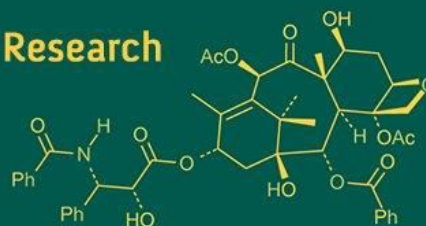


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(1): 945-949
www.biochemjournal.com
Received: 28-10-2025
Accepted: 30-11-2025

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Effects of poultry droppings on water quality, growth performance, feed utilization, and survival of *Cirrhinus mrigala* (Hamilton, 1822) under a vertical integrated fish-poultry farming system

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i11.7160>

Abstract

The present study investigated the influence of poultry droppings on water quality, growth performance, feed utilization, and survival of *Cirrhinus mrigala* fry under an integrated fish-poultry farming system. A poultry-manured treatment tank and a non-manured control tank were compared over the course of the 75-day experiment. Over the course of the experiment, water quality parameters stayed within the acceptable range for carp culture. The water's pH ranged from 7.93 ± 0.08 to 8.64 ± 0.15 , and its temperature ranged from 27.72 ± 0.09 °C to 29.90 ± 0.00 °C. Increased nutrient availability in the integrated system was indicated by electrical conductivity (873.66 ± 47.34 to 933.66 ± 32.96 $\mu\text{S/cm}$) and total dissolved solids (511.33 ± 19.09 to 572.96 ± 26.24 mg/L). Growth performance of *C. mrigala* fry was significantly higher in the treatment group. In the treatment group, weight gain (%) varied from 6.72 ± 1.14 to 48.78 ± 9.47 , while in the control group, it ranged from 6.86 ± 3.49 to 26.18 ± 2.72 . The treatment showed the highest specific growth rate (SGR) of 2.62 ± 0.41 , whereas the control showed 1.54 ± 0.14 . With a lower feed conversion ratio (1.64 ± 0.29) and higher protein and lipid efficiency ratios than the control, the integrated system demonstrated improved feed utilization. Both groups had comparable and high survival rates—above 92%. According to the study's findings, integrated fish-poultry farming has the potential to be a sustainable aquaculture method since it increases pond productivity and greatly improves the growth and feed efficiency of *C. mrigala* fry without adversely affecting survival.

Keywords: *Cirrhinus mrigala*, fish-poultry integration, poultry manure, growth performance, water quality

1. Introduction

Aquaculture stands out as the most promising and rapidly growing sector in comparison to other major food-producing industries worldwide. In the global context, the growing food crises, driven by an increasing population, malnutrition, and inadequate supply of quality food, have become critical concerns. These issues are exacerbated by diminishing available resources such as land and water, coupled with the effects of climate change. It is evident that urgent action is needed to address these challenges and ensure a sustainable food supply for the future.

Reports indicate that fish plays a vital role in meeting the protein needs of more than half of the world's population. Fish flesh provides easily digestible protein containing all the essential amino acids, as highlighted by research conducted by Godara *et al.* in 2015 [7]. Moreover, fish is a valuable component of a nutritious diet due to its low carbohydrate and unsaturated fat content. In the Indian context, carps play a pivotal role in aquaculture, accounting for more than 85% of total production. Among these, *mrigala* stands out as a key freshwater species extensively cultivated in polyculture systems using traditional or semi-intensive methods. Highly valued as a food fish and significant in aquaculture practices across South Asia, *mrigala* is commonly farmed alongside rohu and catla, creating a sustainable polyculture system that provides essential food resources in the region.

Given the limited availability of land for farming, sustaining agricultural activities becomes crucial to expanding food production (Kalantari *et al.*, 2017) ^[10].

To meet customer demand, it becomes imperative to develop alternative aquaculture approaches with integrated farming in such constrained locations. Thus, a technique that combines fish farming with animal husbandry and horticulture has been developed to address the current economic demand for maximizing food output, minimizing production costs, and emphasizing energy conservation. This integrated approach holds significant potential for increasing production of various commodities, generating employment in rural areas, and enhancing the socioeconomic status of farmers, as fish culture can be successfully integrated with livestock or commercial crops (Hirpo, 2017) ^[8]. Moreover, integrated fish-livestock-horticulture farming represents a method that brings together three traditionally distinct farming systems, integrating fish, livestock, and horticulture into a cohesive whole. The key objective is to achieve optimal waste or by-product usage efficiency, where the waste from one subsystem serves as a valuable input for another. This approach has garnered significant attention, particularly focusing on utilizing animal manures as fertilizer and nutrients to stimulate the growth of natural feed in fish ponds (Hirpo, 2017) ^[8]. In this multi-commodity farming system, fish culture takes center stage, and waste recycling becomes a crucial component of the integrated approach. To address the global challenge of feeding the world's growing population and to make efficient use of scarce resources, it is essential to enhance production per unit area. Skyscraper vertical towers in metropolitan cities worldwide have already demonstrated the effectiveness of utilizing land efficiently to accommodate high population density within limited space. Building upon this concept, vertical farming of vegetables and flowers has been adopted in the western world to maximize agricultural output in constrained urban environments. Considering the success of vertical farming in the urban context, the present investigation aims to explore the effects of poultry droppings on water quality, growth performance, feed utilization, and survival of *Cirrhinus mrigala* under a vertical integrated fish-poultry farming system.

2. Materials and Methods

2.1 Experimental Site

The research work was carried out at the College of Fisheries Science (formally known as PGIFER), Kamdhenu University, Rajpur (Nava) Himmatnagar. An experimental set-up to examine the growth performance was conducted at the wet laboratory.

2.2 Experimental Fish

Healthy Mrigal advance fry (*Cirrhinus mrigala*, Family Cyprinidae, and Order Cypriniformes) were used for *in vivo* experiment. The stock of *Cirrhinus mrigala* fish was obtained from the State Fisheries Department-Ukai, Gujarat. The average weight of the fish was 2.99 ± 0.01 g. The prophylactic treatment following the standard protocol of bath treatment in 0.05% potassium permanganate solution was given to fish before placing them in an acclimatization tank. Fish was reared for one month under laboratory conditions for proper acclimatization under the optimal

condition, before taking them for *in vivo* experiment. Commercial feed was used to feed the fish.

2.3 Experimental design

The research was conducted in pretreated (2ppm KmNO_4 , washed 3-4 times thoroughly) 1000 litre circular tanks, and filled with pre-quality tested water. The experimental setup followed CRD design and the tanks were arranged for treatments and control in triplicates of each (Table 3.1). The experimental fish *Cirrhinus mrigala* stocked @ 1g/L of water (180 fish per tank). Siphoning was done every day and water exchange kept 10-15% to compensate losses during siphoning and evaporation. The fish were fed at the rate of 10% of average body weight in split dosed twice a day for first 30 days and 8% for subsequent time. Growth parameters were monitored fortnightly. The set-up was made of six FRP tanks on which three cages were mounted except the three tanks which served as the control. In three tanks daily 10% poultry dropping were added as fertilizer. A total of 8 birds (6-month-old) were used. This experiment lasted for 75 days.

2.4 Water quality parameters

Quality parameters of water such as temperature, pH, TDS and electrical conductivity were determined in the biochemistry lab by HANA multiparameter bench meter (HI 5522, USA).

2.5 Growth parameters

Growth parameters of experimental fish like Percentage Weight Gain (gm), Feed Conversion Ratio, Specific Growth Rate (%), Body Weight Gain (%), Feed Conversion Efficiency, Protein Efficiency Ratio, Lipid Efficiency Ratio, Hepatosomatic Index, and Intestinal Somatic Index were analyzed during the study. The following formulas were used to measure the growth parameters of fish.

Mean Weight gain = Final Weight-Initial Weight

Survival

Survival (%) = total no. of fish h at the end of the experiment/total no. of fish at the beginning of the experiment x100

Specific growth rate (SGR)

$\text{SGR (\%)} = \frac{\text{Ln Final Weight} - \text{Ln Initial Weight}}{100/\text{Number of Days}}$

Feed conversion ratio (FCR)

$\text{FCR} = \frac{\text{Feed given (dry weight)}}{\text{Body weight gain (wet weight)}}$

Feed conversion efficiency (FCE)

$\text{FCE} = \frac{\text{Weight gain}}{\text{Feed given}}$

Protein efficiency ratio (PER)

$\text{PER (\%)} = \frac{\text{Weight gain}}{\text{protein intake}}$

Lipid efficiency ratio (LER)

$\text{LER (\%)} = \frac{\text{Weight gain}}{\text{lipid intake}}$

Hepatosomatic index (HSI)

$\text{HSI (\%)} = \frac{\text{Weight of liver}}{\text{Weight of whole fish}} \times 100$

Intestine somatic index (ISI)

$ISI (\%) = \text{Weight of intestine} / \text{Weight of whole fish} \times 100$

2.6 Statistical Analysis

The results of the present study were statistically analyzed using completely randomized design (CRD) and one-way analysis (ANOVA) using IBM® SPSS® version 26.00 software and significant differences ($p < 0.05$) among treatment means were compared using Duncan multiple range test (DMRT) (Snedecor and Cochran, 2014) [16].

3. Results and Discussion

3.1.1 Water quality parameters

The water quality parameter recorded during experimental period shown in table 1. In the present study water temperature was found in the range from 27.72 ± 0.09 °C to 29.90 ± 0.00 °C. According to Ahmed *et al.* (2011) [1] major carp grew most effectively in water that was between 26 °C to 29 °C. Getu *et al.* (2017) [6] observed 25 °C in fish-poultry-vegetable farming. Sharma *et al.* (2016) [14] found $24.7\text{--}32.5$ °C under the fish-poultry-horticulture farming system. The results obtained in the present study were well within the optimum range and in agreement with the findings of Safi *et al.* (2016) [13]. During, the experiment lowest and highest pH values viz. 7.93 ± 0.08 to 8.64 ± 0.15 were recorded. Getu *et al.* (2017) [6] observed a pH 8.1 in fish-poultry vegetable farming. Bisht *et al.* (2009) [4] conduct a study on integrated poultry cum fish farming they observed pH ranging between 7.30–8.50 and 7.00–8.30 in experimental and control pond respectively. Vijayakumar *et al.* (2020) [19] found pH ranging between 7.1 to 7.7 under integrated system. Endebu *et al.* (2016) [5] reported 8.7 pH under integrated poultry fish farming. Pond water in the fish-poultry cultivation system had a mean pH of 6.40 ± 0.14 , while pond water in the non-integrated system had a mean pH of 7.82 ± 0.06 , which was slightly alkaline (Shoko *et al.*, 2019) [15]. Sharma *et al.* (2016) [14] found pH between 6.8 to 8.3 under the fish-poultry-horticulture farming system. Safi *et al.* (2016) [13] found pH ranging between 6.1 to 7.6 under integrated system. The results obtained in the present study were well within the optimum range and in agreement with the findings of Vohra *et al.* (2012) [20], Ahmed *et al.* (2011) [1]. The fluctuation in pH in the treated ponds with poultry droppings was presumably caused by the interaction of various biotic and abiotic variables as well as the addition of more faeces to the water (Pillay, 1990) [12]. The conductivity values were reported from 873.66 ± 47.34 to 933.66 ± 32.96 $\mu\text{S}/\text{cm}$. Getu *et al.* (2017) [6] observed a conductivity 113.5 μS in fish-poultry-vegetable farming. Ahmed *et al.* (2011) [1] observed electrical conductivity increasing trend ranging between 1.88 ± 0.098 to 2.09 ± 0.176 $\mu\text{S}/\text{cm}$ under integrated poultry fish farming. Safi *et al.* (2016) [12] found conductivity varied from $0.203 \mu\text{S}/\text{cm}$ to $0.584 \mu\text{S}/\text{cm}$ under integrated system which may be due to the high amount of poultry droppings. The preferred and acceptable ranges for fish culture are 100–2,000 $\mu\text{S}/\text{cm}$ and 30–5,000 $\mu\text{S}/\text{cm}$, respectively. (Stone & Thomforde, 2004) [17]. The total dissolved solid fluctuated between 511.33 ± 19.09 to 572.96 ± 26.24 mg/l. Safi *et al.* (2016) [13] found total dissolved solid varied from 68–287 mg/l under integrated system. It was found that total dissolved solid level variations due to poultry dropping and plankton density (Jhingaran, 1991; Vohra *et al.*, 2012) [9, 20].

3.2 Growth Performance

This experiment was carried out to find the effect of poultry dropping on growth and survival of *Cirrhinus mrigala* fry for 75 days of experimental period. The results of growth parameters include mean weight gain, and specific growth rate (SGR) shown in table 2. During the experiment observed body weight gain (%) ranged from 6.86 ± 3.49 to 26.18 ± 2.72 and 6.72 ± 1.14 to 48.78 ± 9.47 in control and treatment respectively. The results agreed with the findings of Ahmed *et al.* (2011) [1] and Safi *et al.* (2016) [13] revealing higher weight gain of *Cirrhinus mrigala* reared in fish-poultry integration systems. The possible reason behind this poultry manure primarily contributes nitrogen and phosphates to pond water, which increases pond productivity (natural food for fish) and hence increases fish weight gain (Kang'ombe *et al.*, 2006) [11]. The highest SGR was noticed 1.54 ± 0.14 and 2.62 ± 0.41 in control and treatments respectively. The results agreed with Shoko *et al.* (2019) [15] they observed 2.36 ± 0.75 in the integrated system while they observed 1.85 ± 0.12 in the non integrated system. Vijayakumar *et al.* (2020) [19] observed 2.31 SGR in *catla catla* in fish cum poultry farming systems. The observed results were also supported by Safi *et al.* (2016) [13], they observed lower SGR (0.39). The possible reason behind this may be insufficient amount of zooplankton and phytoplankton in the control pond. (Szlaminska and Przybye, 1986) [18].

3.3 Feed Utilization

This experiment was carried out to find the effect of poultry dropping on growth and survival of *Cirrhinus mrigala* fry for 75 days of experimental period. The results of feed conversion ratio (FCR), protein efficiency ratio (PER) and lipid efficiency ratio (LER) obtained in the present experiment are given in table 2. The FCR values found at the end of the experiment were 3.86 ± 2.62 and 1.64 ± 0.29 in control and treatment respectively. Similar observation was reported by Ajani *et al.* (2020) [2] they found 1.39 FCR under fish, rice cum poultry system. The highest and lowest values of FCR were calculated fortnightly and at the end of the experiment. The possible reason behind this may be poultry manure can increase fish production because it can adequately offer nitrogen and phosphorus for phytoplankton and zooplankton, which in turn act as food for fish (Banerjee *et al.*, 1979) [3]. In comparison to treatments using cattle and pig manure in unfertilized ponds, Kang'ombe *et al.* (2006) [11] claimed that using poultry manure generated better outcomes. The PER and LER readings showed a rising trend. The PER was 0.60 ± 0.04 and 1.01 ± 0.06 in control and treatment respectively. LER was 4.25 ± 0.29 and 7.11 ± 0.48 in control and treatment respectively.

3.4 Survival Rate

Survival rate of *Cirrhinus mrigala* fry in the respective treatments are presented in Table 2. The survival found at the end of the experiment was 92.03 ± 0.49 and 92.33 ± 0.97 in control and treatment respectively. Safi *et al.* (2016) [13] found survival of *Cirrhinus mrigala* 53% and 57.8% in control and treatment ponds respectively. According to Shoko *et al.* (2019) [15] the survival rates in the integrated system and non-integrated system were 97.58 ± 0.70 and 95.58 ± 0.91 respectively. Bisht *et al.* (2009) [4] observed 58% and 55% survival of *Cyprinus carpio* in control and treatment respectively. Endebu *et al.* (2016) [5] revealing survival rate of *O. niloticus* was 73% in fish-poultry

integration systems. The possible reason behind this insufficient amount of zooplankton and phytoplankton in the control pond may be the cause of the lower survival rates. (Szlaminska and Przybye, 1986) [18].

Table 1: Range of water quality parameters during the experimental period

Water quality parameter	Control	Treatment
Temperature (°C)	27.72-29.63	27.74-29.90
pH	7.96-8.64	7.93-8.45
Conductivity (µS/cm)	901.00-924.33	873.66-933.66
Total dissolved solid (mg/l)	511.33-554.00	551.16-572.96

Table 2: Performance of *Cirrhinus mrigala* during culture period

Growth parameters	Control	Treatment
Initial body weight (g)	2.99±0.01	3.25±0.02
Final body weight (g)	6.31±0.28	11.31±0.16
Body weight gain (%)	26.18±2.72	48.78±9.47
Specific growth rate	1.54±0.14	2.62±0.41
Survival rate (%)	92.03±0.49	92.33±0.97
Feed conversion ratio	3.86±2.62	1.64±0.29
Protein efficiency ratio	0.60±0.04	1.01±0.06
Lipid efficiency ratio	4.25±0.29	7.11±0.48

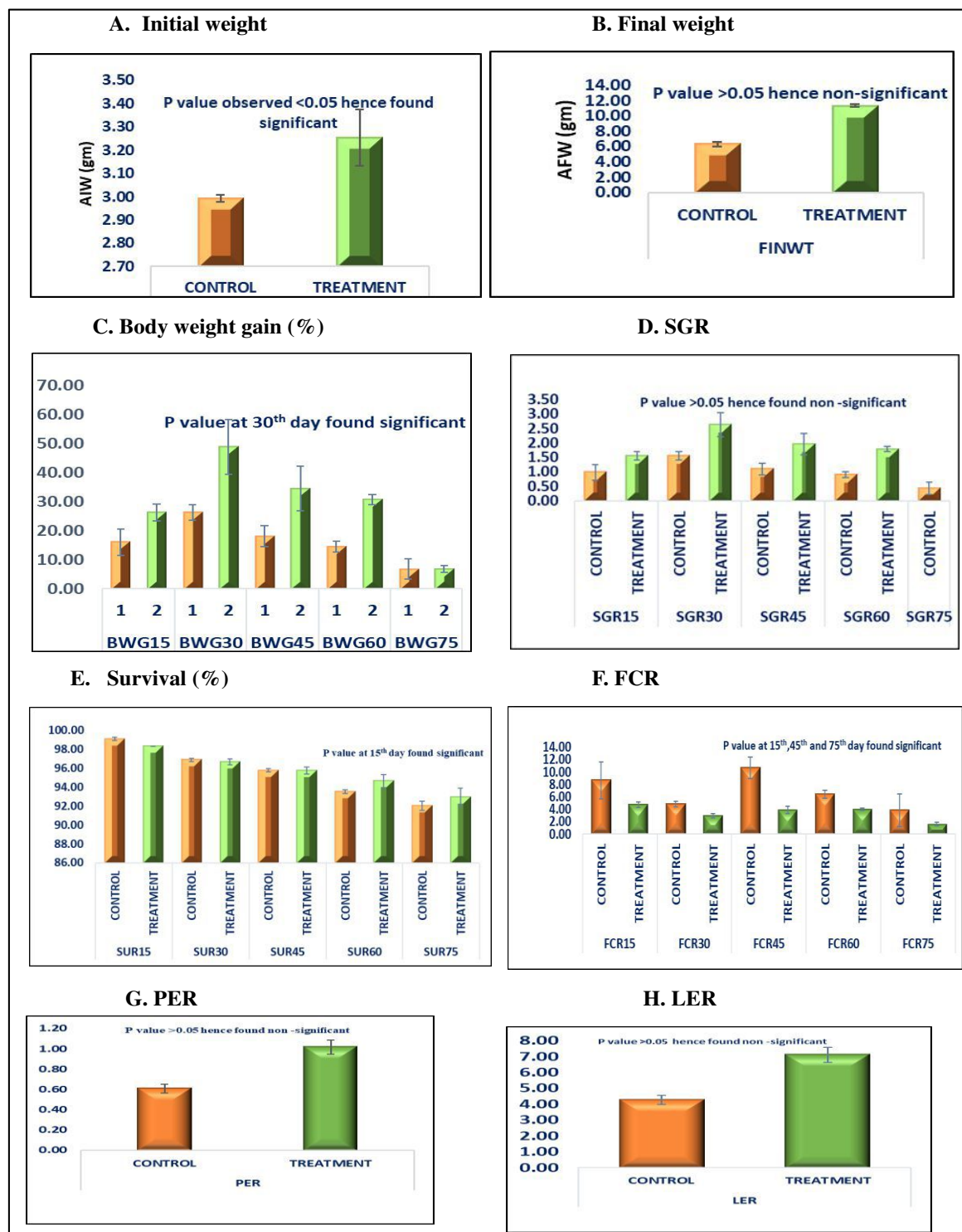


Fig 1: A-H. (A) initial weight (g) (B) Final weight (g) (C) Body weight gain (%) (D) Specific growth rate (SGR), (E) Survival rate (%), (F) Feed conversion ratio (FCR), (G) Protein efficiency ratio (PER) and (H) Lipid efficiency ratio (LER) of *Cirrhinus mrigala* recorded in different treatments during the culture period.

4. Conclusion

The current study shows that the application of poultry droppings in an integrated fish-poultry farming system improves *Cirrhinus mrigala* fry feed utilization, growth performance, and water quality. Temperature, pH, electrical conductivity, and total dissolved solids all stayed within acceptable and ideal ranges for carp culture during the 75-day trial period, suggesting that poultry manure had no negative effects on the water quality. When compared to the control group, fish raised in poultry-manured ponds showed significantly higher weight gain, specific growth rate, and improved feed utilization efficiency. The increased availability of natural food organisms, probably stimulated by the nutrient input from poultry droppings, is reflected in the treatment's lower feed conversion ratio and higher protein and lipid efficiency ratios. The effectiveness and safety of applying poultry manure at the applied level were confirmed by the high and similar survival rates between the control and treatment groups. Overall, the results point to integrated fish-poultry farming as a successful, financially feasible, and ecologically sound strategy for raising freshwater fish production. Fish growth and feed efficiency can be improved while reducing reliance on commercial feeds by using poultry droppings as organic fertilizer. Small-scale farmers have a great deal of potential to use this system to boost freshwater aquaculture productivity and profitability.

5. Acknowledgments

The authors sincerely acknowledge the College of Fisheries Science, Himmatnagar, for providing the necessary facilities and infrastructure to carry out the present research.

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