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Effect of dietary inclusion of blood meal on growth, survival and nutrient utilization of *Clarias gariepinus* fingerlings

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Abstract
This research aimed to assess the growth and survival of *Clarias gariepinus* fingerlings when fed varying levels of blood meal over a 49-day period. One hundred and eighty fingerlings, averaging 5.64±0.11cm in length and 1.49±0.05g in weight, were used. Six diets with approximately 40% crude protein were formulated using different ingredients, including fish meal, blood meal, soybean meal, corn meal, palm oil, table salt, vitamins C, bone meal, vitamin/mineral premix, and starch as a binder. These diets had blood meal inclusion levels ranging from 0% to 25%. Each diet was replicated three times, with 10 fingerlings per replication. The study found that the lowest survival rate (63.33±21.85%) was in fingerlings fed a diet with 25% blood meal, while the highest (93.33±60%) was in those fed a diet without blood meal. The highest weight gain (2.11±0.63g) was in fingerlings fed the diet with 25% blood meal, followed by 20% blood meal (1.81±0.47g), and the lowest (1.45±0.25g) was in the 15% blood meal diet. However, there were no significant differences between the treatments. In terms of specific growth rate, the highest (0.79±0.20%d-1) and lowest (0.50±0.20%d-1) values were observed in the 25% and 10% blood meal diets, respectively. There were also no significant differences in feed conversion ratio and protein efficiency ratio between the treatments. Overall, the study suggests that blood meal can effectively substitute fish meal at a 25% inclusion level in fish feed production, potentially reducing costs without compromising fish growth or health.

Keywords: Fish feed, high cost of fishmeal, blood meal, *Clarias gariepinus*

Introduction
The giant stride in aquaculture industry is predicated on the specific number of nutritional information available for effective and appropriate hatchery management relevant to the fish farmer as recorded by Imgbian and Zarmai. (2011) [22]. It is known that appropriate feed and feeding management are pre-requisites for fish farming like any other Animal production. Reared species have limited natural food, hence to ensure fast growth an efficient conversion of feed to tissue, sufficient feed of the right quality and quantity must be made available by the farmer. In any aquaculture operation today, feed accounts for more than one-half the variable cost (NRC, 1993) [24]. Also suggested was that 70% of production cost represents feed as reported by Aliu and Olomu (2017) [8] and Adikwu, (2003) [5]. Understanding the fundamentals of nutrition and practical feeding is crucial for successful fish farming. Due to the economic downturn in Nigeria, the costs of feed and feeding materials have significantly increased, making them unaffordable for many farmers. This rise is partly due to their alternative uses in human and other livestock nutrition (Imgbian and Zarmai, 2011) [22]. To maintain or increase current fish feed production and meet the growing demand for fish products, it is essential to discover and use less expensive and locally available nutrient sources. While nutrient requirements vary minimally among different fish species (NRC, 1993) [24], certain differences do exist.

An optimal nutrition strategy includes both natural and artificial feeds that effectively meet the nutrient requirements for fish growth and survival. Economically, a desirable nutrition plan should produce healthy, high-quality fish in the shortest possible time and at a cost-effective scale. Unfortunately, this is often lacking in aquaculture in Nigeria, where the cost of conventional feed or feedstuff is continually rising (Fagbenro *et al*., 2003) [18].

Experimental Location

The study took place at the Fisheries Unit within the Teaching and Research Farm of the Faculty of Agriculture at Niger Delta University, located in Bayelsa State, Nigeria. The duration of the experiment was seven weeks.

Experimental Setup

The research utilized a Completely Randomized Design (CRD). Eighteen rectangular plastic aquaria, each measuring 27x37x47cm3 and holding 20 liters of water, were employed. Ten *Clarias gariepinus* fingerlings were randomly placed into each of the 18 aquaria. The experiment included six diets (Treatments), each administered in triplicate.

Experimental Fish and Feed Ingredients

A total of 180 *Clarias gariepinus* fingerlings were sourced from Baka Farm along Imiringi road in Yenagoa, Bayelsa State, Nigeria. After a 3-day acclimatization period in plastic holding tanks, the fish were randomly distributed into the 18 containers. The feed ingredients included *Pelonulla leonensis*, blood meal, soybean meal, corn meal, palm oil, table salt, vitamin C, bone meal, vitamin/mineral premix, and starch as a binder. These ingredients were procured from a feed store in Biogbolo community, Yenagoa, Bayelsa State, and processed accordingly.

Diet Preparation

Six experimental diets with approximately 40% crude protein content were formulated using the Trial and Error method. The diets contained varying levels of blood meal (0%, 5%, 10%, 15%, 20%, and 25%). The ground feedstuffs were sieved to remove impurities, then measured and hand mixed in the correct proportions. Gelatinized starch and water were added to form a dough, which was pelleted using a meat mincer. The pellets were sun-dried for 2 days, cooled, and stored in labeled containers. This process was repeated for each of the six diets used in the experiment.

Table 1: The gross composition of experimental diet

Feed ingredient	T_1 (0%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	T_5 (20%)	T_6 (25%)
Blood meal (81%CP)	0	1.5	3.0	4.5	6.0	7.5
Fish meal (*Pelonulla leonensis* 70%CP)	30	28.5	27	25.5	24	22.5
Soya bean meal (45% CP)	33.3	33.3	33.3	32.5	32.5	32
Wheat bran (16% CP)	15	12	12	12	12	12
Maize meal (9% CP)	12	15	15	15.8	15.8	16.3
Bone meal	1.0	1.0	1.0	1.0	1.0	1.0
Vitamin/mineral premix	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin C	0.1	0.1	0.1	0.1	0.1	0.1
Table salt (NaCl)	0.1	0.1	0.1	0.1	0.1	0.1
Palm oil	5.0	5.0	5.0	5.0	5.0	5.0
Starch	3.0	3.0	3.0	3.0	3.0	3.0
Total	100	100	100	100	100	100

Fish stocking and feeding involved introducing 180 fingerlings into aquaria, with 10 fingerlings per tank. Their initial size and weight were recorded. They were fed twice daily with 5% of their body weight, and their growth was monitored weekly, with feed quantities adjusted accordingly. Water quality parameters, including temperature, dissolved oxygen, and pH, were measured weekly.

Growth parameters were assessed on a weekly basis, including mean body weight gain, percentage weight gain, mean increase in fish length, specific growth rate, condition factor, survival rate, food conversion ratio, and protein efficiency ratio. Statistical analysis was performed using ANOVA and Duncan's Multiple Range Test to evaluate treatment differences, with SPSS software used for data analysis.

Water Quality

The water quality parameters observed during the experiment are summarized in Table 2. The water temperature ranged from 26.50±0.36 °C to 27.00±0.36 °C, with no significant differences between the experimental diets ($p<0.05$). Dissolved oxygen levels varied from 3.60±0.15 mg/l to 4.60±0.15 mg/l, with the lowest level recorded in the treatment with 0% blood meal inclusion (T_1) and the highest in the treatment with 25% blood meal inclusion (T_4). The pH ranged from 6.50±0.10 to 6.75±0.10, with no significant differences across all treatments ($p<0.05$).

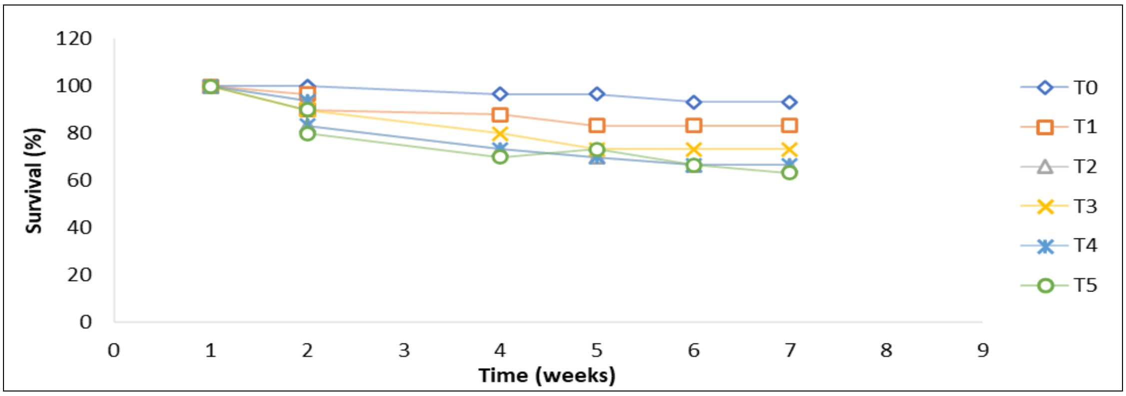

Fig 1: Fish Survival

Figure 1 and Table 3 depict the average percentage of surviving *Clarias gariepinus* fingerlings across all treatments over the study duration. Survival rates varied from 63.33±21.85% to 93.33±6.66%. The lowest survival was noted in fish fed a diet containing 25% blood meal, while the highest survival was observed in fish fed T_1 (0%).

Table 2: Mean and Range of water quality parameters for *Clarias gariepinus* fingerlings fed diets containing different dietary blood meal levels

Parameter	Treatment (Diets)					
	T_1 (0%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	T_5 (20%)	T_6 (25%)
Temperature (^{0}C)	27.00 ± 0.36^{a} (25.0-29.0)	26.50 ± 0.36^{a} (25.0-29.0)	26.50 ± 0.36^{a} (25.0-29.0)	26.00 ± 0.36^{a} (25.0-29.0)	27.00 ± 0.36^{a} (25.0-29.0)	27.00 ± 0.36^{a} (25.0-29.0)
Dissolved Oxygen (mg/l)	4.60 ± 0.17^{a} (4.42-4.72)	4.45 ± 0.15^{a} (4.38-4.57)	4.40 ± 0.14^{a} (4.35-4.61)	3.70 ± 0.09^{a} (3.61-3.79)	3.60 ± 0.08^{a} (3.53-3.77)	4.25 ± 0.13^{a} (4.13-4.51)
pH	6.50 ± 0.10^{a} (6.4-6.7)	6.70 ± 0.10^{c} (6.5-6.8)	6.75 ± 0.10^{ab} (6.6-6.9)	6.50 ± 0.10^{bc} (6.4-6.7)	6.50 ± 0.10^{abc} (6.4-6.7)	6.70 ± 0.10^{a} (6.5-6.8)

Means with the same super script in the same horizontal row are not significantly different (p<0.05).

The results regarding the weight gain of *Clarias gariepinus* fingerlings fed different levels of blood meal in their diets are shown in Figure 2 and Table 3. The lowest mean weight gains were found in T_2 with 5% blood meal inclusion (1.29±0.23g) and T_4 with 15% blood meal inclusion (1.45±0.25g), while the highest mean weight gain was observed in T_6 with 25% blood meal inclusion (2.11±0.63g), followed by T_5 with 20% blood meal inclusion (1.81±0.47g). There was no significant difference among the treatments (p<0.05).

The condition factor (K) ranged from 0.01±0.00 to 0.07±0.06, with the lowest values recorded in T_1 (0%), T_2 (5%), and T_3, and the highest values in T_6 (25%), followed by T_5. Specific growth rates ranged from 0.50±0.20 to 0.79±0.20%d-1, with the lowest rate in T_2 (5% blood meal inclusion) and the highest in T_6 (25% blood meal inclusion). The lowest percentage weight gain was observed in T_2 (5% blood meal inclusion) at 48.21±7.83%, and the highest was in T_6 (25% blood meal inclusion) at 56.09±8.42%.

For nutrient utilization, feed conversion ratio (FCR) values ranged from 0.61±0.15 to 1.05±0.38, with the lowest value in T_3 (10% blood meal inclusion) and the highest in T_4 (15% blood meal inclusion). There was no significant difference among the treatments (p<0.05). The protein efficiency ratio varied from 1.11±0.24 to 3.20±2.07, with no significant difference among treatments (p<0.05), as illustrated in Table 3 and Figure 3.

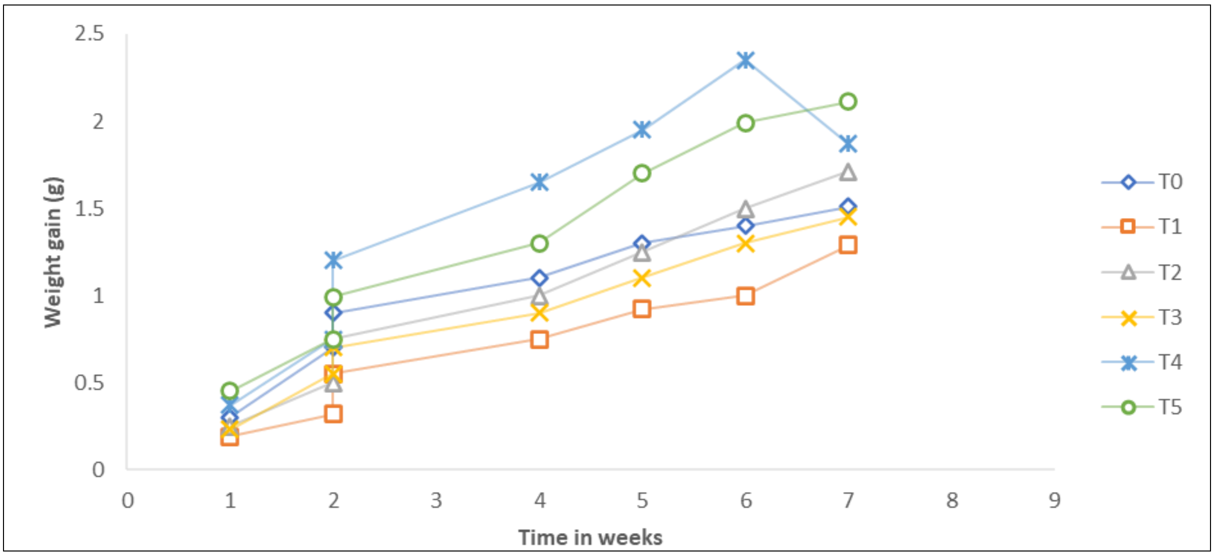

Fig 2: Growth curve of *Clarias gariepinus* fingerlings fed different dietary levels of blood

Table 3: Growth, survival and nutrient utilization of *Clarias gariepinus* fingerlings fed different dietary levels of blood meal

Parameters	Treatment (Diets)					
	T_1 (0%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	T_5 (20%)	T_6 (25%)
Initial number of fish	10	10	10	10	10	10
Initial Mean Weight (g)	1.47 ± 0.30^{a}	1.58 ± 0.30^{a}	1.50 ± 0.20^{a}	1.42 ± 0.30^{a}	1.47 ± 0.20^{a}	1.50 ± 0.20^{a}
Initial Mean Length (cm)	5.43 ± 0.43^{a}	5.60 ± 0.43^{a}	5.70 ± 0.43^{a}	5.63 ± 0.43^{a}	5.70 ± 0.43^{a}	5.80 ± 0.43^{a}
Mean Weight Gain (g)	1.51 ± 0.31^{a}	1.29 ± 0.23^{a}	1.71 ± 0.21^{ab}	1.45 ± 0.25^{a}	1.81 ± 0.47^{a}	2.11 ± 0.63^{a}
Mean Length Increase (cm)	1.66 ± 0.14^{a}	1.67 ± 0.26^{a}	2.05 ± 0.43^{a}	1.83 ± 0.42^{a}	1.80 ± 0.41^{a}	2.19 ± 0.51^{a}
Percent Weight Gain (%)	50.50 ± 6.27^{a}	48.21 ± 7.83^{a}	53.00 ± 2.00^{a}	52.34 ± 2.23^{a}	$54.31\pm5\text{-}37^{a}$	$56.09\pm8.42\text{S}^{a}$
Specific Growth Rate (%d^{-1})	0.63 ± 0.11^{a}	0.53 ± 0.09^{a}	0.50 ± 0.20^{a}	0.64 ± 0.00^{a}	0.68 ± 0.14^{a}	0.79 ± 0.20^{a}
Condition Factor (K)	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	0.02 ± 0.01^{a}	0.01 ± 0.00^{a}	0.06 ± 0.05^{a}	0.07 ± 0.06^{a}
Percentage survival (%)	93.33 ± 6.66^{a}	83.33 ± 8.81^{a}	66.66 ± 14.52^{a}	73.33 ± 12.01^{a}	66.66 ± 23.33^{a}	63.33 ± 21.85^{a}
Food conversion ratio (FCR)	0.96 ± 0.17^{a}	1.00 ± 0.25^{a}	0.61 ± 0.15^{a}	1.05 ± 0.38^{a}	0.65 ± 0.25^{a}	0.63 ± 0.25^{a}
Protein Efficient ratio	1.14 ± 0.21^{a}	1.11 ± 0.24^{a}	1.76 ± 0.41^{a}	1.46 ± 0.28^{a}	2.92 ± 1.81^{a}	3.20 ± 2.07^{a}

Means with the same alphabets for a given parameter in the same horizontal line are not significantly different (p<0.05)

Discussion

Researchers globally have evaluated various alternative protein sources to substitute fish meal in fish diets, a topic highlighted by Njieassam (2016) [23]. It's imperative that the chosen protein sources and inclusion levels support human food security objectives while reducing costs associated with fish meal, all while maintaining the growth performance of African catfish. Interestingly, during the experimental period, no significant differences were observed in any of the parameters. Unexpectedly, the highest average weight gain of 2.11±0.63g was recorded in T_6, with 25% blood meal inclusion, contrary to the suggestion by McDonald *et al.* (1992) [30] that the distinct smell of blood meal could diminish its appeal, advocating for a 5% limit in African catfish diets. The highest percentage weight gain was observed in T_6 at 25%. Across all treatments, the survival rate ranged from 93.33±6.66% in the control (T_1) with no blood meal inclusion to 63.33±2.85% in T_6 with 25% inclusion, consistent with the findings of Njieassam (2016) [23]. Mortality remained generally low throughout the experiment, except for the 15% inclusion level, contrasting with the findings of De Graaf *et al*. (2018) [31], who reported a lower survival rate of 41.5% for *Clarias gariepinus* under different conditions. The T_4 treatment with 15% inclusion had the highest food conversion ratio, indicating optimal diet utilization by the fingerlings. This result contradicts the findings of Olukunle (2012) [32], where the best feed conversion ratio and specific growth rate were observed in fish fed the control diet. However, it aligns with Njieassam's (2016) [23] study, which also reported the best food conversion ratio and specific growth rate with 15% blood meal inclusion. The highest protein efficiency ratio was observed in T_6, where fish were fed with a 25% inclusion rate, deviating from studies suggesting improved performance with lower blood meal inclusion levels, such as 1 to 4% (Petkov *et al*., 1980; Donkoh *et al*., 2001) [28, 12]. Conversely, some authors have utilized higher levels of blood meal without adverse effects on growth (Hassan *et al*., 1974; Donkoh *et al.*, 1999, 2001, 2002) [12-14]. However, Hassan Khan and Ansari (2007) [33] discovered that diets with over 3% blood meal negatively impacted feed intake and weight gain. Some studies propose that blood meal, supplemented with methionine, can address amino acid deficiencies in shrimp diets (Davies *et al*., 1989) [11]. While Viola and Zohar (1984) [29] and Otubusin (1987) [27] suggest that up to 50-75% of fish meal could be replaced by blood meal in tilapia feeds, Otubusin (1987) [27] reported reduced fish performance with blood meal inclusion levels above 50%. Aladetohun and Sogbesan (2013) [7] indicated that factors like feeding rates, rearing conditions, and environmental factors could influence blood meal's effectiveness as a fish meal substitute. Agbebi *et al*. (2009) [6] found no adverse effects on growth, survival, and feed conversion when replacing fish meal with blood meal in *Clarias gariepinus* juvenile diets, consistent with the findings of Aladetohun and Sogbesan (2013) [7] regarding tilapia. Overall, the experiment supports Njieassam's (2016) [23] suggestion that blood meal can replace fish meal if bone meal and essential amino acids are included, alongside proper environmental management.

Regarding water quality, the parameters closely mirrored those documented by Njieassam (2016) [23]. There was a significant difference (p<0.05) in pH values between T_2 (15% blood inclusion) and T_6 (20% blood inclusion), with pH ranging from 6.5±0.0 to 6.75±0.0 across treatments. However, temperature showed no significant difference among treatments, nor did dissolved oxygen, consistent with the findings of Sogbesan *et al*. (2006) [34] and Eyo *et al*. (2004) [17], who observed consistent pH, dissolved oxygen, and temperature across treatments with varying levels of blood meal inclusion.

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