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COMPARATIVE ASSESSMENT OF MORPHOMETRIC AND GROWTH CHARACTERISTICS OF AFRICAN CATFISH (*CLARIAS GARIEPINUS)* IN CULTURED AND WILD HABITATS IN ZARIA, NIGERIA

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ABSTRACT

This study provides an assessment of the condition factor, length-weight relationship, and sex ratio of *Clarias gariepinus* (Burchell, 1822) in both controlled (cultured) and uncontrolled (wild) habitats within Zaria, Nigeria. As a key species for commercial fisheries and food security, the African catfish plays a vital role in fisheries management. Using standard methods, 360 samples of *Clarias gariepinus* were collected and subjected to morphometric measurements, including total length (TL) and body weight (W). The condition factor (K) was determined using the formula $K = (W/L^3) \times 100$, while the length-weight relationship (LWR) was expressed as $W = aL^b$, revealing allometric growth patterns. Controlled populations exhibited a greater average total length and weight (35.06 ± 5.13 cm, 318.05 ± 146.75 g) compared to their wild counterparts (30.69 ± 7.51 cm, 232.45 ± 154.89 g). The condition factor in both environments was relatively low (<1.00), suggesting possible environmental stress. The sex ratios indicated a slight female predominance in both settings, with ratios of 1.00:1.52 for controlled environments and 1.00:1.47 for wild populations. These results emphasize the need for further research into the environmental factors influencing fish health and growth, providing critical information for optimizing fisheries management and conservation strategies.

Keywords: Condition factor, Length-weight relationship, Allometric growth, Fisheries management, Environmental stress, *Clarias gariepinus*

INTRODUCTION

Fish play a vital role as a source of protein and nutrition worldwide, especially in developing nations, where they significantly help mitigate protein deficiencies and enhance food security (FAO, 2021). In countries like Nigeria, the demand for fresh fish has seen remarkable increased over the last ten years, prompting a surge in aquaculture practices to meet this increasing need (Cao *et al*., 2019). However, while intensive aquaculture boosts production, it frequently brings about stressors such as substandard water quality, overcrowding, and insufficient nutrition, which can compromise fish welfare and result in economic losses for farmers (Ellis *et al*., 2020). The repercussions of these inadequate conditions, particularly in densely stocked settings, are severe, making fish more vulnerable to injuries, diseases, and a rise in mortality rates (FAO, 2018).

In aquaculture systems, poor water quality is particular a major stressor, often triggering widespread mortality events (Kasper *et al*, 2022). Therefore, to successfully monitor and tackle such challenges as inadequate water quality, overcrowding, and insufficient nutrition, it is often beneficial to evaluate important biological indicators like the condition factor and the length-weight ratio.

The condition factor (K) quantitatively reflects the relationship between fish weight and length, serving as a crucial indicator of fish health. It provides information about the nutritional condition, environmental influences, and overall, vitality of fish (Jobling, 1994). The length-weight relationship further reveals the growth trends and the physiological state of fish populations, offering important information for managing fisheries (Abdul-Azeez & Mohammed, 2024). Together, these parameters provide a holistic perspective on fish growth and condition in response to varying environmental factors.

The sex ratio is another important element of fish biology which plays a significant role in the reproductive dynamics and population structure of various species. For instance, in *Clarias gariepinus*, a widely recognized African catfish that holds both economic and ecological importance, the sex ratio is instrumental for breeding success (Laboni *et al*, 2024). Renowned for its remarkable adaptability to a wide range of harsh environments, *Clarias gariepinus* is a favoured species of Nigeria's aquaculture sector and is increasingly gaining popularity in European markets. Its resilience and capacity for air-breathing facilitate cultivation even in sub-optimal conditions (FAO, 2020). This species also exhibits strong parental care, making it highly valuable for aquaculture breeding initiatives, especially in regions with environmental constraints.

Given the ecological and economic importance of *Clarias gariepinus*, a knowledge of the morphometric relationships, growth patterns, and sex ratios of both farmed and wild populations is vital for optimizing management practices. Such knowledge can inform strategies that enhance the sustainability and productivity of aquaculture systems while maintaining environmental balance. This study aims to provide a comprehensive analysis of these parameters in both cultured and wild *Clarias gariepinus* populations in Nigeria, with implications for improving fisheries management and conservation efforts.

MATERIALS AND METHODS

Study Area

This study was conducted in Zaria, Kaduna State, Nigeria, situated at longitude 7°42'E and latitude 11°4'N, approximately 80 km north of Kaduna City, along the Kaduna-Kano highway (Figure 1). The region's tropical climate and diverse water bodies make it an ideal location for comparing cultured and wild populations of *Clarias gariepinus*.

Study Sites

Sampling was carried out at three wild and three cultured locations. The wild populations were sampled from Ahmadu Bello University (ABU) Dam, Zaria Dam, and Shika Dam, while the cultured populations were collected from BZ Farm, Zango Farm, and Sabon Gari Farm, all commercial backyard fish farms within Zaria.

Zaria Dam, constructed in 1975 on the Galma River, serves as the primary water supply for Zaria inhabitants and supports irrigation activities. The dam has a storage capacity of 15.875 million Litres, a length of 900 meters, and a maximum height of 15 meters from the riverbed (Butu & Bichi, 2013).

Ahmadu Bello University Dam, built in 1973 on the Kubanni River, supplies water to the university community. The Kubanni River originates from the Kampagi hills and provides irrigation water for nearby agricultural lands.

Shika Dam, located in Kakeyi village, was constructed to provide water to Zaria inhabitants and neighbouring areas.

The cultured populations were sampled from local commercial farms utilizing intensive p0aquaculture systems in controlled environments. These sites were selected to represent typical backyard fish farming practices in the region.

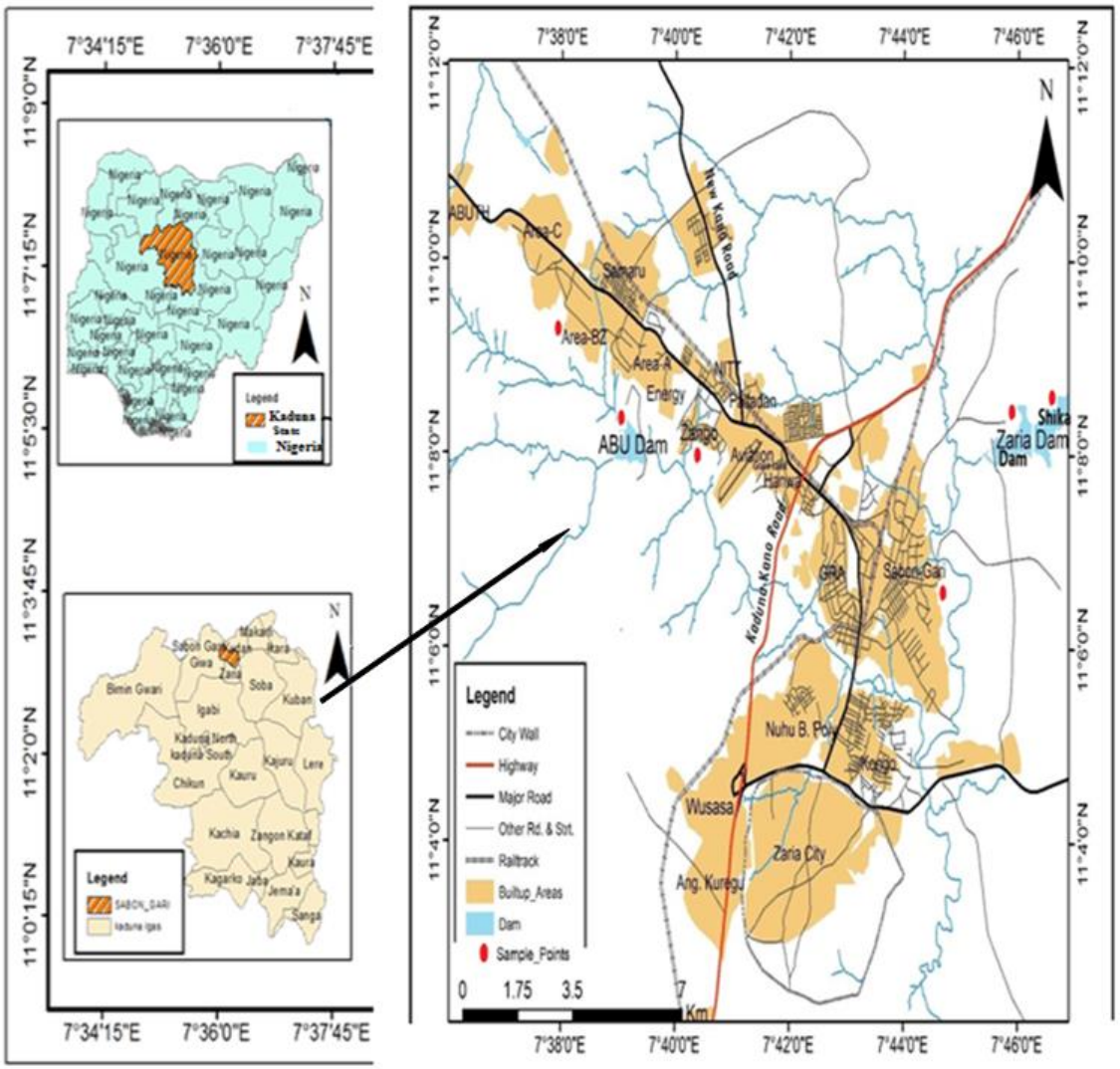

Figure 1: Map of Nigeria showing Zaria and the sampling areas (Modified from Maplandia, 2021)

Fish Sample Collection and Analysis

A total of 360 *Clarias gariepinus* specimens were sampled monthly over 12 months, with 30 individuals collected from each site. To minimize stress, the fish were transported within one hour of collection in open containers filled with site water. Samples were immediately analyzed in the laboratory.

Sex Determination

Sex was determined based on observation of the external morphology of the genital papillae. Males exhibited small, fleshy papillae protruding from the anal region, while females had round, flat papillae (Adeyemi *et al*., 2020; Oyekanmi *et al*, 2023).

Morphometric Measurements

Morphometric data, including total length (TL), standard length (SL), and weight (W), were recorded using standard methods (LeCren, 1951; Asres *et al*, 2023). The Total Length (TL) was evaluated by measuring from the tip of the snout to the distal end of the caudal fin using measuring boards (to the nearest 0.1 cm), while Standard Length (SL) and Weight (W) were respectively assessed by being measured from the snout to the caudal peduncle (to the nearest 0.1 cm), and by weighing with a digital top-loading balance (Sartorius Entris, model 1201-1S).

Condition Factor (K)

The condition factor (K), a measure of the fish's well-being and physical condition, was calculated using the formula:

$K = (W/L^3) \times 100$

Where:

W = fish weight (g)

L = total length (cm)

Weight-Length Relationship (WLR)

The weight-length relationship was determined following the method of Adeniyi, & Agbugui, (2024) using the equation:

$W=aLb$

Where:

W = weight (g)

L = total length (cm)

a = intercept (constant)

b = slope (growth exponent).

The parameters a and b were estimated through linear regression of the logarithmic transformation of equation 1 above, following the method of Brahim *et al.,* (2024);

$\text{Log } W = \log a + b \log L$

Statistical Analysis

Statistical analyses were performed using GraphPad Prism® software (version 9.0). The student's t-test was used to evaluate significant differences between the morphological characteristics and condition factors of cultured and wild populations, with significance set at $P < 0.05$.

RESULTS AND DISCUSSION

The morphometric analysis of *Clarias gariepinus* revealed distinct growth patterns and sex ratio between cultured and wild populations, with key findings summarized in Table 1. The mean total length of fish from uncontrolled environments (dams) was 30.69 ± 7.51 cm, with individual lengths ranging from 28.90 cm to 32.39 cm. In contrast, fish from controlled environments (aquaculture farms) displayed significantly greater mean lengths of 35.06 ± 5.13 cm, ranging from 33.43 cm to 36.45 cm. This difference in length suggests enhanced growth conditions in farmed systems. The significant difference in mean total length between the two populations, with farmed fish exhibiting longer lengths than their wild counterparts (35.06 ± 5.13 cm vs. 30.69 ± 7.51 cm), shows that enhanced growth conditions might exist in aquaculture systems. This result aligns with studies suggesting that controlled environments often provide more consistent access to nutrition and favourable growth conditions compared to the variability of natural habitats (Arechavala-Lopez, 2022). It also agrees with the findings of Jobling (2012), who demonstrated that aquaculture systems, through precise feed management and environmental control, can significantly enhance growth performance over wild populations. The greater lengths observed in the cultured fish reveal the potential of aquaculture to maximize growth rates under optimized conditions, contributing to higher productivity in fisheries. However, Tsaparis *et al*, gave a caution arising from the result of their study, that rapid growth in cultured fish may come at the cost of reduced genetic diversity or fitness in natural environments. Therefore, while aquaculture provides clear advantages in growth performance, its long-term sustainability may depend on balancing productivity with genetic and physiological health as opined by Thomas *et al*, (2021) in their study on taking advantage of species diversity to move towards sustainable aquaculture.

Although cultured fish had higher mean weights (318.05 ± 146.75 g) than wild fish (232.45 ± 154.89 g), the difference was not statistically significant (Table 1). This result may be a reflection of the influence of environmental factors in wild habitats, such as fluctuating resource availability, predation pressures, and ecological stressors, which can lead to more variable growth outcomes (Segun *et al*, 2023). However, this finding is in disparity with that of Fagbuaro *et al*. (2015), who reported similarities in the morphometric composition of *Clarias gariepinus* collected from a fish pond in Emure- Ekiti (controlled population) and Ogbese River (uncontrolled population).

Despite length disparities, the absence of significant weight differences suggests that factors other than length may influence weight distribution in wild populations, possibly related to environmental variability or available resources (Nwabueze & Nwabueze, 2021; Lopez-Mas *et al*, 2021).

The condition factor (K), which indicates the overall health and vitality of the fish, ranged from 0.64 to 0.77 in uncontrolled environments and from 0.67 to 0.74 in controlled environments. Although the values were slightly higher for cultured fish, the differences were not statistically significant. This similarity in condition factor values shows suboptimal conditions in both environments, implying that fish in both environments might be subjected to some level of environmental stress, such as high stocking densities or poor water quality, which could hinder the ability of farmed fish to achieve their full growth potential despite more controlled feeding regimes (Canosa & Bertucci 2023). Conversely, wild populations may face environmental challenges such as limited food availability or competition, which could also impede optimal weight gain. The condition factor results in this study are in disparity with the results of Olatunji, (2021) who recorded condition factor of 0.94-0.99 in his study in Lagos, Nigeria.

In both habitats, the sex ratio exhibited a notable female predominance, with ratios of 1.47:1.00 in wild populations and 1.52:1.00 in cultured populations. A skewed female sex ratio is vital for successful reproduction and the sustainability of the population, as females play a crucial role in producing offspring (Miller *et al*, 2023). Understanding these dynamics is essential for fisheries managers, especially in aquaculture, where maintaining a balanced sex ratio can enhance reproductive success and ensure the long-term viability of the stocks. The results of the sex ratio from this study disagree with those of Nwokocha *et al*. 2019 in which they recorded a ratio of 2:1 in favour of males. The results are also in disparity with those of Balogun *et al*, (2025) who reported sex ratio that was not significantly different from the expected 1:1.

The length-weight relationship, a critical measure of fish growth patterns, was assessed using linear regression. Figures 2 and 3 illustrate the positive linear relationships between weight and total length for fish in controlled and uncontrolled environments respectively, with the controlled environment showing a stronger correlation ($R^2 = 0.851$) than the uncontrolled environment ($R^2 = 0.759$). The regression equations for the length-weight relationship were derived as $W = 0.013L^{2.799}$ (for the controlled environment), and $W = 0.023L^{2.669}$ (for the uncontrolled environment).

The elevated exponent (b) in the length-weight equation for cultured *Clarias gariepinus* suggests a more favourable growth relationship between length and weight, indicative of better environmental conditions and refined feeding strategies within aquaculture systems (Oyebola *et al*, 2022). The stronger correlation ($R^2 = 0.851$) observed in controlled conditions, as opposed to the wild environment ($R^2 = 0.759$), further confirms that growth patterns are more consistent and efficient when managed under controlled circumstances.

Table 1: Mean Length, Weight, Condition Factor and sex ratio of *C. gariepinus* collected from Selected Dams and Fish Farms in Zaria and its Environs

Sampling Site	Mean Total Length (mm)	Mean Weight (g)	Sex ratio Male to Female	Mean Condition Factor (K)
Controlled Environment				
ZANGO FARM	36.45±7.05	360.02±199.50	1. 00: 1.46	0.74±0.36
SABO FARM	33.43±4.43	262.76±116.65	1. 00: 1.46	0.67±0.10
AREA BZ FARM	35.30±3.91	331.37±124.09	1. 00: 1.65	0.74±0.25
Mean (Farms)	35.06±5.13	318.05±146.75	1. 00: 1.52	0.72±0.24
Uncontrolled Environment				
A.B.U DAM	32.39±6.73	258.64±164.43	1.00: 1.00	0.69±0.18
ZARIA DAM	28.90±8.00	181.94±139.32	1.00: 1.60	0.64±0.14
SHIKA DAM	30.77±7.80	256.78±160.90	1.00: 1.80	0.77±0.35
Mean (Dams)	30.69±7.51	232.45±154.89	1.00: 1.47	0.70±0.22
p-value	0.0419	0.0889	0.4025	0.2799

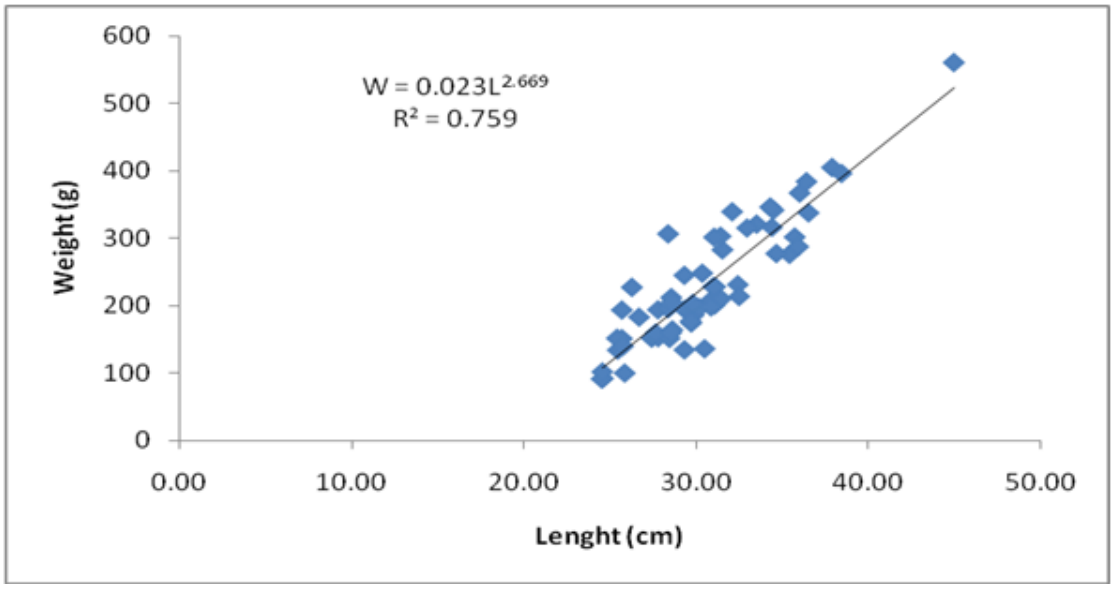

Figure 2: Relationship between weight and length of *Clarias gariepinus* samples collected from dams (uncontrolled environment)

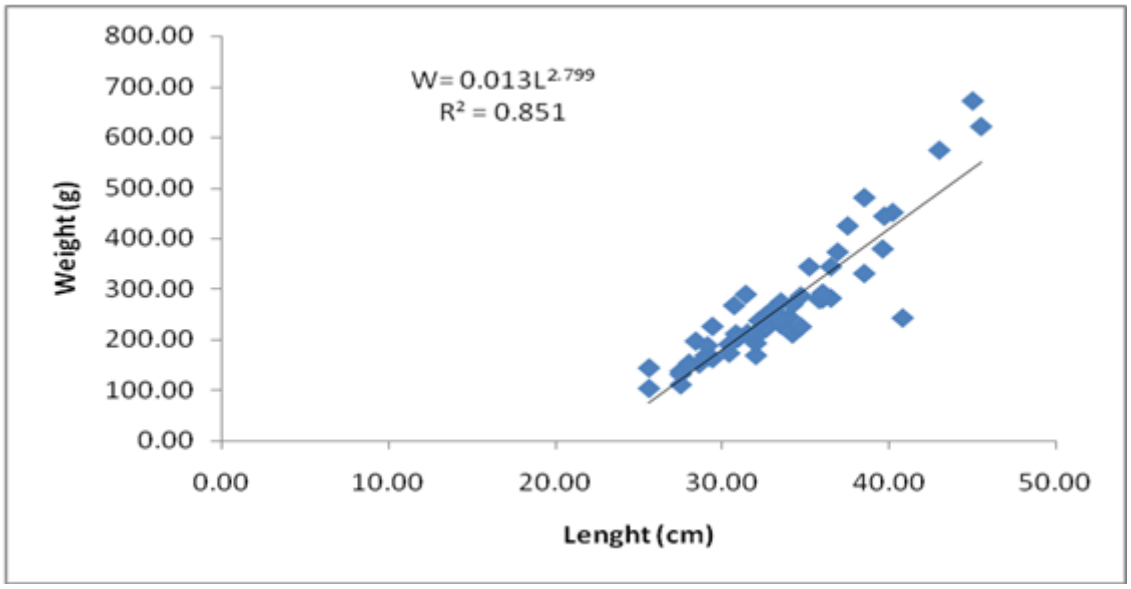

Figure 3: Relationship between weight and length of *Clarias gariepinus* samples collected from Farms (controlled environment).

CONCLUSION

This research offers important information about the growth dynamics of *Clarias gariepinus* in both aquaculture and natural habitats. The notable variations in total length and the positive length-weight correlation observed in farmed fish imply that aquaculture offers more conducive conditions for growth. Conversely, the absence of significant differences in weight, condition factor, and sex ratio suggests that both settings may be subject to environmental stressors. These results emphasize the necessity for additional studies to explore the specific elements impacting fish health and growth in these environments. A better understanding of these factors is necessary for enhancing fisheries management and promoting the sustainability of *Clarias gariepinus* populations in Nigeria.

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