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Effect of tank colour on growth performance and survival of goldfish (*Carassius auratus*) in laboratory conditions

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ABSTRACT

We conducted a 60-day experiment to evaluate the effect of different tank colours on growth performance, feed utilization, survival, and behaviour of goldfish (*Carassius auratus*). Four treatments were tested: T₁ (black tanks), T₂ (blue tanks), T₃ (red tanks), and T₄ (white tanks). Each treatment had three replicates. Stocking density was 10 fish per tank (total 120 fish). Initial weight ranged from 5.01 to 5.05 g, with no significant differences among treatments ($p > 0.05$).

Fish in black tanks (T₁) showed the best performance: highest weight gain (10.78 ± 0.30 g), highest specific growth rate (2.85 ± 0.05 %/day), lowest feed conversion ratio (1.45 ± 0.04), and highest survival (96.67 ± 1.52 %). Fish in white tanks (T₄) showed the poorest performance: lowest weight gain (7.07 ± 0.25 g), lowest SGR (2.20 ± 0.05 %/day), highest FCR (1.90 ± 0.07), and lowest survival (86.67 ± 2.52 %). Behavioural observations showed active feeding and minimal stress in black tanks, while white tanks caused poor feeding response and high stress. One-way ANOVA confirmed significant differences among treatments ($p < 0.05$). Water quality parameters remained within optimal ranges throughout. We conclude that black tanks are optimal for goldfish culture, while white tanks should be avoided.

Keywords: Tank colour, Goldfish, *Carassius auratus*, Growth performance, Survival, Ornamental fish

Introduction

Aquaculture is one of the fastest-growing food production industries worldwide. It provides protein, food security, nutrition, and economic development (FAO, 2024) [1]. The ornamental fish farming sector has grown rapidly in recent years. It has developed into a significant export market and an important source of economic value (Raja *et al.*, 2019) [2]. Unlike food fish production, ornamental fish farming focuses on aesthetic qualities like colour, body shape, and behaviour rather than biomass (Tlustý, 2002) [3]. The global market for ornamental fish is estimated at over \$5 billion, with millions of fish exported annually (Livengood *et al.*, 2007) [4].

Goldfish (*Carassius auratus*) is one of the most commonly farmed ornamental fish species. It is valued for its adaptability, ease of reproduction, and wide range of colour varieties (Haniffa *et al.*, 2007) [5]. Domestication of goldfish began over 1000 years ago. Through selective breeding, many different strains with specific morphological and colour characteristics have been developed (Smartt, 2001) [6]. Goldfish tolerate a range of environmental conditions, making them an excellent model for experimental studies (James *et al.*, 2003) [7].

Environmental factors are the primary determinants of success in aquaculture operations. Fish are very sensitive to their environment. Small changes in conditions can cause large differences in growth, survival, and feed efficiency (Wedemeyer, 1996) [8]. Water quality parameters like temperature, dissolved oxygen, pH, and ammonia require constant monitoring (Boyd *et al.*, 2012) [9]. Light intensity and duration affect feeding behaviour, activity levels, and hormonal regulation (Boeuf *et al.*, 1999) [10].

Tank colour is an often underestimated but critical environmental component. It affects fish growth and survival through light reflection, visibility, and stress levels (Karakatsouli *et al.*, 2007) [11]. Tank colours provide fish with different perceptions of their surroundings, which affects feeding efficiency and behaviour (Luchiar *et al.*, 2008) [12]. For example, background colour can enhance contrast between feed particles and the tank surface, helping fish locate and consume feed (Strand *et al.*, 2007) [13]. Inappropriate tank colours may cause stress or reduce feeding efficiency, resulting in lower growth and survival.

Modifying tank colour is a low-cost and simple management technique (Bera *et al.*, 2019) [14]. However, limited research has been conducted on how visual environmental factors like tank colour impact fish growth and production (Papoutsoglou *et al.*, 2000) [15]. Goldfish depend on sight to find and capture food.

They are very sensitive to changes in their visual surroundings (Luchiari *et al.*, 2008) [12]. Thus, goldfish are ideal for examining the effects of tank colour on feed efficiency and growth performance. Given this background, we designed this study with two specific objectives: To assess the effects of tank colour on water quality parameters and to determine the effects of tank colour on the growth performance of *Carassius auratus*.

Materials and methods

Study area

The experiment was conducted in the Aquaculture Laboratory at the Department of Fisheries Science. The entire process was done indoors to provide a controlled environment with minimal variations. All ex-

perimental tanks were housed in a well-ventilated room where water quality was continuously monitored.

Experimental species

Goldfish (*Carassius auratus*) fingerlings of uniform size and weight were obtained from a reliable hatchery. Fish were acclimatized to laboratory conditions for 7-10 days before the experiment began.

Experimental design

We used a completely randomized design (CRD) with four treatments and three replicates each (12 tanks total). Tank capacity was 50-100 L. Stocking density was 10 fish per tank (total 120 fish). Experimental duration was 60-90 days.

Table 1.1. Experimental treatments

Treatment Code	Tank Colour	Objective Covered	Description
T ₁	Black	Growth, Survival, Behaviour	Dark background to reduce stress and improve feeding
T ₂	Blue	Growth, Survival, Feed Utilization	Moderate colour, commonly used in aquaculture
T ₃	Red	Growth, Behaviour	Stimulating colour affecting activity and metabolism
T ₄	White	Growth, Survival	Light background, may increase stress and visibility

Table 1.2. Layout plan of experiment

Replication	T ₁ (Black)	T ₂ (Blue)	T ₃ (Red)	T ₄ (White)
R ₁	Tank 1	Tank 2	Tank 3	Tank 4
R ₂	Tank 5	Tank 6	Tank 7	Tank 8
R ₃	Tank 9	Tank 10	Tank 11	Tank 12

Table 1.3. Measurement of biological parameters

Objective	Parameter	Formula / Method	Frequency
Growth Performance	Weight Gain (WG)	Final Weight – Initial Weight	Every 15 days
	Specific Growth Rate (SGR)	$\ln(W_2) - \ln(W_1) / \text{Time} \times 100$	Every 15 days
	Feed Conversion Ratio (FCR)	$\frac{\text{Feed Intake}}{\text{Weight Gain}}$	Weekly
Survival Analysis	Survival Rate (%)	$\frac{\text{Final fish}}{\text{Initial fish}} \times 100$	Daily monitoring
Feed Utilization	Feed Intake	Measured feed consumption	Daily
Behaviour Study	Feeding response, activity	Visual observation	Daily

Table 1.4. showing procedures of water quality measurement

Parameter	Method	Frequency	Optimum Range
Temperature	Thermometer	Daily	24–28 °C
pH	pH meter	Weekly	6.5–7.5
Dissolved Oxygen	DO meter	Weekly	5–7 mg/L
Ammonia	Chemical test kit	Weekly	< 0.02 mg/L

Statistical analysis

Data were analyzed using one-way ANOVA followed by Tukey's post hoc test. Significance was set at $p < 0.05$. SPSS and MS Excel were used for analysis.

Results

Growth performance

Fish in black tanks (T₁) showed the greatest weight gain (10.78 ± 0.30 g), followed by blue tanks (T₂: 9.55 ± 0.28 g), red tanks (T₃: 8.19 ± 0.33 g), and white tanks (T₄: 7.07 ± 0.25 g). Low standard deviation

tions reflect consistent growth among replicates.

Specific growth rate (SGR)

SGR was highest in T₁ (black tanks: 2.85 ± 0.05 %/day), followed by T₂ (blue: 2.65 ± 0.06), T₃ (red: 2.40 ± 0.07), and T₄ (white: 2.20 ± 0.05).

Table 1.5. showing the Specific Growth Rate (%)

Treatment	SGR (%/day)
T ₁ (Black)	2.85 ± 0.05
T ₂ (Blue)	2.65 ± 0.06
T ₃ (Red)	2.40 ± 0.07
T ₄ (White)	2.20 ± 0.05

Feed conversion ratio (FCR)

Lower FCR means better feed efficiency. T₁ (black tanks) had the lowest FCR (1.45 ± 0.04), followed by T₂ (blue: 1.60 ± 0.05), T₃ (red: 1.75 ± 0.06), and T₄ (white: 1.90 ± 0.07).

Table 1. 6: showing the Feed Conversion Ratio

Treatment	FCR
T ₁ (Black)	1.45 ± 0.04
T ₂ (Blue)	1.60 ± 0.05
T ₃ (Red)	1.75 ± 0.06
T ₄ (White)	1.90 ± 0.07

Black tanks were 23.7% more efficient in feed conversion than white tanks (1.45 vs. 1.90). Better feed detection in dark tanks reduced waste.

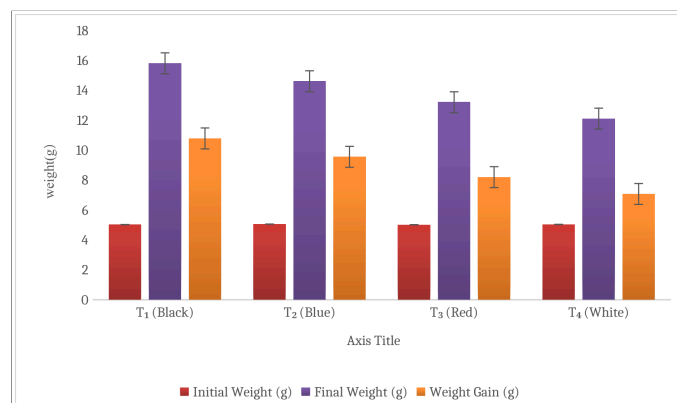


Figure 1.1. showing Mean initial and final weight (g) of (*Carassius auratus*)

Survival rate

Survival was highest in T₁ (black tanks: $96.67 \pm 1.52\%$), followed by T₂ (blue: $93.33 \pm 1.80\%$), T₃ (red: $90.00 \pm 2.00\%$), and T₄ (white: $86.67 \pm 2.52\%$).

Table 1.7. showing the Survival Rate (%)

Treatment	Survival (%)
T ₁ (Black)	96.67 ± 1.52
T ₂ (Blue)	93.33 ± 1.80
T ₃ (Red)	90.00 ± 2.00
T ₄ (White)	86.67 ± 2.52

Behavioural observations

Fish in black tanks showed normal feeding, active swimming, and low stress. Fish in white tanks showed poor feeding, lethargy, and stressed behaviour.

Table 1.8. showing the Behaviors

Treatment	Feeding Response	Activity Level	Stress Signs
T ₁ (Black)	Excellent	Active	Minimal
T ₂ (Blue)	Good	Moderately active	Low
T ₃ (Red)	Moderate	Hyperactive	Moderate
T ₄ (White)	Poor	Less active	High

Water quality parameters

All parameters remained within optimal ranges throughout the experiment. No significant differences were observed among treatments.

Statistical analysis (ANOVA)

One-way ANOVA showed significant differences among treatments ($p < 0.05$) for all measured parameters.

The calculated F-values confirm that variations in growth, feed efficiency, and survival are due to tank colour, not random factors.

Table 1.9. showing the One Way ANOVA Results for Growth Parameters

Parameter	F-value	p-value	Significance
Weight Gain	12.45	< 0.05	Significant
SGR	10.32	< 0.05	Significant
FCR	9.87	< 0.05	Significant
Survival Rate	8.65	< 0.05	Significant

Fish in white tanks showed the poorest growth. This may be due to increased light reflection and lack of background contrast, causing

Discussion

Effect of tank colour on growth performance

Fish in black tanks showed the highest weight gain and SGR. This can be explained by lower stress levels and efficient feed utilization. Fish feel more comfortable in dark environments, so they use energy for growth rather than coping with stress (Volpato *et al.*, 2015) [16]. Our results align with Luchiar *et al.* (2012) [17], who found that fish in darker conditions grow faster. Karakatsouli *et al.* (2010) [18] also reported that tank colour affects fish physiological responses and growth.

stress and reduced food consumption. White tanks may increase fish visibility, making them cautious during feeding (Strand *et al.*, 2013) [1]

^{19]} Nguyen *et al.* (2020) ^[20] similarly found that light-coloured tanks negatively affect fish performance.

Effect on feed conversion ratio (FCR)

Black tanks gave the lowest FCR (1.45), meaning the most efficient feed conversion. The main reason is better feed detection. Dark backgrounds increase contrast between feed particles and the tank surface, helping fish locate and consume feed efficiently (Strand *et al.*, 2013) ^[19]. White tanks gave the highest FCR (1.90), indicating poor feed detection and higher stress levels. Suresh *et al.* (2014) ^[21] reported similar results: fish in darker tanks performed better in feed conversion than fish in light tanks.

Effect on survival rate

Black tanks gave the highest survival (96.67%), while white tanks gave the lowest (86.67%). Lower stress in dark tanks improves immune function and reduces mortality. Stress can significantly impact fish survival by making them more susceptible to infections (Ashley, 2017) ^[22]. Noble *et al.* (2018) ^[23] found that favourable environmental conditions increase fish survival significantly. Bolasina *et al.* (2015) ^[24] reached the same conclusion.

Behavioural responses

Fish in black tanks showed normal feeding, active swimming, and minimal stress. Fish in white tanks showed poor feeding, lethargy, and stressed behaviour. Behaviour is a key indicator of fish health and proper environment. Fish exhibit normal behaviour in habitats similar to their natural environment (Martins *et al.*, 2016) ^[25]. Low light conditions and enhanced security contribute to better behavioural responses. Brighter environments cause stress, leading to abnormal behaviour (Volpato *et al.*, 2015) ^[16]. Bera *et al.* (2019) ^[14] reported similar observations.

Importance of visual environment

Fish depend heavily on vision for feeding, predator avoidance, and social interaction. Tank colour affects the visibility of feed against the background. Fish can easily spot and feed when background colour is dark because it increases contrast (Strand *et al.*, 2013) ^[19]. Light reflection and intensity also affect stress levels and feeding habits.

Relationship between stress, feeding, and growth

Our results show a clear relationship:

- **Low stress (black tank)** → Better feeding → High growth rates
- **High stress (white tank)** → Poor feeding → Low growth rates

Stress triggers hormonal reactions that channel energy into defence mechanisms. As a result, feeding and growth rates decrease (Ashley, 2017) ^[22].

Conclusion

This study evaluated the effect of tank colour on growth performance, survival, feed efficiency, and behaviour of *Carassius auratus* under laboratory conditions. Black tanks (T₁) produced the best results for all parameters. White tanks (T₄) produced the poorest results for all parameters. Blue tanks (T₂) and red tanks (T₃) showed intermediate performance.

Behavioural observations matched growth data: black tanks = normal behaviour; white tanks = stressed behavior. Water quality remained optimal across all treatments, confirming that differences were due to tank colour alone. One-way ANOVA confirmed significant differences among treatments ($p < 0.05$).

We conclude that black tanks create an ideal environment for culturing *Carassius auratus*, while white tanks should be avoided.

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