Global Journal of Science Frontier Research: C
Biological Science
Volume 21 Issue 2 Version 1.0 Year 2021
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Enhancing the Production of Carp Polyculture and Tilapia by Integrating with Duck Farming in Nepal"- Aquaculture for Small Scale Farmers and Sustainability

By Puja Banmali, Manish Devkota, Hemraj Kathayat & Aung Myo Win
Can Tho University

Abstract- Integrated duck cum fish farming is suitable for developing countries like Nepal as it uses the locally available resources. This study was conducted for 120 days in an earthen pond of area 575 m^2. The fish stocked were *Labeorohita*(25%), *Cirrhinus Mrigala* (10%), *Cyrinuscarpio* (25%), *Aristichthys nobilis* (5%), *Ctenopharyngodonidella* (15%) and *Oreochromis niloticus*(20%) with the stocking density of 13000 fingerlings/ha. Fish were fed with dough formed with locally available ingredients like MOC and rice bran containing 20% CP at the rate of 2% of total body weight daily. The results showed the extrapolated GFY to be 4.0 t/ha/yr and extrapolated NFY was 2.9 t/ha/yr of total fish species. The total fish yield was 53.2 kg and the total feed supplied was 76.8 kg. The overall survival rate of fish was 66.0% whereas the AFCR was 1.4. Duck growth showed a normal trend from mean stock weight of 161±69.8 g/duck to mean harvest weight 1114.4±296.4 g/duck. Similarly, daily weight gain was 7.95 g/duck/day. The benefit: cost ratio for duck and fish production was 1.24and 1.65 respectively. This study concludes that carp- tilapia polyculture in integration with duck is reliable, economically viable, and effective for the small-scale fish farmers as well as the marginal groups.

Keywords: integrated duck-fish, polyculture, tilapia, economic efficiency, small-scale farmers, nepal.

GJSFR-C Classification: FOR Code: 069999

Strictly as per the compliance and regulations of:

Enhancing the Production of Carp Polyculture and Tilapia by Integrating with Duck Farming in Nepal”- Aquaculture for Small Scale Farmers and Sustainability

Puja Banmali [α], Manish Devkota [σ], Hemraj Kathayat [ρ] & Aung Myo Win [ω]

Abstract- Integrated duck cum fish farming is suitable for developing countries like Nepal as it uses the locally available resources. This study was conducted for 120 days in an earthen pond of area 575 m^2. The fish stocked were *Labeorohita*(25%), *CirrhinusMrigala* (10%), *Cyrinuscarpio* (25%), *Aristichthys nobilis* (5%), *Ctenopharyngodonidella* (15%) and *Oreochromis niloticus*(20%) with the stocking density of 13000 fingerlings/ha. Fish were fed with dough formed with locally available ingredients like MOC and rice bran containing 20% CP at the rate of 2% of total body weight daily. The results showed the extrapolated GFY to be 4.0 t/ha/yr and extrapolated NFY was 2.9 t/ha/yr of total fish species. The total fish yield was 53.2 kg and the total feed supplied was 76.8 kg. The overall survival rate of fish was 66.0% whereas the AFCR was 1.4. Duck growth showed a normal trend from mean stock weight of 161±69.8 g/duck to mean harvest weight 1114.4±296.4 g/duck. Similarly, daily weight gain was 7.95 g/duck/day. The benefit: cost ratio for duck and fish production was 1.24and 1.65 respectively. This study concludes that carp- tilapia polyculture in integration with duck is reliable, economically viable, and effective for the small-scale fish farmers as well as the marginal groups.

Keywords: integrated duck-fish, polyculture, tilapia, economic efficiency, small-scale farmers, nepal.

I. Introduction

Sustainable aquaculture, innovation of modern technologies, enhancing livelihoods, and global food security are the long-term goals of aquaculture development (Rai *et al*., 2008). Nepal is a landlocked country with an abundance of freshwater water bodies having a high possibility of aquaculture. Fish is considered auspicious and symbolizes a sign of fertility, power, and prosperity in Nepal (Gurung *et al*., 2003). In Nepal, fish culture is the prevailing type of aquaculture and is cultured in different systems. Aquaculture is at its blooming phase with an annual growth rate of about 8-9% in Nepal (Gurung, 2016).Aquaculture and fisheries contribute about 4.29% in agriculture domestic production (AGDP) and nearly 1.34% in GDP (DoFD, 2017). National production of fish was 77,000 mt of which about 72% contributed by aquaculture and 28% from capture fisheries (Kunwar and Adhikari, 2016).

Stocking the complementary species of fishes in a pond can increase the maximum standing crop by allowing a wider range of available foods and ecological niches (Da silva *et al*., 2006). Polyculture is also known as multi-trophic aquaculture, co-culture, or integrated aquaculture (Bunting, 2008).One of the most widely practiced pond aquaculture systems in Central Asia is carp polyculture (Woynarovich, 2010). Literally, polyculture fits the principles of sustainable aquaculture. With advanced ecological stability and optimizing the use of available resources, this system reduces the environmental impact of the activity and increases producer profitability (McKinnon *et al.,* 2002). In Nepal, pond fish culture contributes about 89.1% of total production from aquaculture which is mainly prevailed by the carp polyculture in earthen ponds (CFPCC, 2018).

Combination of mainly IMC (Indian Major Carps) and CMC (Chinese Major Carps) along with Common carp (*Cyprinus carpio*) is the most commonly used concept in carp polyculture Polyculture of carp species contributes about 70% of total aquaculture production in four countries (India, Myanmar, Nepal and Pakistan) of south Asia (FAO, 2016). Among different experiments, the addition of Nile tilapia (*Oreochromis niloticus*) and Sahar (*Tor putitora*) has been successfully proven to increase the total production and gross margin in pond aquaculture (Shrestha *et al.,* 2011).

Nile tilapia, in comparison to other species, has many aquaculture attributes such as excellent growth rates, low dietary protein requirement, and its prolific breeding nature. Tilapia can tolerate wide ranges of environmental conditions, less susceptibility to disease, and responsive to handling and captivity.

Integrated fish farming mainly focuses on production, integrated management, and comprehensive use of aquaculture, agriculture, and livestock, with an emphasis on aquaculture. The major features of this system include recycling of by-products

Author α: Agriculture and Forestry University, Nepal.
e-mail: pujabanmali01@gmail.com
Author σ ρ Ѡ: College of Aquaculture and Fisheries, Can Tho University, Vietnam. e-mails: manish.devkota21@gmail.com, hkfisherian22@gmail.com, winaungmyo609@gmail.com

in which the waste of one system becomes the input of other systems and efficient utilization of space. According to Latif (1993), integrating duck farming with aquaculture is an economically viable and productive system for both farmers and commercial entrepreneurs.

The duck droppings act as excellent organic fertilizer for the fish pond which accounts for 60% of the total input cost in fish culture (Shrestha& Pandit, 2012). Duck manure is considered one of the effective nutrients for enhancing the growth of natural food (Latif, 1993). Some fish species like common carp *(Cyprinus carpio)* intake duck dropping directly as their feed (Biswas, 2015).

Integrating duck with fish farming has many benefits like utilization of duck droppings by the fish as natural food, space utilization, and droppings can be used as manure. If the ducks are raised in ponds 2-3% of protein in duck feeds will be reduced. Ducks act as natural aerators by their swimming and dabbling activities. Integrating duck with fish culture ensures the farmers high profit with less investment (Majhi, 2018).

II. Materials and Methods

a) *Study Site*

The duck cum fish integrated farming was practiced in the Aquaculture farm of Fisheries Program, Agriculture and Forestry University located in Rampur, Chitwan. The study was conducted for 120 days from March 15 to mid-July. The area of the pond was 575 m^2 with a duck shed on the dyke previously constructed by the farm.

b) *Materials and Methodology*

Pond was prepared by draining, thorough cleaning, and removal of the existing fish and aquatic vegetation. Dry liming was done at the rate of 200 kg/ha with agriculture lime ($CaCO_3$). After 7 days of liming, the pond was fertilized with fresh cow dung at the rate of 3000 kg/ha. The ponds were filled with fresh water after the organic fertilization. Water depth was maintained at 1 meter deep. Inorganic fertilizers such as Urea and DAP were applied at the rate of 4.7 g/m^2/week and 3.5 g/m^2/week respectively.

The pond was stocked with Common carp (25%), Bighead carp (5%), Grass carp (15%), Rohu (25%), Mrigal (10%), and Nile tilapia (20%). The number and amount of fingerlings stocked is tabulated below:

Table 1: Stocking number and weight of the fish species in the pond

S.No.	Species	Stocked Number(No/Pond	Total Stocked Weight (g/pond)	Percentage (%)
1	*Cyprinus carpio*	145	2760	25
2	*Aristichthys nobilis*	30	1730	5
3	*Ctenopharyngodonidella*	82	890	15
4	*Labeorohita*	140	6000	25
5	*Cirrhinusmrigala*	55	530	10
6	*Oreochromis niloticus*	130	8200	20
	Total	582	20110	100

Feed containing 20% CP was given twice a day at 10 am and 3 pm at the rate of 2% of total body weight. Farm-made feed was fed to the fish for the reduction of the cost of production. The mixture of locally available rice bran and mustard oil cake in a 1:1 ratio was made in a dough form each day. The vitamin and mineral mixture was added at the rate of 1kg per 100 kg feed. For Grass carp, different types of vegetation like *Colocassia*, banana leaves, Para grass, and *Napier* were fed by chopping them into small pieces. Sampling was done every 2 weeks to check the growth performance and to estimate the amount of feed required. After 3 months of stocking the fish, partial harvesting was initiated. Complete harvesting was done by draining the pond water completely.

c) *Rearing of Duck*

Prior to stocking, the duck shed was cleaned with water thoroughly. Total 14 ducklings with an average weight of 161±69.8g were stocked. Mainly, rice husk was fed by mixing homogeneously with water in a feeding tray. Feed was given 4 times daily at 10 am, 12 pm, 3pm, and 5 pm. Sampling of duck was done every month to observe the growth rate. Each duckling was weighed individually on a weighing machine separately. After 4 months of rearing, ducks were harvested.

d) *Analytical Method*

i. *Fish Growth Measurements*

Growth and production was calculated using the following formulae:

$$Daily\ Weight\ Gain(g/fish/day) = \frac{Average\ Harvest\ Weight(g) - Average\ stocked\ Weight\ (g)}{Culture\ period\ (days)}$$

$$Total\ Weight\ Gain = \frac{Harvested\ Weight\ (g) - Stocked\ Weight(g)}{Pond\ Area(m^2)} * 100$$

$$Survival\ rate\ (\%) = \frac{Total\ number\ of\ fish\ harvested}{Total\ number\ of\ fish\ stocked} \times 100$$

$$Net\ fish\ yield\ (g/m^2/day) = \frac{Total\ harvested\ weight\ (g) - Total\ stocked\ weight\ (g)}{Culture\ peiod\ (days) \times Culture\ Units\ (m^2)}$$

$$Apparent\ food\ conversion\ ratio\ (AFCR) = \frac{Quantity\ of\ feed\ fed\ (kg)}{Net\ fish\ yield\ (kg)}$$

$$Extrapolated\ NFY\ (t/ha/yr) = \frac{Total\ harvest\ weight(g) - Total\ stocked\ weight(g)}{Culture\ period(days) * Culture\ Unit(m^2) * 1000 * 1000} * 10000 * 365$$

$$Extrapolated\ GFY\ (t/ha/yr) = \frac{Total\ harvest\ weight(g)}{Culture\ period(days) * Culture\ Unit(m^2) * 1000 * 1000} * 10000 * 365$$

e) Water quality analysis

Water quality parameters were monitored and recorded daily during the entire culture period. Physical parameters like dissolved oxygen (DO), temperature with DO meter (Lutran, DO 5519), and pH by using pH meter (Lutran, pH 222)were recorded daily.

f) Economic analysis

Simple gross margin analysis was done after the complete harvesting of the fish. Gross margin analysis was based on the farm prices for the harvested fish. The rate of fish per kg was estimated as NRs.300 per/day for all species of fish.

$$Gross\ margin\ (NRs) = Gross\ return\ (NRs) - Total\ variable\ cost\ (NRs)$$

$$Gross\ return\ (NRs) = Price\ of\ fish\ \left(\frac{NRs}{kg}\right) \times Total\ quantity\ produced(kg)$$

$$Total\ variable\ cost\ (NRs) = \sum cost\ incurred\ in\ all\ the\ variable\ items\ (NRs)$$

g) Statistical analysis

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

III. Results and Discussion

a) Water quality analysis

Water quality parameters like temperature, dissolved oxygen, and pH were recorded daily during the culture period of 117 days. The mean and range of water quality parameters recorded are presented in Table 2 and Figures 1-3. The range of all the water quality parameters is similar as reported by Jena *et al.,*(2002) and Jha *et al*., (2018).

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

Parameter	Unit	Average	Range
Dissolved oxygen	mg/L	3.0±0.6	0.9-7.2
Temperature	ºC	27.9±1.4	23.8-30.6
pH		6.7	6.09-9.7

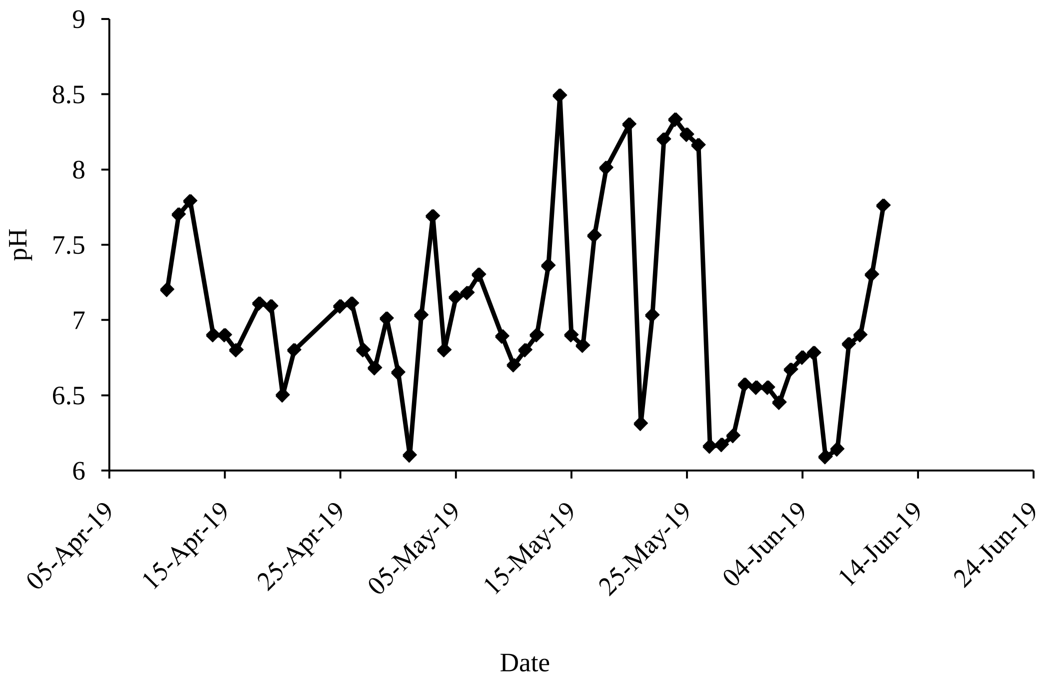

Figure 1: pH of pond water during the culture period

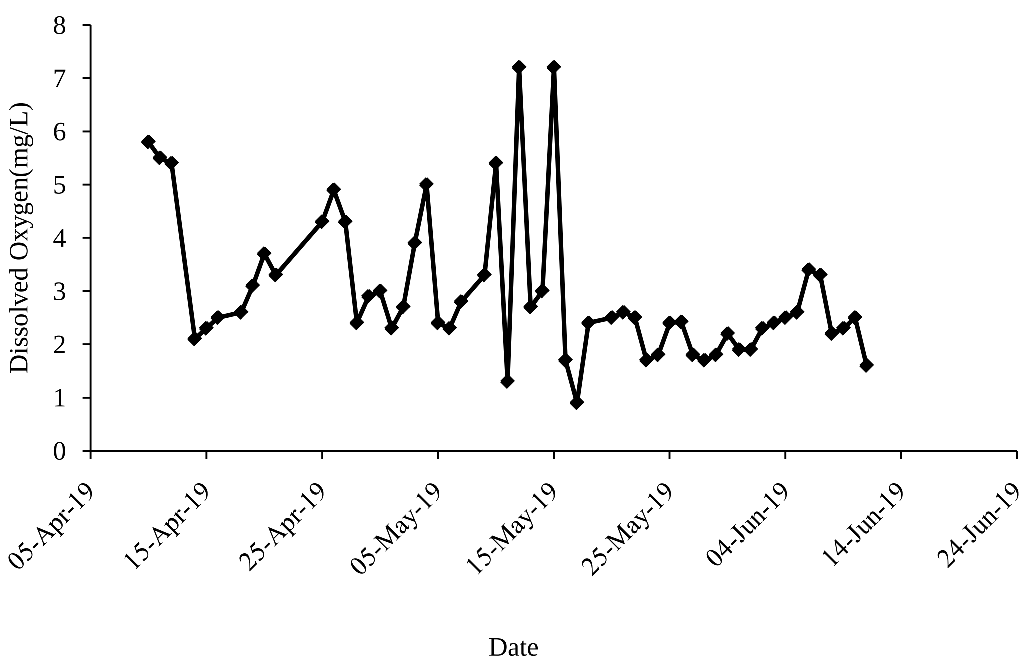

Figure 2: Dissolved oxygen (mg/L) during the culture period

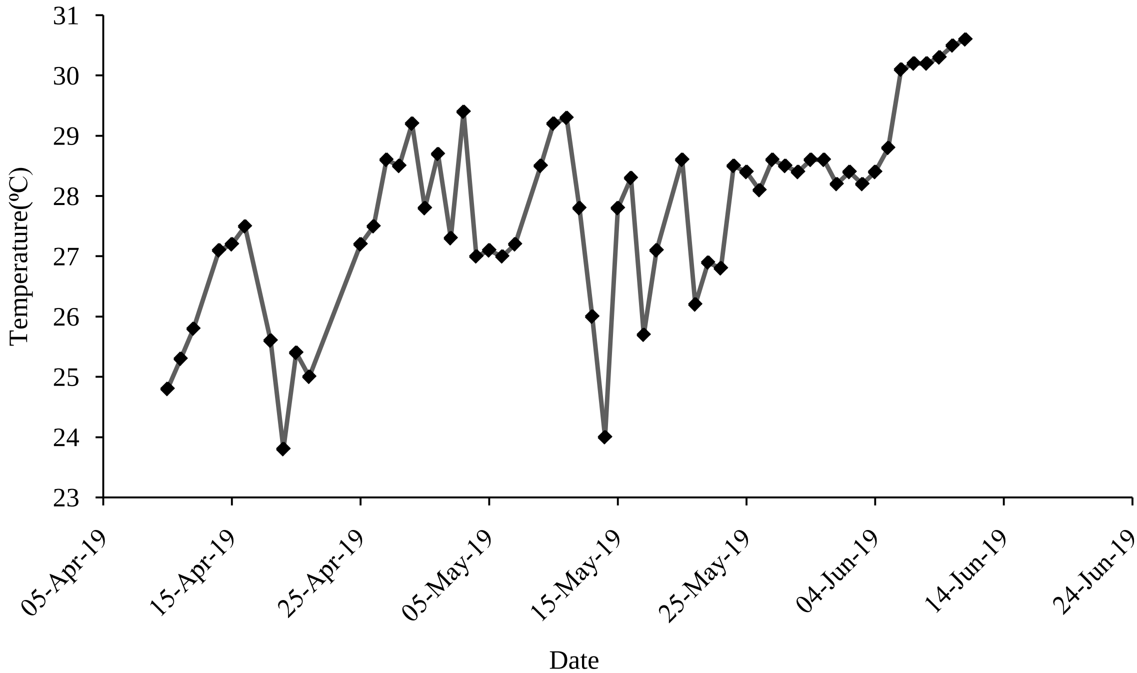

Figure 3: Temperature (ºC) during the culture period

b) Fish growth and production

Table 3: Growth and production parameters

Growth and Production Parameters	*C. mrigala*	*C. carpio*	*A. nobilis*	*C. idella*	*O. niloticus*	*L. rohita*
Total weight gain (g/100m^{2})	240.3	3742.0	1736.0	359.4	1110.1	2050.3
Daily weight gain (g/fish/day)	2.0	1.7	3.0	0.6	0.6	1.5
Survival rate (%)	14.5	80.7	93.3	47.6	81.5	61.4
Extrapolated GFY (t/ha/yr)	0.1	1.3	0.6	0.2	0.8	1.0
Extrapolated NFY (t/ha/yr)	0.07	1.17	0.54	0.11	0.35	0.64

Table 3 shows the growth and production parameters of all fish species during the culture period of 117 days. The daily weight gain and total weight gain of Rohu was found to be 1.5 g/fish/day and 2.05kg/100m^2 respectively. Similarly, the survival rate was 61.4%, and extrapolated GFY and NFY were1.0 t/ha/yr and 0.64 t/ha/yr respectively. The daily weight gain and total weight gain of Mrigal was found to be 2.0 g/fish/day and 240.3 g/100m^2 respectively. Similarly, the survival rate was 14.5% and extrapolated GFY and NFY 0.1 t/ha/yr and 0.07 t/ha/yr respectively. The daily weight gain and total weight gain of Common carp were found to be 1.7 g/fish/day and 3742.0 g/100m^{2}respectively. Similarly, the survival rate was 80.7% and extrapolated GFY and NFY 1.3 t/ha/yr and 1.17 t/ha/yr respectively. The daily weight gain and total weight gain of Bighead carp were found to be 3.0 g/fish/day and 1736.0 g/100m^2 respectively. Similarly, the survival rate was 93.3%, and extrapolated GFY and NFY was 0.6 t/ha/yr and 0.54 t/ha/yr respectively. The daily weight gain and total weight gain of Grass carp were found to be 0.6 g/fish/day and 359.4 g/100m^2 respectively. Similarly, the survival rate was 47.6%, and extrapolated GFY and NFY were0.2 t/ha/yr and 0.11 t/ha/yr respectively. The daily weight gain and total weight gain of Tilapia were found to be 0.6 g/fish/day and 1110.1 g/100m^2 respectively. Similarly, the survival rate was 81.5%, and extrapolated GFY and NFY were0.8 t/ha/yr and 0.35 t/ha/yr respectively.

c) Growth Trend of Fish

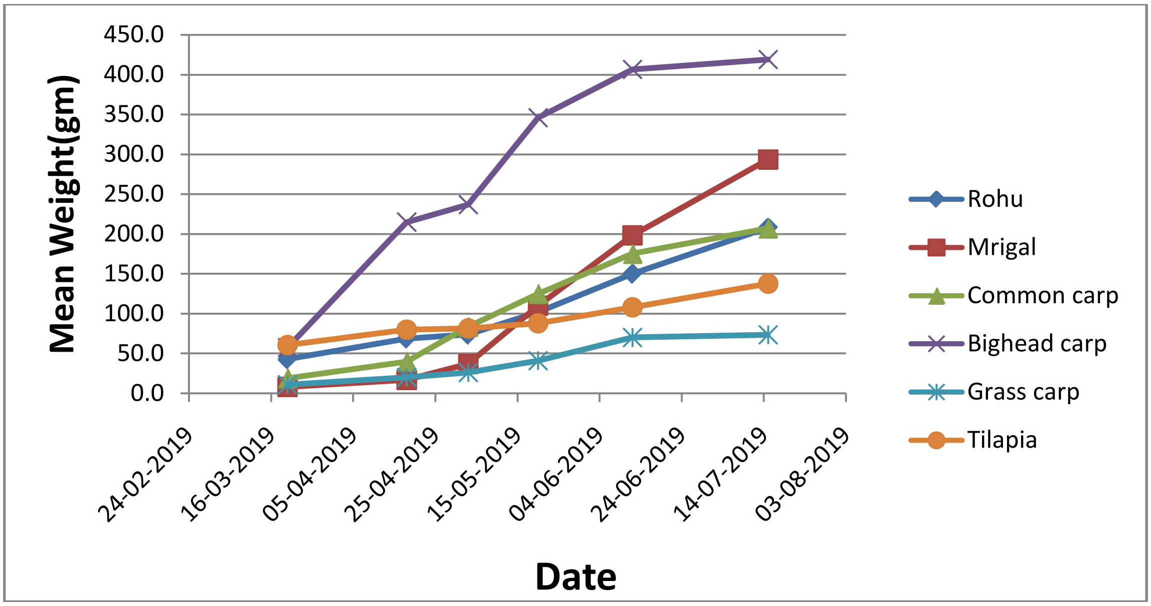

Figure 4: Growth trend of carps and nile tilapia during the culture period

i. *Rohu (Labeorohita)*

From the graph, it is clear that the growth of Rohu followed a normal trend from an average stocking weight of 42.1±4.6 g/fish to an average harvested weight of 212.2±6.8 g/fish. The daily weight gain of Rohu in the present study showed lower (1.5 g/fish/day) than as reported (2.5±0.1 g/fish/day) by Mandal *et al*., (2018) but higher than as reported by Jha *et al*. (2018). The higher weight gain might be due to the availability of natural food due to duck droppings incorporation. The survival rate of present work was 61.4% which is lower than as reported by Uddin *et al*., (2012), lower than that reported (91.0%) by Roy(2016), and also lower than as reported by Azim & Wahab (2003) which was 71%.

ii. *Mrigal(Cirrhinusmrigala)*

From the graph, it is clear that the growth of Mrigal followed a normal trend from an average stocking weight of 9.8±0.4 g/fish to an average harvesting weight of 242.8±32.4g/fish. In the present work, the daily weight gain was 2.0 g/fish/day which was slightly higher than as reported (1.8±0.1 g/fish/day) by Mandal *et al*., (2018) and also higher than as reported (0.7±0.1 g/fish/day) by Jha *et al.,*(2018). According to Uddin *et al*., (2012), the survival rate of Mrigal was 90.2±2.20 % which was 14.5% during the present work. Also, the survival rate of Mrigal as reported by Mandal *et al*., (2018) in previous work was 40.5±4.1%. and 66.0±5.3 % as reported by Jha *et al.,*(2018).

iii. *Common Carp (Cyprinus carpio)*

From the graph, it is clear that the growth of Common carp followed a normal trend from an average stocking weight of 15.1±3.7g/fish to an average harvesting weight of 208.6±84.0g/fish. DWG of Common carp during present work is 1.7 g/fish/day which is lower than 2.2±0.1 g/fish/day as reported by Mandal et al., (2018) and also lower than as reported (5.1±1.7 g/fish/day) by Jha *et al.,* (2018) but higher than as reported (1.11±0.07 g/fish/day) by Bhandari (2016). The survival rate of Common carp is higher in present work (80.7%) than as reported (22.7±3.8%) by Jha *et al.,* (2018) and (78±7%) by Bhandari(2016) but lower than as reported (84%) by Azim & Wahab(2003) in development of a duckweed fed carp polyculture system in Bangladesh.

iv. *Bighead Carp(Aristichthys nobilis)*

From the graph, it is clear that the growth of Bighead carp followed a normal trend from an average stocking weight of 57.2±2.5g/fish to an average harvesting weight of 411.1±42.7g/fish. Bighead Carp showed a daily weight gain of 3.0 g/fish/day in the present work which is higher than as reported (2.6±0.8 g/fish/day) by Mandal *et al.,*(2018) and also higher than 2.1±0.1 g/fish/day as reported by Jha et al. (2018). The survival rate of bighead carp was relatively similar as reported by Mandal et*al.,*(2018). It was remarkably higher than that as reported (45.4±2.5 %) by Jha et al.(2018) in the production of periphyton to enhance yield in polyculture ponds with carps and small indigenous species.

v. *Grass Carp(Ctenopharyngodon idella)*

From the graph, it is clear that the growth of Grass carp followed a normal trend from an average stocking weight of 15.1±3.7g/fish to average harvesting weight of 208.6±84.0g/fish. As reported in Jha *et al.,*(2018), the daily weight gain of Grass carp is 2.2±0.2 g/fish/day which is only 0.6 g/fish/day in the current work. Pandit *et al*.,(2004) reported the daily weight gain of Grass carp to be 3.14±0.15 g/fish/day when stocked at 0.5 fish/m^2. The survival rate of Grass carp is 47.6% in the present work is similar to as reported (45.4±2.6%) by Jha *et al.,*(2018) but reported higher by Bhandari (2016) in carp and tilapia culture.

vi. *Nile Tilapia(Oreochromis niloticus)*

From the graph, it is clear that the growth of Tilapia followed a normal trend from an average stocking weight of 59.4±13.4g/fish to an average harvesting weight of 132.2±15.9g/fish. According to Guerrero III *et al*.,(1988), the survival rate of Nile tilapia was 100% in commercial diet and 93% in chicken manure but it is 81.5% in the present work where duck droppings were used. Also, the survival rate was reported lower as compared to the present work by Bhandari(2016) which was 69±5 %.The DWG of Nile tilapia was estimated to be 0.8-1.0 g/fish/day by Shrestha & Jaiswal (2011) is higher compared to the present work (0.6 g/fish/day).But the DWG in the present work is higher as compared to the result reported by Pandit *et al*., (2004) which was 0.40±0.02 in polyculture of grass carp and Nile tilapia with Napier grass as the sole nutrient input in the subtropical climate of Nepal where tilapia was stocked at 0.5 fish/m^2.

d) Combined Fish Production

Table 4: Production of fish species

Production parameters	Unit	Value
Stocked weight	kg/pond	19.92
Stocked number	Number/pond	582
Harvested fish	kg/pond	73.13
Harvest number	Number/pond	384
Fish yield	kg/pond	53.21
Feed supplied	kg	76.75
Pond area	m^2	576
Culture period	Days	117
Extrapolated GFY	t/ha/yr	4.0
Extrapolated NFY	t/ha/yr	2.9
Overall survival rate	%	66.0
AFCR		1.4

Table 4 presents the production and yield parameters of fish during the culture period of 120 days. Total fish yield of 53.21 kg of fish was gained from the pond of 575m^2.Extrapolated NFY and GFY were calculated to be 4.0 t/ha/yr and 2.9 t/ha/yr respectively. The overall survival rate was 66 %. The apparent food conversion ratio was found to be 1.4.

The overall survival rate of the present work was estimated to be 66% which is lower than that as reported by Bhandari (2016) in the value of Nile tilapia and Sahar in carp polyculture pond in improving pond productivity. Similarly, Mandal *et al*., (2018) reported a survival rate of 75.2±5.8 %, and Jena *et al.,*(2002) reported an 88.0±0.2% survival rate. Bhandari (2016) reported the FCR to be 2.62±0.17 which in present work is 1.4. Similarly, Mandal *et al.,*(2018) reported the FCR value of 1.5±0.2 which is nearly equal to that of the present work.

e) Duck growth and production

Figure 5 indicates the average weight of duck during the rearing period. The growth of duck showed a normal trend from mean stock weight of 161±69.8 g/duck to mean harvest weight 1114.4±296.4 g/duck.

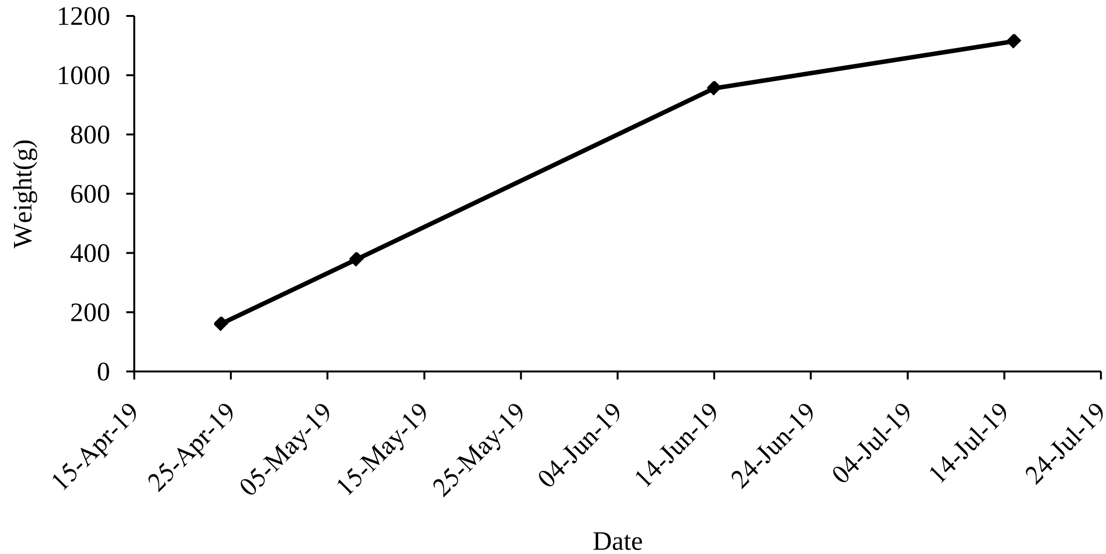

Figure 5: Average weight of duck during rearing period

Table 5 indicates the growth of duck during the rearing period. The rearing period of duck was about 120 days. The mean stock weight and mean harvest weight was 161±69.8 g/duck and 1114.4±296.4 g/duck respectively. Similarly, daily weight gain was 7.9 g/duck/day.

During the rearing period of a duck the mean weight harvest was 1114.1±296.4 g/duck in the present work which is similar as reported(1304g) by Kumar *et al.*,(2012) for the same work period. According to Latif *et al.*,(1993) the final mean weight ranged from 1200-1800g for a period of 4-6 months.

Table 5: Growth and production of Duck during rearing period

Growth Parameters	Unit	Value
Stocked no	Number	14
Stocked weight	kg	2.25
Mean stocked wt.	g/duck	161±69.8
Total harvest no	Number	14
Total harvest wt.	kg	15.6
Mean harvest wt.(g/duck)	g/duck	1114.4±296.4
Daily weight gain (g/duck/day)	g/duck/day	7.94

f) Gross margin Analysis

i. *Gross margin analysis of duck cum fish integration*

The total variable cost involved in the fish production was NRs.18,286.54. Similarly, the production cost was NRs. 150.7 per kg and benefit: cost ratio was 1.69. All the variables and costs are tabulated below in Table 6.

Table 6: Gross margin analysis of Carp-Tilapia-Duck integrated farming

Variable cost	Unit	Quantity	Rate (Rs/kg)	Amount
Variables				
Urea	kg	5.41	20	108.2
DAP	kg	4.0	55	221.76
Cow dung	kg	57.6	2	115.2
Lime	kg	11.52	12	138.24
Feed				

MOC	kg	38.378	30	1151.34
Ricebran	kg	38.378	35	1343.23
Vitamin	kg	0.76	300	228
Fish seed	kg	19.92	300	5976
Diesel	L	9.25	100	925
Electricity	kWh	81	10	810
Ducklings	Number	14	300	4200
Duck feed	kg	65.31	47	3069.57
Total variable cost(NRs.)				18286.54
Return				
Rohu	kg	17.8	300	5340
Mrigal	kg	1.9	300	570
Common	kg	24.2	300	7260
Bighead	kg	11.7	300	3510
Grass	kg	2.9	300	870
Tilapia	kg	14.6	300	4380
Duck	kg	15.6	576	8985.6
Gross return (NRs.)				30915.6
Net return (NRs.)				12629.06
Production cost (NRs./kg)				150.71
B:C ratio				1.69

g) Cost analysis of duck farming

Table 7 indicates the economic analysis of duck farming integrated with the fish culture. The ducklings were reared for 120 days. The production cost was estimated as NRs.465.99 per kg and the benefit: cost ratio was 1.24.

Table 7: Economic analysis of duck farming

Variable cost	Quantity(kg)	Rate (Rs/kg)	Amount
Ducklings	14	300	4200
Duck feed	65.31	47	3069.57
Total variable cost(NRs.)			7269.57
Return			
Duck	15.6	576	8985.6
Production cost (NRs./kg)			465.99
B:C ratio			1.24

IV. Conclusion

Integrated fish farming is a sustainable and effective tool for improving the livelihood of rural people. It offers the effective and efficient utilization of the locally available resources and diversification of the income of the small-scale farmers. This research concluded that integrated duck-fish farming can resolve the issues of sustainability effectively.

Acknowledgment

We would like to thanks the Department of aquaculture and Fisheries, Agriculture and Forestry University for providing research facilities to carry out this work. We would also like to thanks Mr. Rahul Ranjan, Prof. Dr. Madav Kumar Shrestha, Prof. Dr. Sunila Rai, Prof. Dr. Dillip Kumar Jha, and Asst. Prof. Dr. Narayan Prasad Pandit for their invaluable suggestion, persistent co-operation, continuous supervision, and guidance throughout the period of this research.

References Références Referencias

1. Azim, E. & Wahab, Md. (2003). Development of a duckweed-fed carp polyculture system in Bangladesh. *Aquaculture*. 218. 425-438. 10.1016/S0044-8486(03)00012-7.

2. Bhandari, M.P.(2016). Value of Nile Tilapia and Sahar in carp polyculture pond in improving pond productivity. *Master Thesis. Agriculture and Forestry University.*
3. Biswas, Dr. (2015). Fish Duck Integrated Farming.
4. Bunting S.W. (2008). Horizontally integrated aquaculture development: exploring consensus on constraints and opportunities with a stakeholder Delphi. *Aquaculture International* 16, 153–169.
5. CFPCC. (2017/18). Annual Progress Report. *Central Fisheries Promotion and Conservation Center. Balaju, Kathamandu, Nepal.*
6. Da Silva, L. B., Barcellos, L. J., Quevedo, R. M., De Souza, S. M. J., Kreutz, L. C., Ritter, F. (2006). Alternative species for traditional carp polyculture in southern South America: Initial growing period. *Aquaculture,* 255: 417–428.
7. DOFD. (2017). Fisheries Data and Annual Progress Report, 2016/17. Directorate of Fisheries Development, Balaju, Kathmandu, Nepal.
8. FAO. (2016). The State of World Fisheries and Aquaculture: Contributing to Food Security and Nutrition For All. Rome.
9. Guerrero III, R.D., Guerrero, L.A &Alamar, M.E.(1988). Polyculture of Nile Tilapia, grass carp and common carp in freshwater ponds. *Trans. Nat. Acad. Science and Tech.(Philippines).*1988:10:365-368.
10. Gurung, T. B. (2016). Role of inland fishery and aquaculture for food and nutrition security in Nepal. Agri Food Secur 5: 18.
11. Gurung, T., & Basnet, S. R. (2003). Introduction of Rainbow trout *Onchorynchus mykiss* in Nepal: constraints and prospects*. Aquacult.Asia ,* VIII(4): 16-18*.*
12. Jena, J.K., Ayyappan, S. & Aravindakshan, P.K. (2002). Comparative evaluation of production performance in varied cropping patterns of carp polyculture systems. *Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar 751 002, India. Aquaculture* 207 (2002) 49–64.
13. Jha, S., Rai, S., Shrestha, M., James, S.D., Mandal, R. &Egna, H. (2018). Production of periphyton to enhance yield in polyculture ponds with carps and small indigenous species*. Aquaculture Reports.* 9. 74-81. 10.1016/j.aqrep.2018.01.001.
14. Kumar, J. Y., Chari, M. S. &Vardia, H. K. (2012). Effect of integrated fish-duck farming on growth performance and economic efficiency of Indian major carps. *Livestock Research for Rural Development. Vol 24, Article #219.*
15. Kunwar, P. S., & Adhikari, B. (2016). Status and development trend of aquaculture and fisheries in Nepal. *Nepalese Journal of Aquaculture and Fisheries*, 3, 1-11.
16. Latif, M. A., Alam, M. J., & Rahman, M. A. (1993). Integrated Duck-cum-Fish Farming in Bangladesh. *Journal of the World Aquaculture Society,* 24(3), 402–409. doi:10.1111/j.1749-7345.1993.tb00172.x
17. Majhi, A. (2018). Role of integrated duck cum fish farming and its economic efficiency: A study in Purulia district, West Bengal. *International Journal of Information Research and Review.* Vol. 05, Issue, 05, pp.5443-5450, May, 2018
18. Mandal, R.B., Rai, S., Shrestha, M.K., Jha, D.K. & Pandit, N.P.(2018). Effect of red algal bloom on growth and production of carps. *Our Nature.* 16(1): 48-54.
19. McKinnon, A.D., Trott, L.A., Alongi, D.M. & Davidson, A. (2002). Water column production and nutrient characteristics in mangrove creeks receiving prawn farm effluent. *Aquaculture Research.* 33: 55-73.
20. Pandit, N.P., Shrestha, M.K., Yi, Y. & Diana, J.S. (2004). Polyculture of grass carp and Nile tilapia with napier grass as the sole nutrient input in the subtropical climate of Nepal. In: R. Bolivar, G. Mair, and K. Fitzsimmons (Editors), *Proceedings of the Sixth International Symposium on Tilapia in Aquaculture,* pp. 558-573*.*
21. Rai, A. K., Clausen, J. & Smith, S. F. (2008). Potential development interventions for fisheries and aquaculture development in Nepal*. Food and agriculture organization of the United Nations Regional office for Asia and the Pacific Bangkok. Asia Pacific Fishery Commission Ad hoc Publication.*
22. Roy, D.(2016). Large scale fish production through carp polyculture system in a fish farm in Bangladesh.*Vestnik of Astrakhan State Technical University. Series: Fishing Industry*, (4).
23. Shrestha, M.K. & Pandit, N.P. (2012). A Text Book of Principles of Aquaculture.
24. Shrestha, M.K. & Jaiswal, R. (2011). Incorporation of Tilapia and Sahar into the existing carp polyculture system of Nepal. *Technical Reports Investigations* 2009-2011.
25. Shrestha, M.K. & Jaiswal, R. (2011). Incorporation of Tilapia and Sahar into the existing carp polyculture system of Nepal. *Technical Reports Investigations* 2009-2011.
26. Uddin, M.N., Shahjahan, Md. & Haque, M.M. (2012). Manipulation of Species Composition in Small Scale Carp Polyculture to Enhance Fish Production. *Bangladesh Journal of Progressive Science and Technology.* 10. 9-12.
27. Woynarovich, A., Poulsen, T. M., & Peteri, A. (2010). Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia. Rome: *Food and Agriculture Organization of the United Nations.*