



Research Paper

Condition Factor and Feeding Ecology of *Auchenoglanis occidentalis* from River Mada, North-Central Nigeria

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Abstract

The condition factor and feeding ecology of *Auchenoglanis occidentalis* were investigated in River Mada, Akwanga Local Government Area, Nasarawa State, Nigeria, using specimens obtained fortnightly from artisanal fishers between November 2020 and October 2021. Length–total weight relationships were derived from $\log_{10}$ -transformed total length (TL) and body weight (BW) data for males, females and combined sexes, and Fulton's condition factor (K) was determined monthly. The combined-sex regression equation was $\log_{10}(\text{BW}) = 1.108 + 0.908 \log_{10}(\text{TL})$ ($R^2 = 0.284$; $b = 0.908$), while males ($b = 0.823$, $R^2 = 0.245$) and females ($b = 1.027$, $R^2 = 0.336$) both showed negative allometric growth, indicating that fish increased more in length than in weight. Mean monthly K values ranged from 0.865 to 4.775, peaking in March, May and June, and declining sharply in July, a pattern attributed to reproductive and feeding cycles. Stomach content analysis of 522 specimens (438 with food; vacuity index = 16.09%) revealed a broad, omnivorous diet dominated by worms (IRI = 1425.01), plant material (IRI = 1106.02), insects (IRI = 1010.68) and fish remains (IRI = 971.11), with minor contributions from insect parts, algae, molluscs, mud and sand. Mean gut length and weight were 23.74 ± 0.53 cm and 3.48 ± 0.10 g, respectively, and both increased with increasing stomach fullness. These findings confirm that *A. occidentalis* in River Mada is an opportunistic, benthic-feeding omnivore that, despite a negative allometric growth pattern, maintains good physiological condition for much of the year, driven largely by feeding intensity and reproductive cycling.

1. Introduction

Fish remains one of the most accessible and nutritionally valuable sources of animal protein for people in developing tropical countries, providing about 20% of animal protein intake in over 120 developing nations (Thompson and Subasinghe, 2011) and reaching as much as 90% in some coastal and island communities (Farmery et al., 2020). Beyond direct nutrition, capture fisheries and their associated value chains support the livelihoods of hundreds of millions of people globally (McIntyre et al., 2016; Basurto et al., 2025), and are often the primary economic activity available in remote riverine communities (McIntyre et al., 2016; Temesgen et al., 2019). However, wild fish stocks in many African river systems are under growing pressure from overexploitation (Tweddle et al., 2015), habitat degradation (Cowx, and Portocarrar-Aya, 2011) and weak fisheries management (Ogutuh-Ohwayo and Balirwa, 2006), underscoring the need for baseline biological information to guide sustainable exploitation (Marshall, 2015).

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Among the biological attributes routinely used to assess the status and well-being of exploited fish populations, the length–weight relationship and its derivative, the condition factor (K), occupy a central place. The length–weight relationship describes how body mass scales with linear growth and indicates whether a species grows isometrically or allometrically, while the condition factor provides a numerical expression of the “well-being” of a fish, reflecting the interplay of feeding intensity, gonadal development, and general physiological state at the time of capture. Because K is sensitive to short-term changes in food availability and reproductive condition, it is frequently used alongside feeding ecology data to interpret seasonal patterns of growth and health in fish populations (Julius et al., 2025). *Auchenoglanis occidentalis* (Valenciennes, 1840), commonly known as the giraffe catfish, is a benthic, bottom-dwelling claroteid catfish widely distributed across West and Central African river systems (Mohammed et al., 2026). It is of considerable importance to artisanal fisheries in Nigeria owing to its relatively large body size and market value (Yusuf et al., 2024), yet detailed biological information on the species remains scarce for many Nigerian river systems, including River Mada in Nasarawa State.

Existing studies from other Nigerian water bodies, such as Lake Akata (Ikongbeh et al., 2013), Zaria Reservoir (Onimisi and Oniye, 2010), Kontagora Reservoir (Ibrahim et al., 2009), and the Upper River Benue (Edward, 2018), report considerable variation in growth pattern and condition factor for the species, suggesting that these parameters are strongly influenced by local habitat conditions, feeding regimes and exploitation pressure. This variability makes it necessary to generate site-specific data rather than extrapolate findings from one water body to another.

There is presently little or no documented information on the biology of fish species inhabiting River Mada, despite increasing anecdotal reports of declining catches attributed to poor management and conservation practices. This gap constrains the development of evidence-based management strategies for the river's fisheries and limits the prospects for domesticating economically important indigenous species such as *A. occidentalis* to diversify Nigeria's largely catfish (Clariid)-dominated aquaculture industry. This study was therefore designed to determine the length–weight relationship and condition factor of *A. occidentalis* and to describe its food and feeding habits in River Mada, with a view to generating baseline biological information for its conservation, management and potential domestication.

2. Materials and Methods

2.1 Study Area

The study was conducted on River Mada (Figure 1) located in Akwanga Local Government Area of Nasarawa State, north-central Nigeria. The river originates from Kura Falls in Plateau State, meanders through the Kaduna Forest, and empties into the River Benue at Akwanga West. Its water level rises to a maximum during the rainy season (June–October) and recedes to a minimum just before the onset of rains in May, with the extent of flooding varying with rainfall intensity. The river supports a substantial artisanal fishery on which the economic well-being of many riparian communities depends

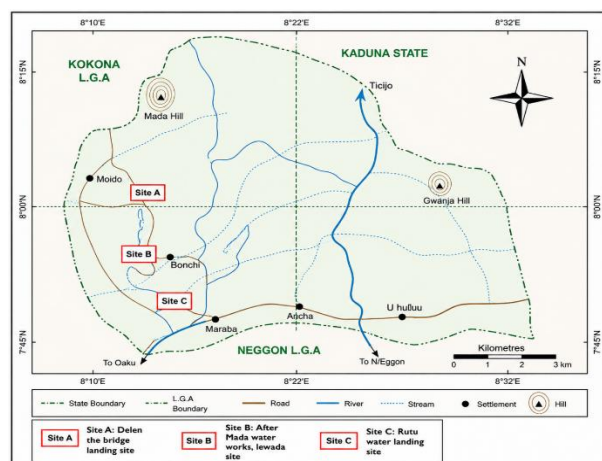


Figure 1: Map of Mada River in Nasarawa State Nigeria showing the Sampling Site

2.2 Fish Sampling

Specimens (522 samples: 268 Males and 258 Females) of *A. occidentalis* were obtained fortnightly, between 6:00 and 8:00 am, from artisanal fishers at designated landing sites along River Mada over a twelve-month period (November 2020–October 2021). The fishers employed a range of passive and active gear, including traps, seine nets, cast nets, gill nets and hook-and-line. Freshly caught specimens were placed in an ice chest and transported to the Fisheries Department Laboratory, College of Agriculture, Science and Technology, Lafia, where they were serially numbered prior to morphometric and stomach content analysis.

2.3 Morphometric Measurements

For each specimen, total length (TL) was measured to the nearest 0.1 cm from the tip of the snout to the tip of the caudal fin using a measuring board, while body weight (BW) was recorded to the nearest 0.01 g using a digital weighing balance (Mettler Toledo® ML3100E).

2.4 Length–Weight Relationship and Condition Factor

The length–weight relationship was computed for males, females and combined sexes using the standard power equation of Bagenal (1978):

$$W = aL^b$$

which was linearised by logarithmic transformation as:

$$\log_{10}W = \log_{10}a + b \log_{10}L$$

where W is body weight (g), L is total length (cm), a is the intercept (initial growth coefficient), and b is the growth exponent (regression coefficient/slope) describing the growth pattern of the fish. Regression parameters were estimated by ordinary least-squares regression at 5% confidence level. Following the interpretation of Crook and Gillanders (2013), growth was considered negative allometric when $b < 3$, isometric when $b = 3$, and positive allometric when $b > 3$.

Fulton's condition factor (K) was calculated monthly for each fish, and separately for males and females, using the formula of Bagenal (1978):

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

where W is body weight (g) and L is total length (cm). Monthly mean K values ($\pm$ standard error) were computed for males, females and the combined population to describe temporal (seasonal) variation in the physiological condition of the fish in relation to feeding activity and reproductive state, following the interpretation of Edward (2018), who regarded $K > 1.0$ as indicative of good condition.

2.5 Stomach Content Analysis

Stomachs of dissected fish were assessed for fullness, preserved in 5% formalin, and their contents subsequently emptied into Petri dishes and examined under a binocular microscope. Food items were identified to the lowest possible taxonomic level using identification keys, and dietary composition was assessed using the frequency of occurrence and numerical abundance methods, following Hyslop (1980).

Frequency of occurrence (%) was calculated as:

$$F(\%) = (\text{Number of stomachs containing a given food item} / \text{Total number of stomachs with food}) \times 100$$

Numerical abundance (%N) was calculated as:

$$\%N = (N_i / \Sigma N) \times 100$$

where N_i is the total number of individuals of a given food category and ΣN is the grand total number of all food items identified. A simplified index of relative importance (IRI), based solely on numerical abundance and frequency of occurrence in the absence of volumetric data, was calculated as:

$$IRI = \%N \times \%F$$

Gut length and gut weight were also recorded for each specimen and related to the degree of stomach fullness (scored on a scale of 0 [empty] to 1 [full], in increments of 0.25) to assess gut morphometric response to feeding intensity.

2.6 Statistical Analysis

Length–weight regression parameters (a , b , R^2) were estimated for males, females and combined sexes using linear regression in Microsoft Excel. Monthly mean condition factor values, dietary composition and gut morphometric data were summarised descriptively as means $\pm$ standard error and presented in tables and figures. Data were analysed using Minitab 14 and Genstat Discovery Edition 4.

Seasonal Variation of zooplankton taxa abundance and Physicochemical Parameters data were subjected to statistical analysis through one-way ANOVA in each of the station and subsequent post hoc multiple comparison with DMRT by adopting SPSS (v20.0). A multiple regression analysis was used to investigate the cause and effect between the zooplankton abundance and physico-chemical parameters. The $P < 0.05$ were considered statistically significant by 95%.

3. Results

3.1 Length–Weight Relationship

A positive, statistically significant linear relationship was observed between $\log_{10}(\text{TL})$ and $\log_{10}(\text{BW})$ for the

combined-sex population of *A. occidentalis* (Figure 2). The regression equation was $\log_{10}(\text{BW}) = 1.108 + 0.908 \log_{10}(\text{TL})$, with $R^2 = 0.284$, indicating that total length accounted for only about 28.4% of the variation in body weight in the pooled sample (Table 1).

The length–weight relationship was comparatively stronger in females (Figure 3), described by $\log_{10}(\text{BW}) = 0.938 + 1.027 \log_{10}(\text{TL})$ ($R^2 = 0.336$). The growth exponent ($b = 1.027$), being only marginally above 1 and far below the isometric value of 3, still indicates a negative allometric growth pattern, though relatively closer to isometry than in males. In males (Figure 4), the relationship was weaker, given by $\log_{10}(\text{BW}) = 1.228 + 0.823 \log_{10}(\text{TL})$ ($R^2 = 0.245$); the growth exponent ($b = 0.823$) confirms a clear negative allometric growth pattern, in which increase in length outpaced increase in weight. All b -values (0.823–1.027) were substantially below the isometric value of 3, indicating that *A. occidentalis* in River Mada grows disproportionately more in length than in weight, irrespective of sex. Intercept (a) values were highest in males (16.91), intermediate in the combined population (12.83) and lowest in females (8.67).

Table 1: Estimated length–weight relationship parameters of *Auchenoglanis occidentalis* in River Mada, Akwanga

Sex	$\log_{10}(a)$	a ($10^{\log_{10}(a)}$)	b	R^2
Combined	1.108	12.83	0.908	0.284
Female	0.938	8.67	1.027	0.336
Male	1.228	16.91	0.823	0.245

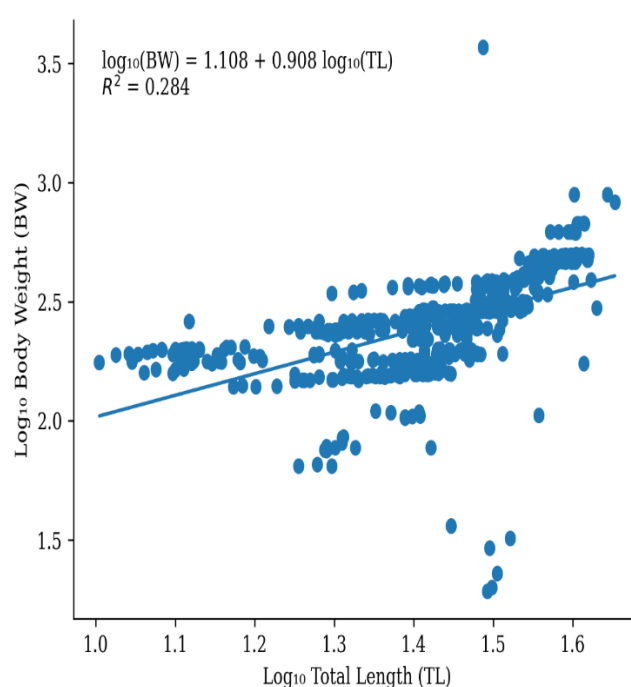


Figure 2: Length–weight relationship of *Auchenoglanis occidentalis* (combined sexes, $N=522$) in River Mada, Akwanga

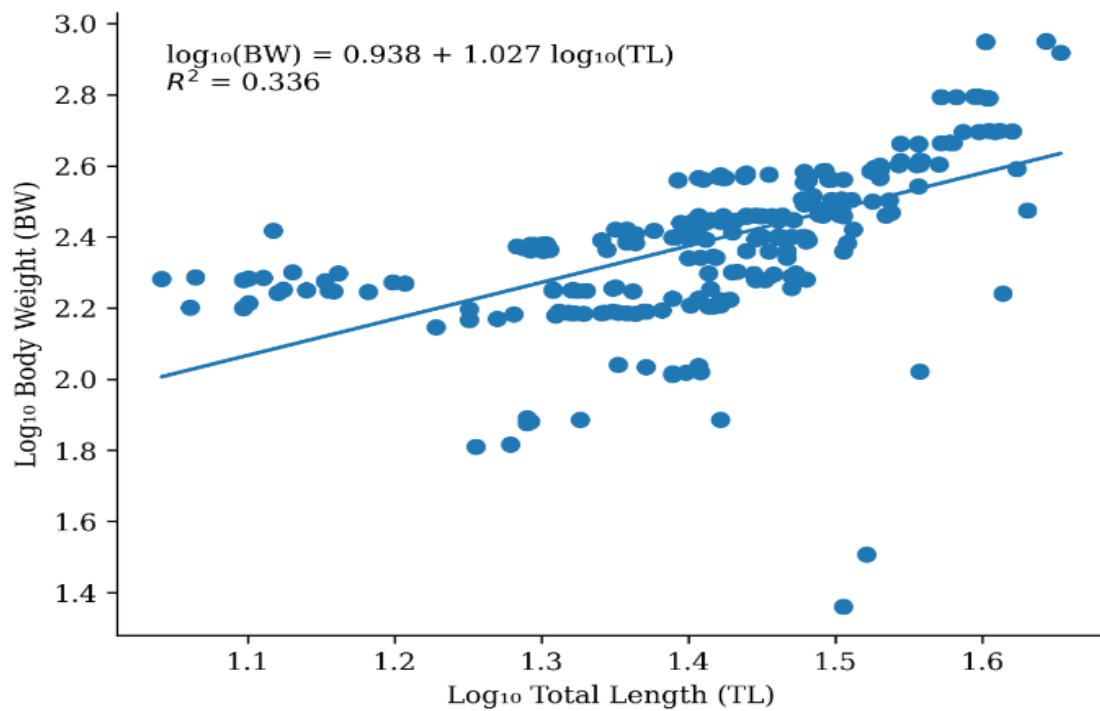


Figure 3: Length–weight relationship of female (N=258) *Auchenoglanis occidentalis* in River Mada, Akwanga

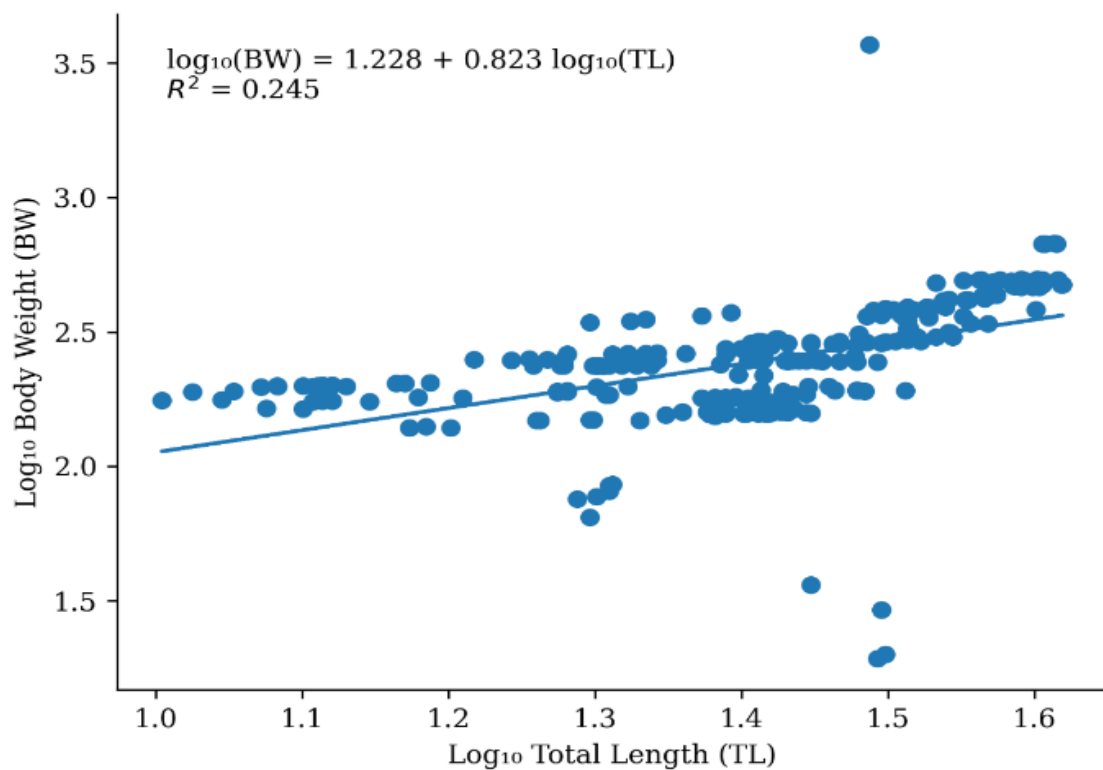


Figure 4: Length–weight relationship of male (N=264) *Auchenoglanis occidentalis* in River Mada, Akwanga

3.2 Condition Factor

Monthly mean condition factor (K) of *A. occidentalis* showed pronounced temporal fluctuations in males, females and the combined population (Figure 5), indicating dynamic physiological responses to feeding and reproductive activity across the sampling period. Male K values ranged from about 0.95 to 5.02, and female values from about 0.85 to 4.93, with overall monthly means generally intermediate between the sexes.

Moderate condition factors were recorded between November 2020 and February 2021 (male: 0.95–1.56; female: 1.30–1.37), suggesting broadly favourable feeding conditions. A sharp rise occurred in March 2021, when males attained their highest recorded value (≈ 5.02), females reached ≈ 4.16 , and the overall mean peaked at ≈ 4.55 , likely reflecting gonadal development and/or increased feeding activity ahead of spawning. K then declined in April 2021 (male ≈ 2.19 ; female ≈ 1.76 ; overall ≈ 1.96), consistent with post-spawning depletion, before a second peak in May 2021 (male ≈ 4.62 ; female ≈ 4.93 ; overall ≈ 4.76). Values fell sharply from June to July, with the lowest values of the year recorded in July (male ≈ 0.95 ; female ≈ 0.85 ; overall ≈ 0.90), coinciding with the period of most intense wet-season hydrological disturbance. Condition improved moderately again from August to October 2021 (generally 1.1–1.6), indicating a gradual stabilisation of physiological condition toward the end of the sampling period. Across the full study period, overall mean K was highest in March (4.574), May (4.775) and June (3.211), and lowest in July (0.865); males peaked in March (5.012) and females in May (4.936).

3.3 Food and Feeding Habits

Diet composition analysis showed that *A. occidentalis* in River Mada consumed a wide range of food items, indicative of an omnivorous, opportunistic feeding strategy (Table 2). Worms were the dominant dietary component (frequency of occurrence = 52.05%; numerical abundance = 27.38%; IRI = 1425.01), followed by plant material (46.12%; 23.98%; IRI = 1106.02), insects (45.66%; 22.13%; IRI = 1010.68) and fish remains (42.92%; 22.62%; IRI = 971.11). Insect parts contributed a smaller share of the diet (7.53%; 3.47%; IRI = 26.11), while algae and molluscs were minor components (both $\leq 1.60\%$ frequency, IRI < 1). Mud and sand occurred only rarely (0.23% frequency; IRI ≈ 0.00), consistent with incidental ingestion during benthic (bottom) feeding.

A total of 522 stomachs were examined, of which 438 contained food and 84 were empty, giving a stomach vacuity index of 16.09% (Table 3), indicative of consistently active feeding within the study period. Mean gut length and gut weight were 23.74 ± 0.53 cm and 3.48 ± 0.10 g, respectively.

Gut length and weight varied with stomach fullness (Table 4). Fish with empty stomachs (fullness = 0) had a

mean gut length of 22.90 ± 1.03 cm and gut weight of 3.23 ± 0.24 g ($n = 84$). Gut weight increased progressively with increasing stomach fullness, reaching a maximum of 3.96 ± 0.34 g in fully-filled stomachs (fullness = 1; $n = 46$), while gut length remained comparatively stable across fullness categories (22.80–24.65 cm). This trend indicates active ingestion and digestion of food, while the relative stability of gut length across fullness levels suggests that gut structure does not change markedly with short-term feeding intensity.

4. Discussion

4.1 Length–Weight Relationship and Condition Factor

The length–weight relationship of *A. occidentalis* in River Mada showed that body weight increased with total length, but the rate of increase was weak and distinctly negative allometric across sexes and the combined population, with all b-values falling well below the isometric value of 3. This finding is consistent with Edward (2018), who reported b-values of 1.30, 1.22, 0.85 and 1.15 for *A. occidentalis* across four sites in the Upper River Benue, also indicating negative allometric growth, and suggests that *A. occidentalis* in riverine environments may commonly display length-dominant rather than weight-dominant growth. A comparable pattern was reported by Ikongbeh et al. (2013) for Lake Akata, where male and female b-values (2.4729 and 2.5029, respectively) were also below 3, although closer to isometry than the present River Mada values; both studies nonetheless indicate that increase in length outpaced increase in body mass. The present result, however, contrasts sharply with the positive allometric growth reported by Onimisi and Oniye (2010) in Zaria Reservoir (combined $b = 3.50$) and by Usman (2012) in Kontagora Reservoir ($b = 3.292$). This discrepancy may reflect differences in habitat type, since reservoirs typically offer more stable lentic conditions, reduced current stress and greater food retention than the more hydrologically dynamic riverine environment of River Mada, in addition to possible differences in exploitation pressure between systems (Tu et al., 2018).

The comparatively low coefficients of determination obtained in the present study ($R^2 = 0.245$ – 0.336) point to considerable individual variation in body form within the River Mada population, in contrast to the very high R^2 values (0.9348–0.9406) reported by Ikongbeh et al. (2013) for Lake Akata, and the strong correlations reported for the reservoir populations. According to Edward (2018), b-values and the strength of the length–weight relationship can be influenced by food intake, gonadal state, season, time of capture, spawning activity and stomach fullness at the time of sampling; the scattered pattern observed in River Mada is therefore likely a biological reflection of a population sampled across mixed physiological and reproductive states rather than an absence of a genuine length–weight relationship.

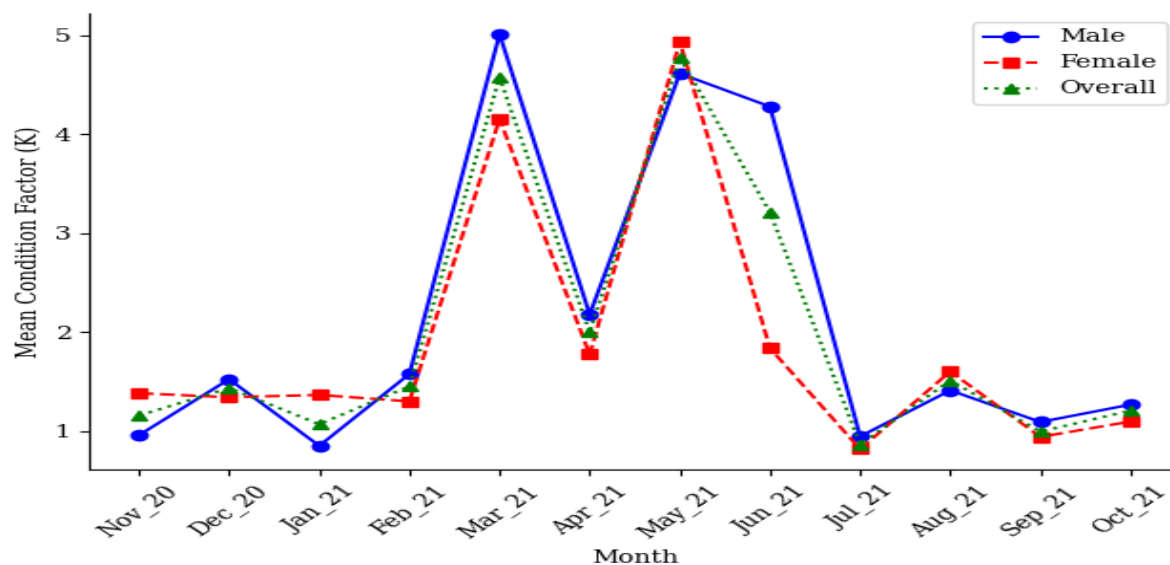


Figure 5: Mean monthly condition factor (K) of *Auchenoglanis occidentalis* in River Mada, Akwanga

Table 2: Frequency of occurrence, numerical abundance and index of relative importance (IRI) of food items in the diet of *Auchenoglanis occidentalis* in River Mada

Food item	Frequency of occurrence (%)	Numerical abundance (%)	IRI
Worm	52.05	27.38	1425.01
Plant	46.12	23.98	1106.02
Insect	45.66	22.13	1010.68
Fish	42.92	22.62	971.11
Insect part	7.53	3.47	26.11
Algae	1.60	0.22	0.35
Molluscs	1.60	0.19	0.30
Mud/Sand	0.23	0.01	0.00

Table 3: Stomach content summary, gut morphometric characteristics and stomach vacuity index of *Auchenoglanis occidentalis* in River Mada

Parameter	Value
Total stomachs examined	522
Stomachs with food	438
Empty stomachs	84
Stomach vacuity index (%)	16.09
Gut length (cm)	23.74 ± 0.53
Gut weight (g)	3.48 ± 0.10

Table 4: Relationship between stomach fullness, gut length and gut weight of *Auchenoglanis occidentalis* in River Mada

Stomach fullness	Gut length (cm)	Gut weight (g)	n
0	22.90 ± 1.03	3.23 ± 0.24	84
0.25	24.43 ± 1.03	3.42 ± 0.15	211
0.5	23.42 ± 1.05	3.33 ± 0.22	84
0.75	22.80 ± 1.06	3.72 ± 0.24	97
1	24.65 ± 1.41	3.96 ± 0.34	46

Females showed a slightly higher b -value and R^2 than males, in agreement with Ikongbeh et al. (2013), possibly reflecting the influence of ovarian development and greater somatic energy reserves in females during some months; nonetheless, both sexes remained clearly length-biased in growth.

The condition factor results provide a complementary picture of the physiological status of *A. occidentalis* in River Mada. Although the length–weight relationship indicated negative allometric growth, monthly K values showed that the species was frequently in good condition, with overall K especially high in March, May and June, and lowest in July. Following the benchmark of Edward (2018), who considered $K > 1.0$ as indicative of good condition, most monthly values recorded in River Mada suggest that the population remained physiologically robust for much of the study period. This demonstrates that negative allometric growth and good body condition are not mutually exclusive; a population can display a length-dominant growth pattern while still maintaining favourable condition during periods of active feeding or gonadal development.

Condition factor values in River Mada were both higher and more variable than those reported for *A. occidentalis* elsewhere in Nigeria. Ikongbeh et al. (2013) recorded much lower and more stable mean K values in Lake Akata (1.53 ± 0.03 for males, 1.52 ± 0.03 for females, 1.53 ± 0.02 combined), Onimisi and Oniye (2010) reported monthly values of 0.71–1.17 in Zaria Reservoir, and Usman (2012) reported 0.98–2.16 in Kontagora Reservoir. The markedly higher peaks recorded in River Mada, particularly between March and May, suggest periods of strong energy accumulation associated with intense feeding activity and/or gonadal development. This monthly pattern supports the view of Domínguez-Petit et al. (2017) that condition factor reflects food supply and reproductive timing: the elevated K values in March–May in the present study may indicate pre-spawning energy accumulation, while the sharp decline in July likely represents post-spawning depletion, reduced feeding efficiency, or physiological stress associated with wet-season hydrological disturbance, consistent with the interpretation of Onimisi and Oniye (2010) and Ikongbeh et al. (2013) that lower K -values in *A. occidentalis* coincide with the spawning period, while higher values reflect weight gain after spawning and favourable feeding conditions.

4.2 Feeding Ecology

The present study revealed that *A. occidentalis* consumed a wide variety of food items — including worms, insects, fish remains, plant material, algae, molluscs and insect parts — confirming an omnivorous feeding strategy with pronounced benthic tendencies. Worms formed the dominant dietary component across all three dietary indices, followed by plant material, insects and fish remains, while the negligible

occurrence of mud and sand indicates incidental ingestion during benthic (bottom-grazing) feeding. The comparatively low stomach vacuity index recorded (16.09%) further indicates active feeding and generally favourable trophic conditions within River Mada during the study period.

These findings agree closely with Ikongbeh et al. (2014), who reported that *A. occidentalis* in Lake Akata fed mainly on insects, insect larvae, algae and fish scales, and similarly described the species as an omnivore with a tendency to predate more heavily on insects. The dominance of worms and insects in the present study therefore corroborates earlier evidence that aquatic invertebrates form an important dietary component of the species. Onimisi et al. (2009) likewise reported that *A. occidentalis* in Zaria Reservoir consumed chironomid larvae, organic detritus, insect remains and plant remains as major food items, classifying the species as omnivorous; the substantial occurrence of plant material recorded in the present study is consistent with their suggestion that plant remains may be ingested incidentally during benthic grazing. Chukwuemeka et al. (2019) and Abobi et al. (2019) similarly described the species as an opportunistic omnivore capable of exploiting both plant and animal food resources across different West African water bodies, while broader cross-system reviews (Hasimuna et al., 2023; Gardin et al., 2023) identify insects, detritus, plant material and algae as recurring principal diet components of the species in shallow, muddy, benthic habitats. Collectively, these sources reinforce the conclusion that *A. occidentalis* is a generalist, opportunistic omnivore with strong benthic foraging tendencies, capable of exploiting a wide range of invertebrate, plant and detrital resources according to local availability.

The relatively high occurrence of fish remains in the present study further supports the opportunistic and, at times, piscivorous feeding behaviour of the species, in agreement with the characterization of *A. occidentalis* as an opportunistic feeder able to exploit both plant and animal resources. Minor discrepancies between the present findings and earlier reports — such as the greater dietary importance of algae recorded by Ikongbeh et al. (2014) in Lake Akata, or the dominance of organic detritus reported by Onimisi et al. (2009) in Zaria Reservoir, compared with the dominance of worms and fish remains in River Mada — may be attributable to differences in habitat productivity, seasonal prey availability, and local ecological conditions between water bodies, since the feeding habits of fishes are known to vary with season, age, habitat and food availability (Helfman, 2009).

The observed relationship between gut morphometrics and stomach fullness, in which gut weight increased progressively with increasing stomach fullness while gut length remained comparatively stable, provides further physiological corroboration of the dietary data: active ingestion and digestion of food are reflected in increased gut mass, while gut architecture itself does not appear to change substantially with short-term

feeding intensity. Taken together, the feeding ecology data are consistent with the condition factor results, in which periods of elevated K (March–May) likely coincide with periods of intensified feeding activity and energy accumulation ahead of spawning.

5. Conclusion

This study established that *A. occidentalis* in River Mada exhibits a negative allometric length–weight relationship in both sexes and the combined population, with body length increasing disproportionately relative to weight. Despite this, monthly condition factor values indicate that the species maintains good physiological condition for much of the year, with pronounced peaks in March, May and June coinciding with likely gonadal development and intensified feeding, and a marked decline in July associated with probable post-spawning depletion and wet-season hydrological stress. Stomach content analysis confirmed that the species is an omnivorous, opportunistic benthic feeder, relying predominantly on worms, plant material, insects and fish remains, with a comparatively low stomach vacuity index reflecting consistently active feeding. These findings provide essential baseline biological information on the growth pattern, condition and feeding ecology of *A. occidentalis* in River Mada, and should inform sustainable exploitation strategies and future consideration of the species for aquaculture diversification in the region. Continued monitoring across a longer time series and comparison with additional Nigerian river systems are recommended to further clarify the environmental drivers of the pronounced seasonal variation in condition factor observed in this study.

6. Statements and Declarations

Ethical Approval: Not applicable

Conflict of Interest: The authors of this paper state that they have no known conflicting financial interests or personal connections that would have affected the research presented in this study.

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