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Pre-fattening of fish *Clarias gariepinus* (Burchell, 1822) (*Siluriformes, Clariidae*) on local feed in an above-ground tank culture system in Kinshasa, Democratic Republic of the Congo

Lusasi, S. W. [1,2], Mbele, M. G. [2], Mbomba, N. B. [1,2], & Pwema, K. V. [1,2]

[1]*Limnology, Hydrobiology and Aquaculture Laboratory, Life Sciences Department, Faculty of Science and Technology, University of Kinshasa, Democratic Republic of the Congo*

[2]*Department of Biology, Faculty of Science, University of Kinshasa, Democratic Republic of the Congo*

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Correspondence to:
S. W. Lusasi
willy.lusasi@unikin.ac.cd

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ABSTRACT

Introduction

Fish farming plays a major role in combating poverty and malnutrition by supplying poor populations with fish. In the Democratic Republic of Congo, *Clarias gariepinus* farming dates back to colonial times but remains underdeveloped due to difficulties in producing juveniles in captivity and the availability of good-quality local feed. This situation does not contribute effectively to the availability of animal proteins from fish.

Purpose

The aim of this study was to evaluate the growth of fry of the African catfish *Clarias gariepinus* Burchell, 1822, in a soilless rearing system to promote home fish production in the city of Kinshasa.

Methods

Rearing activities took place over 54 days between August and September 2021. The physicochemical parameters (pH, conductivity, turbidity, and temperature) of the water and the growth of the fry were monitored every ten days. A total of one hundred and fifty (150) *Clarias gariepinus* fry, with mean weights ranging from 1.00±0.35 g to 1.20±0.61 g and mean sizes ranging from 49.27±5.15 mm to 65.09±6.98 mm, were tested in an experimental setup using out-of-water tanks. The fry were divided into three batches and fed three times a day (8:00, 12:00, and 15:00) with three types of feed ration. Several zootechnical parameters were assessed to determine the growth of the reared fry.

Results

The pH, temperature, conductivity, and turbidity values recorded in the water of the tanks remained within the range required for the growth of *Clarias gariepinus* fry. The fry were well maintained in the experimental structures throughout the study period. The survival rate was between 86% (B1 and B3) and 88% (B2). Feed B1, composed largely of fish meal, had a greater influence on the weight (8.44±0.64 g) and linear growth (124.56±8.4 mm) of the fry than the control feed B3 (mean final weight = 5.35±0.7 g and mean final size = 105.75±5.13 mm) and feed B2 (mean final weight = 4.97±0.46 g and mean final size = 109.04±8.2 mm). Feed B1 also had a significant effect on the individual daily growth of fry (0.124 g/d) compared with feeds B2 (0.063 g/d) and B3 (0.069 g/d). The weight-total length relationship of the fry from the three batches confirms that the fish rearing system (concrete tanks) used in this study allowed the maintenance and development of the fry without negatively influencing the growth pattern of this fish species.

Conclusion

This study demonstrated the importance and effectiveness of the soilless culture system and the use of local feed for rearing *Clarias gariepinus* in the city of Kinshasa. The results of this study are of great importance for the development of fish farming in the Democratic Republic of Congo, using locally available feeds to increase the quantity of fish consumed in the country.

INTRODUCTION

African fish farming has long attracted the interest of researchers worldwide (Lusasi et al., 2022). It was in the Belgian Congo, now the Democratic Republic of Congo, just after the end of World War II in the former province of Katanga (now Upper Katanga Province), that fish farming was conceived to feed African populations (Micha, 2013).

The Food and Agriculture Organization (FAO, 2010) reports that fish has a high nutritional value and provides more than 30 to 40% of the animal protein on the market. Whether fresh, smoked, or dried, fish plays a crucial role in combating malnutrition and is an important source of protein in the human diet (Adouvi, 2013; Lusasi et al., 2019a, 2020; Masua et al., 2020). Fish flesh contains less saturated fat and more protein. Fish flesh also has a cardio-protective effect due to its long-chain polyunsaturated fatty acids, is easier to digest, and contains little cholesterol (Kavumbu et al., 2020). Fish flesh also contains other nutrients such as minerals and vitamins A and D (Adouvi, 2013). The fatter the fish, the more omega-3 fatty acids it provides, and all you have to do is eat fish twice a week, alternating between oily fish rich in omega-3 fatty acids and lean fish, or choosing semi-fatty fish both times to obtain the essential nutrients in your diet (Kavumbu et al., 2020). Ensuring the availability of fish that can play this role in the human diet is necessary to provide consumers with the essential nutrients.

According to the FAO (2017), national fisheries production in the Democratic Republic of Congo was 401,742 tons, of which 240,586 tons came from fishing and 161,156 tons from fish farming. However, due to the irrational exploitation of these resources, fishery products have significantly decreased and have been replaced by smaller species, leading to the scarcity of larger species (Lusasi et al., 2022). This decline in production has increased demand, forcing the country to import up to 1,200,000 tons (MINEP, 2017; Lusasi et al., 2019a). Integrating fish farming into the development program is a crucial tool in the formulation of development strategies, particularly in combating malnutrition (Zungatipay, 2014).

According to Lusasi et al. (2024a), the fish farming tradition is not well established in the Democratic Republic of Congo. To date, fish have been bred in earthen ponds in valleys and wetlands, where they are raised in extensive and semi-intensive family fish farms (Lusasi et al., 2024a). Several factors contribute to the underperformance of Congolese fish farming, including the absence and inadequacy of quality juveniles, the lack of fish feed, poor farm management, and difficult access to investment capital (Pwema et al., 2020; Lusasi et al., 2022). Since the 1970s, monoculture associations of Clarias gariepinus have been considered a fish of the future due to their performance, rapid growth, omnivorous diet, high fecundity, low oxygen requirement, tolerance of high density, and disease resistance (Nyna & Kestemont, 2007). However, the availability of locally produced adequate feed is a limiting factor for the development of this activity. Due to the many advantages of producing this species, several studies related to its feeding using vegetable seeds as a protein source in a controlled environment, such as soybeans, have been conducted (Toviwazon, 2004; Toko, 2007), Leucaena leucocephala seeds, Moringa oleifera leaves (Edénakpo, 2002; Hossoue, 2002; Gandaho, 2007), cotton seeds (Toko, 2007), Azolla (Kanangire, 2001; Akitikpa, 2002), and Néré (Parkia biglobosa) seed meal and soybean meal (Glycine maxima) (Adouvi, 2013). In this context, we chose to test the growth performance of *Clarias gariepinus* Burchell, 1822 (*Siluriformes*, *Clariidae*) in pre-growth in an above-ground rearing system of concrete tanks by focusing on the development of feeds based on agro-industrial by-products available in Kinshasa. The results of this study are of great importance in improving fish production conditions in the city of Kinshasa while positively enhancing the availability and nutritional quality of fresh fish intended for human consumption in the Democratic Republic of Congo.

METHODS

Study Setting

This study was conducted at the University of Kinshasa, specifically at the Experimental Garden and Plot Breeding (ONG/D JEEP) in the commune of Lemba, Kinshasa, Democratic Republic of Congo. The experiment lasted 60 days, spanning August and September 2021.

Experimental Structure

Three above-ground concrete tanks, each measuring 100 cm in length, 100 cm in width, and 80 cm in depth, were interconnected by ½ inch PVC pipes to form a continuous closed-loop water renewal system. Each tank had a 50 mm PVC overflow pipe in a vertical position to discharge water into the concrete tanks once the established depth was reached. The overflow water was collected by a 100 mm diameter PVC pipe, which served as a collector before reaching the filters. After filtration, the water passed into a tank containing a motor pump that circulated the water into two plastic barrels linked to the aquaculture system to feed the tanks. These tanks **(Figure 1)** were intended for research purposes.

Figure 1:
Experimental structure used to rear *Clarias gariepinus* fish (photo Lusasi, 2021)

Biological Material

The biological material for this study consisted of *Clarias gariepinus* Burchell, 1822 fry, purchased from the hatchery of the Kinoise des Poissons farm located at number nine on Avenue Yandonge in the Pigeon district of the commune of Ngaliema in Kinshasa. These fish were artificially reproduced following the methods described by Viveen et al. (1985), De Graaf et al. (1996), and Ducarme and Micha (2003). The choice of this species is due to its widespread farming throughout the country, its adaptability to artificial feeding in the form of pellets (Pwema et al., 2020), and its high nutritional value, which is appreciated by the Congolese population (Kavumbu et al., 2020).

Obtaining Agro-Industrial By-Products

The ingredients used to formulate the feed rations were selected based on their availability in the local market and their bromatological composition. These included fish meal, corn meal, cassava meal, *Moringa oleifera* meal, palm kernel cake, and wheat bran. In addition, palm oil, a vitamin-mineral complex, and cooking salt were incorporated into the feed rations. The ingredients were purchased from markets in Kinshasa, and the *Moringa* leaves were collected from a plot in the Kindele district in the commune of Mont Ngafula, Kinshasa.

Production of Experimental Food Rations

The selection of ingredients for feed formulation was based on the dietary requirements of the fry (Lusasi et al., 2024b) and the natural crude protein content of the raw materials, previously determined using the empirical method proposed by Guillaume et al. (1999) and Bocek (2007). Coarse and wet by-products were sun-dried and ground into flour using a 1 mm mesh cassava mill. The flour of each ingredient was weighed using a precision electronic scale (0.1 g accuracy) according to the proportion used for the feed formulation. The ingredients were mixed in a plastic container until a homogeneous flour was obtained, followed by the preparation of the actual mixture. Two liters of tap water were boiled in a pot and mixed with the flour of each feed ration. The mixture was kneaded into a soft dough, which was then compacted into 1 mm spaghetti using a manual chopper. The feed rations were sun-dried for 72 hours on trays. After drying, the experimental feeds were stored in plastic bags and kept in a cool place for the duration of the experiment (Lusasi et al., 2019b; Pwema et al., 2020). Two feed rations were developed with crude protein content ranging from 35.6±0.49% (R2) to 42.2±0.31% (R1). A third ration, serving as a control feed with 45.07±2.5% crude protein, was purchased from the fish farming company CAP Congo. The bromatological composition of the feed rations tested on *Clarias gariepinus* fry is presented in **Table 1**.

Table 1 :
Bromatological composition of tested feed rations

Parameters	Food rations		
	B1	**B2**	**B3**
Moisture (%)	13.4±0.4	10.6±0.8	11.6±0.3
Protein (%)	42.2±0.31	35.6±0.49	45.07±2.5
Fat (%)	16.6±0.23	12.99±0.23	14.7±0.6
Ash (%)	6.4±0.4	7.19±0.29	8.4±1.2
Fiber (%)	8.3±0.3	6.54±0.38	7.2±0.1
Carbohydrates (%)	29.7±0.54	28.35±0.25	31.3±3.1
Energy (Kcal)	382.28±0.8	343.09±0.6	394.2±4.2

Measurement of Environmental Variables of the Experimental Structures

To assess the abiotic conditions in which *Clarias gariepinus* fry were reared, four physicochemical parameters were measured: hydrogen potential (pH), temperature (°C), conductivity (µS/cm), and turbidity (ppm) in the tanks used in this experiment. These parameters were assessed during fish monitoring sessions every ten days from the start of the experiment. The parameters were sampled in situ three times a day—in the morning, at midday, and in the evening—using a HANNA Combo HI9812-5 pH/°C/EC/TDS multiparameter probe.

Weighing and Measuring of Fry

Weighing and measuring the fish was essential for monitoring their growth. The weight of each fry was measured with a precision electronic scale, and their total length was measured with a caliper.

Fish Feeding

Since the fish were reared in an above-ground concrete tank culture system, they could not benefit from primary production (phyto- and zooplankton). Therefore, the fry were fed daily throughout the experiment. The feed was distributed three times a day: 8:00 a.m., 12:00 p.m., and 3:00 p.m., by free hand. The daily amount of feed administered to the fish was 10% of their total biomass (Pwema et al., 2020). Feed B1 was distributed to fish in tank B1, fish in **Tank B2** received feed B2, and fish in tank B3 were fed ration B3.

Economic Aspects of the Feed Rations

Production Cost of the Feed Rations

The production cost of the feed rations was estimated by calculating the price of each ingredient incorporated. The price of a given ingredient in one kilogram of feed was obtained by multiplying the price of one kilogram of that ingredient by its incorporation rate, divided by 100. The total production price of one kilogram of a feed ration is the sum of the prices of each ingredient in the ration (Lusasi et al., 2019b; Pwema et al., 2020).

Cost of Production of One Kilogram of Fish with Feed Rations

The production cost of one kilogram of fish with the tested feed rations was estimated by multiplying the production cost of one kilogram of feed by the feed conversion ratio, defined as the ratio of feed consumed to weight gain (Lusasi et al., 2019b; Pwema et al., 2020).

Zootechnical Parameters and Calculated Indices

To estimate the growth of the fish and the efficiency of feed utilization during the experiment, the following zootechnical parameters and indices were calculated (Lusasi et al., 2019b; Pwema et al., 2020):

1. **Survival Rate (SR)**: Calculated from the total number of fish at the end of the experiment and the number at the beginning, using the formula: SR=NfNi×100SR = \frac{N_f}{N_i} \times 100SR=NiNf×100, where NiN_iNi is the initial number of fish and NfN_fNf is the final number of fish.
2. **Average Weight (AW)**: The ratio between the total weight of the fry and the total number of fish, calculated as MW=BNPMW = \frac{B}{NP}MW=NPB, where MW is the average weight (g), B is the biomass (g), and NP is the total number of fish.
3. **Average Size (TM)**: The ratio between the sum of the total lengths of the fry and the total number of fish, calculated as TM=SLtNPTM = \frac{SL_t}{NP}TM=NPSLt, where SLtSL_tSLt is the sum of total fry lengths and NP is the total number of fry.
4. **Body Mass Gain (BMC)**: The weight gained by the fish over a given time, calculated using the formula: BMC=MWf−MWiBMC = MW_f - MW_iBMC=MWf−MWi, where MW_f is the final average weight and MW_i is the initial average weight.
5. **Average Size Gain (ASG)**: The average size added by the fish over time, calculated using the formula:

ASG=TMf−TMiASG = TM_f - TM_iASG=TMf−TMi, where TM_f is the final average size and TM_i is the initial average size.

6. **Individual Daily Growth (IDG)**: Also called Daily Specific Growth Rate (DSGR), it indicates the daily weight gain of the fish during rearing, determined using the relation: IDG=Pf−PiDEIDG = \frac{Pf - Pi}{DE}IDG=DEPf−Pi, where Pf is the final weight (g), Pi is the initial weight (g), and DE is the rearing duration.
7. **Consumption Index (CI)**: Determined using the formula: CI=QASIBMCCI = \frac{QASI}{BMC}CI=BMCQASI, where QASI is the quantity of dry feed ingested and BMC is the body mass gain (g).
8. **Performance Index (PI)**: Determined using the formula: PI=SR×IDGPI = SR \times IDGPI=SR×IDG.
9. **Weight-Length Relationship**: Determined using the relation W=a×LbW = a \times L^bW=a×Lb, where W is the weight, and LbL^bLb is the length of the regression line.

Data Analysis and Processing

Data on weight and linear growth, survival rate, weight gain, individual daily growth of fry, and food consumption index were encoded in Excel 2013. The means were compared by analysis of variance with a classification criterion (ANOVA 1) (Scherrer, 1984). Fisher's LSD (Least Significant Difference) test (Saville, 1990) was used at a 95% confidence interval to determine the differences between the means of the different fish batches, using Statistix version 10 software. Results were presented in the form of tables and graphs, with Origin 6.1 software used to generate the graphs.

RESULTS AND DISCUSSION

Physicochemical Parameters of the Water in the Tanks

The minimum, maximum, and average variations of the physicochemical parameters of the water in the tanks used for the pre-growth of *Clarias gariepinus* fry are shown in **Table 2**.

Table 2:
Values of the physico-chemical parameters of the tank waters (T° = temperature, Cond = conductivity, Turb = turbidity, Mi = minimum and Ma = maximum)

Paramètres	Bac 1			Bac 2			Bac 3		
pH	Mi	Ma	Average	Mi	Ma	Average	Mi	Ma	Average
	7.5	7.9	7.65±0.11	7,5	7.9	7.63±0.07	7.4	7.6	7.53±0.05
T° (°C)	25.2	25.4	25.18±0.12	24	25.4	24.75±0.50	24	26.2	25.13±0.34
Cond (µS/cm)	23	36	29.55±4.37	29	37	32.11±3.45	24	37	29±4
Turb (NTU)	12	18	14.88±1.92	14	18	15.66±1.4	12	18	14.33±1.77

For optimal survival and growth, Anusuya et al. (2017) emphasized the importance of good water quality, as water quality plays a critical role in fish health, and its deterioration can be a stressor (Arulampalam et al., 1998). Factors such as dissolved oxygen, temperature, and ammonia are crucial, while pH, alkalinity, hardness, and clarity generally affect fish health but are not directly toxic (Edea et al., 2019). The results from this experiment indicated that the physicochemical parameters of the tank water remained within the acceptable range for fish growth. As shown in **Table 2**, the physicochemical parameters varied between treatments. Overall, the water showed a neutral to slightly basic pH (B1 = 7.65±0.11; B2 = 7.63±0.07; B3 = 7.53±0.05), with no significant difference between treatments ($F = 3.03$; $p = 0.0671$). The optimal pH for *Clarias gariepinus* is around 7 (Viveen et al., 1985), though variable pH values between 6 and 8.5 are reported, with the species thriving in waters with a pH between 6 and 9. Extreme pH values below 4.5 or above 10 can result in mortality (Edea et al., 2019). Water temperatures remained warm, ranging from 24.75±0.50°C **(Tank 2)** to 25.18±0.12°C **(Tank 1)**, with no significant difference in temperature averages ($F = 2.19$; $p = 0.1332$). *C. gariepinus* is tolerant of temperatures between 8 and 35°C, with optimal growth reported between 28 and 30°C (Teugels, 1986). The water's conductivity ranged from 29±4 µS/cm in **Tank B3** to 32.11±3.45 µS/cm in **Tank B2**, with no significant difference ($F = 1.08$; $p = 0.3546$). These results are lower than those reported by Pwema et al. (2020), who found mean conductivities between 148.16±42.16 and 151.83±45.5 µS/cm in *C. gariepinus* rearing systems. The concentration of total dissolved solids was low, varying from 14.33±1.77 ppm in **Tank B3** to 15.66±1.4 ppm in **Tank B2**, with no significant difference ($F = 0.87$; $p = 0.4302$).

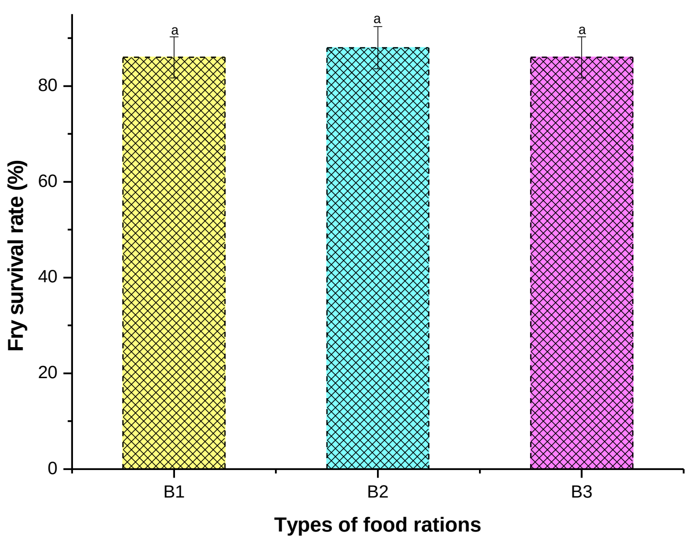
Variation in Growth of Clarias gariepinus *Burchell, 1822*

The variation in the growth of *Clarias gariepinus* fry after 60 days depended on zootechnical parameters and feed rations.

Survival Rate

Fry survival rates ranged from 86±1.6% for fish fed diets B1 and B3 to 88±0.9% for those fed diet B2. Analysis of variance indicated no significant difference in survival rates between fish batches (F = 13.1; p = 0.0713) (**Figure 2**). These survival rates are considerably higher than those reported by Pwema et al. (2020), who observed rates between 13.33±4.03% and 73.3±2.5%. The high survival rates in this study are likely due to the low stocking density, which minimized cannibalism. Low mortality is not attributed to feeding or incompatibility of rearing structures but rather to handling stress during control fisheries (Adouvi, 2013), as mortality cases were more frequent on days when fish were measured. These findings suggest that the fry adapted well to the above-ground system.

Figure 2:
Variation in fry survival (%) as a function of feed rations



Average Weight

The final average weight of fish varied with feed type. Fry fed B1 increased from 1.00±0.35 g to 8.44±0.64 g. Fish fed B2 had an initial mean weight of 1.19±0.55 g and a final mean weight of 4.97±0.46 g. Fish fed B3 started at 1.20±0.61 g and ended at 5.35±0.7 g **(Figure 3)**. Analysis of variance showed no significant difference in mean weights between feed rations (F = 0.63; p = 0.5487). Variations in average daily gain can be influenced by feeding method, rearing duration, stocking density, and system design (Edea et al., 2019). The performance of fry fed B1 is likely related to the high protein content from fish meal. Results are comparable to those by Pwema et al. (2020), who reported weights of 9.2±4.41 g, 11.60±4.95 g, and 27.5±10.9 g. Differences between these results and those of Elegbe et al. (2015), who reported final weights ranging from 20.95±1.12 g to 42.56±2.26 g, are attributed to different experimental setups, as Elegbe et al. (2015) used lowland ponds benefiting from primary production.

Figure 3:
Variation in mean fry weight (g) with rearing period

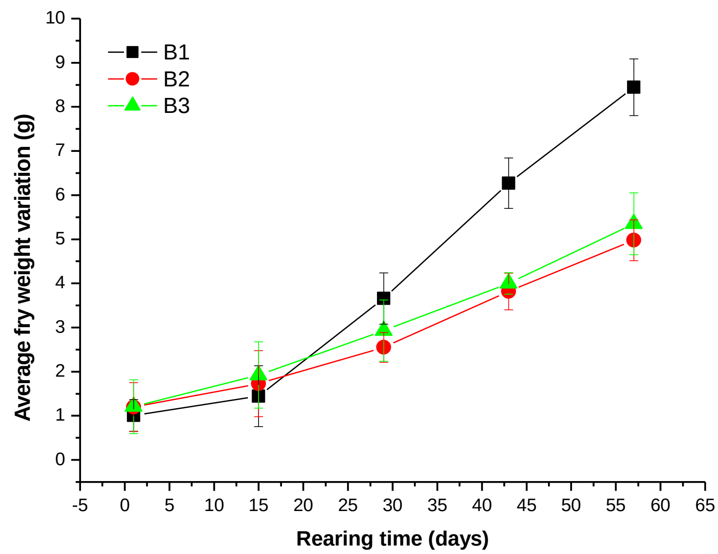
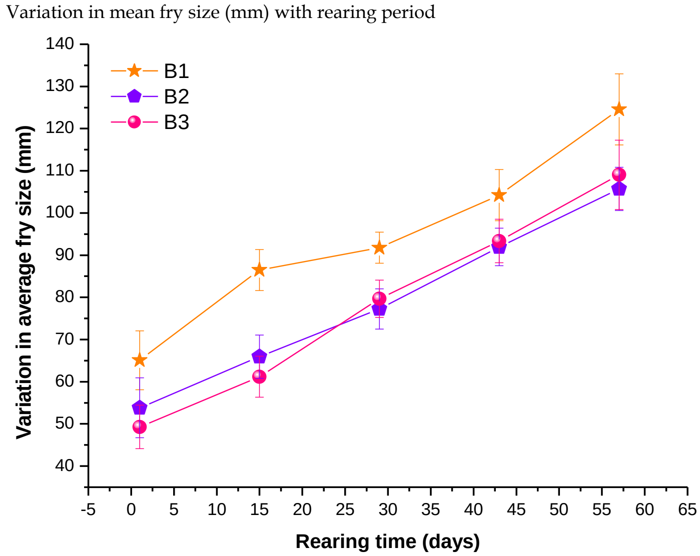


Figure 4:
Variation in mean fry size (mm) with rearing period

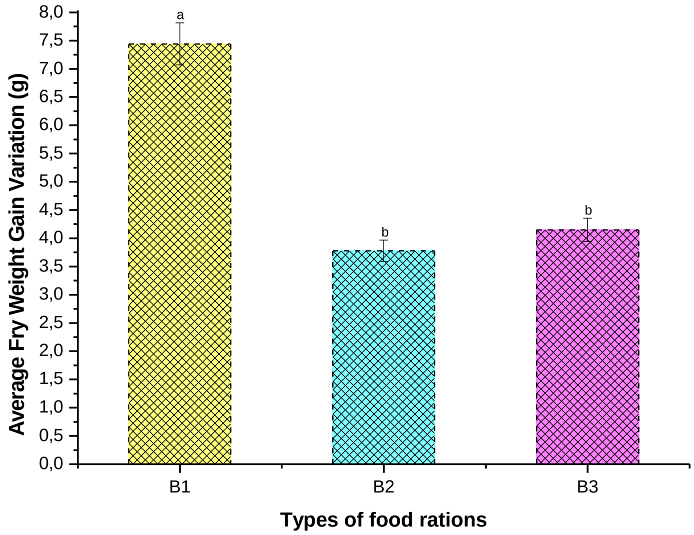


Average Weight Gain

Fish gained significantly more weight with feed ration B1

(7.44 g) and B3 (4.15 g) compared to those fed B2, which showed a weight gain of 3.78 g **(Figure 5)**. Analysis of variance indicated that feed B1 significantly influenced the weight gain of fish (F = 4.4; p = 0.04788; LSD = 1.4362) compared to feeds B3 and B2. These results demonstrate that the fishmeal-based feed B1 significantly enhanced the weight gain of fry compared to those fed with imported feed (B3) and Moringa-based feed (B2).

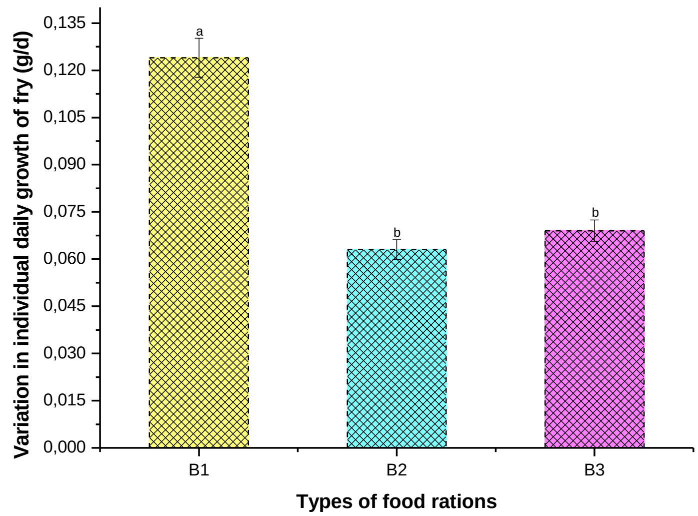
Figure 5:
Variation in average fry weight gain (g) as a function of feed rations



Individual Daily Growth

Regarding individual daily growth, the developed feed rations differed significantly (F = 4.39; p = 0.0480). The LSD test with a critical value of 2.6242 revealed that feed ration B1 significantly influenced the individual daily growth of the fry, with a rate of 0.124 g/d, compared to feed B2 (0.063 g/d) and B3 (0.069 g/d) **(Figure 6)**. Edea et al. (2019) report a growth rate of 2.6 g/d for *Clarias gariepinus* fingerlings reared in monoculture in concrete tanks. Overall, *C. gariepinus* exhibits a notable growth rate, reaching 500 to 1,000 g in 8 months (Fermon, 2011). The individual daily growth rate of fish remained generally low, with feed B1 significantly influencing growth at 0.124 g/d compared to B2 (0.063 g/d) and B3 (0.069 g/d). Fiogbe et al. (2009) found daily growth rates between 0.19% and 0.38%. These results are lower than those reported by Pwema et al. (2020), who found specific growth rates of 0.25%/d, 0.9%/d, and 0.6 g/d. Edea et al. (2019) indicated that *C. gariepinus* juveniles have growth and food conversion rates comparable to other fish species. Optimal feeding levels show a decrease in specific growth rate from 12% per day for juveniles (0.3–14 g) to less than 2% per day for adults (200–300 g), while food conversion rates increase from 0.7 for juveniles to 1.5 for adults. Thus, feed rations B1 and B2, containing 35% and 45% protein based on local by-products, promoted fry growth similarly to the imported feed (B3). Some authors have reported variations in fingerling size from the same *Clariidae* broodstock, potentially related to egg size (Edea et al., 2019). These positive growth results suggest that above-ground fish farming may contribute positively to fish production and improve fish availability for human consumption.

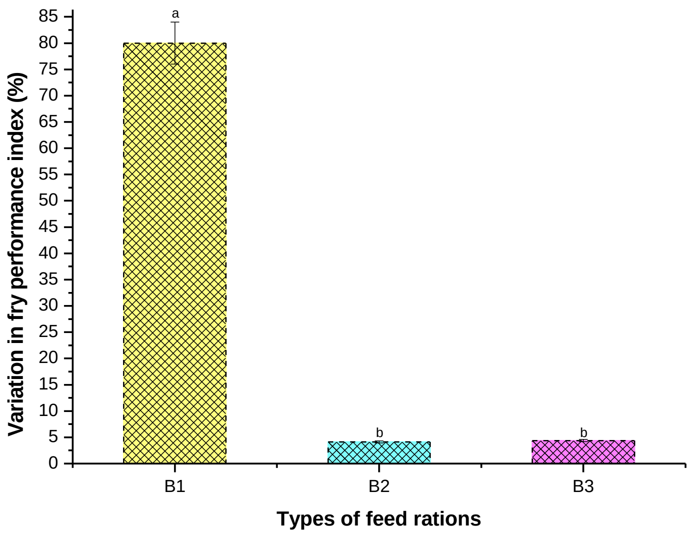
Figure 6:
Variation in individual daily growth of fry (g/d) as a function of feed rations



Performance Index

Fish fed feed B1 showed a high performance index (79.98%), followed by those fed feed B3 (4.38%) and feed B2 (4.13%) **(Figure 7)**. Analysis of variance showed a highly significant difference (F = 29.49; p = 0.001); the LSD test with a critical value of 3.3152 indicated that feed B1 performed better than the others. These results confirm observations regarding the food consumption index (FCI) during this study. Fish fed B2 (FCI = 6.49) and B3 (FCI = 6.05) had higher FCI values than fry fed B1 (3.37). These findings are consistent with Elonga (2018), who reported an FCI between 2.67 and 6.43 for *Clarias gariepinus* larvae.

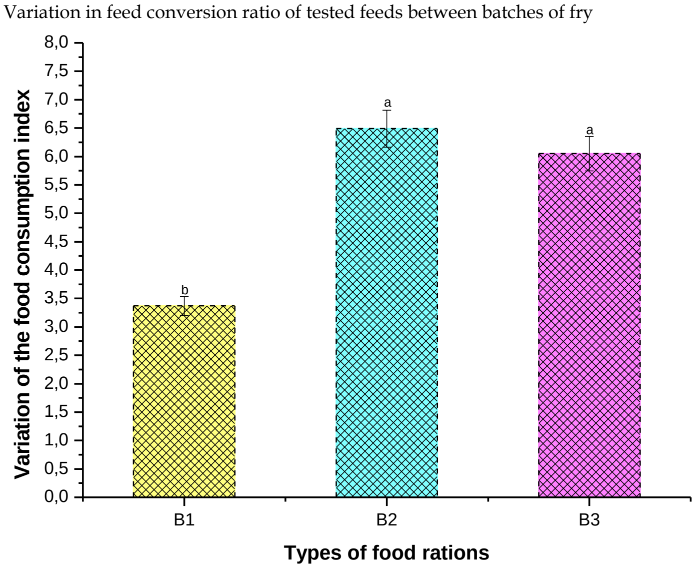
Figure 7:
Variation in fry performance index (%) with feed rations



Food Consumption Index

The feed consumption index (FCI) varied significantly (F = 5.4; p = 0.0321) based on feed type. The LSD test with a critical comparison value of 4.1436 showed that fish fed diets B2 (FCI = 6.49) and B3 (FCI = 6.05) had higher FCI values than those fed diet B1 (3.37) **(Figure 8)**.

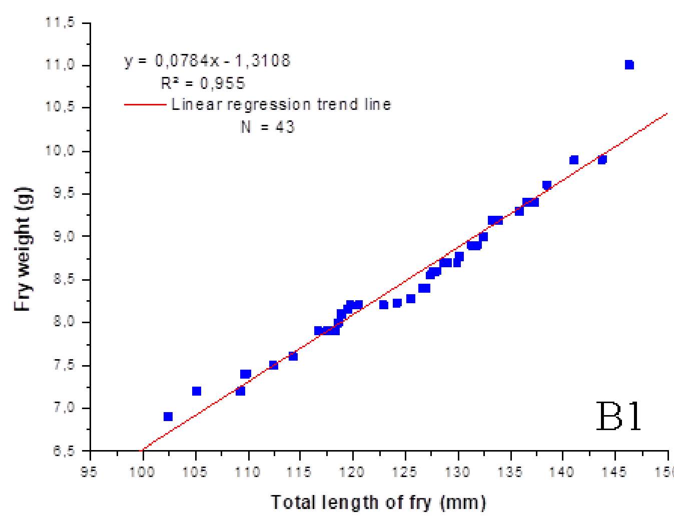
Figure 8:
Variation in feed conversion ratio of tested feeds between batches of fry

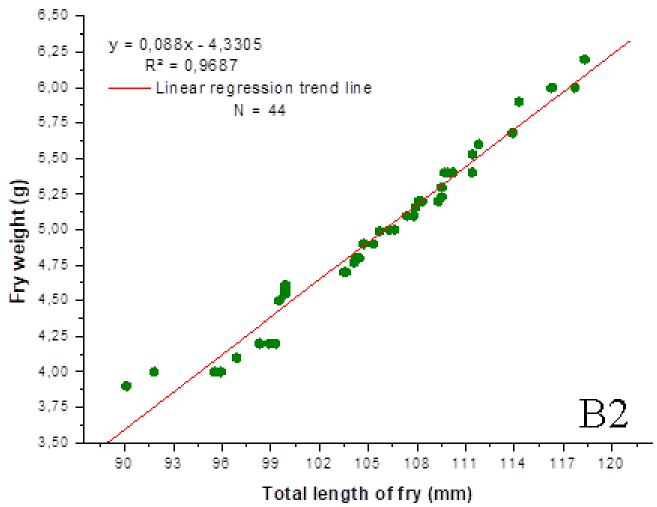


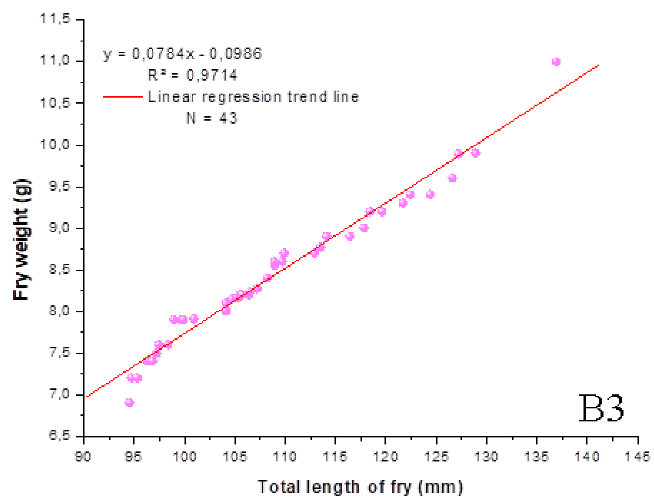
Relationship Between Weight and Total Length of Fry

The relationship between weight and total length for fish fed B1, which contained mostly fish meal, showed a minorizing allometry (y = 0.078), indicating that during the experiment, the weight of the fry changed less rapidly than their size. A positive correlation (R^2 = 0.955) was established between weight and size **(Figure 9)**. A positive correlation (R^2 = 0.9842) was found between weight and size for fry fed B2. The relationship between these parameters showed minorizing allometric growth (y = 0.088), with size increasing significantly more than weight. A positive correlation (R^2 = 0.9856) was also established for fry fed B3, showing minorizing allometric growth (y = 0.0784) **(Figure 9)**. This indicates that during the experiment, weight growth changed less rapidly than linear growth. These results align with findings by Adouvi (2013) and Elonga (2018). Adouvi (2013) observed positive allometric growth (b = 0.94) for one batch and isometric growth (b = 0.58) for another batch of fish. These results confirm that the experimental setup (concrete tanks) supported fry development without negatively affecting growth type. From an environmental perspective, above-ground fish farming helps preserve wetlands and aquatic ecosystems. Large-scale production above ground helps protect and sustain fish species used in this farming system.

Figure 9:
Relationship between weight (g) and total length (mm) of fry from treatments B1, B2, and B3







Economic Approach of the Formulated Feed Rations

Cost of One Kilogram of Feed

The financial cost in Congolese Francs (CF) of producing one kilogram of different types of feed is shown in **Table 3**.

Table 3:
Production cost of the tested feed rations (1 USD = 20,000 CF; + = Used; - = Not in use).

Ingredients	Price (CF)	Types of food		
		B1	B2	B3
Fish meal	100	2000 x 100/100 = 2000	2000 x 25/100 = 500	+
Corn flour	250	1200 x 25/100 = 300	1200 x 30/100 = 360	+
Cassava flour	250	1000 x 25/100 = 250	1000 x 10/100 = 100	+
Palm kernel cake	300	1500 x 30/100 = 450	1500 x 25/100 = 375	-
Moringa flour	Gratuit	0 x 10/100 = 0	0 x 100/100 = 0	-
Wheat bran	250	250 x 10/100 =250	250 x 10/100 = 25	+
Palm oil	2.000	2000×35/100 = 700	2000×35/100 = 700	+
Table salt	1.000	1000×50/100 = 500	1000×50/100 = 500	+
Vitamin and mineral premix	250.000	500×2/100 = 10	25000×2/100 = 500	+
Quantity (g)		**2.000**	**2.000**	**2.000**
Total cost in CF		**4.460**	**3.060**	**10.000**

According to **Table 3**, the cost of acquiring one kilogram of imported feed (B3) is higher (5,000 CF) than producing one kilogram of feed B1 (2,230 CF) and B2 (1,530 CF). These results are consistent with Lusasi et al. (2019a), who found that developing fish feed from locally available ingredients is less expensive than acquiring imported feeds.

Production Cost of One Kilogram of Clarias gariepinus Fish

The cost of producing one kilogram of *Clarias gariepinus* fish with the three types of feed formulations is detailed in **Table 4**.

Table 4:
Production cost of one kilogram of *Clarias gariepinus* fish with different types of feed (FCI = Food Consumption Index).

Food type	Price (FC)	FCI	Cost (CF) of production
B1	2.230	3.37	7.515
B2	1.530	6.49	9.929
B3	5.000	6.05	30.250

Table 4 shows that producing one kilogram of *C. gariepinus* fish with feed B3 is more expensive (30,250 FC) than with B1 (7,515 FC) and B2 (9,929 FC). These findings are similar to those of Diayeno (2016), Lusasi et al. (2019b), and Pwema et al. (2020), who concluded that local feeds are more cost-effective than imported feeds. The high cost of imported feed (5,000 CF) highlights its uneconomic nature. To make fish production with locally formulated feeds more profitable, it is important to use less expensive, locally available, digestible, and protein-rich ingredients to improve feed nutritional quality and reduce production costs.

CONCLUSION AND PERSPECTIVES

The objective of this study was to evaluate the early growth of African catfish (*Clarias gariepinus* Burchell, 1822) fry in an above-ground concrete tank culture system to promote home fish farming. The results demonstrated the effectiveness and efficiency of concrete tanks for maintaining and growing *Clarias gariepinus* fry in an above-ground system under Kinshasa conditions. Survival rates varied by feed type, with 86 ± 1.6% (B1 and B3) and 88 ± 0.9% (B2). Fingerlings fed feed B1, which primarily contained fish meal, had a higher average final weight (8.44 ± 0.64 g) compared to those fed the control feed, B3 (5.35 ± 0.7 g), and those fed B2 (4.97 ± 0.46 g). The cost of acquiring one kilogram of imported feed (5,000 CF), as well as the cost of producing one kilogram of *Clarias gariepinus* with this feed, highlighted the economic disadvantage of using imported feed in fish farming. Thus, producing fish with feed rations formulated from local by-products is more cost-effective than using imported feed. Studies on yield per unit area for different above-ground rearing structures can further elucidate the economic profitability of fish produced with the tested feeds. Congolese fish farmers, particularly in Kinshasa, are encouraged to focus on locally formulated feeds to enhance their production.

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ORCID iDs:

Lusasi, S. W. [1,2]: https://orcid.org/0000-0002-2526-7903
Mbele, M. G. [2]: Nil identified
Mbomba, N. B. [1,2]: Nil identified
Pwema, K. V. [1,2]: https://orcid.org/0009-0002-2355-1668

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