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Evaluation of African Catfish (*Clarias gariepinus*) Growth and Survival at Different Stocking Densities in Ethiopian Aquaculture

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Abstract

African catfish (*Clarias gariepinus*) is the most suitable candidate species for aquaculture, widely farmed next to tilapia. However, its production in intensive pond culture has not yet been practiced in Ethiopia. The main objective of this experiment was to evaluate its growth performance and survival rate at different stocking densities. Fingerlings of African catfish of similar size were collected from Koka Reservoir, introduced to concrete ponds at Batu fish and other aquatic life research centre, and acclimatized for 15 days. The fish were then stocked into 4.8 m^3 experimental ponds at low stocking density (T3=10 fish/m^3), medium stocking density (T2=20 fish/m^3), and high stocking density (T1=30 fish/m^3), in duplicate. All the fish were fed with 35% crude protein pelletized feed, and water quality parameters were monitored. Data were collected for five months and analyzed using one-way ANOVA at a $p<0.05$ significance level for mean separation. Survival rates of fish were 100%, 98.95%, and 96.45% at low (T3), medium (T2), and high (T1) stocking densities, respectively. Daily growth rates (g/fish/day) were 0.76, 0.91, and 0.81 in T1, T2, and T3, respectively, and all values indicated good growth performance. The average mean length (cm) and weight (g) of the fish in T1 were statistically significantly different from T3 for the first four months. Individual fish weight gains in all treatments were promising. Total biomass across all treatments showed differences, with the highest biomass (7.41 kg/m^3) obtained in T1, followed by T2 (6.06 kg/m^3) and T3 (2.71 kg/m^3). Therefore, considering higher biomass as a target in the economics of fish culture, we recommend the higher stocking density of 30 fish/m^3.

Keywords: *Clarias gariepinus*; Growth performance; Stocking density; Pond

Introduction

Aquaculture stands as a promising alternative to address animal protein deficiency, a pressing issue in many developing countries. Globally, aquaculture significantly contributes to food and nutritional availability, household food security, income generation, job creation, poverty alleviation, and improved living standards [1]. Fish provide a rich source of high-quality protein, essential amino acids, vitamins, fats, fatty acids, omega series, and minerals [2]. However, the gap between the demand and supply of food fish continues to widen due to declining capture fishery production and a rapidly growing global population. Consequently, aquaculture is becoming the primary method to boost food fish production, with aquaculture outputs recently surpassing those from capture fisheries.

Among the numerous candidate species for aquaculture worldwide, African catfish (*Clarias gariepinus*) has emerged as a leading candidate, second only to tilapia (*Oreochromis niloticus*) [3]. This is due to its numerous advantageous traits [4], including a fast growth rate at high stocking densities, high feed conversion efficiency, excellent meat quality, superior yield, adaptability to captivity, high resistance to environmental stressors, and potential for year-round production. Typically, catfish are opportunistic feeders, adaptable to various feed types. They naturally feed at the bottom but can also feed at the surface under captivity.

African catfish can survive in low dissolved oxygen conditions for extended periods by utilizing their arborescent organs to breathe atmospheric air [5]. Additionally, they can grow to an average market size of 700 to 800 grams in 8 months at a stocking density of 5 to 5.7 fish/m^2 when provided with 38% Crude Protein (CP) feed [6].

Stocking density is a critical factor in determining the growth and final biomass of harvested fish. It also plays a significant role in regulating the behavior of *Clarias gariepinus* and is a key parameter in fish culture operations, directly influencing growth, survival, and production [7]. A review of global fisheries indicates that the benefits of aquaculture can only be fully realized if issues such as the optimal stocking density of aquaculture species are addressed [8]. Environmental variables, farming conditions, and food availability are other important factors affecting fish growth in cultured conditions.

Some fish farmers recognize that catfish can tolerate a broad range of dissolved oxygen levels and water deficits, prompting them to experiment with high-density farming. However, increased stocking density can lead to high mortality unless waste management is strictly controlled. Therefore, aquaculture production and productivity can be enhanced by employing modern techniques and facilities, such as optimizing fish stocking density, improving pond management, controlling waste, and providing high-quality feed.

Currently, some African countries like Nigeria, Uganda, South Africa, Kenya, and Ghana have industrially formulated fish feeds, which have fostered the growth of fish farming at various scales. In Nigeria, for instance, catfish are used in intensive monoculture farming [9]. In Ethiopia, a company producing pelletized fish feed has recently begun operations. However, fish feed production is demand-based, making it difficult to obtain industrial feed without special orders. This indicates that aquaculture is still underdeveloped in Ethiopia, despite high unemployment, significant food and nutrition gaps, and numerous suitable aquaculture areas.

This study aims to evaluate the growth performance, survival rate, and biomass yield of *Clarias gariepinus* at different stocking densities in concrete ponds in the Central Rift Valley of Ethiopia.

Materials and Methods

Description of study area

The study was conducted in the Central Rift Valley of Ethiopia at the Batu (Ziway) Fish and other Aquatic Life Research Center, located 1640 meters above sea level (m.a.s.l.).

Experimental design

The experiment was carried out in small rectangular concrete ponds, each with a water volume of 4.8 m^3. Six concrete ponds, were cleaned, disinfected, and filled with groundwater 15 days after disinfection. The pond water depth was maintained at 80 cm and left to stabilize for 15 days. Juveniles of African catfish (*Clarias gariepinus*) were collected from the wild (Koka Reservoir), acclimatized for 15 days, measured (average size of 15 ± 0.3 cm mean length and 18 g average weight), counted, and randomly stocked into the experimental tanks. The experiment comprised three treatments with two replications, arranged in a completely randomized design. A total of 568 juveniles of African catfish were assigned to three treatments:

- T1: 282 fish, 30 fish/m^3
- T2: 188 fish, 20 fish/m^3
- T3: 96 fish, 10 fish/m^3

The fish were fed 35% CP commercial pelletized feed at a feeding rate of 3% body weight daily, delivered in two split doses at 9:00 am and 4:00 pm for the entire experimental period of 150 days. Feed adjustment was made for each treatment based on monthly fish sample data and average biomass changes. Pond water was refreshed twice weekly to maintain the 80 cm water depth after gentle stirring from the bottom to avoid turbidity, following the procedure outlined by Viveen et al.

Measurements

Fish Total Length (TL, cm) and Total Weight (TW, g) were recorded monthly. Water physico-chemical parameters, including temperature, pH, and Dissolved Oxygen (DO), were measured twice weekly. Plankton sampling was conducted monthly to control algal blooms if any [10].

Survival rate (%)=Number of fish harvested/Number of fish stocked × 100

Daily growth rate was calculated as:

Daily growth rate (g/day)=Mean final weight (g)-Mean initial weight (g)/Experimental days

Mean differences in fish length and weight among treatments were analyzed using one-way Analysis Of Variance (ANOVA) with a significant difference multiple range test at a 5% probability level.

Results and Discussion

Water quality parameters

Water physico-chemical parameters were measured *in situ* twice weekly during the experimental period. Laboratory analysis of water quality was performed at the end of the experiment. Results are presented in Table 1. Water temperature ranged from 20.34°C to 27.45°C, with a mean temperature of 25°C. The highest water temperature was recorded in April, while the lowest was observed in July. All measured water quality parameters were in acceptable range for growth of African catfish.

Table 1: Some water quality parameters of the experimental fish tanks.

Parameter	Standard	T1	T2	T3
K µg/ml	<25	15.85	15.45	15.3
Na µg/ml		199.55	195.35	194.35
Phosphate		1.87	2.15	2.58
DO (mg/L)		>3.3	>4.00	>4
Ca (µg/ml)		117	114.85	114.1
TDS (g/l)		2.32	1.22	1.17

Salinity (PPT)		1.21	1.19	1.85
Resistivity Ω		427	419	422
Secchi-disc depth (cm)		36.4	26.4	20.8
Temperature (°C)		25	25	25

Growth response

In this study, a relatively lower survival rate of 96.45% was recorded in the highest stocking density (T1) compared to 98.95% and 100% in T2 and T3, respectively. Higher stocking densities create crowded conditions, leading to high-density stress due to aggressive feeding interactions, increased waste production, and reduced feed intake. This stress can result in growth retardation and even death [11]. The highest stocking density in this experiment was 30 fish/m^3, which is modest compared to Hecht's study with 250 fish/m^3. The 96.45% survival rate in this study is high compared to Hecht's reported 75%, likely due to lower stocking density, improved pond management, and frequent water exchange. Generally, mortality is inversely related to stocking density.

Growth performance across treatments was measured in terms of length, weight, and daily growth rate over 150 days. Daily growth rates (g/fish/day) were 0.76 in T1, 0.91 in T2, and 0.81 in T3. These rates are higher than those reported by Akinwole and Faturoti, which were 0.26 ± 0.02 in hatchery conditions, but lower than the 4.03-6.25 g/fish/day observed in grow-out ponds with higher stocking densities. Differences in daily growth rates can be attributed to the size of the fish, with larger fish gaining more weight daily compared to fingerlings [12].

The combined mean length, as shown in Table 2, indicated significant differences across treatments in the first and fourth months (March and June) but no significant differences in the other months. During most of the experimental period, T2 and T3 did not differ significantly in mean length and weight, although T2 exhibited slightly better performance. The combined mean weight followed a similar trend as mean length. Despite appreciable weight gain across all treatments, T2 and T3 showed better growth performance, with no significant differences between them except in June. These closer results may be due to the relatively small differences in stocking density, suggesting that small differences in stocking density may not immediately result in significant growth differences.

Table 2: Summary of fish growth performance (Mean ± SD) across experimental months.

Parameter	Treatment	Experimental months					
		0	1	2	3	4	5
Fish total length (cm)	T1	15	15.87 ± 0.28^{b}	17.73 ± 0.30^{a}	21.21 ± 0.33^{a}	24.31 ± 0.38^{c}	26.84 ± 0.37
	T2	15	16.61 ± 0.32^{ab}	18.48 ± 0.36^{a}	22,33 ± 0.40^{a}	27.20 ± 0.36^{a}	27.38 ± 0.86
	T3	15	17.28 ± 0.33^{a}	18.74 ± 0.38^{a}	22.28 ± 0.43^{a}	25.61 ± 0.40b	27.61 ± 0.45
	p<0.05		*	ns	ns	*	ns
Weight (g)	T1	18	27.03 ± 01.5^{b}	40.19 ± 1.86^{a}	63.09 ± 2.8^{b}	95.59 ± 4.18^{c}	131.27 ± 5.74^{b}
	T2	18	31.60 ± 1.8^{b}	46.17 ± 2.87^{a}	77.22 ± 3.8^{a}	137,93 ± 6.08^{a}	155.49 ± 8.21^{a}
	T3	18	36.86 ± 2.05^{a}	46.16 ± 2.81^{a}	75.11 ± 4.2^{a}	111.05 ± 5.34^{b}	139.11 ± 7.25^{ab}
	p<0.05		*	ns	*	*	*

Various studies have shown that catfish production biomass varies with the intensity of the farming technique. In extensive polyculture farms with tilapia, biomass rarely exceeds 1.5 tonnes/ha/year or 30 kg/200 m^2 pond. However, under conditions of 26°C-28°C, better water recirculation, and feeding with 30-35% protein pelletized feed, catfish can grow from 1 g to 800 g in 8 months. Ayinla reported growth performance under static pond conditions ranging from 15-20 tons/ha/cycle, which can be improved to 25-40 tons/ha/cycle under flow-through conditions [13].

To assess the overall growth performance, data on weight gain and length were collected and analyzed. This data highlights the trend of fish growth through different months, each characterized by environmental variables affecting fish growth, feed availability, waste production, and overall fish physiology. As shown in Figures 1 and 2, the mean monthly growth in length mirrored the growth in weight gain. Fish growth showed progressive improvement across all treatments, with T2 exhibiting higher growth, although the difference was not significant compared to T3 in most months. Mean fish length was significantly different between T1 and T3 during the first month, but no significant differences were observed in subsequent months. This suggests the potential for catfish farming at higher stocking densities, and extending the culture period may be necessary to achieve more biomass and determine the optimal stocking density.

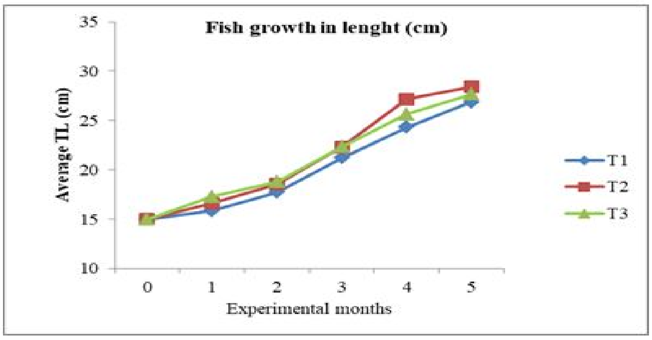

Figure 1: Monthly growth of the fish in length.

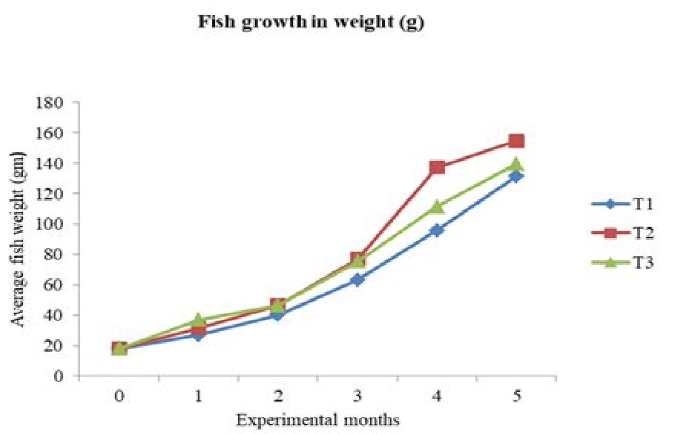

Figure 2: Monthly growth of fish in weight.

Individual fish growth performance is crucial for determining the best biological growth, but total biomass, feed costs, and seed costs are also vital for evaluating aquaculture profitability. Although the mean growth parameters of the three treatments appeared similar, there were observable differences in biomass (Figure 3).

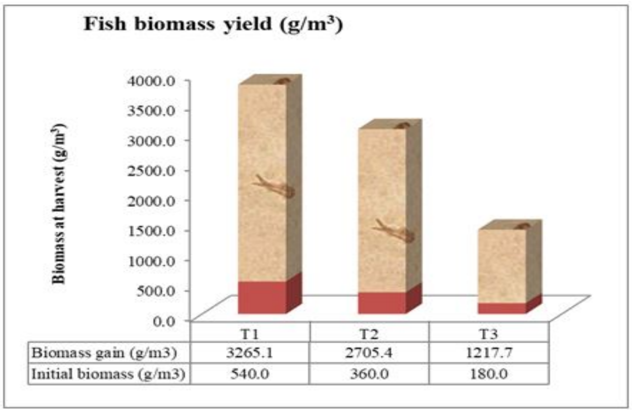

Figure 3: Fish biomass per treatment at the end of the experiment.

All treatments were fed pelletized industrial feed with 35% crude protein at a daily feeding rate of 3% body weight. Biomass gains per cubic meter were 3,265.1 g, 2,705.4 g, and 1,217.7 g in T1, T2, and T3, respectively, over the 150-day experimental period. T1 had the highest total biomass per unit volume (3,805.1 g/m^3) and biomass gain (3,265.1 g/m^3/150 days).

Based on feed price, feed delivered to the experimental fish, and weight gain, the production cost was estimated for each treatment. The cost to produce a kilogram of fish was calculated at 122.33 Birr for T1, 129.99 Birr for T2, and 132.06 Birr for T3. The fish production cost per kg was lowest in the highest stocking density (T1) and highest in the lowest stocking density (T3).

Fish feed is a significant factor in aquaculture profitability, often more expensive than the live fish price. The current market price of catfish (whole) at landing sites is 50.00-70.00 Birr/kg, much lower than the production cost calculated in this experiment. Wild-caught fish generally have minimal associated costs, which the market price does not reflect. In local markets, catfish fillet is priced at 150.00 Birr/kg, whereas cattle meat is 600.00 Birr/kg, making cattle meat four times more expensive than catfish fillet. Despite price increases for both fish and meat in Ethiopia, meat prices have risen more sharply, likely due to cultural dietary preferences and lower market demand for catfish compared to other species like tilapia, trout, and Nile perch.

However, high protein pelletized fish feed, being available from only one local processor, is quite expensive (50.00–75.00 Birr/kg) and equivalent to the whole fish price at landing site. This suggests that intensive catfish farming with less expensive local feed might be feasible.

Table 3: Fish growth performance under three stocking densities during 150 experimental days.

African catfish growth parameters	Treatments

	T1	T2	T3
Culture duration (days)	150	150	150
Number of stocked fish per pond	282	190	96
Number of harvested fish	272	188	96
Survival rate (%)	96.45	98.95	100
Initial biomass weight (g/m^3)	540	360	180
Average final weight (g/fish)	131.5	154.9	139.77
Average final length (cm)	21.2	22.61	22.35
Daily growth rate (g/fish/day)	0.76	0.91	0.81
Final biomass (g/m^3)	3,805.10	3,065.40	1,397.70
Net biomass gain (g/m^3)	3,265.10	2,705.40	1,217.70

Conclusion

Stocking density affects the survival rate, growth rate, and final biomass of African catfish in channel tanks. Survival rates decreased with increasing stocking density, though all rates tested were acceptable. Mean fish length and weight were lower at the highest stocking density of 30 fish/m^3, while differences between lower densities of 10 fish/m^3 and 20 fish/m^3 were not statistically significant. However, total biomass was higher at the highest density, indicating potential for even higher densities in catfish culture. Production cost per unit of catfish was lower for higher stocking densities and increased with decreasing density. The high cost of pelletized fish feed, a new and expensive input, was a major factor in the high production costs. Further studies are recommended to explore the economic feasibility of using locally formulated high-protein feeds and higher stocking densities under commercial systems.

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