.33±7.02^{a}	2.74	0.14
Final weight (g)	780.67±11.15^{a}	740.00±14.11^{b}	714.33±9.71^{c}	24.11	0.00
Weight gain (g)	364.00±16.52^{a}	338.00±2.65^{ab}	319.00±15.59^{b}	8.78	0.02
% weight gain	87.48±6.38^{a}	84.13±2.36^{a}	80.75±5.32^{a}	1.37	0.32
ADG (g)	24.26±1.10^{a}	22.53±0.17^{ab}	21.27±1.04^{b}	8.75	0.02
SGR (%/day)	4.19±0.23^{a}	4.07±0.09^{a}	3.94±0.20^{a}	1.36	0.33

Figures in the same row having similar superscript letter indicates no significant difference (P > 0.05). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

Table 5.16 Growth performances of fish at different treatment during 5th fortnight sampling fed with floating pellet feed

Parameters	Treatments				
	T_1	T_2	T_3	F-value	P-value
Initial weight (g)	780.67±11.15[a]	740.00±14.11[b]	714.33±9.71[c]	24.11	0.00
Final weight (g)	1081.00±5.29[a]	1037.00±7.55[b]	1010.00±12.17[c]	49.61	0.00
Weight gain (g)	300.33±14.50[a]	297.00±21.66[a]	295.67±20.11[a]	0.05	0.95
% weight gain	38.50±2.40[a]	40.18±3.71[a]	41.42±3.33[a]	0.63	0.56
ADG (g)	20.02±0.97[a]	19.80±1.44[a]	19.71±1.34[a]	0.05	0.95
SGR (%/day)	2.17±0.12[a]	2.25±0.18[a]	2.31±0.16[a]	0.65	0.56

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

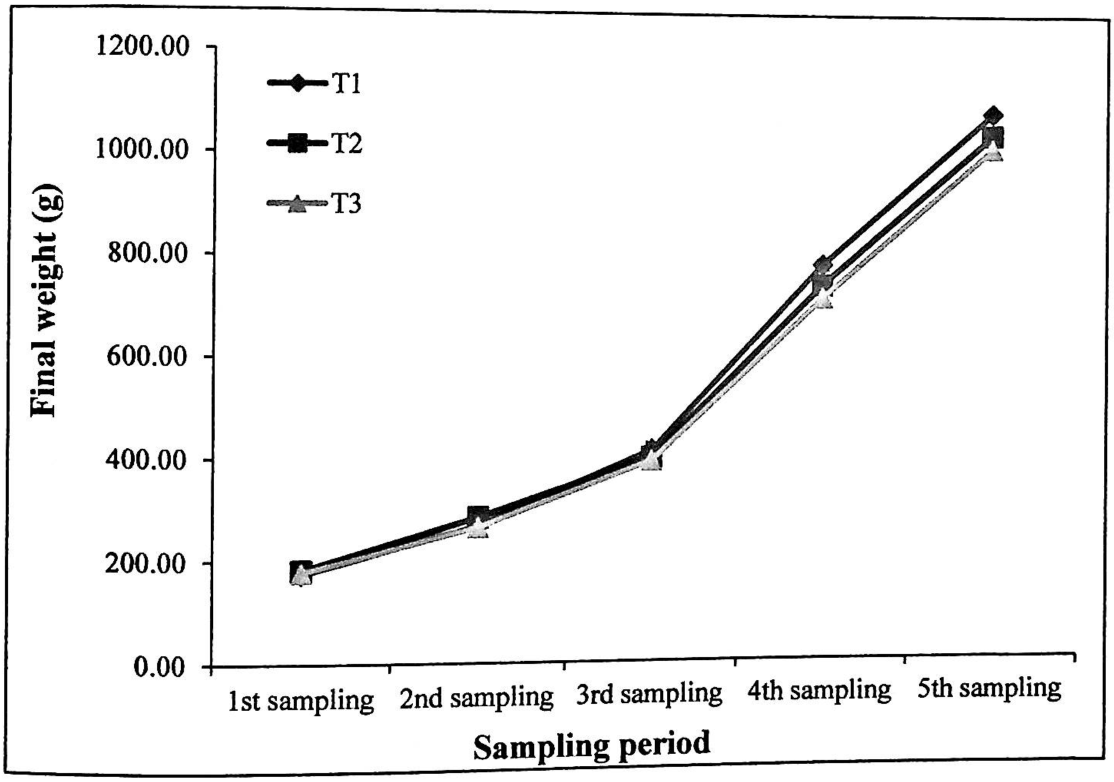

Figure 5.5 Fortnight values of final weight of pangas at different treatments fed with floating pellet feed

Table 5.17 Growth performances of fish at different treatments fed with floating pellet feed during the study period

Parameters	Treatment			F-value	P-value
	T_1	T_2	T_3		
Initial weight (g)	103.00±1.00^a	104.00±1.00^a	101.33±1.53^a	3.77	0.19
Final weight (g)	1303.67±7.57^a	1260.56±9.99^b	1235.43±32.51^b	8.83	0.02
Initial length (cm)	12.00±2.00^a	11.67±0.58^a	11.00±1.00^a	0.44	0.67
Final length (cm)	36.73±1.25^a	34.10±1.71^{ab}	33.12±1.55^b	4.56	0.06
Weight gain (g)	1200.67±7.29^a	1156.56±10.99^b	1134.10±32.84^b	8.24	0.02
Length gain (cm)	24.73±2.82^a	22.43±1.93^a	22.12±1.44^a	1.33	0.33
% Weight gain	1165.76±12.06^a	1112.22±21.26^a	1119.42±40.25^a	3.43	0.10
% Length gain	212.41±56.83^a	192.90±23.25^a	202.43±26.15^a	0.19	0.83
ADG_W (g)	13.34±0.08^a	12.85±0.12^b	12.60±0.36^b	8.42	0.02
ADG_L (g)	0.28±0.03^a	0.25±0.02^a	0.25±0.02^a	1.50	0.30
SGR_W (%/day)	2.82±0.01^a	2.77±0.02^a	2.78±0.04^a	3.31	0.11
SGR_L (%/day)	1.25±0.21^a	1.19±0.09^a	1.23±0.10^a	0.13	0.88
FCR	1.20±0.10^a	1.23±0.06^a	1.20±0.10^a	0.14	0.87
Survival rate (%)	97.67±0.58^a	96.33±0.58^a	95.67±0.58^a	9.33	0.09
Gross production (t/ha)	62.89±0.25^a	59.99±0.81^b	58.38±1.27^b	20.12	0.00

Figures in the same row having similar superscript letter indicates no significant difference ($P > 0.05$). T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, ADG = Average daily gain, SGR = Specific growth rate.

5.3.2.3 Economics

Economics of the experiment using floating pellet feed is shown in Table 5.18. Lease value, pond preparation cost, seed cost harvesting and marketing cost and labour cost were fixed for all the treatments. However, significantly higher feed cost was recorded at treatment T_2 (BDT 2599493.91) and the lowest at treatment T_1 (BDT 2371530.02). Furthermore, significantly higher total cost was recorded at treatment T_2 (BDT 2999343.90) and the lowest at treatment T_1 (BDT 2771380.01). Income from fish sale was varied significantly among the treatments, whereas significantly higher gross return was recorded at treatment T_1 (BDT 5660775.25) followed by T_2 (BDT 5174136.64) and T_3 (BDT 5035351.51). As a result, higher benefit-cost ratio was obtained from treatment T_1 (2.04) followed by T_2 (1.73) and T_3 (1.72).

Table 5.18 Economic analysis of Thai pangas culture with floating pellet feed

Cost items		Treatment			F-value	P-value
		T_1	T_2	T_3		
[1]Lease value		40000.00	40000.00	40000.00	-	-
[2]Pond preparation		40500.00	40500.00	40500.00	-	-
Seed cost		259350.00	259350.00	259350.00	-	-
Feed cost	Starter	455831.49^b	478671.48^a	486570.24^a	24.25	0.00
	Grower	1915698.53^b	2120822.43^a	2036525.87^a	9.94	0.01
	Total	2371530.02^b	2599493.91^a	2523096.11^a		
Harvesting and marketing		30000	30000	30000	-	-
Labour cost		30000	30000	30000	-	-
Total cost		2771380.01^b	2999343.90^a	2922946.11^a	10.93	0.01
Gross return (fish sales)		5660775.25^a	5174136.64^b	5035351.51^c	55.53	0.00
Benefit-cost ratio (BCR)		2.04^a	1.73^b	1.72^b	49.07	0.00

[1]Lease value = For 5 months lease period
[2]Pond preparation = pond repairing, Removal of predatory fish, liming, fertilization and disinfection of pond

5.4 Discussion

The water quality parameters measured in both the feeding trials were found more or less similar and all of them were within the acceptable, as recommended for tropical aquaculture (Boyd 1982). In feeding trial one with sinking pellet feed, water temperature ranged between 30.41±1.61°C to 30.47±1.64°C, while in feeding trial two with floating pellet feed, water temperature was ranged between 30.17±1.09°C to 30.44±1.63°C which is within the range of water temperature recorded for Thai pangas culture pond by Shah et al. (2014) and Uddin (2002). Feeding trial with sinking feed showed the transparency ranged between 15.72±1.64 cm to 16.19±1.79 cm and in feeding with floating feed was ranged between 25.12±2.98 cm to 25.92±3.51 cm. In both of the feeding trials, transparency was not varied significantly among the treatments. Variations in water depth in the two feeding trials were also insignificant among the treatments. Although, pH was insignificant among the treatments, in feeding trial with sinking pellet feed it ranged between 7.16±0.50 to 7.47±0.59, and in feeding trial with floating pellet feed it was varied between 7.25±0.48 to 7.43±0.40. The range of pH during the present study was suitable for Thai pangas culture, and it almost similar to the findings of previous researcher (Shah et al. 2014; Akter et al. 2009 and Hoq et al. 1996). Dissolved oxygen was also found suitable for Thai pangas culture and it ranged between 5.34±0.61 mg/l to 5.86±0.97 mg/l in feeding trial with sinking pellet feed and 5.70±0.75 mg/l to 5.86±0.69 mg/l in feeding trial with floating pellet feed which was similar to the finding of Shah et al. (2014), Ahmed et al. (2013) and Ahmed et al. (2009). Difference in NH_3 content of water was insignificant among the treatments in feeding trial with sinking pellet feed, while it was significant in feeding trial with floating pellet feed, which might be due the effect of formulation of pellet feed, whereas fish fed with floating pellet feed excreted higher amount of NH_3 in water. However, increased level of NH_3 did not exerted any significant effect on cultured Thai pangas as it is within the range reported in the Thai pangas polyculture ponds (0 to 0.6 mg/l) reported by Ahmed et al. (2013).

Growth performance and economics of Thai pangus using different formulations of sinking and floating pellet feeds were investigated for a period of three months. In the both feeding trials, significant effect of feed formulation was observed on growth of Thai pangas. Final weight showed a significant difference among the treatments fed with sinking pellet feed with the highest value was recorded at treatment T_2 (1137.34±32.11 g) and the lowest at treatment T_1 (1051.29±5.47 g). However, in feeding trial with floating pellet feed, significantly higher final weight was obtained at treatment T_1 (1303.67±7.57 g) and the lowest at treatment T_3 (1235.43±32.51 g), which indicated comparatively better performance of floating pellet feed over sinking pellet feed. Furthermore, weight gain of Thai pangas fed sinking pellet feed was ranged between 948.95±6.65 g (T_1) to 1032.34±35.34 (T_2) was comparatively lower than the floating pellet feed fed groups at feeding trial two which was ranged between 1134.10±32.84 g (T_3) to 1200.67±7.29 g. Therefore, floating feed formulation was proved better than the sinking pellet feed for growth performance of pangas. Cremer et al. (2002) initiated average weight gain of pangus was 6.88 g in two earthen ponds and Sayeed et al. (2008) recorded 2.80, 2.56 and 2.64 g average weight gain at an 11 months feeding trial using three supplementary feeds in nine rectangular shaped earthen culture ponds, which are definitely lower than the result of the present experiment. Comparatively higher weight gain in the present study might be due to the use of larger initial weight and improved feed formulation and feeding practice of fish. During the study period, in both of the feeding trials with sinking and floating feed, SGR of weight and length was not varied significantly among the treatments. However, SGR of weight in feeding trial with sinking pellet feed ranged between 2.59±0.03 %/day to 2.60±0.03 %/day and 2.77±0.02 %/day to 2.82±0.01 %/day. Present findings was much higher than the SGR of Thai pangas reported by Shah et al. (2014) and Razzaque et al. (2008) who reported SGR ranged between 0.65 %/day to 1.13 %/day. However, the present findings is similar to the findings of Khan et al. (2009) who reported SGR of Thai pangas ranged between 2.46 %/day to 2.71%/day cultured for a 135 days in ponds.

During the study period, FCR in both of the feeding trial was not varied significantly among the treatment. However, ranges of FCR (1.57±0.06 to 1.70±0.04) feeding trial with sinking pellet feed was inferior compared to FCR (1.20±0.10 to 1.23±0.06) in feeding trial with floating pellet feed, which indicated better utilization of floating pellet feed compared to sinking pellet feed by Thai pangas. Among the three formulation of feed, formulation one at treatment T_1 was found for better FCR of Thai pangas culture. Shah et al. (2014) also reported better FCR for formulated feed compared to commercial packet feed in their experiment on Thi pangas. However, FCR recorded in the floating feed fed group was lower than the findings of Amin et al. (2005) and Halder and Jahan (2001) who reported FCR of pangas culture 1.65 and 2.96-3.09, respectively. Survival rate was not varied among the treatment in the two experimental feeding groups. However, floating pellet feed (95.67±0.58 % to 97.67±0.58 %) showed better survival compared to sinking pellet feed (93.33±1.53 % to 95.00±1.00 %). Better survival with floating feed was also reported by Ahmed et al. (2013) who reported a survival rate ranged 96.17 % to 97.78 %. Sayeed et al. (2008) found the survival rates of Thai pangus were 94 to 97% in nine earthen ponds with a period of 11 months. The survival rate of Thai pangus was about 94% to 96% in polyculture of *Pangsius sutchi* with carps in a fish farm reported by Maniruzzaman (2001).

Among the formulation of sinking pellet feed, significantly higher gross production was recorded at treatment T_2 (40.02±0.76 t/ha) and among the formulation of floating pellet feed treatment T_1 (62.89±0.25 t/ha) showed higher gross production. Along with significantly higher feed cost, total cost was also recorded higher at treatment T_3 (BDT 2839109.37) for sinking pellet feed fed feeding trial. However, significantly higher gross return from fish sales was obtained from treatment T_3 (BDT 3802303.80), and therefore, BCR was also recorded higher from treatment T_2 (1.64). On the other hand, in feeding trial two with floating pellet feed, significantly higher total cost was recorded at treatment T_2 (BDT 2999343.90) and the gross return from fish sales from treatment T

(5660775.25). Moreover, significantly higher BCR was obtained from treatment T_1 (2.04). Therefore, it is evident that formulation process of floating pellet feed at treatment T_1 provided better economic return compared to its subsequent treatments and sinking pellet feed group.

5.5 Conclusion

In conclusion it can be said that the utilization of the prepared floating feed can be used as an important means for better growth, production and economic performance of Thai pangas culture in Bangladesh. The results showed that farmers have the scope to increase fish production and quality pangas by using economically efficient floating feed formulation used at treatment T_1. These results encourage feed manufacturers and Thai pangas farmers to continue on improving the floating diets that are mostly produced on-farms.

Chapter Six

Summary and Conclusion

Thai pangas (*Pangasius sutchi*) is an economically important species to Bangladeshi aquaculture. It has a huge range of qualities that make it a suitable candidate for aquaculture. It is particularly important for their fast growth, year round production and high productivity. In recent years, economic benefit from this farming is being depleted partly due to increasing feed cost, lack of proper management, unavailability of low cost supplementary feeds and some socio-economic constraints. As a result, farmers are gradually losing their interest to invest in Thai pangasius farming in Bangladesh. Under the above circulstance the present study was designed to evaluate the existing farming practices in some selected areas of Bangladesh to find out the present constraint and their possible solutions.

In the first experiment, existing condition of pangas farming was evaluated from six upazila of four districts, namely Jikorgacha and Monirumpur Upazila from Jessore district, Sujanagar and Kashinathpur Upazila from Pabna district, Bogura sadar Upazila from Bogura district and Trishal upazila from Mymensing district. Study revealed that most of the pangas farmers were within the age group of 31-40 and majority of the farmers had the farming experience of 6-10 years (38.33%). Responded farmers of the study area were mostly educated with 38% had higher secondary and 25% had primary level of education. Pangas farmers were economically developed with majority (45%) of the farmers had Paka house. Furthermore, majority of the farmers (78%) were within the income category of BDT 25-35 lac per year. Farmers were mostly holding their possession for medium sized farm (54.17%) with the less number with large farm holder (19.17%). However, majority of the farmer's culture fish in leased pond (48%). 92% of the respondent farmers were found to follow polyculture method in their pond, while only 8% were found practicing monoculture of pangas. Water quality parameters of the studied ponds were within the suitable range for pangas farming with the average temperature 25.52±0.52 °C, pH 7.24±0.17, dissolved oxygen 5.28±0.19 mg/l, NH_3-N 0.18±0.04 mg/l, NO_3-N 0.26±0.03 mg/l, and PO_4-P 1.09±0.12 mg/l. Most of the study locations had the loamy soil structure (65%), while 26% of the ponds had Sandy loamy soil and 9% had silt loamy soil structure. Majority of the ponds had average annual water depth of 1.51-2 m range (68%) and no any ponds with less than 1 m water depth was noted. Farmers were regularly fertilize their ponds with Urea and TSP. They also used rotenone for the removal of unwanted aquatic weeds. Pangas farmers were found to maintain the stocking density from 9854 to 18410 nos./ha. Majority (65%) of the farmers were found to use commercial feed, while a small number of farmers were found to use home-made feed (13%) in their ponds. In the present study, the average production of Pangas was 37.50 t/ha along with carps and tilapia was 3.50 t/ha. Study showed lower FCR for commercial feed compared to home-made feed. FCR of commercial feed was found to ranging from 1.96 to 2.20. Overall, 83% pangas ponds surveyed had CBR within 1.0-2.0, 14% less than 1.0 and only 3% had greater than 2.0. In the present study, major problems were identified as lack of quality feed and their higher market price.

In the second experiment, feed formulation was practiced with locally available fish feed ingredients to reduce the feed cost and improve the FCR and CBR of Pangas farming. Using nine raw materials and seven feed additives, four diets (8 formulas) were prepared which consist of two types of sinking and two types of floating feeds each having both starter and grower graded feed. Sinking pellets were 2.0-3.0 mm in diameter and 4-7 mm in length and the floating pellets were 2.0-3.0 mm in diameter. Production cost of these two types of feeds was evaluated whereas the price of sinking starter was BDT 36.17 and 38.32; the growers were BDT 34.50 and 36.39. Furthermore, production cost of floating starter was BDT 44.24 and 46.01; and the grower was BDT 40.95 and 43.39.

Protein content ranged from 27.42 to 30.55% in sinking pellet feed and 27.95 to 30.85% in floating pellet feed. Lipid content was ranged from 9.26 to 9.45% in sinking pellet feed and 9.15 to 9.53% in floating feed.

In the third experiment, the formulated sinking and floating feeds were evaluated for their performance in pangas farming comparing with commercial pellet feed. The study was conducted in Jikorgacha Upazila of Jessore district for a period of 4 months from April to July 2016. Among the formulation of sinking pellet feed, significantly higher gross production was recorded at treatment T_2 (40.02±0.76 t/ha) and among the formulation of floating pellet feed treatment T_1 (62.89±0.25 t/ha) showed higher gross production. Along with significantly higher feed cost, total cost was also recorded higher at treatment T_3 (BDT 2839109.37) for sinking pellet feed fed feeding trial. However, significantly higher gross return from fish sales was obtained from treatment T_3 (BDT 3802303.80), and therefore, BCR was also recorded higher from treatment T_2 (1.64). On the other hand, in feeding trial two with floating pellet feed, significantly higher total cost was recorded at treatment T_2 (BDT 2999343.90) and the gross return from fish sales from treatment T_1 (5660775.25). Moreover, significantly higher BCR was obtained from treatment T_1 (2.04). Therefore, it is evident that formulation process of floating pellet feed at treatment T_1 provided better economic return compared to its subsequent treatments and sinking pellet feed groups.

References

Aas, T.S., Sixten, H.J., Hillestad, M., Ytrestøyl, T., Harald, S., Åsgård, T., 2020. Feed intake, nutrient digestibility and nutrient retention in Atlantic salmon (*Salmo salar* L.) fed diets with different physical pellet quality. J. Fish. 8(2), 768-776.

Adeparusi, E.O., Famurewa, J.A., 2011. Water temperature and surface coating effect on floatability, water absorption and thickness swelling of feed. J. Agri. Sci. 3(4), 254-260.

Adewumi, A.A., Olaleye, V.F., 2011. Catfish culture in Nigeria: Progress, prospects and problems. Afr. J. Agri. Res. 6(6), 1281-1285.

Ahmed, G.U., Chakma, A., Shamsuddin, M., Minar, M. H., Islam, T., Majumdar, M.Z., 2013. Growth performance of Thai pangas (*Pangasianodon hypophthalmus*) using prepared and commercial feed. Int. J. Life Sci. Biotechnol. Phar. Res. 2(3), 93-102.

Ahmed, G.U., Hossain, M.M., Hossain, M.S., 2009. Histopathology of disease of an air breathing teleost *Anabas testudineus* (Bloch) from freshwater fisheries of Bangladesh, Int. J. Sustain. Agril. Tech. 5(4), 75-81.

Ahmed, N., Alam, M.F., Hasan, M.R., 2010. The economics of sutchi catfish (*Pangasianodon hypophthalmus*) aquaculture under three different farming systems in rural Bangladesh. Aquacult. Res. 41, 1668-1682.

Aktar, S.S., Khan, M.A., Haque, M.M. P., Mukta, M.A., 2018. Farm size, productivity and efficiency nexus: The case of pangas fish farming in Bangladesh. J. Bangladesh Agri. Univ. 16(3), 513–522.

Akter, M.N., Ahmed, G.U., Hossain, M.S., 2009. Seasonal variation of gill pathology of a climbing perch in lake fisheries of Bangladesh. Int. J. Anim. Fish. Sci. 2(3), 208-213.

Akter, N., 2001. An economic analysis of pond pangas fish production in a selected are of *Trishal upazilla* in Mymensingh district. MS Thesis. Department of Agriculture Economics, BAU, Mymensingh, 44.

Alam, F., 2011. Measuring technical, allocative and cost efficiency of pangas fish farmers of Bangladesh. Aquacult. Res. 42(10), 1487-1500.

Ali, H., 2009. Assessment of stakeholders' perceptions on Pangasius Aquaculture Dialogue (PAD) standards in two villages, Mymensingh, Bangladesh. MS thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Ali, H., Haque, M.M., Belton, B., 2013. Striped catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878) aquaculture in Bangladesh: an overview. Aquacult. Res. 44, 950-965.

Ali, H., Rahman, M.M., Murshed-e-Jahan, K., Dhar, G.C., 2018. Production economics of striped catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878) farming under polyculture system in Bangladesh. Aquacult. 491, 381–390.

Almaraaj, S., 2015. Extruded floating fish feed, a Boost for Farmers. Retrieved Online: http://www.thehindu.scitech/agriculture.

Amin, A.K.M.R., Bapary, M.A.J., Islam, M.S., Shahjahan, M., Hossain, M.A.R., 2005. The impacts of compensatory growth on food intake, growth rate and efficiency of feed utilization in Thai Pangas (*Pangasius hypophthalmus*)", Pak. J. Biol. Sci. 8(5), 766-770.

Amin, A.K.M.R., Islam, M.A., Kader, M.A., Bulbu, M., Hossain, M.A.R., Azim, M.E., 2012. Production performance of sutchi catfish *Pangasianodon hypophthalmus* S. in restricted feeding regime: effects on gut, liver and meat quality. Aquacult. Res. 43, 621-627.

AOAC, 1980. Official methods of analysis. 13th edition. Association of Official Analytical Chemist. Wasington DC, USA, 56-32 pp.

AOAC. 2005. (Association of Official Analytical Chemists) International Official Methods of Analysis of AOAC International, 18th Edition. Gaithersburg, Maryland, USA, AOAC International.

Asaduzzaman, M.A., Wahab, M.C.J., Verdegem, R.K., Adhikary, S.M.S., Rahman M.E., Azim, J.A.J., 2010. Effects of carbohydrate source for maintaining a high C:N ratio and fish driven re-suspension on pond ecology and production in periphyton-based freshwater prawn culture systems. Aquacult. 301, 37-46.

Asif, A.A., Samad, M.A., Rahman, B.M.S., Rahman, M.A., Rahman, M.H., Yeasmin, S.M., et al., 2014. Study on management of fish fry and fingerling marketing of Jessore in Bangladesh. Int. J. Busin. Social. Sci. Res. 2, 127-135.

Begum, M, Akhter, T., Minar, M.H., 2012. Analysis of the proximate composition of domesticated Pangus (*Pangasius hypophthalamus*) in laboratory condition. J. Environ. Sci. Nat. Resour. 5(1), 69-74.

Belton, B., Azad, A., 2012. The characteristics and status of pond aquaculture in Bangladesh. Aquacult. 358–359, 196–204.

Belton, B., Haque, M.M., Little, D.C., 2012. Does size matter? reassessing the relationship between aquaculture and poverty in Bangladesh. J. Dev. Stud. 48, 1-19.

Belton, B., Karim, M., Thilsted, S., Jahan, K.M., Collis, W., Phillips, M., 2011. Review of aquaculture and fish consumption in Bangladesh. Stud. Rev. 53. The WorldFish Center, Penang.

Bhilave, M.P., 2018. Evaluation of nutritional parameters of feed formulated from Soyabean. Int. J. Fish. Aqua. Stud. 6(1), 166-169.

Bhosale, S.V., Bhilave, M.P., Nadaf, S.B., 2010. Formulation of fish feed using ingredients from plant sources. Res. J. Agri. Sci. 1(3), 284-287.

Boyd, C.E., 1982. Water quality parameters for fish culture, Elsevier Science Publishers, Amsterdam, The Netherlands. pp. 318.

Boyd, C.E., Tucker, C.S., 1998. Pond Aquaculture Water Quality Management. Kluwer, Norwell, Massachusetts.

Castell, J.D., Tiews, K. (eds.)., 1980. Report of the EIFAC, IUNS and ICES working group on the standardization of methodology in fish nutrition research, Hamburg, Federal Republic of Germany, 21- 23 March, 1979, EIFAC Tech. Paper. 26 p.

Chowdhury, A.A., Uddin, M.S., Vaumik, S., Asif, A.A. 2015. Aqua drugs and chemicals used in aquaculture of Zakigonj upazilla, Sylhet, Asian J. Med. Biol. Res. 1, 336-349.

Chowdhury, M.A., Roy, N.C., Chowdhury, A., 2020. Growth, yield and economic returns of striped catfish (*Pangasianodon hypophthalmus*) at different stocking densities under floodplain cage culture system. Egyptian J. Aqua. Res. 46, 91–95.

Craig, S., 2009. Understanding Fish Nutrition, Feeds, and Feeding. Virginia Cooperative Extension. publication 420-256. Web site: http://pubs.ext.vt.edu/420/420-256/420-256.html.

Craig, S., Helfrich, L.A., 2002. Understanding Fish Nutrition, Feeds and Feeding, Cooperative Extension Service, publication 420-256. Virginia State University, USA.

Crampton, E.W., Harris, L.E., 1969. Applied animal nutrition, 2nd edition, Freeman and Co.., San Francisco, 50p.

Cremer, M.C., Jian, Z., Enhua, Z., 2002. Pangasius catfish production in ponds with soy-based feeds. American Soybean Association, http://www.soyaqua.org/pdf2/ 02 PangasiusTRHainan.pdf

Debnath, C., Sahoo, L., Debnath, B., Yadav, G.S., 2019. Effect of supplementary feeding on growth responses of endangered Indian butter catfish (*Ompok bimaculatus*) in polyculture. Indian J. Anim. Res. 53(1), 84-88.

Devenport, J., 2003. Aquaculture. Blackwell Science Ltd., Oxford.

DOF (Department of Fisheries). 2017. National Fish Week Compendium (in Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh. 126-131 pp.

DOF (Department of Fisheries). 2020. National Fish Week Compendium (in Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh. 128-130 pp.

Duncan, D.B., 1955. Multiple range and multiple F-Tests. Biometri. 11, 1-42.

FRSS 2016 Yearbook of Fisheries Statistics of Bangladesh. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh. Volume 33: 124p.

FRSS 2020 Yearbook of Fisheries Statistics of Bangladesh. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh. Volume 37: 129 p.

Gomez, K.A., Gomez, A.A., 1984. Statistcal Procedures for Agricultural Research. 2nd ed. John Wiley and Sons. New York, 640 pp.

Haldar, G.C., Jahan, D.A., 2001. Polyculture of pangus with carp at low density in a farmer's pond", *Final Report On Post Flood Rehabilitation and Adaptive Research Support Project*" Bangladesh Fisheries Research Institute, Chandpur and Bangladesh Agricultural Research Council, Dhaka, pp. 66-74.

Hassan, A., Ambak, M.A., Samad, A.P.A., 2011. Crossbreeding of *Pangasianodon hypophthalmus* (Sauvage, 1878) and *Pangasius nasutus* (Bleeker, 1863) and their larval development. J. Sustain. Sci. Manag. 6(1), 28-35.

Hoq, M.E., Islam, M.M., Hossain, M.M., 1996. Polyculture of freshwater prawn (*Macrobracium rosenbergii*) with chinese and Indian carps in farmer's pond. J. Aquacult. 57, 135-141.

Hugues, deV., Komen, H., Quillet, E., Chatain, B., Allal, F., Benzie, J.A.H., Vandeputte, M., 2018. Improving feed efficiency in fish using selective breeding: a review. Aquacult. 10(4), 833-851.

Hung, L.T., Truc, L.T.T., Huy, H.P.V., 2007. Case study on the use of farm-made feeds and commercially formulated pellets for pangasiid cat¢sh culture in the Mekong Delta, Vietnam. In: Study and Analysis of Feeds and Fertilizers for Sustainable Aquaculture Development, FAO Fisheries Technical Paper 497 (ed. by M.R. Hasan, T. Hecht, S.S. De Silva & A.G.J. Tacon), pp. 363–377. Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.

Jacobs, M.B., 1973. The chemical Analysis of Feeds & Foods production. 3rd dition, Kriegar, New York, USA, pp 31-44.

Kader, M.A., Hossain, M.A., Hossain, M.D., 2013. A comparative study on the effect of commercial fish feeds on the growth of Thai pangas, *Pangasius hypophthalmus*. Bangladesh J. Fish. Res. 7(1), 53-58.

Kaliba, A.R., Osewe, K.O., Senkondo, E.M., Menmbuka, B.V., Quagrainie, K.K., 2006. Economic analysis of nile tilapia (*Oreochromis niloticus*) production in Tanzania. J. World Aquacult. Socie. 37, 464-473.

Kausari, M.M.T., 2001. An economic study of pangas fish culture in selected area of Mymensingh and Jamapur district. MS Thesis. Department of Agricultural Economics, BAU, Mymensingh, 2001, 89.

Khan, S., Hossain, M.S., Haque, M.M., 2009. Effects of feeding schedule on growth, production and economics of Pangasiid catfish (*Pangasius hypophthalmus*) and silver carp (*Hypophthalmichthys molitrix*) polyculture. J. Bangladesh Agril. Univ. 7(1), 175-181.

Kristiansen, T.S., Fernö, A., 2007. Individual behaviour and growth of halibut (*Hippoglossus hippoglossus* L.) fed sinking and floating feed: Evidence of different coping styles. Appl. Anim. Behav. Sci. 104(3), 236-250.

Lazu, M.A.A., Sumi, K.R., Das, M., Ali, M.L., Sharker, M.R., 2013. Proximate composition of different Thai pangus feed (*Pangasius hypophthalmus*) available in Mymensingh region. Bangladesh J. Environ. Sci. 25, 34-38.

Lefevre, S., Huong, D.T.T., Ha, N.T.K., Wang, T., Phuong, N.T., Bayley, M., 2011b. A telemetry study of swimming depth and oxygen level in a Pangasius pond in the Mekong Delta. Aquacult. 315, 410-413.

Lefevre, S., Huong, D.T.T., Wang, T., Phuong, N.T., Bayley, M., 2011a. Hypoxia tolerance and partitioning of bimodal respiration in the striped catfish (*Pangasianodon hypophthalmus*). Compar. Biochem. Physiol. Part A. 158, 207-214.

Limbu, S.M., Jumanne, K., 2014. Effect of restricted and re-feeding regime on feeding cost, growth performance, feed utilization and survival rate of mixed sex Nile tilapia *Oreochromis niloticus* cultured in tanks. Int. J. Fish. Aqua. Stud. 2(1), 118-123.

Lovell, R.T., 1975. Laboratory manual for fish feed analysis and fish nutrition studies. Album University. 1-2 pp.

Malik, A., Kalhoro, H., Shah, S.A., Kalhoro, I.B., 2014. The effect of different stocking densities on growth, production and survival rate of pangas (*Pangasius hypophthalmus*) fish in cemented tanks at fish hatchery Chilya Thatta, Sindh-Pakistan. Int. J. Interdis. Multidis. Stud. 1(10), 129-136.

Mamun-Ur-Rashid, M., Belton, B., Phillips, M., Rosentrater, K.A., 2013. Improving aquaculture feed in Bangladesh: From feed ingredients to farmer profit to safe consumption. World Fish, Penang, Malaysia. Working Paper: 2013-34.

Maniruzzaman, M., 2001. Polyculture of *Pangsius sutchi* with carps at a fish farm of Saleque Enterprize, Namopara, Rajshahi", MS Thesis, Department of Fisheries, RU, Rajshahi, pp 49.

Maynard, J., 1970. Methods in food Analysis. 2nd Edition. Academic press, new York, 109-118/143-155 pp.

Miah, A.A., 2001. An economic study on alternative Pangasiid catfish Farming in Mymensingh areas of Bangladeh. MS Thesis. Department of Agricultural Economics, BAU, Mymensingh, 2001, 75.

Momoh, A.T., Abubakar, M.Y., Ipinjolu, J.K., 2016. Effect of ingredients substitution on binding, water stability and floatation of farm-made fish feed. Int. J. Fish. Aqua. Stud. 4(3), 92-97.

Monir, M.S., Haque, M.R., Rahman, S., 2011. Study on technical aspects of Pangasius *Pangasianodon hypophthalmus* farming in Mymensingh region. Int. J. Sustain. Crop Prod. 6, 36-42.

Orire, A.M., Sadiku, S.O.E., 2011. Protein sparing effects of lipids in the practical diets of *Oreochromis niloticus* (Nile tilapia). Nigerian J. Basic Appl. Sci., 19(1), 142-150.

Patwary, Y.A., Sarker, B.S., Hossain, M.B., Minar, M.H., Shamsuddin, M., 2013. Study of mechanical effects on the quality of fish feed during different stages of manufacturing. Pak. J. Biol. Sci. 16(17), 865-870.

Pearson, D. 1977. The Chemical Analysis of Foods. 7th edition, Chemical Publishers Co., Newyork,pp 9-11

Pham, T.A.N., Miranda, P.M., Meuwissen, Le. C.T., Roel, H. Bosma, J.V., Lansink, A.O., 2016. Economic feasibility of recirculating aquaculture systems in pangasius farming, Aquacult. Econo. Manag. 20[illegible]

Phuong, N.T., Sinh, L.X., Thinh, N.Q., Chau, H.H., Anh, C.T., Hau, N.M., 2007. Economics of aquaculture feeding practices: Vietnam. In: Economics of Aquaculture Feeding Practices in Selected Asian Countries, FAO Fisheries Technical Paper 505 (ed. by M.R. Hasan), pp. 183–205. Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.

Rachmawati, D. and Prihanto, A.S.E.P. A. 2019. Effect of papain enzyme supplementation on growth performance and nutrient utilization of catfish (Pangasius hypopthalmus). Malays. Appl. Biol. 48(5), 1-10.

Rahman, M.A., Hossain, M.I., Shikha, F.H., 2019. Changes in the nutritional composition of fish pickle prepared from Thai pangus (*Pangasianodon hypophthalmus*) during longer storage at low temperature. J. Food Sci. Nutr. Res. 2(3), 299-308.

Ramakrishna, R., Shipton, T.A., Hasan, M.R., 2013. Feeding and feed management of Indian major carps in Andhra Pradesh, India. FAO Fisheries and Aquaculture Techni-cal Paper No. 578. FAO, Rome, Italy.

Razeim, M.A., Farouque, M.G., Sarker, M.A., Asif, A.A., Ahmed, M., 2017. Attitude of farmers towards Pangas farming for their livelihood improvement. Asian Australas. J. Biosci. Biotechnol. 2, 106-119.

Razzaque, M.A., Mazid, M.A., Islam, M.N., Mansur, M.A., 2008. Culture possibility of scheilbeid catfish using formulated feed in natural pond. J. Bangladesh Agril. Univ. 6(2), 375-380.

Samad, M.A., Nahiduzzaman, M., Ashrafuzzaman, M., Rashid, M.A., Akter, M., 2017. Culture of indigenous catfish Shingi, *Heteropneustes fossilis* (Bloch, 1794), with available low cost formulated feed in earthen ponds of Bangladesh. J. Coastal Life Medi. 5(7), 288-292.

Sarker, M.T., 2000. *Pangus Chash Babosthapana (Management of Pangus culture)*", Department of Fisheries, Bangladesh, p. 25.

Sayeed, M.A.B., Hossain, G.S., Mistry, S.K., Huq, K.A., 2008. Growth performance of Thai Pangus (*Pangasius hypophthalmus*) in polyculture system using different supplementary feeds. Rajshahi Univ. J. Zool. 27, 59-62.

Shah, S. A., Malik, A., Kalhoro, H., Kalhoro, I. B., Wadhar, G. M., Maher, G. M., 2014. Growth performance of exotic catfish Pangas, *Pangasius hypophthalmus* (Sauvage, 1878) at Fish Hatchery Chilya Thatta, Sindh, Pakistan. Sindh University Res. J. (Sci. Series). 46(2), 205-208.

Sharif, B.M.N., Asif, A.A., 2015. A present status of fish hatchlings and fry production management in greater Jessore, Bangladesh. Int. J. Fish. Aquat. Stud. 2, 123-127.

Silva, Q., 2002. Análise de alimentos:Métodos químicos e biológicos. Editora Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil

Sku, S., Lupa, S.T., Hossen, M.N., Kamal, M., 2019. Studies on effects of aquaboost and megavit on the growth performances of Thai Pangus (*Pangasius sutchi*) in pond condition. J. Pharm. Biol. Sci. 14(6), 11-16.

Sørensen, M., 2012. A review of the effects of ingredient composition and processing conditions on the physical qualities of extruded high-energy fish feed as measured by prevailing methods. Aquacult. Nutr. 18(3), 233-248.

Subagja, J., Slembrouck, J., Hung, L.T., Legendre, M., 1999. Larval rearing of Asian catfish *Pangasius hypophthalmus* (Siluroidei, Pangasiidae): Analysis of precocious mortality and proposition of appropriate treatments. Aqua. Living Resour. 12(1), 37-44.

Tacon, A.G.J., Hasaan, M.R., Metian, M., 2011. Demand of supply of feed ingredients for farmed fish and crustaceans: trends and prospects FAO Fisheries and Aquaculture technical paprer 564. FAO 2011. 87pp

Tacon, A.G.J., Metian, M., Hasan, M.R., 2009. Feed ingredients and fertilizers for farmed aquatic animals: sources and composition. FAO Fisheries and Aquaculture Technical Paper. No. 540. Romes, FAO. 2009. 209p.

Toufique, K.A., Belton, B., 2014. Is aquaculture pro-poor? Empirical evidence of impacts on fish consumption from Bangladesh. World Dev. 64, 609–620.

Uddin, M.A., 2002. Effect of addition of small fish on the pond ecology and the production in polyculture, MS Thesis. Department of Fisheries Management, BAU, Mymensingh, p. 81.

Udo, I.U., Umoren, U.E., 2011. Nutritional evaluation of some locally available ingredients use for least-cost ration formulation for African Catfish (*Clarias gariepinus*) in Nigeria. Asian J. Agri. Res. 5, 164-175.

Vaishnav, M., Sharma, S.K., Sharma, B.K., Ojha, M.L., 2017. Growth performance of *Pangasius sp.* cultured at different stocking density in floating net cages in Mahi Bajaj Sagar Dam of Banswara (Rajasthan). J. Entomol. Zool. Stud. 5(5), 649-652.

Wahab, M.A., Faruk, M.A.R., Haque, M.M., Hossain, M.S., 2008. Paper presented Pangasius *Pangasianodon hypophthalmus* farming in Bangladesh: current status and future challenges in the catfish symposium in Can Tho University, Can Tho Vietnam, 2008, 5-7.

Yeasmin, S.M., Rahman, M.A., Hossain, M.M.M., Rahman, M.H., Asif, A.A., 2015. Identification of causative agent for fungal infection and effect of disinfectants on hatching and survival rate of common carp *C. carpio* larvae. Asian J. Med. Biol. Res. 1, 578-588.

Zaman, M.F.U., Samad, M.A., Islam, M.A., Jaman, M.H.U., Khondoker, S., Asif, A.A., 2017. Assessment of sustainability of Pangasius (*Pangasius hypophthalmus*) farming at Jhikargachha upazila in Jessore district, Bangladesh. Int. J. Fauna Biol. Stud. 4(5), 109-119.

Appendix-1

Feeding trial with sinking pellet

Water quality parameters

Treatment-1

Treatment	Sampling Date	Temp	Trans	Water depth	pH	DO	NH_3
T_1	1st fortnight	27.70	18.50	6.90	7.10	3.80	0.07
T_1	1st fortnight	27.50	16.80	6.60	7.20	3.60	0.08
T_1	1st fortnight	27.80	13.00	6.50	7.50	3.70	0.05
T_1	2nd fortnight	29.70	17.60	7.00	6.50	4.90	0.09
T_1	2nd fortnight	29.80	16.50	5.60	6.90	4.50	0.07
T_1	2nd fortnight	29.80	14.80	6.60	6.60	4.70	0.08
T_1	3rd fortnight	30.10	14.20	6.80	7.10	5.20	0.03
T_1	3rd fortnight	30.20	18.20	6.80	7.50	5.50	0.06
T_1	3rd fortnight	30.10	14.50	6.40	7.20	5.60	0.06
T_1	4th fortnight	30.50	16.80	6.50	7.50	3.90	0.08
T_1	4th fortnight	30.50	14.60	6.70	7.60	4.40	0.02
T_1	4th fortnight	30.40	16.10	6.50	7.40	4.60	0.06
T_1	5th fortnight	32.10	17.60	6.60	8.10	5.50	0.07
T_1	5th fortnight	32.20	13.70	6.80	6.90	5.30	0.08
T_1	5th fortnight	31.50	16.30	6.40	8.10	3.20	0.09
T_1	6th fortnight	32.70	14.80	6.50	9.00	4.90	0.04
T_1	6th fortnight	32.50	14.60	6.60	8.20	4.60	0.07
T_1	6th fortnight	32.20	14.30	6.70	7.50	5.80	0.09

Treatment-2

Treatment	Sampling Date	Temp	Trans	Water depth	pH	DO	NH_3
T_2	1st fortnight	27.60	16.80	6.80	6.60	4.30	0.07
T_2	1st fortnight	27.60	17.20	6.60	7.00	4.20	0.07
T_2	1st fortnight	27.70	13.80	6.80	6.50	4.20	0.05
T_2	2nd fortnight	29.80	18.60	6.70	7.50	6.40	0.07
T_2	2nd fortnight	29.90	16.40	6.50	6.60	4.90	0.06
T_2	2nd fortnight	29.90	15.90	6.70	7.10	6.50	0.06
T_2	3rd fortnight	30.20	14.50	6.60	7.70	5.10	0.09
T_2	3rd fortnight	30.10	18.80	6.80	7.50	6.50	0.06
T_2	3rd fortnight	30.20	14.70	6.90	7.40	6.80	0.07
T_2	4th fortnight	30.40	16.40	6.70	6.90	6.50	0.06
T_2	4th fortnight	30.30	14.50	6.60	7.50	5.40	0.08
T_2	4th fortnight	30.50	16.90	6.50	7.50	7.10	0.07
T_2	5th fortnight	32.20	18.40	6.50	8.40	6.40	0.09
T_2	5th fortnight	32.10	13.80	6.60	7.80	5.30	0.07
T_2	5th fortnight	31.70	17.40	6.60	7.80	6.90	0.08
T_2	6th fortnight	32.80	14.60	6.70	8.20	6.50	0.08
T_2	6th fortnight	32.40	15.50	6.60	8.20	5.90	0.06
T_2	6th fortnight	32.30	16.50	6.50	8.20	6.50	0.09

Treatment-3

Treatment	Sampling Date	Temp	Trans	Water depth	pH	DO	NH_3
T_3	1st fortnight	27.80	19.60	6.80	6.90	5.20	0.06
T_3	1st fortnight	27.70	15.70	6.60	6.60	4.70	0.07
T_3	1st fortnight	27.80	14.90	6.90	6.80	4.50	0.07
T_3	2nd fortnight	29.60	18.50	6.40	6.50	5.00	0.07
T_3	2nd fortnight	29.70	15.50	6.50	6.60	4.80	0.05
T_3	2nd fortnight	29.60	16.60	6.80	6.80	4.40	0.08
T_3	3rd fortnight	30.40	14.80	6.80	6.50	5.10	0.05
T_3	3rd fortnight	30.40	19.30	6.40	6.90	5.20	0.07
T_3	3rd fortnight	30.30	15.80	6.50	7.60	5.00	0.06
T_3	4th fortnight	30.40	15.80	6.60	6.90	5.40	0.06
T_3	4th fortnight	30.40	15.70	6.50	7.50	6.20	0.07
T_3	4th fortnight	30.30	17.30	6.70	7.50	5.80	0.05
T_3	5th fortnight	32.40	18.90	6.70	7.00	5.60	0.03
T_3	5th fortnight	32.10	14.40	6.80	7.70	6.50	0.06
T_3	5th fortnight	31.90	15.30	6.50	7.90	5.50	0.06
T_3	6th fortnight	32.60	14.60	6.40	7.50	6.50	0.06
T_3	6th fortnight	32.50	15.20	6.60	7.80	5.40	0.05
T_3	6th fortnight	32.60	13.60	6.70	7.90	5.40	0.06

Growth performance

Treatment-1

Treatment	Sampling Date	IW (g)	FW (g)	WG (g)	%WG	ADG (g)	SGR (%/day)
T_1	1st fortnight	105.00	156.00	51.00	48.57	3.40	2.64
T_1	1st fortnight	102.00	135.00	33.00	32.35	2.20	1.87
T_1	1st fortnight	100.00	145.00	45.00	45.00	3.00	2.48
T_1	2nd fortnight	156.00	236.00	80.00	51.28	5.33	2.76
T_1	2nd fortnight	135.00	225.00	90.00	66.67	6.00	3.41
T_1	2nd fortnight	145.00	232.00	87.00	60.00	5.80	3.13
T_1	3rd fortnight	236.00	352.00	116.00	49.15	7.73	2.67
T_1	3rd fortnight	225.00	345.00	120.00	53.33	8.00	2.85
T_1	3rd fortnight	232.00	325.00	93.00	40.09	6.20	2.25
T_1	4th fortnight	352.00	625.00	273.00	77.56	18.20	3.83
T_1	4th fortnight	345.00	612.00	267.00	77.39	17.80	3.82
T_1	4th fortnight	325.00	650.00	325.00	100.00	21.67	4.62
T_1	5th fortnight	625.00	852.00	227.00	36.32	15.13	2.07
T_1	5th fortnight	612.00	842.00	230.00	37.58	15.33	2.13
T_1	5th fortnight	650.00	854.00	204.00	31.38	13.60	1.82

Treatment-2

Treatment	Sampling Date	IW (g)	FW (g)	WG (g)	%WG	ADG (g)	SGR (%/day)
T_2	1st fortnight	100.00	163.00	63.00	63.00	4.20	3.26
T_2	1st fortnight	108.00	145.00	37.00	34.26	2.47	1.96
T_2	1st fortnight	107.00	134.00	27.00	25.23	1.80	1.50
T_2	2nd fortnight	163.00	252.00	89.00	54.60	5.93	2.90
T_2	2nd fortnight	145.00	242.00	97.00	66.90	6.47	3.41
T_2	2nd fortnight	134.00	236.00	102.00	76.12	6.80	3.77
T_2	3rd fortnight	252.00	389.00	137.00	54.37	9.13	2.89
T_2	3rd fortnight	242.00	385.00	143.00	59.09	9.53	3.10
T_2	3rd fortnight	236.00	395.00	159.00	67.37	10.60	3.43
T_2	4th fortnight	389.00	685.00	296.00	76.09	19.73	3.77
T_2	4th fortnight	385.00	695.00	310.00	80.52	20.67	3.94
T_2	4th fortnight	395.00	699.00	304.00	76.96	20.27	3.81
T_2	5th fortnight	685.00	942.00	257.00	37.52	17.13	2.12
T_2	5th fortnight	695.00	936.00	241.00	34.68	16.07	1.98
T_2	5th fortnight	699.00	932.00	233.00	33.33	15.53	1.92

Treatment-3

Treatment	Sampling Date	IW (g)	FW (g)	WG (g)	%WG	ADG (g)	SGR (%/day)
T_3	1st fortnight	105.00	117.00	12.00	11.43	.80	.72
T_3	1st fortnight	103.00	132.00	29.00	28.16	1.93	1.65
T_3	1st fortnight	108.00	125.00	17.00	15.74	1.13	.97
T_3	2nd fortnight	117.00	200.00	83.00	70.94	5.53	3.57
T_3	2nd fortnight	132.00	215.00	83.00	62.88	5.53	3.25
T_3	2nd fortnight	125.00	210.00	85.00	68.00	5.67	3.46
T_3	3rd fortnight	200.00	312.00	112.00	56.00	7.47	2.96
T_3	3rd fortnight	215.00	326.00	111.00	51.63	7.40	2.78
T_3	3rd fortnight	210.00	320.00	110.00	52.38	7.33	2.81
T_3	4th fortnight	312.00	610.00	298.00	95.51	19.87	4.47
T_3	4th fortnight	326.00	612.00	286.00	87.73	19.07	4.20
T_3	4th fortnight	320.00	623.00	303.00	94.69	20.20	4.44
T_3	5th fortnight	610.00	899.00	289.00	47.38	19.27	2.59
T_3	5th fortnight	612.00	845.00	233.00	38.07	15.53	2.15
T_3	5th fortnight	623.00	858.00	235.00	37.72	15.67	2.13