

Effect of Stocking Density on the Growth Performance, Feed Utilization, and Survival of *Catla catla* Fingerlings in Biofloc Technology (BFT) Systems

Mr. Puri D. G.¹, Dr. Baisthakur P. O.², Mr. Alse V. B.³ and Dr. Desai R. B.^{1*}

Department of Zoology, Mahtma Gandhi Mahavidhyalaya, Ahmedpur, Latur (MS)

Department of Microbiology, Late Baburao Patil Arts and Science College, Hingoli (MS)

Department of Botany, Late Baburao Patil Arts and Science College, Hingoli (MS)

* Email for correspondence: ps.srtmun@gmail.com

Abstract

Biofloc Technology (BFT) presents a zero-water-exchange aquaculture solution suitable for semi-arid regions such as Parbhani, Maharashtra. This study evaluated the effect of three stocking densities on the growth, feed efficiency, and survival of *Catla catla* fingerlings cultured in circular outdoor BFT tanks (10,000 L volume) over 90 days. Fingerlings (15.20 ± 0.35 g) were stocked at three treatment densities: Treatment 1 (T_1 : 30 fish/m³), Treatment 2 (T_2 : 50 fish/m³), and Treatment 3 (T_3 : 70 fish/m³), in triplicate. Water quality parameters (DO, pH, TAN, Nitrite, and Floc Volume) remained within safe physiological ranges, maintained via jaggery-based carbon addition (C:N ratio = 15:1). Results indicated that T_2 achieved optimal balance, displaying a final mean weight of 118.45 ± 2.12 g, a Specific Growth Rate (SGR) of 2.28 ± 0.04 % day⁻¹, a Feed Conversion Ratio (FCR) of 1.24 ± 0.03 , and a survival rate of 92.6%. Although T_1 yielded slightly higher individual weights (126.30 ± 1.80 g), total biomass yield per unit volume was highest in T_2 (5.48 kg/m³). Conversely, T_3 exhibited significantly suppressed growth (94.10 ± 3.10 g) and lower survival (81.4%) due to spatial stress and elevated total suspended solids (TSS). Thus, a stocking density of 50 fish/m³ is recommended for commercial *Catla catla* biofloc culture in the Marathwada region.

Keywords: Biofloc, *Catla catla*, Stocking Density and Growth Effect.

1. Introduction

Aquaculture development in inland regions of Maharashtra, particularly the Marathwada district of Parbhani, faces critical constraints due to seasonal water scarcity and temperature fluctuations. Traditional pond culture of Indian Major Carps (IMCs) requires extensive land areas and high water replacement rates (Hossain et al., 2022). Biofloc Technology (BFT) is an eco-friendly farming technique that immobilizes toxic inorganic nitrogen compounds through microbial heterotrophic assimilation into single-cell protein (flocs), which serve as supplementary in situ feed (Dheeran et al., 2025).

Among IMCs, *Catla catla* (Hamilton, 1822) is a surface-feeding macro-zooplanktonophage valued for its rapid growth rate and high market demand (Singh et al., 2018). However, optimizing stocking density is critical (Puri et al., 2025). Overstocking leads to spatial competition, physiological stress, reduced growth rates, elevated Feed Conversion Ratios (FCR), and increased biological oxygen demand (Wu et al., 2026). Conversely, understocking underutilizes the carrying capacity of biofloc systems, decreasing economic returns (Raza et al., 2024). This study investigates the growth performance and survival of *C. catla* fingerlings under different stocking densities in outdoor BFT tanks under the agro-climatic conditions of Parbhani, Maharashtra.

2. Methodology

2.1 Study Site and Experimental Setup

The 90-day trial was conducted at an experimental aquaculture facility in nearby location, Maharashtra. Circular cement-concrete tanks (10,000 L capacity; effective water volume 9,000 L) equipped with continuous aeration (2 HP ring blower; continuous fine-bubble aeration) were used.

2.2 Biofloc Inoculation and Management

Biofloc was developed 10 days prior to stocking by inoculating well-aerated water with rich pond soil, commercial multi-strain probiotics (*Bacillus* spp.), and jaggery as an organic carbon source to establish a C:N ratio of 15:1. Jaggery

application was calculated daily based on feed input (35% crude protein) to process excreted total ammonia nitrogen (TAN).

2.3 Experimental Design and Stocking

Healthy *Catla catla* fingerlings (mean weight: 15.20 ± 0.35 g; mean length: 10.4 ± 0.3 cm) were acclimated and randomly assigned across three treatment groups in triplicate using a Completely Randomized Design (CRD):

- **Treatment 1 (T₁):** 30 fish/m³ (270 fish/tank)
- **Treatment 2 (T₂):** 50 fish/m³ (450 fish/tank)
- **Treatment 3 (T₃):** 70 fish/m³ (630 fish/tank)

Fish were fed a commercial floating pelleted diet (32% crude protein) twice daily (09:00 and 17:00 h) at 3–4% of body weight, adjusted bi-weekly following batch sampling.

2.4 Parameter Measurements and Calculations

Dissolved Oxygen (DO), temperature, and pH were recorded daily using digital meters. Total Ammonia Nitrogen (TAN), Nitrite-Nitrogen (NO₂-N), and Nitrate-Nitrogen (NO₃-N) were analyzed weekly using spectrophotometric methods. Floc Volume (FV) was measured on-site using Imhoff cones.

Growth performance was calculated using standard formulae:

- **Specific Growth Rate (SGR% day⁻¹):**

$$SGR = \frac{\ln(\text{Final weight}) - \ln(\text{Initial weight})}{\text{Experiment Duration (days)}} \times 100$$

- **Feed Conversion Ratio (FCR):**

$$FCR = \frac{\text{Total Feed Given (G)}}{\text{Total Weight Gain (G)}} \times 100$$

- **Survival Rate (SR%):**

$$SR = \left(\frac{\text{Final Number of Fish}}{\text{Initial Number of Fish}} \right) \times 100$$

3. Results and Discussion

3.1 Water Quality Dynamics

Water quality parameters across all treatments remained within acceptable limits for carp production throughout the 90-day experiment (Table 1).

Table 1: Mean Water Quality Parameters Across Experimental Treatments over 90 Days

Parameter	Treatment T ₁ (30/m3)	Treatment T ₂ (50/m3)	Treatment T ₃ (70/m3)
Water Temp (°C)	27.4 ± 1.2	27.5 ± 1.1	27.3 ± 1.3
pH	7.82 ± 0.15	7.75 ± 0.18	7.62 ± 0.21
DO (mg/L)	6.42 ± 0.31	5.85 ± 0.28	5.12 ± 0.35
TAN (mg/L)	0.28 ± 0.05	0.41 ± 0.08	0.78 ± 0.12
Nitrite-N (mg/L)	0.12 ± 0.03	0.18 ± 0.04	0.35 ± 0.07
Floc Vol (mL/L)	18.5 ± 2.1	24.2 ± 2.8	32.8 ± 3.4

Note: Values with different superscript letters in a row are significantly different ($p < 0.05$).

Dissolved oxygen decreased significantly as stocking density increased ($p < 0.05$), driven by higher respiration rates and microbial oxidation of organic matter in higher-density treatments. TAN and Nitrite levels were highest in T₃ but remained below lethal thresholds due to heterotrophic conversion driven by microbial bioflocs.

3.2 Growth Performance and Yield

Stocking density had a statistically significant impact ($p < 0.05$) on final weight, SGR, FCR, and total harvest biomass (Table 2).

Individual weight gain was highest in T1 (126.30 g), followed by T2 (118.45 g). However, total net yield per cubic meter was significantly higher in T2 (5.48 kg/m³) than in T1 (3.60 kg/m³) due to greater total fish count. In T3, despite higher stocking numbers, biomass yield (5.36 kg/m³) did not increase significantly over T2 due to reduced growth rates and lower survival (81.4 %).

Table 2: Growth and Production Metrics of *Catla catla* after 90 Days

Parameter	Treatment T1 (30/m3)	Treatment T2 (50/m3)	Treatment T3 (70/m3)
Initial Mean Wt (g)	15.18 ± 0.32	15.22 ± 0.38	15.20 ± 0.35
Final Mean Wt (g)	126.30 ± 1.80	118.45 ± 2.12	94.10 ± 3.10
Weight Gain (g)	111.12 ± 1.62	103.23 ± 1.95	78.90 ± 2.88
SGR (%day ⁻¹)	2.35 ± 0.03	2.28 ± 0.04	2.02 ± 0.05
FCR	1.18 ± 0.02	1.24 ± 0.03	1.52 ± 0.06
Survival Rate (%)	95.2 ± 1.8	92.6 ± 2.1	81.4 ± 3.2
Total Biomass (kg/m ³)	3.60 ± 0.08	5.48 ± 0.12	5.36 ± 0.18

The decline in growth parameters in T3 aligns with general density-dependent growth depression observed in carp systems, caused by physical crowding, social stress, reduced grazing efficiency on suspended flocs, and higher maintenance energy costs. The optimal FCR in T1 (1.18) and T2 (1.24) indicates efficient supplemental utilization of the microbial biofloc biomass as natural feed.

4. Conclusion

This study demonstrates that stocking density significantly influences the culture success of *Catla catla* in biofloc systems under local conditions in Parbhani, Maharashtra. While lower stocking densities (30 fish/m³) yield maximum individual growth, a stocking density of 50 fish/m³ (T2) delivers the optimal economic combination of individual growth rate, feed conversion efficiency (1.24), survival (92.6 %), and maximum system yield (5.48 kg/m³). Exceeding 50 fish/m³ impairs water stability, survival, and growth, making it economically unviable for local farmers.

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