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Effect of feeding rate on growth performance and survival of *Labeo rohita* fry fed with traditional feeds (rice bran and mustard oil cake)

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ABSTRACT

We conducted a 60-day experiment to evaluate the effect of different feeding rates on growth performance, feed utilization, survival, and water quality of *Labeo rohita* fry (initial weight 2.00 ± 0.05 g). Four treatments were tested: T₁ (2% body weight/day), T₂ (4%), T₃ (6%), and T₄ (8%). Each treatment had three replicates. Fish were fed a mixture of rice bran (50%) and mustard oil cake (50%) twice daily. The 6% feeding rate (T₃) produced the best results: highest final weight (15.40 g), highest weight gain (13.40 g), highest specific growth rate (3.40%/day), lowest feed conversion ratio (1.50), and highest survival (97.5%). Both underfeeding (2%) and overfeeding (8%) reduced growth performance and survival. Water quality parameters showed increased ammonia (0.16 to 0.65 mg/L) and decreased dissolved oxygen (6.4 to 5.2 mg/L) with higher feeding rates. One-way ANOVA confirmed significant differences among treatments ($p < 0.001$). We conclude that 6% body weight per day is the optimal feeding rate for *Labeo rohita* fry under controlled conditions.

Keywords: Feeding rate, *Labeo rohita*, Growth performance, Survival, Rice bran, Mustard oil cake

Introduction

Aquaculture has become the fastest-expanding animal food production industry globally during the last four decades. Marine capture fisheries are already at biological limits, and the world population is expected to reach 9 billion by 2050. Aquaculture is therefore crucial in closing the gap between demand and supply of high-quality animal protein (FAO, 2022) [1]. Aquaculture currently supplies more than 56% of fish consumed globally.

India ranks among the leading aquaculture-producing countries, with freshwater aquaculture being the mainstay of inland fish production (DoF, 2023) [2]. Indian Major Carps (IMC) comprising *Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala* are major contributors to freshwater aquaculture production (Jhingran, 1991) [3]. These species are preferred because of their fast growth rate, adaptability, and consumer preference (Sarkar et al., 2018) [4]. The ecological complementarity of IMC species contributes to improved productivity: *Catla* is a surface feeder, Rohu is a mid-water feeder, and Mrigal is a bottom feeder (Jayaram, 2010) [5].

Feed costs range between 50-70% of total operational costs in aquaculture systems (Tacon & Metian, 2015; Hasan et al., 2020) [7, 6]. Optimizing feed efficiency can therefore have a positive impact on profitability. The feed conversion ratio (FCR) is a widely accepted measure of feed efficiency. Lower FCR values indicate better feed efficiency and less nutrient waste. Studies have shown that even a slight improvement in FCR can lead to substantial increases in net returns (Engle et al., 2017) [8].

Despite the availability of commercial pelleted feeds, traditional feeds such as rice bran and mustard oil cake are still used in Indian carp culture, especially in small-scale operations (Ghosh et al., 2018; Mohanty et al., 2019) [9, 10]. Rice bran is a high-carbohydrate feed with moderate lipid content (Ravichandran et al., 2017) [11]. Mustard oil cake contains 30-35% protein and is used as a cheaper protein source (Mondal et al., 2021) [12]. Similar patterns of resource optimization have been documented in other aquaculture systems, where efficient use of available inputs improves sustainability (Dar et al., 2022) [13].

Feeding rate as a percentage of body weight per day is an important factor affecting growth performance and feed efficiency (Ali et al., 2018). There is a curvilinear relationship between feeding rate and growth: growth increases with feeding rate up to a certain point, after which further increases yield diminishing returns (Bureau et al., 2000) [14]. Underfeeding causes poor growth and high mortality (Hepher et al., 1981) [15]. Overfeeding causes poor FCR and poor water quality (Talbot, 1985; Boyd et al., 2020) [17, 16]. Studies on biofloc technology have shown that optimizing feeding rates also improves water quality and reduces environmental stress (Ratnakar et al., 2024) [18]. Given this background, we designed this study. To evaluate the effect of different feeding rates (2%, 4%, 6%, and 8% body weight per day) on the growth performance of *Labeo rohita* fry and To assess the impact of feeding regimes on survival rate

Materials and Methods

Experimental location and duration

The experiment was conducted under controlled conditions in the Wet Laboratory Facility of the Department of Fisheries/Aquaculture. The laboratory had constant aeration, water supply, drainage, and water quality assessment tools.

Experimental species

Labeo rohita (Rohu) fry were used. Selection criteria: similar size and weight, disease-free and active fish, procured from a certified hatchery. Initial average weight was 2.00 ± 0.05 g (mean $\pm$ SE).

Experimental design

We used a Completely Randomized Design (CRD) with 4 treatments, each replicated 3 times (12 tanks total). Tank capacity was 200 L with 150 L working water volume. Stocking density was 20 fry per tank (total 240 fry).

Table 1.1. Experimental design layout

Treatment Code	Feeding Rate (% body weight/day)	Number of Replicates	Total Tanks
<i>T</i> ₁	2%	3	3
<i>T</i> ₂	4%	3	3
<i>T</i> ₃	6%	3	3
<i>T</i> ₄	8%	3	3
Total	—	—	12

Feed composition

Traditional supplementary feed ingredients were used.

Table 1.2. Feed composition

Ingredient	Inclusion Level (%)	Crude Protein (%)
Rice Bran	50	12–14
Mustard Oil Cake	50	30–35
Estimated Composite CP	—	~22–24

Feeding management

Feeding frequency was twice daily (09:00 AM and 04:00 PM). Feeding duration was 60 days. Biomass was adjusted every 15 days. Uneaten feed was removed after 2 hours.

Water quality monitoring

Table 1.3. Water quality parameters

Parameter	Instrument/Method	Frequency	Acceptable Range
Temperature	Digital thermometer	Daily	25–30 °C
pH	Digital pH meter	Weekly	7.0–8.5
Dissolved Oxygen	DO meter	Weekly	> 5 mg/L
Total Ammonia Nitrogen	Nessler's method	Weekly	< 0.5 mg/L

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Growth performance parameters

Fish were bulk weighed at 15-day intervals using a digital electronic balance (accuracy ± 0.01 g).

Table 1.4. Growth parameters and formulas

Parameter	Formula
Weight Gain (WG)	Final Weight – Initial Weight
Specific Growth Rate (SGR)	$[(\ln W_2 - \ln W_1) / T] \times 100$
Feed Conversion Ratio (FCR)	Feed given/Weight gain
Survival Rate (%)	(Final number/Initial number) $\times 100$
Protein Efficiency Ratio (PER)	Weight gain/Protein intake

Statistical analysis

Data were analyzed using one-way ANOVA followed by post-hoc tests. Significance was set at $p < 0.05$.

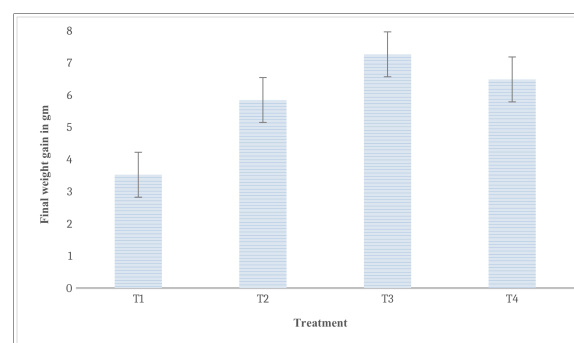
Results**Initial weight**

Initial average weight was 2.00 ± 0.05 g. No significant differences were found among treatments before the experiment ($p > 0.05$).

Effect on final body weight

Final body weight increased significantly ($p < 0.05$) with feeding rate up to 6%. Maximum final weight (15.40 g) was in T₃. A slight decrease (14.20 g) was noticed at 8%. Growth increased up to 6% then

decreased. The 8% rate caused reduced nutrient utilization efficiency.

**Figure 1.1.** showing Final body weight of *Labeo rohita* fry

F -value (32.64) is much higher than critical value (4.07). Effect of feeding rate on final weight is highly significant.

Specific growth rate (SGR)

SGR increased from T₁ to T₃, then declined slightly at T₄.

F -value (21.52) indicates significant variation among feeding rates.

Table 1.5. Final body weight of *Labeo rohita* fry

Treatment	Feeding Rate (%) BW/day)	Final Weight (g)	Mean $\pm$ SE
T1	2%	7.1	7.10 $\pm$ 0.30
T2	4%	12.8	12.80 $\pm$ 0.42
T3	6%	15.4	15.40 $\pm$ 0.50
T4	8%	14.2	14.20 $\pm$ 0.45

Table 1.6: One-way ANOVA for final body weight

Source of Variation	df	Sum of Squares (SS)	Mean Square (MS)	F -value	p -value
Between Treatments	3	120.84	40.28	32.64	< 0.001
Within Treatments (Error)	8	9.87	1.23		
Total	11	130.71			

Table 1.7. One-way ANOVA for specific growth rate

Source of Variation	df	Sum of Squares (SS)	Mean Square (MS)	F -value	p -value
Between Treatments	3	2.18	0.73	21.52	< 0.001
Within Treatments (Error)	8	0.27	0.034		
Total	11	2.45			

Feed conversion ratio (FCR)

Lowest (best) FCR (1.50) was at 6% feeding rate. Higher FCR at 8% shows feed wastage.

F -value (24.88) shows significant differences among treatments.

Table 1.8. One-way ANOVA for FCR

Source of Variation	df	Sum of Squares (SS)	Mean Square (MS)	F -value	p -value
Between Treatments	3	1.56	0.52	24.88	< 0.001
Within Treatments (Error)	8	0.17	0.021		
Total	11	1.73			

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Survival percentage

Highest survival (97.5%) was at 6% feeding rate.

Treatment	Survival (%)
T ₁	89.4
T ₂	94.2
T ₃	97.5
T ₄	92.1

Water quality parameters

Dissolved oxygen decreased and ammonia increased with higher feeding rates.

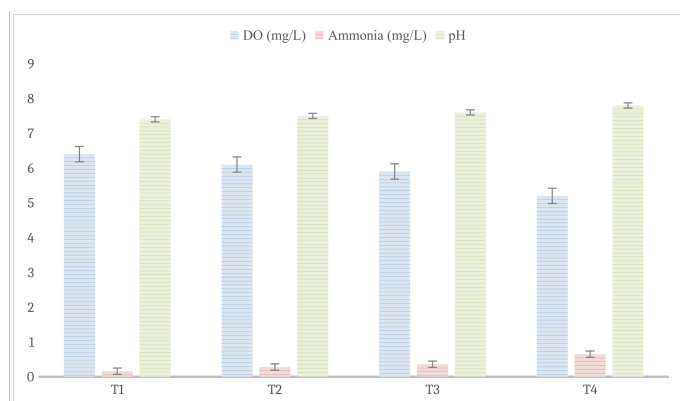


Figure 1.2. showing Mean Water Quality during Experiment

Discussion

Our results showed that feeding rate significantly affected growth, feed efficiency, survival, and water quality. The 6% feeding rate produced the best results across all parameters.

Growth performance: The curvilinear response (increasing growth up to 6%, then decreasing) matches classical fish nutrition studies. Brett *et al.* (1979) [19] and Bureau *et al.* (2000) [14] established that growth increases with ration size up to an optimal point, after which metabolic costs reduce efficiency. At 2% feeding, fish received insufficient nutrients for protein synthesis. At 8% feeding, decreased digestive efficiency and increased metabolic demands reduced growth. Similar findings were reported by Ali *et al.* (2018) and Kumar *et al.* (2019) [20] for carp species.

Specific growth rate: Maximum SGR (3.40%/day) at 6% indicates optimal nutrient conversion to biomass. SGR is highly related to protein deposition and metabolic activity (NRC, 2011) [21]. The decline at 8% reflects metabolic inefficiency and increased nitrogen excretion, as explained by Dawood (2021) [22].

Feed conversion ratio: Best FCR (1.50) at 6% indicates efficient nutrient utilization. Poor FCR at 2% (2.42) reflects nutrient limitation. Poor FCR at 8% (1.95) reflects feed wastage. Hasan *et al.* (2020) [6] noted that feed costs constitute 50-70% of operational costs, so FCR optimization is economically critical. Engle *et al.* (2017) [8] proved that improved FCR significantly enhances net returns.

Survival: Highest survival (97.5%) at 6% reflects adequate nutrition for immune competency. Lower survival at 2% (89.4%) indicates nutritional stress. Dawood (2021) [22] noted that insufficient feeding affects immune response. Lower survival at 8% (92.1%) reflects water quality deterioration. Boyd *et al.* (2020) [16] noted that organic load from overfeeding reduces dissolved oxygen.

Water quality: Ammonia increased from 0.16 to 0.65 mg/L as feeding rate increased. Ip *et al.* (2001) [23] showed that high ammonia affects gill function and oxygen uptake. Similar patterns of environmental stress affecting aquatic organisms have been documented in river ecosystems (Dar *et al.*, 2022) [13]. Troell *et al.* (2014) [24] noted that nutrient discharge is a major environmental concern in aquacul-

ture intensification. However, all values remained within tolerable limits. Studies on biofloc technology have shown that carbon supplementation can help manage ammonia peaks (Ratnakar *et al.*, 2024) [18].

Comparison with literature: Our results align with Sarker *et al.* (2021) [25] and Kumar *et al.* (2019) [20], who found optimal growth of rohu at moderate feeding rates. The curvilinear growth response matches theoretical feeding optimization models (Bureau *et al.*, 2000) [14]. The quadratic nature of growth response validates the need for precise feeding rate determination.

Conclusion

This study evaluated the effect of graded feeding rates (2%, 4%, 6%, and 8% body weight per day) on *Labeo rohita* fry under controlled conditions. 6% body weight per day is the optimal feeding rate for *Labeo rohita* fry. Underfeeding (2%) causes poor growth and reduced survival. Overfeeding (8%) causes reduced feed efficiency and increased ammonia. Water quality parameters correlated with feeding intensity. ANOVA confirmed significant differences among treatments ($p < 0.001$).

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