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Carp-tilapia polyculture integration with pigs-"enhancing benefits to uplift the economic status of small scaled farmers of Nepal

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Abstract
Pig cum fish farming practice with proper management techniques helps to uplift the living standard of Nepalese people. Culture of carp-tilapia polyculture in integration with the pig was conducted for 120 days in 580 m^2. The stocking density of fish species was 10,000 fish/ha. The ratio of fish stocked was 5:2:4:1:3:5 (*Labeo rohita*: *Cirrhinus mrigala*: *Cyprinus carpio*: *Hypophthalmichthys nobilis*: *Ctenopharyngodon idella*: *Oreochromis niloticus*), integrated with two pigs. The total weight of fishes was 83.7 kg with a stocking weight of 18.75 kg. The mean harvest weight of *L. rohita, C. mrigala, C. carpio, H. nobilis, C. idella,* and *O. niloticus* was 197.3±9.0, 157.4±29.9, 402.2±102.6, 394.3±13.8, 121.5±36.8, and 139.4±20.1 g/fish. The extrapolated GFY and NFY for *L. rohita*, *C. mrigala*, *C. carpio*, *H. nobilis*, *C. idella* and *O. niloticus* was 0.97, 0.19, 1.73, 0.57, 0.27, 0.65 t/ha/yr, and 0.76, 0.15, 1.58, 0.39, 0.20 and 0.30 t/ha/yr respectively. Overall, extrapolated GFY, NFY, survival rate and AFCR were 4.2 t/ha/yr, 3.4 t/ha/yr, 62.93 %, 2.72, respectively. It was found that the B: C ratio of 1.65 can be obtained in carp-Tilapia polyculture in integration with the pig. Thus, it can be concluded that it is an economic enterprise, and can be recommended for small-scale fish farmers of Nepal.

Keywords: Production system, benefit-cost ratio, yield, growth, Nepal

1. Introduction

Nepal being a small mountainous country is the richest in terms of freshwater resources that make it a country with a potential fish farming. The total area of Nepal is 147,516 sq. Km of which 818,500 ha cover by the total water surface area (Rai *et al*., 2008) [18]. Aquaculture is a fairly new activity in Nepal with formal fish farming practices using Indian major carps for the economic purpose of 1947 (Rai *et al*., 2008) [18]. The total pond aquaculture of area 11,895 ha contributes about 89% of total production indicating about 65,544 Mt while capture fisheries contribute around 21000 Mt in the country (CFPCC, 2018) [4]. With the increase in population and demand in a country, Nepal is not self-reliant in fish production as the current production supplies only 3.01 kg of fish to an individual in a year (DoFD, 2017) [10]. The aquaculture sector of Nepal currently seems to be small but it has great potential for growth (Gurung, 2003) [11]. There was a great increment of fish production in Nepal i.e. 46779 tons in 2006/07 to 64700 tons in 2013/14 (Labh *et al*., 2017) [15], While this increase up to 65,544 Mt in 2016 (CFPCC, 2018) [4]. The rate was inclined in the annual per capita consumption has been greatly increased from 0.33 kg per person in 1982 (Labh *et al*., 2017) [15] to 2.10 kg in 2013 (Budhathoki & Sapkota, 2018) [3].

Fish polyculture refers to the culture of various compatible fish species, together with by fully using all ecological niches, food available in the pond, and obtain high fish production. Generally, carp polyculture in the country includes the culture of Chinese major carp (*Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis*, *Ctenopharyngodon idella*), and Indian major carp (*Labeo rohita*, *Cirrhinus mrigala*, *Catla catla*) along with *Cyprinus carpio* and Tilapia. Carp polyculture has become advance in terms to combat the problem of food security, malnutrition, and low household income for the rural poor farmer. During the time of 1960s, Carp polyculture was drastically ameliorated in most countries of Europe and Asia by the introduction of Chinese carp (Labh *et al*., 2017) [15]. Carp polyculture is outmost in terms of the intensive fish farming system because the requirement of protein is highly satisfied by natural fish food instead of using expensive allochthonous protein i.e. fish meal.

The undesirable reproduction of tilapia affect other carp species in term of feed and space, thus overall output will be ceased (Labh *et al*., 2017) [15]. Thus, adding Nile tilapia with a suitable measure to carp species increase the total production and profit without negatively affecting pond water quality or growth and production of carp species.

Integrated fish farming means the field of various reconcilable agricultural enterprises into a functional or unified whole farming system for sustainability. It is a low cost, no waste, and low energy production system in which the by-products of one enterprise are recycled into another as input. Various types of livestock have been integrated with fish farming. Integration with animal husbandries like pig-cum-fish, Cattle-cum fish, Duck cum-fish, Poultry-cum-fish, and Goat-cum-fish farming. The livestock enterprises with fish farming obtained the highest production by using pigs, ducks, and chicken, a very widespread technique in Asia (Labh *et al*., 2017) [15]. The livestock excreta contain about 70 to 80% water and 20 to 25% dry matter, A cow produces 15 to 18 kg dung/ day, a layer bird can produce 68 kg of excreta annually and a pig of 50 kg can produce 2.5 kg dung in a day whereas; 90 kg pig produces 5 kg dung per day (Chakrabarti, 2014) [5]. The N, P, and K level in excreta of different species of animal-like sheep/goat has 0.65, 0.50 and 0.03%, cattle has 0.15, 0.01 and 0.05%, pig has 0.60, 0.50 and 0.20% , poultry has 0.76, 0.63 and 0.22% and duck has 0.91, 0.38, and 0.36% , respectively (Chakrabarty, 2014) [5]. Livestock is an integral part of the agriculture system in Nepal. A distinct pivoted role of livestock is well established in the farming system of Nepal as a supplier of manure and high-value animal protein. There are 7.27 million cattle, 5.24 million buffalo, 0.81 million sheep, 9.78 million goats, 1.16 million pigs, 47.95 million chicken, and 0.38 million ducks in Nepal (AICC, 2014) [1]

Pig cum fish farming has become an important farming system in pond culture since more than 70% of the food of pigs remains undigested and rich in nutrients acts as a beneficial role in feeding and fertilization (Sharma, 1989). The major advantages of fish cum pig farming include that the fish utilize the food spilled by pigs and their excreta which is very rich in nutrients, whereas the pig dung acts a pivot role in pond fertilization as well as supplementary fish feed that ultimately reduces the cost of fish production. About 30-40 pigs can be recommended for one hectare of water bodies (Chakraborty *et al*., 2011) [6]. The major pig breed used in pig cum fish farming is large and middle white Yorkshire, Duroc, Hereford, Landrace, Chester White, Tamworth, etc. In China fish ponds stocked with 60,000 fingerlings per ha (average weight 20–30 g) of different species raised together with about 45–75 pigs/ha produced between 2-18 tons of fish and 4-7 tons of pigs (live weight) per ha/year (Pillay *et al*., 2005).

Moreover, this study aims at increased productivity, profitability, sustainability, balanced food, clean environment, recycling of resources, and income round the year. In addition, carp-tilapia integration with pigs farming system represents a key solution for enhancing livestock production, minimizing the effects of intensive farming, and safeguarding the environment through efficient usage of resources.

2. Materials and Methods

2.1 Site Selection

The pond of area 580 m^2 was selected for carp-tilapia polyculture with pigs, located in the fish farm of Agriculture and Forestry University, Rampur Chitwan Nepal. The cultural period was 120 days.

2.2 Pond Preparation

The pond water was completely drained out and dried for some days. The dykes were cleaned by cutting grasses and maintaining the dyke. The pond was drained with the removal of aquatic plants and existing fishes. Afterward, the pond was limed using agricultural limes ($CaCO_3$) at the rate of 200 kg/ha, which was about 11.50 kg in the pond. The pond was filled with clean and fresh water at depth of 1 m. And finally, the pond was fertilized by using inorganic Urea and DAP at the rate of 4.7 kg/ha/week and 3.5 kg/ha/week respectively (Shrestha *et al*., 2007) [21].

2.3 Stocking of Fish

Two weeks after fertilization carp and tilapia were stocked in the ratio of 5: 2: 4: 1: 3: 5 (*L. rohita*: *C. Cirrhinus mrigala*: *C. carpio*: *H. nobilis*: *C. idella*: *O. niloticus)*. Before stocking, all fish were measure by weight using electric balance (Denver Instrument, model XP-3000). The given table 1 shows the stocking ratio, weight, percentage, and number.

Table 1: Stocking density of different carps and Tilapia in culture pond.

S.N.	Species	Percentage (%)	Stocked No.	Weight (Kg)
1.	*Labeo rohita*	25	140	4.2
2.	*Cirrhinus mrigala*	10	55	0.580
3.	*Ctenopharyngodon idella*	20	85	1.260
4.	*Hypophthalmichthys nobilis*	5	43	4.440
5.	*Cyprinus carpio*	15	140	2.770
6.	Tilapia (*Oreochromis niloticus)*	25	130	8.1

2.4 Feeding

Fish were fed with the locally available and freshly prepared dough of mustard oil cake and rice brain in 1:1, to reduce production cost. Similarly, for proper growth and development of fish, supplementary vitamins and minerals were added to feed. Feed containing 20% CP was provided in a bamboo tray in a pond every morning (10-11 am) and every evening (3-4 pm) at the ratio of 2% of body weight. Similarly, for the feeding of *C. idella*, chopped pieces of Colocasia, Banana leaves, Napier were used. After each sampling at 15 days of interval, the feeding amount was altered as per the requirement of their total body weight.

2.5 Fish Sampling and harvesting

Fish sampling was done every 15 days interval of culture period to check the growth of fish and feed amount required by fish as it depends on the total weight of fish. Harvesting was done after 3 months of the culture period. Initially, partial harvesting was done as per the consumer demand, later final harvesting was done by complete draining and dried of the pond with the help of a generator.

2.6 Pig culture

The pig shed was built at the dyke of the pond, using cemented bar, bamboo, and tin as a roof. The area of the pig shed was 7.2 (4X1.8) m^2 in which two pigs can be accommodated in two blocks inside of it. A tap and a storehouse were built near the shed for regular water supply and storage of food for the pigs. Pigs were fed pig-feed, waste foods regularly and intestine of fish during the time of fish harvesting. To avoid disease transmission by waste feed and excreta, regular flushing of pig shed and bathing of pigs was done. The cemented feeding tray and water trough were flushed and cleaned with water daily.

2.7 Analytical methods

2.7.1 Growth and production analysis

Growth and production were calculated from the data obtained using the following formula.

- $\text{Survival rate (\%)} = \frac{Total\ number\ of\ fish\ harvested}{Total\ number\ of\ fish\ stocked} \times 100$
- $\text{Fish growth rate (g/day)} = \frac{Mean\ final\ weight(g) - Mean\ initial\ weight\ (g)}{Culture\ period\ (days)}$
- $Net\ fish\ yield\ \left(\frac{\frac{g}{m^2}}{day}\right) = \frac{Total\ harvested\ weight(g) - Total\ stocked\ weight\ (g)}{Culture\ period(days) \times Culture\ Units\ (m^2)}$
- $Apparent\ foodconversion\ ratio(AFCR) = \frac{Quantity\ of\ feed\ fed\ (kg)}{Net\ fish\ yield\ (kg)}$
- $\text{Extrapolated NFY (t/ha/yr.)} = \frac{Total\ harvested\ weight(g) - Total\ stocked\ weight(g)}{Culture\ period(days) \times Culture\ unit(m^2) \times 1000 \times 1000} \times 10{,}000 \times 365$
- $\text{Extrapolated GFY (t/ha/yr.)} = \frac{Total\ harvested\ weight(g)}{Culture\ period(days) \times Culture\ unit(m^2) \times 1000 \times 1000} \times 10{,}000 \times 365$

2.7.2 Water quality analysis

The water parameter was measured in every morning (5 am) during the culture period. Water quality parameters like DO, pH, and temperature were measured. The dissolved oxygen was measured using Handy Polaris 2 Dissolved Oxygen meter; pH was measured by Handy pH meter and temperature by using thermometer. In some case, weather condition also affects in measuring physical data in the pond, weak dyke, seepage, and lack of regular water source create problem to measure other parameters, and thus only DO, pH and temperature were measured during the culture period.

2.8 Economic Analysis

$$Grossmargin(NRs) = Grossreturn(NRs) - Totalvariablecost\ (NRs)$$

$$Grossreturn(NRs) = Priceoffish\left(\frac{NRs}{kg}\right) \times Totalquantityproduced(kg)$$

$$Total\ variable\ cost(NRs) = \sum costicurredinallthevariableitems\ (NRs)$$

2.9 Statistical Analysis

Statistical analysis of data was performed by using MS- Excel 2016. Mean and standard deviation was calculated and differences were compared i.e. (Mean± SD).

3. Results

3.1 Water quality parameter

Mean, Standard deviation, and range of water quality parameter i.e. Dissolved oxygen, temperature, and pH of pond water were measured daily during the culture period are presented in table 2. The parameter was measured from 10 April 2019 to 10 June 2019 daily. The Mean (±SD) of temperature during the culture period was 27.9±1.1 °C, Dissolved oxygen was 4.9±0.5 mg/l and the average pH was 7.8.

Table 2: Mean (±SD) and range of water quality parameter during the culture period

SN.	Parameter	Unit	Average
1	Dissolved Oxygen	mg/L	4.9±0.5
2	Temperature	°C	27.9±1.1
3	pH		7.8

The following graph indicates the temperature, pH, and DO parameters of the pond during the culture period.

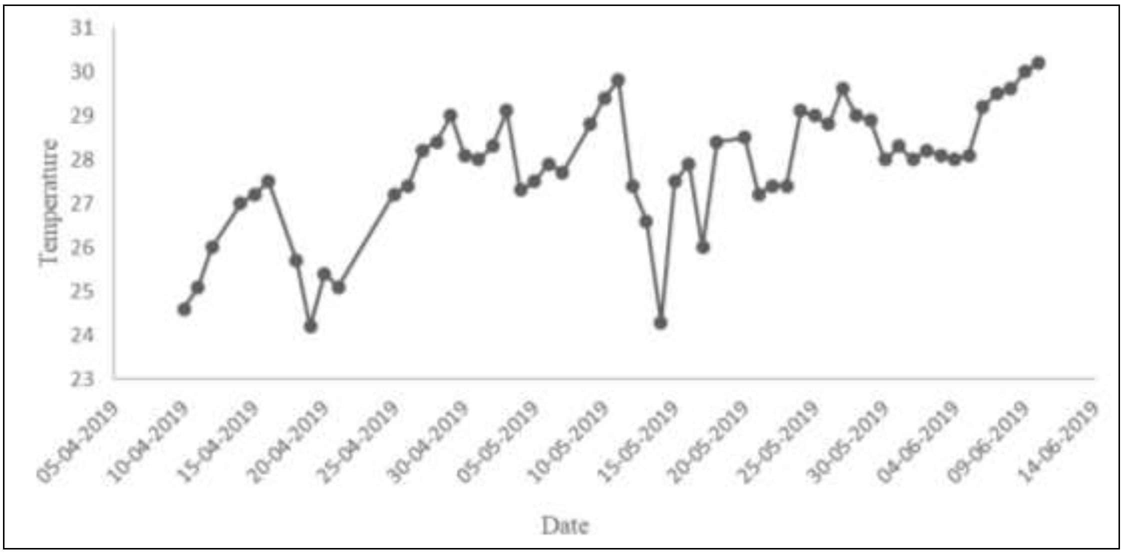

Fig 1: Temperature of the pond during the cultural period

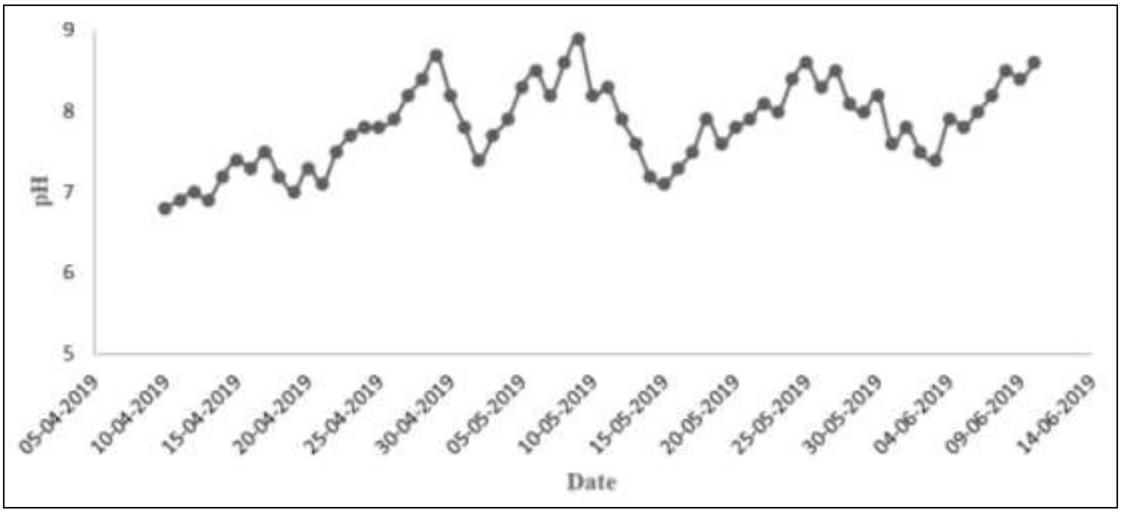

Fig 2: pH of the pond during the culture period

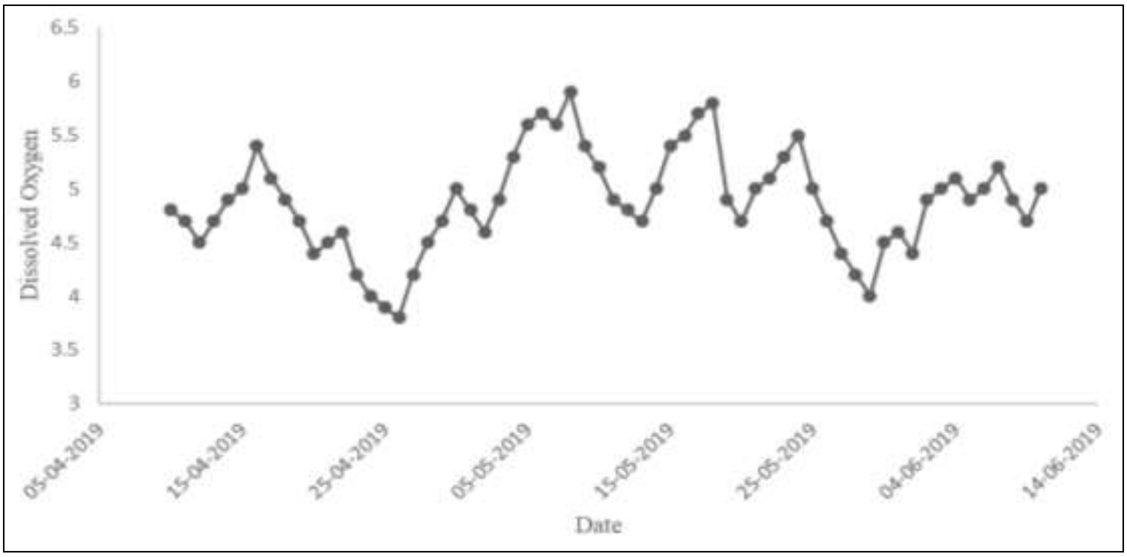

Fig 3: Dissolved oxygen of the pond during the culture period

3.2 Fish growth and production

The overall growth of all carp and tilapia were measured, as shown in figure 4. With comparative analysis of growth among the fish species, it was found that the daily weight gain of *Cyprinus carpio* was relatively high than other because of the quality and quantity of planktonic food organism at the bottom. The following table 3 shows the growth and production parameter during the culture period.

Table 3: Growth and production parameter of different fish species

Growth and production parameter	*Labeo rohita*	*Cirrhinus mrigala*	*Cyprinus carpio*	*Hypophthalmichthys nobilis*	*Ctenopharyngodon idella*	Tilapia
Total stocked No.	140	55	140	30	85	130
Total Stocked Wt. (g)	4200	580	2770	3440	1260	6501.6
Mean stocked wt. (g/fish)	28.6±10.7	10.6±1.4	20.2±4.4	113.5±4.9	13.5±6.4	59.2±8.3
Total Harvest No.	96	23	83	28	45	90
Total Harvest Wt. (g)	18639.8	3593.5	32915.6	10942	5092	12399
Mean Harvest wt. (g/fish)	197.3±9.0	157.4±29.9	402.2±102.6	394.3±13.8	121.5±36.8	139.4±20.1
Total weight gain (g/100m^2)	1616.3	195.3	1183.7	1302.4	412.2	1023.9
Daily weight gain (g/fish/day)	1.5	1.3	3.3	2.4	0.9	0.7

The graph indicates the good production of *C. carpio* with a mean harvested weight of 402.2±102.6 g/fish and the lowest in *C. mrigala* with 157.4±29.9 g/fish.

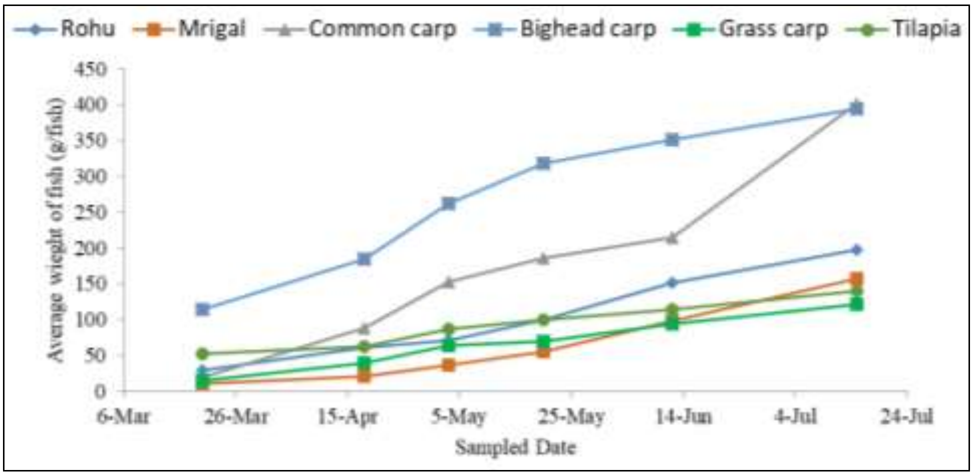

Fig 4: The Growth curve of different fish species

3.3 Production and yield

3.3.1 Fish production and yield

Table 4 shows that the Extrapolated GFY and extrapolated NFY was 4.3 t/ha/yr. and 3.4 t/ha/yr. respectively. The overall survival rate was 62.93% and AFCR was 2.72.

Table 4: Production and yield of carp polyculture with tilapia

Growth and production parameters	Value
Extrapolated GFY (t/ha/yr.)	4.3
Extrapolated NFY (t/ha/yr.)	3.4
Overall survival rate (%)	62.93
AFCR	2.72

3.3.2 Pig production and yield

Initially, two pigs were stocked with an average weight of 52 kg and 48 Kg. after 3 months of the culture period, it was found to be 85 and 79 kg respectively as shown in table 5.

Table 5: The initial and final weight of pig during pig-cum fish farming integration

S. N.	Pig	Initial weight(kg)	Final weight(kg)
1	Pig-1	52	85
2	Pig-2	48	79

3.4 Economic analysis

Table 6: Economic analysis of carp-tilapia polyculture with integration to pig

Variable	Quantity	Rate (NRs/kg)	Amount
Urea	5.41	20	108.2
DAP	4	55	220
Cow dung	57.6	2	115.2
Lime	11.52	12	138.24
Feed			
MOC	45	30	1350
Rice bran	45	35	1575
Vitamin	0.9	300	270
Fish seed	18.75	300	5625
Diesel (L)	7	100	700
Pig (NOS)	2	9000	18000
pig feed (Kg)	250	40	10000
Total variable cost (NRs.)			38101.64

Return	Quantity (Kg)	rate (NRs. /Kg)	Amount (NRs.)
Labeo rohita	18.63	300	4,053
Cirrhinus mrigala	1.7	300	510
C. carpio	9.58	300	2,874
H. nobilis	10.94	300	3,282
C. idella	3.63	300	1,089
O. niloticus	12.39	300	3,717
Pig	164	290	47,560
Gross return (NRs)	51.75	300	63,085
Net return (NRs)			24983.36
Production cost (NRs. /Kg)		260.98	
B: C cost			1.65

Table 6 shows the economic analysis of carp-tilapia polyculture with integration to pigs. It was found that the total variable cost was NRs. 38101.64. It also shows that the Gross return and production cost was NRs. 63,085 and 260.98 respectively. The B: C ratio was found to be 1.65. The cost for Urea, DAP, lime, and cow dung was NRs 216.576, 443.52, 138.24, and 230.4. The cost of feed i.e. MOC and rice bran was NRs. 1350 and 1575 respectively. The cost of diesel was NRs. 700, which was used in pond refilling and draining.

4. Discussion

4.1 Growth and yield of carp species

During the culture period, means daily growth of *C. carpio* was 3.3 g/fish/day, which was higher than that of other carp, stocked in the pond. The daily weight gain was low in tilapia, which might be due to the stocking of mix-sex tilapia. In the case of mix-sex tilapia, energy from the feed is diverted to gonadal growth and breeding which results in a lower growth rate (Chakraborty *et al*., 2011) [6]. The daily weight gain by *L. rohita*, *C. mrigala*, *C. carpio*, *H. nobilis*, and *C. idella* was similar to the finding by Devkota (2010) [7].

The survival rate of all carp species except *H. nobilis* was found too low. This might be due to several factors. Seepage of water from the pond led to temperature rise, which may have caused high mortality of fish. Although water addition was done periodically, daily and frequent addition of water during the scorching heat of summer was not possible due to limited resources. Similarly, the pond used for the study was more than 30 years old which has a high amount of accumulated organic material. A high amount of organic material may lead to hypoxia to fish (Devkota, 2010) [7]. In the present study, it can be noted that the survival of bottom dwellers i.e., *C. mrigala* and *C. carpio* was lowest. In integration with pigs, the accumulation of organic matter was increased and semi-digested fecal matter and urine of pigs might have added much more ammonia in the fish pond. This added ammonia may have caused high mortality of bottom-dwelling fishes. However, the surface feeder *H. nobilis* was unaffected by the ammonia problem. Similarly, Nile tilapia can survive in a wide range of water quality and can tolerate a high level of ammonia (Chakraborty *et al*., 2011) [6], such that Nile tilapia may have been unaffected by the presence of raised ammonia level. The water parameter was described to be the most critical factor for the growth of small-sized fish (Sharma *et al*., 2008) [19]. The survival rate of *L. rohita*, *C. mrigala*, *C. carpio*, *H. nobilis*, and *C. idella* in the present study was 68.57, 41.8, 59, 93.33, 52.94 respectively, which is comparatively lower than that of the report by Shrestha *et al*., (2018) [14].

The extrapolated GFY of *H. nobilis* in the present study was 0.4 t/ha/year and 0.57 t/ha/yr. respectively, which was lower as compared to 0.8±0.2 t/ha/yr., and 0.7±0.2 t/ha/yr. reported by Shrestha *et al*., (2018) [14]. Similarly, the extrapolated GFY and extrapolated NFY of *C. idella* were 0.2 t/ha/yr. and 0.26 t/ha/yr. respectively, which was lower as reported by Shrestha *et al*., (2018) [14].

The extrapolated GFY and extrapolated NFY of *C. carpio* were 1.5 t/ha/yr. and 1.72 t/ha/yr., which was higher than as reported by Devkota, (2010) [7]. Both extrapolated GFY and extrapolated NFY of *C. mrigala* were 0.15 and 0.18 t/ha/yr. which was lower than 0.38±0.08 t/ha/yr and 0.19±0.02t/ha/yr as reported by Mandal *et al*., (2018) [14]. Compared to Jha *et al*., (2018) [14], the extrapolated GFY of the present study was lower (0.7 t/ha/yr.) which was 0.91±0.09 t/ha/yr. in the previous study. Similarly, the extrapolated NFY is also lower (0.5t/ha/yr.) than the previous study done by Jha *et al*., (2018) [14]. In the present study of *L. rohita*, the extrapolated GFY (0.7 t/ha/yr.) is higher as compared to 0.5±0.1 t/ha/yr. reported by Shrestha *et al*.,(2018) [14], whereas the extrapolated NFY at present study was 0.97 t/ha/yr., which is similar as reported by Shrestha *et al*., (2018) [14]. Extrapolated GFY in the present study is 4.3 t/ha/yr., which is higher than as reported (carp & Tilapia: 0.65±0.09) by Bhandari *et al*., (2015). Overall, the extrapolated GFY and extrapolated NFY of each species was related to the daily weight gain and survivability of each species. On lower DWG and survival rate, lower the extrapolated GFY and extrapolated NFY and vice-versa.

4.2 Production of fish

Total production with species -wise in terms of kg has shown in table 3. Total production ranged between 3593.5 kg to 32915.6 kg during the experimental period of 120 days. The bottom dweller *Cyprinus carpio* has the highest harvested quantity with 32915.6 kg while *Cirrhinus mrigala* has found to be the lowest rate of harvest with 3593.5 kg during the culture period. The main reason for the highest and lowest harvest rate was found to be stocked size, accumulation of organic matter, and mixed-sex tilapia that compete for food and space (Lin, 1996) [13]. The mean harvest weight of *C. carpio* was found to be high, followed by *H. nobilis*, *L. rohita*, *C. mrigala*, tilapia, and *C. idella* with 402.2±102.6 g, 394.3±13.8 g, 197.3±9.0 g, 157.4±29.9 g, 139.4±20.1 g, and 121.5±36.8 g. The major reason for the high growth with species wise might be the acceptance level of supplement and natural feed, due to the abundance of plankton during the culture period with integrated pigs (Azad, *et al*., 2004) [2]. Pond with polyculture of different species occupy different ecological niche with their complementary feeding habit, thus fully utilizing the natural food in the culture system which ultimately enhance the productivity in total fish from the pond (Tang, 1970) [22].

4.3 Water quality parameter

Water quality parameter are an integral part of any aquaculture system that play a vital role in the health of fish and worsening of water quality, which causes a serious problem in the pond ecosystem (Padmavathy & Aanand, 2017) [16]. The pig manure did not affect on physio-chemical parameter of water, which remained within the favorable range required for carps (Jhingram, 1991). According to Dhawan & Kaur (2002) [8, 9], it was found that the pig dung even at a high dose of 36 t/ha/yr. didn't affect the physio-chemical parameter of water. This experiment presented that the dissolved oxygen and Nitrogen-nitrate content does not affect the water quality parameter; however, phosphorus present in pig dung imparted the higher concentration of water-soluble phosphate in pond water.

In addition, plankton communities can be increase by the pig manure (Sharma, 1989) [20]. The water quality parameter in this experiment were Temperature, dissolved oxygen, and pH, which were in the optimum range required for carps and tilapia.

4.4 Integrated carp-tilapia polyculture with pigs

Integrated fish-pig culture is an old classic Chinese practice, which widely spread all over the Asian countries. The pigsties constructed on the dikes of the pond provides highly efficient foe pond fertilizer that can be utilized directly by fish as a feed. The pig manure and as fish feed ingredient play vital role in the maintaining water quality parameter, improving the productivity of pond, and survival and growth of carp species in polyculture (Asha Dhawan & Kaur, 2002) [8, 9]. The phosphates and nitrates level can be significantly better with the pond manure of 36 t/ha/yr. that impart in better condition of plankton production (Phyto and zooplankton) (Asha Dhawan & Kaur, 2002) [8, 9]. According to Kumar *et al*., (2004) [12], it was found that the 1 ppm N: 0.5 ppm P was the most effective nutrient ratio for pond fertilizer that has a significant effect on fish production as well as lower mortality. Thus, with this research, it was also found that pig manure was significantly more effective than cow manure. Pig manure contains about 70% digestible food for fish and is thus well suited for integrated fish-pig farming. Fresh pig manure was found to be more effective than that of fermented pig manure since fish directly feed upon manure detritus and nutrients that release into the system (Yejin *et al.*, 1987). According to STOAS (1993), 5 kg of manure can be produced by 100kg of pig in a day that contains an organic matter of about 18%, 0.8% of nitrogen. 0.4% of P_2O_5 and 0.3% of K_2O. This overall shows the importance of pig manure in the primary and secondary productivity in integrated fish-pig culture system.

5. Conclusion

It can be concluded that carp-tilapia polyculture in integration with the pig is an economic enterprise with B: C ratio 1.6, if proper management is practiced and can be recommended for small-scale fish farmers of Nepal. With the addition of Nile tilapia in carp polyculture integrated with pig ultimately generate higher fish productivity and profit compared to existing polyculture practice in terms of GFY and NFY.

Successful trials and demonstrations on nutrient dynamics, utilization of resources, and sustainable aquaculture production in integrated farming systems have to be carried out in developing countries and more comparative feasibility studies on the economics of the different polyculture systems and livestock fish farming systems have to be conducted, analyzed, and published.

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