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# Biological Aspects of Preferred Fish Species in White Volta at Pwalugu, Ghana: A pre-impoundment Study

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**ABSTRACT:** The socio-economic benefits derived from impounding rivers are extremely important but the ecological imbalances that are usually created in the process can be devastating. It is therefore imperative to understand some aspects of the biology of fishes before the impoundment of a river. This study was conducted to assess the length-weight relationship, condition factor, feeding, and reproductive ecology of fish species with high local market value. Biometric measurements were obtained from monthly samples of fish at two sites. Specimens were transported to the laboratory for gut and gonad analyses. *Auchenoglanis occidentalis*, *Marcussenius senegalensis* and *Heterobranchus bidorsalis* were the most preferred fish species. All three fish species recorded 'b' values less than 3 which implies they exhibited a negative allometric growth. Their condition factors (K) indicated they were in good health since K values were greater than 1. *A. occidentalis and H. bidorsalis* demonstrated a feeding habit comparable to that of an omnivore, whilst *M. senegalensis* presented a feeding habit that implied it was an invertivore. *M. senegalensis* registered the uppermost mean gonado-somatic index (GSI) (2.14 ± 0.83) whereas the highest mean fecundity (495 ± 450.96) was noted in *A. occidentalis*. This study contributed bio-ecological baseline information about the ichthyofauna prior to the damming of the reservoir in the Pwalugu area of the White Volta.

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Impoundments are man-made standing waterbodies, constructed by damming rivers or streams. Lotic water systems are primarily impounded for varied reasons including hydroelectric power, irrigation agriculture, animal watering, flood control and other domestic uses. Though the socio-economic benefits that are derived from damming rivers are extremely important, the ecological imbalances created in the process should never be over-looked (Hoeinghaus *et al.*, 2009). To this end, it is imperative to understand the natural ecosystems of these water bodies before they are artificially converted into reservoirs. Factually, river impoundments can profoundly restructure the population of downstream ichthyofauna due to changes to flow regimes of water (Taylor *et al*., 2014). However, the extent of change and related ecological alteration may not be clear without reliable pre-impoundment data. The Pwalugu expanse of the White Volta has been commissioned for a multipurpose dam project for the purposes of power generation, irrigation development, flood control and integrated water resource management of the White Volta basin (VRA, 2014). The sod-cutting was carried out on November 29, 2019, for construction activities to commence (Joynews, 2019). The project is funded by the Government of Ghana and is envisaged to take about

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4 years to complete. The global predominant threat to freshwaters is river impoundment as it has the predisposition to alter natural hydrological regimes (Zarfi *et al*., 2015). The impact of river damming (impoundment) on sediment deposition, fish migration, hydrological structure and potential earthquakes has long been a worry (Zhong *et al.*, 2012). Previous studies have shown that the impounding of rivers changes the ecosystem, decreases biodiversity, causes species extinction, contributes to climate variability, and reduces water quality and wastewater (Chirag, 2022; Silga *et al*., 2021; de Silva and de Silva, 1994). In Ghana, small-scale fisheries provide enormous benefits such as income, employment, food and nutritional security for riparian communities. In order to safeguard the continuity of the aquatic ecosystem supporting the livelihoods and well-being of families, there is the need to undertake scientific investigations on the biological characteristics of preferred fish species for the formulation and implementation of sound and sustainable fisheries policies. Few studies on the fisheries of the Volta Lake were conducted prior to its damming. The only documented study was Roberts (1967), who reported the list of freshwater fish and their potential economic importance. Several post-impoundment studies of the Volta basin reported a significant change in the fish community structure through the decline in fish population, disappearance and death of certain fish species attributable to ecological changes (Abobi *et al.*, 2014; Béné, 2007; Braimah, 1995; Petr, 1969, 1968). Even though a lot of related studies in the past have been carried out as noted above, little is known regarding the length-weight relationship, condition factor, feeding and reproductive ecology of commercially preferred fish species in the White Volta stretch around Pwalugu where the multipurpose dam is to be constructed. It has been established that the nutritional status of fish reveals its health and/or overall well-being and this is commonly related to physiological factors linked to energy reserve (protein, lipids and carbohydrates) (Le Cren, 1951).

Empirically, the stored energy can be determined in varied ways including morphometric (condition factor and weight-length), physiological (mass of liver and gonad) and biochemical (protein/lipid content) measurements (Lloret *et al.*, 2002). Therefore, the nutritional position of fish is immensely affected by biotic and abiotic factors (Bojsen, 2005; Lima-junior and Goitein, 2004). When these biotic and abiotic factors go through a process of imbalances, the river ecosystem is said to be unstable and the fish assemblages face several challenges and respond to such modifications in the environment with changes in their metabolism.

Many researchers have reported that several impounded lotic systems have recorded major changes in the fish assemblages and community structure (Turgeon *et al*., 2018; Zhu and Yang, 2016; Moura *et al*., 2014; Quarcoopome *et al*., 2011; Gao *et al*., 2010). These changes can be accurately observed if only the pre-impoundment data exist for easy comparative analysis. It is for this reason that this pre-impoundment study sought to generate relevant biological information of some preferred fish species in the Pwalugu area of the White Volta for future reference and policy direction.

## MATERIALS AND METHODS

*Study area:* Pwalugu can be located in the Talensi District of the Upper East Region on latitude 10° 36′ 02″ N and longitude 00°19′ 50″ W. One of the four tributaries of the Volta Lake in Ghana is the White Volta which flows through the North of Ghana from Burkina Faso into the Volta Lake at Yeji in the recently created Bono East Region. The Pwalugu area is predominantly a guinea savanna which is characterised by dwarf shrubs, grass and comparatively short trees. The people are mostly farmers with a few involved in fishing. The role of the White Volta in the lives of the people in the area cannot be underestimated. Crop farmers use the water from the river to irrigate their crops during the dry season. The river is also a source of water for livestock in the area. When water becomes scarce in the dry season, riparian communities heavily depend on the river for water to cook, drink and wash in their homes.

*Data collection:* Monthly fishery-dependent data were collected for the determination of length-weight relationship, condition factor (K), food and feeding habits, and reproductive characteristics of preferred fish species in the Pwalugu area of the White Volta.

*Length-weight relationship and condition factor (K) of preferred fish species:* Six (6) specimens of fish were purchased each for all the three selected commercial fish species every month. Three specimens out of the six were obtained from the landing site at the headstream and the other three collected at the landing site at the downstream. The total length of fish was measured by placing fish on a measuring board and taking the total length with a metre rule from the tip of the snout (with mouth closed) to the extended caudal fin and body weight was taken with an electronic scale. Body weight and total length were measured in grams (g) and centimetres (cm) respectively and recordings done separately for fish samples in the upstream and downstream landing sites. Estimation of the length-weight relationship of fish species was determined according to Le Cren (1951) as shown in equation 1.

$$W = aL^b \dots (1)$$

W is fish weight in grams (g) and L is fish length in centimetres (cm), a is a coefficient related to the fish body form and b, an exponent showing allometric or isometric growth.

The Condition factor (K) was determined according to Williams (2000) as presented in equation 2.

$$K = \frac{W}{L^3} \times 100 \dots (2)$$

W is fish weight in grams (g) and L is fish length in centimetres (cm).

*Food and feeding habits of preferred commercial fish species:* To determine the food eaten by the major preferred fish species and thus determine their feeding habits, fish guts were inspected. Six (6) specimens were purchased for each of the three preferred fish species every month. Three specimens were obtained from each of the two landing sites. The guts of eighteen (18) fish specimens were therefore inspected every month. Fish specimens were usually alive at the time of collection from local fishermen. Fish specimens were immediately iced to prevent them from deteriorating and stomach content being digested. Fish samples were then transported to the Spanish Laboratory of the University for Development Studies at the Nyankpala Campus for gut inspection. Before dissection of the specimens, the total and standard lengths were recorded using a fish measuring board. The weight of the specimens was then taken using an electronic scale. Fish was then cut open at its lateral side and stomach removed and classified based on fullness. The stomach with its content were weighed using an electronic scale and value recorded. Stomach was then cut open and poured into a petri dish for stomach content analysis. The empty stomach then was weighed and the value recorded. Analysis of the gut content was conducted based on the frequency of occurrence method (Hyslop, 1980) and the numerical composition method (Ugwumba and Ugwumba, 2007). The stomach content of fish then inspected and specific food substances sorted and identified using identification keys by Shiel (1995). The frequency of occurrence was determined as the number of times a specific food substance found in a stomach is tallied and computed as a percentage of the overall number of stomachs with food (stomachs without food are exempted) following the method of Hyslop (1980) as expressed in equation 3:

$$F\ (\%) = \frac{\text{TSSF}}{\text{TSF}} \times 100 \dots (3)$$

Where F (%) is the percent Occurrence of a food item, TSSF is total numer of stomach s with the specific food item; TSF is total number of stomachs with food

The overall number of a specific food substance was noted and computed as percentage of overall number of all food substances and organisms using the expression of Ugwumba and Ugwumba (2007) as indicated in equation 4:

$$N\ (\%) = \frac{TSFS}{TFS} \times 100 \dots (4)$$

Where N (%) is percent Numerical Method, TSFS = total numer of specific food substract per organism; TFS = total number of all food substances

To determine the Index of Relative Importance (IRI), the product of the measures of the number of food (N) and frequency of occurrence (F) was computed to determine the key food substance or organism for each of the three preferred commercial fish species using the formula of Clark (1985) as presented in equation 5:

$$IRI = N \times F \dots (5)$$

*Reproductive characteristics of the three major commercial fish species:* Fish samples collected from the study area were immediately iced to avoid deterioration and were transported to the Spanish Laboratory of the University for Development Studies in Nyankpala for gonad inspection. The total and standard length of fish samples collected for gonad inspection was taken in centimetres (cm) and weight taken in grams (g).

Fish was then cut open at its lateral side with the aid of a pair of scissors and gonads gently removed. Gonads were preserved in formalin concentration of 10%. Gonads were critically examined using the description of gonad maturity stages by Bagenal and Braum (1968). Gonads were weighed and value recorded. Gonads were then cut open with the aid of a surgical blade and content pressed out to determine their stage of maturity according to Bagenal and Braum (1968) as shown in Table 1.

Gonado-somatic index (GSI) was then calculated using equation 6 (Afonso-Dias *et al*., 2005):

$$GSI = \frac{Gw}{Bw} \times 100 \ldots (6)$$

Gw is the weight of the gonad and Bw is the body weight of fish.

**Table 1**: Gonad maturity stages and their interpretation

| Stage | State |
|---|---|
| 0 | Virgin |
| 1 | Maturing Virgin |
| 2 | Developing |
| 3 | Developed |
| 4 | Gravid |
| 5 | Spent |

The fecundity of fish was determined using a technique adopted by Baxter (1959). Hundred (100) eggs were counted and the weight taken on an electronic balance in grams (g). The total weight of all the eggs in the gonad were then taken in grams (g) using an electronic scale. The total number of eggs per gravid female was then estimated using equation 7 by Baxter (1959).

$$\text{Fecundity} = \frac{\text{Weight of total eggs}}{\text{Weight of 100 eggs}} \times 100 \ldots (7)$$

## RESULTS AND DISCUSSION

*Length-weight relationship and condition factor and growth (k) of the preferred commercial fish species:* A total of 216 fish specimens of the preferred commercial fish species were collected to determine their morphometry, growth pattern and condition factors. Seventy-two (72) specimens each were collected for all three commercial fish species. The average length of the three fish species ranged from 14 cm to 20 cm whilst their average weight ranged 55 – 153 g (Table 5). The mean 'b' values for *A. occidentalis, M. senegalensis* and *H. bidorsalis* were in the range 2.02 – 2.37 and that of the condition factors ranged 1.76 – 2.06 (Figures 6, 7 and 8).

Table 2: Morphometric features and condition factor (K) of the preferred commercial fish species in the White Volta at the Pwalugu area in July 2019 – June 2020

| Species | Total Length (cm) | | | Total Weight (g) | | | Month | | Mean K ± SD |
|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Mean | Max | Min | Mean | Max | Min | |
| *A. occidentalis* | 31 | 11 | 17.47 | 316 | 32 | 115.58 | March | Nov/Feb | 1.97 ± 0.46 |
| *M. senegalensis* | 21 | 10 | 13.74 | 155 | 20 | 55.19 | March | February | 2.06 ± 0.45 |
| *H. bidorsalis* | 35 | 12 | 20.44 | 932 | 43 | 153.04 | April | April | 1.76 ± 0.59 |

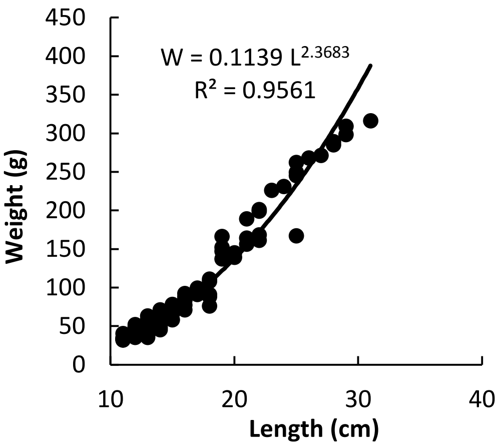


**Figure 1:** Length-weight relationship of *A. occidentalis* caught from the White Volta at the Pwalugu area from July 2019 to June 2020

*Food and feeding habits of the preferred commercial fish species*: An overall number of 216 stomachs of the three preferred commercial fish species were examined; 112 stomachs representing 52 % were empty, 62 stomachs representing 29 % were quarter full, 23 stomachs representing 11% were half full, 8 stomachs representing 4 % were three-quarter full whilst 11 stomachs representing 5 % were full. Seventy-two (72) stomachs each of *A. occidentalis, M. senegalensis* and *H. bidorsalis* were examined and nearly 50 % or more stomachs of each species was empty and less than 7 % of each of the stomachs was full (Table 6).

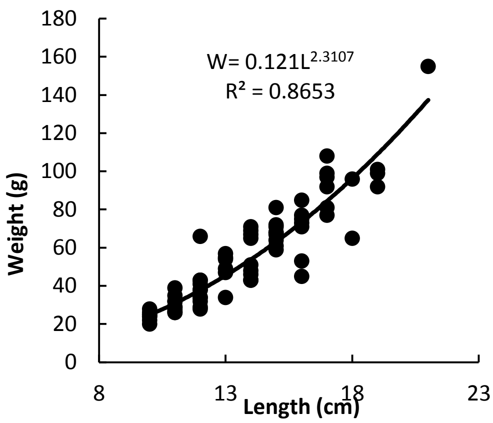


**Fig 2:** Length-weight relationship of *M. senegalensis* caught from the White Volta at the Pwalugu area from July 2019 to June 2020

Table 7 indicates a checklist for the food items or organisms identified over the period of study. The food items identified were grouped into Phytoplankton, Zooplankton, Macrophytes, Animal derivatives, Sand and Detritus. In all the three preferred commercial fish species, the food group 'animal derivative' was the highest contributor recording 30 %, 48 % and 39 % of the total food consumed for *Auchenoglanis occidentalis, Marcusenius senegalensis* and *Heterobranchus bidorsalis* respectively.

Fish remains was the highest food for *Auchenoglanis occidentalis* and *Heterobranchus bidorsalis* whilst the food item 'insects' was the highest contributor of the total food consumed by *Marcusenius senegalensis.* Animal derivatives registered the highest index of relative importance (IRI) for all the three species. Table 8 presents the correlation of food items found in the stomachs of the three major commercial fish species in the White Volta in the Pwalugu area.

The correlation analysis revealed a significant difference ($p$ < 0.05, r = 0.93) between food items consumed by *Marcusenius senegalensis* and *Heterobranchus bidorsalis* whilst there was no significant difference between food items by *Auchenoglanis occidentalis* and *Marcusenius senegalensis* as well as food items consumed by *Heterobranchus bidorsalis* and *Auchenoglanis occidentalis.*

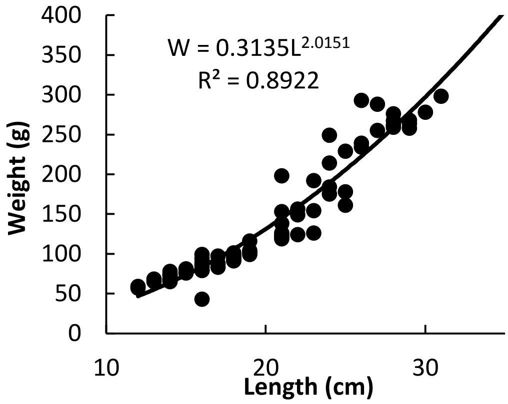


**Fig 3:** Length weight relationship of *H. bidorsalis* caught from the White Volta at the Pwalugu area from July 2019 to June 2020

**Table 3:** State of gut of the three preferred commercial fish species caught from the White Volta at the Pwalugu area from July 2019 to June 2020

| Species | % Occurrence | | | | |
|---|---|---|---|---|---|
| | **Empty** | **Quarter** | **Half** | **Three-Quarter** | **Full** |
| *A. occidentalis* | 48.61 | 33.33 | 11.11 | 2.78 | 4.17 |
| *M. senegalensis* | 51.39 | 26.39 | 9.72 | 5.56 | 6.94 |
| *H. bidorsalis* | 55.56 | 26.39 | 11.11 | 2.78 | 4.17 |
| All three species | 51.85 | 28.7 | 10.65 | 3.72 | 5.09 |

**Table 4:** Checklist and relative contribution of food items found in the stomachs of the three preferred commercial fish species caught from the White Volta at the Pwalugu area from July 2019 to June 2020

| Food item | Fish species | | | Frequency of occurrence (%) | Number (%) | IRI |
|---|---|---|---|---|---|---|
| **Phytoplankton** | | | | **18.98** | **11.15** | **212** |
| *Cyclotella* spp. | - | ii | iii | | | |
| *Sida* spp. | - | ii | - | | | |
| *Stigeoclonium* spp. | - | ii | iii | | | |
| *Staurastrum* spp. | - | ii | - | | | |
| *Suriella* spp. | - | ii | - | | | |
| *Anabaena* spp. | i | ii | - | | | |
| *Microcystis* spp. | i | ii | iii | | | |
| *Pseudoanabaena* spp. | - | ii | - | | | |
| *Phormidium* spp. | - | ii | - | | | |
| *Tribonema* spp. | i | ii | - | | | |
| *Navicula* spp. | - | ii | - | | | |
| *Eunotia* spp. | - | ii | - | | | |
| *Volvox* spp. | i | - | iii | | | |
| *Closterium* spp. | i | - | iii | | | |
| **Zooplankton** | | | | **11.57** | **6.64** | **77** |
| *Rotifer* spp. | - | ii | - | | | |
| *Cypridopsis* spp. | i | ii | iii | | | |
| *Polyphemus* spp. | i | - | - | | | |
| **Macrophytes** | | | | **22.22** | **13.16** | **292** |
| Plant parts | i | ii | iii | | | |
| Seeds | i | ii | iii | | | |
| **Animal Derivatives** | | | | **37.04** | **38.47** | **1425** |
| Worms | i | - | iii | | | |
| Insect remains | i | ii | iii | | | |
| Fish remains | i | ii | iii | | | |
| **SANDS** | i | ii | iii | **26.35** | **18.42** | **495** |
| **Detritus** | i | ii | iii | **16.2** | **12.16** | **197** |

*(-) indicates absence of food item in fish species stomach;* ***i*** *=Auchenoglanis occidentalis,* ***ii*** *= Marcusenius senegalensis,* ***iii*** *= Heterobranchus bidorsalis*

**Table 5:** Correlation of food items consumed by the three commercial fish species in the White Volta in the Pwalugu area

| | ***A. Occidentalis*** | ***M. Sengalensis*** | ***H. Bidorsalis*** |
|---|---|---|---|
| ***A. occidentalis*** | 1.000 | | |
| ***M. sengalensis*** | 0.409 | 1.000 | |
| ***H. bidorsalis*** | 0.502 | 0.934* | 1.000 |

**indicates correlations with p-values that are significant (p < 0.05)*

*Reproductive characteristics of the commercial fish species:* Table 8 gives information on the reproductive characteristics of the three preferred commercial fish species in the study area. All 216 samples of the three preferred commercial fish species had an overall male: female sex ratio of 1.1: 1. The maturity stages of the specimens were in the order 59%, 47%, 36%, 32% and 21% representing Developing, Developed, Maturing Virgin, Gravid and Virgin/Spent respectively (Table 9). There was no significant difference in the GSI of males and females ($p > 0.05$) of all the three preferred commercial fish species. The highest and lowest mean Gonadosomatic Index (GSI) was recorded in *M. senegalensis* (2.14 ± 0.83) and *A. occidentalis* (1.81 ± 0.67) respectively (Table 9). *Auchenoglanis occidentalis, M. senegalensis* and *H. bidorsalis* recorded a mean gonad weight of 2.03 ± 1.59 g, 1.18 ± 0.68 g and 2.75 ± 2.16 g respectively. Figure 9 illustrates the monthly GSI of females recorded by the three preferred commercial fish species. The major peaks of GSI of the females of the commercial fish species were recorded in April, 2020, August, 2019 and September, 2019 for *A. occidentalis, M. senegalensis and H. bidorsalis* respectively. The lowest monthly female GSI was recorded by both *A. occidentalis* and *M. senegalensis*, in September, 2019 and December, 2019 respectively.

**Table 6**: Reproductive characteristics of the three preferred commercial species caught from the White Volta at the Pwalugu area from July 2019 to June 2020

| | *A. occidentalis* | *M. senegalensis* | *H. bidorsalis* |
|---|---|---|---|
| Male: Female | 1.1:1.0 | 1.0:1.1 | 1.4:1.0 |
| N | 2 | 2 | 2 |
| DF | 1 | 1 | 1 |
| Spearman's, r | 0.1634 | 0.0359 | 0.1093 |
| *p* -value | 0.3556 | 0.8378 | 0.5725 |
| Fecundity | 495 ± 450.96 | 188 ± 71.78 | 268 ± 114.66 |
| GSI | 1.81 ± 0.67 | 2.14 ± 0.83 | 1.84 ± 0.76 |
| SL range (cm) | 11 – 31 | 10 – 21 | 12 – 35 |
| Weight range (g) | 32 – 316 | 20 – 155 | 43 – 932 |
| Number of individuals in each stage of maturity of gonads | | | |
| Stage 0 – Virgin | 1 | 15 | 5 |
| Stage 1 – Maturing virgin | 4 | 17 | 15 |
| Stage 2 – Developing | 21 | 16 | 22 |
| Stage 3 – Developed | 17 | 13 | 17 |
| Stage 4 – Gravid | 16 | 8 | 8 |
| Stage 5 – Spent | 13 | 3 | 5 |

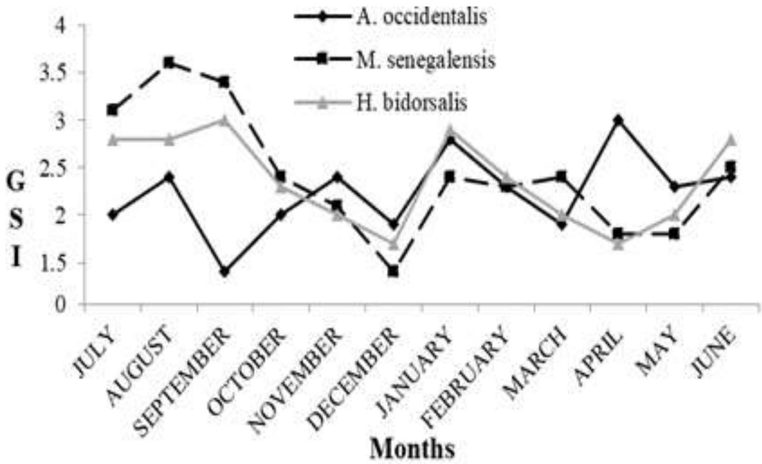


**Figure 4:** Monthly variation of gonadosomatic indices for females of the three cmmercial fish species of the White Volta in the Pwalugu area, Ghana from July 2019 to June, 2020

*Length-weight relationship and condition factor of commercial fish species:* The sizes of *Heterobranchus bidorsalis* examined in this study showed that they were relatively larger than the other preferred commercial fish species (*Auchenoglanis occidentalis* and *Marcusenius senegalensis*). The bigger sizes recorded for *Heterobranchus bidorsalis* may be as a result of their growth rate, feeding habit and reproduction. According to Oni *et al.* (1983), the main factors that determine the size of a fish are the feeding and reproductive characteristics of that fish. All the three fish species examined showed a negative allometric growth as they recorded a regression coefficient, 'b' values of less than 3. This is similar to the findings of Ikongbeh *et al.* (2013) as they recorded negative allometric growth for *Auchenogkonanis occidentalis* on Lake Akata in the Benue State of Nigeria. Conversely, the results contrast with the findings of Shinkafi and Ipinjolu (2010) as they reported an isometric growth for *A. occidentalis* samples collected from River Rima in North-western Nigeria. The correlation co-efficient of determination ($R^2 = 0.91$) recorded for *A. occidentalis* in this study suggests a positive and highly strong relationship between the length and weight indicating that when length increases, weight also increases.

The mean condition factor recorded for *A. occidentalis* is 1.74 ± 0.59 which suggests that *A. occidentalis* is doing well in the White Volta in the Pwalugu area. However, the mean condition factor recorded in this study is lower than the mean condition factor recorded by Shinkafi and Ipinjolu (2010) on River Rima in Northwestern Nigeria but comparable to the condition factors of tropical fish species examined and reported by Lizama *et al.* (2002).

With respect to *Marcusenius senegalensis*, a negative allometric growth was recorded, indicative of a faster increase in length relative to the weight. Similar findings were observed by Kien *et al.* (2022) at Bandama River, Ivory Coast. The co-efficient of determination ($R^2$) of 0.86 was recorded for the length-weight analysis suggesting a strong positive and significant correlation, which means as the length increases, its weight also increases. The mean condition factor recorded for *M. senegalensis* was the highest (2.05 ± 0.45) amongst the three preferred commercial fish species. This therefore suggests that, *Marcusenius senegalensis* is in a very good condition. According to Abowei (2010), a fish that records a condition factor greater than 2 implies that it is in a good state. The length-weight relationship of samples of *Heterobranchus bidorsalis* collected from the stiudy ashowed a negative allometric growth and this conforms to the findings of Adaka and Olele (2015) who recorded a negative allometric growth for female and male samples of *Heterobranchus bidorsalis* collected from the Njaba River in South-eastern Nigeria. The regression co-efficient ($R^2$) or correlation co-efficient recorded (0.96) for *Heterobranchus bidorsalis* showed a strong positive correlation that suggests that as the length of the fish increases, weight also increases. In this study, the mean condition factor recorded for *Heterobranchus bidorsalis* was below 2 (K = 1.9775) and this conforms to the findings of Owodeinde (2010) who recorded a condition factor of 1.24 for H. *bidorsalis.*

*Food and feeding habits of the preferred fish species:* In any aquatic environment, knowledge on the feeding ecology of fish species or fish families is of great significance for the growth of aquaculture industries, effective fisheries management, species conservation and protection of habitats (Pianka, 1994). The study results showed that *A. occidentalis* fed on a wide spectrum of food items or organisms categorized into zooplankton, phytoplankton, animal derivatives, macrophytes, sand and detritus. This is similar to the findings of Akongyuure (2020), Kuebutornye *et al.* (2019), Onimisi *et al.* (2010) and Chukwuemeka *et al.* (2019) who studied the guts of *Auchenoglanis occidentalis* collected from the Tono Reservoir, Libga Reservoir in Ghana, Zaria in Nigeria and Tagwai Lake in Minna State, Nigeria respectively. It may therefore be concluded that *A. occidentalis* is an omnivorous fish taking into consideration the findings of previous studies and the current study. *Auchenoglanis occidentalis* was found to feed more on animal derivatives (fish remains, worms and insects) which is similar to the findings of Kuebutornye *et al*. (2019). This may be as a result of the abundance of animal derivatives on the White Volta in the Pwalugu area. A considerably high percentage (48 %) of the stomachs of *Auchenoglanis occidentalis* in this study were empty and this may be as result of the distance covered in transporting fish samples from the study area in the Upper East Region to the University for Development Studies Spanish Laboratory in Nyankpala, Northern Region of Ghana. It might also have been so because of the easy-to-digest nature of the food consumed by the fish. The commercial fish species *Marcusenius senegalensis* fed on a variety of food items or organisms that ranged from zooplankton, phytoplankton, animal derivatives, macrophytes, sand and detritus. *M. senegalensis* were found to feed predominantly on animal derivatives and for that matter, insects to be precise. This conforms to the findings of Adjibade *et al.* (2019) who inspected the guts of samples of *M. senegalensis* collected from the Niger River in Northern Benin. *M. senegalensis* showed similar feeding habit from the Niger River in

Northern Benin (Adjibade *et al.* 2019). Previous studies have corroborated that Mormyrids mainly exhibit feeding trends that is of an invertivore (Olele, 2013; Leveque and Paugy, 2006). *Heterobranchus bidorsalis* was found to feed on a variety of food items and organisms that were grouped into zooplankton, phytoplankton, animal derivatives, macrophytes, sand and detritus. This is in conformity with the findings of Fagbenro (1992) who reported that *Heterobranchus bidorsalis* fed mainly on plankton, insects, fish and detritus although, they also fed on tadpoles, plant parts and benthic invertebrates. *Heterobranchus bidorsalis*fed more on animal derivatives and for that matter fish remains to be precise on the White Volta River area in Pwalugu. This is however in contrast to the findings of Fagbenro (1992) who reported detritus as the prominent food of *Heterobranchus bidorsalis*in the Owena Reservoir in Southwestern Nigeria. The difference in the prominent food consumed by *Heterobranchus bidorsalis*in the Owena Reservoir and the White Volta River area in Pwalugu may be as result of the differences in the morphology of the two water bodies.

*Reproduction of preferred commercial fish species:* An overall (male and female) mean of 1.81 ± 0.67 was recorded for the gonadosomatic index (GSI) of *Auchenoglanis occidentalis.* Mean GSI of 2.19 ± 0.69 and 1.47 ± 0.41 was recorded for female and male samples of *Auchenoglanis occidentalis* respectively. A study by Shinkafi and Ipinjolu (2012) on River Rima in North-western Nigeria reported a mean GSI of 2.01 ± 2.75 and 0.17 ± 0.32 for female and samples of *Auchenoglanis occidentalis* respectively. This is in contrast to the findings of this study as the GSI recorded for male samples of *Auchenoglanis occidentalis* by Shinkafi and Ipinjolu (2012) is relatively smaller when compared to that of this study (1.47 ± 0.41). Shinkafi and Ipinjolu (2012) recorded a mean fecundity of 2834 ± 2530.45 for *Auchenonglanis occidentalis* which is relatively higher than the mean fecundity recorded in this study (495 ± 450.96). However, it is important to note that in this study, a total of 72 samples of *Auchenonglanis occidentalis* were inspected over a period of one year on the White Volta River area in Pwalugu while in the study conducted by Shinkafi and Ipinjolu (2012), a total of 800 samples of *Auchenonglanis occidentalis* were inspected spanning over a period of three years on River Rima in North-western Nigeria. This may be the reason why there is a difference in the findings of the two studies. GSI recorded by samples of *Auchenonglanis occidentalis* was high in July, August and September 2019 and this time was characterised by rainfalls given an idea that, *Auchenonglanis occidentalis* spawn during the raining season. This is similar to the findings of Araoye (1999) and Offem *et al*. (2008) as they reported that most fish species spawn in the raining season.

An overall (males and females) average mean GSI of 2.41 ± 0.83 was recorded for samples of *Marcusenius senegalensis* whilst 1.85 ± 0.82 and 2.41 ± 0.76 were observed for males and female samples of *Marcusenius senegalensis* respectively. Adjibade *et al.* (2020) reported a mean GSI of 0.12 ± 0.09 and 1.32 ± 1.56 for males and female samples of *Marcusenius senegalensis* respectively, collected from the Niger River in Northern Benin which is dissimilar to the findings in this study as relatively low mean GSI values were noted. A mean fecundity of 188 ± 71.78 was recorded in this study for *Marcusenius senegalensis*, which is smaller when compared to the mean fecundity reported by Adjibade *et al.* (2020). However, it is important to note that Adjibade *et al.* (2020) inspected 2,019 samples of *Marcusenius senegalensis* collected from the Niger River in Northern Benin over a period of 18 months whereas in this study, only 72 samples of *Marcusenius senegalensis* collected from the White Volta River area in Pwalugu were inspected over a period of 12 months. The difference in time and the number of species used in the analysis may be the reasons why there were differences in the findings of both studies. Samples of *Heterobranchus bidorsalis* collected from the White Volta in the Pwalugu area recorded mean overall GSI of 1.84 ± 0.76 for males while recording means GSI of 1.43±0.57 and 2.47±0.65 for male and female samples respectively. Amongst all the three commercial species inspected, *Heterobranchus bidorsalis* recorded the highest GSI for female samples that were inspected. Absalom *et al.* (2017) reported a mean GSI of 3.54 for female samples of *Clarias gariepenus* collected from the Pandam Lake in Quan – Pan Local Government Area of the Plateau State in Nigeria. This is dissimilar to the findings in this study as GSI recorded by Absalom *et al.* (2017) for female samples of *Clarias gariepenus* is higher than the GSI recorded for female samples of *Heterobranchus bidorsalis* in this study. The difference may be as a result of differences in the two species. Even though, they belong to the same family (Clariidae), they do belong to different species and genera as well and this may be the basis for which different findings were recorded for the two species. GSI recorded for samples of *Heterobranchus bidorsalis* was generally higher in the rainy season and this conforms to the findings of Adjibade *et al*. (2020) and Offem et al. (2018) as they reported higher GSI for different fish species during raining seasons. It may therefore be suggested that, *Heterobranchus bidorsalis* of the White Volta area in Pwalugu spawns during the rainy season.

*Conclusion:* Negative allometric growth was observed in all the three preferred commercial fish species. The mean condition factors recorded in all the three species were above one, suggesting that the fish species were in good condition. Gut analysis of three commercial fish species revealed animal derivatives (fish remains, worms and insects) as the principal food fed by the three commercial fish species. The females spawned mostly in the rainy season that is July, August and September. Further studies should explore the culturability of the three preferred species.

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