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The study of some morphometric parameters, food and feeding habits of *Hydrocynus forskalii* (tiger fish) and *Alestes nurse* from lower River Benue

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Abstract

Studies on the morphometric parameters, food and feeding habits, of *Hydrocynus forskalii* (tiger fish) and *Alestes nurse* in lower River Benue, Nigeria was carried out between January 2023 and April 2023. Samples were collected from different landing sites in Makurdi. Both *Hydrocynus forskalii* (tiger fish) and *Alestes nurse* in lower River Benue showed negative allometric (2.60) and (2.73) growth pattern respectively, with strong relationship and direct proportionality between length-weight. The condition factor (K=1.38±0.07) and (K=1.26±0.02) showed that the river was conducive for the survival of the fish because it was greater than 1. The positive correlations in the morphometric parameters confirmed the presence of the species in the river. Four (4) major items ingested by *Hydrocynus forskalii* in lower River Benue are (Detritus 100%), plant materials (83.78%), Plankton (51.35%), and Fish Parts (43.24%) while and *Alestes nurse* has (Detritus 95%), plant materials (80.00%), Plankton (50.00%), and Fish Parts (42.50%) There was high feeding intensity due to few numbers of fish stomachs without food. Alestes nurse is an omnivore with moderate gut length. It is recommended that morphometric and meristic parameters be used to identify the fish, study on population structure to reveal more class sizes be done, culture trials should also be done, and the feed components to be plant and animal materials.

Keywords: Feeding Habits; Stomach Content; Gut Length; Morphometric Parameters; *Hydrocynus Forskalii*; *Alestes Nurse*

Abbreviation: LWR: Length Weight Relationship; DNA: Deoxyribonucleic acid

Introduction

Inland waters of Nigeria consist of water bodies that support a wide array of aquatic organisms, which includes phytoplankton, zooplanktons, crustaceans, and vertebrates such as fish, crocodile, and aquatic mammals. Nigeria is the largest consumer of fish in Africa with an approximately 1.2 million tonnes of fish needed annually to satisfy the demand of the ever-increasing population. FAO [1] estimated fish demand for Nigeria from 1997-2025, based on projected population and gave an average of 1.11 million tonnes for a decade (2000-2010). The country is highly blessed and endowed with vast expanse of inland freshwater and brackish ecosystems with abundant fish species, which have potentials for culture. These water bodies also play an important role in the provision of protein to Nigerians, especially now that imported fish is becoming expensive to the common man [2].

Morphological characters such as morphometric and meristic have been commonly used to identify stocks of fish and the differences between fish populations [3]. These parameters or characters include standard length, snout length, body depth, head length, pre dorsal distance, pre pelvic distance, and pelvic length, and anal base length, depth of the caudal peduncle, eye diameter and suborbital width. Meristic (counts) parameters include numbers of rays (spines or soft rays), gill rakers, scales and total number of vertebrae. The use of chromosome numbers and genetic parameters such as DNA sequences (requiring sophisticated measuring techniques) are the newest methods for identification of fish stocks [4].

The study of food and feeding habits of fish based on stomach content analysis is commonly used in fishery ecology to show the

position of fish within a food web and to provide information on the contribution of different prey items to the diets. Information about food habits of fish is also useful in defining predator-prey relationships, estimating trophic level and in the creation of trophic models as a tool to understanding complex ecosystem. Different kinds of items, ranging from plant to animal materials, be it micro or macro in nature, are eaten as food by fish. These items are of great diversity in the aquatic environment and differ in size and kind [5]. Study of Feeding habits of fish is an important tool of bionomics of species which the stomach content analysis method for investigating fish diet is adequate, this help to describe food chain and webs shared by different species which reveals the interactions among and between species and that accurate quantification of fish diets is an important aspect of fisheries. Several behavioural responses have been linked to methods of feeding, feeding habits, frequency of feeding, mechanisms of food detection, and food preferences [6]. Examining the stomach contents of fish is very useful in guiding the formulation of artificial diets in fish farming. Fish exploit food substances in the aquatic ecosystem according to their morphological adaptations (mouth, gills, dentition and intestinal system) that are related to diet [7]. The food and feeding habits of *Hydrocynus forskalii* (tiger fish) and *Alestes nurse* fish is for the sustainable exploitation and management of the fishery *Hydrocynus forskalii* is a pelagic predator that is widely distributed in Nigerian inland waters except the Cross River. This piscivorous species prefers long bodied fish as they are easier to swallow as well as insects, grass and snails. *Alestes nurse*, sometimes called *Brycinus nurse*, is native to freshwater systems in Africa, thriving well in both lacustrine and riverine conditions. It is a common freshwater characid species with wide distribution in the Guinean and Sudan Sahelian basins of Africa excluding the Upper Guinea and Nile. *A. nurse* has been reported to utilize various kinds of food resources that may be available in its habitat. It has been described as a planktivore, an entomophagous fish and a detritivore [8]. The aim of this study is to investigate the morphometric parameters, food and feeding habits, of *Hydrocynus forskalii* (tiger fish) and *Alestes nurse* in lower River Benue.

Materials and Methods

Study area

The study was carried out in Makurdi, Benue State (7º 46'N; 8º 29'E). Makurdi has two main seasons: a wet season usually between May and September and a dry season usually between October and April. Average annual rainfall is between 1000 and 1500 mm. River Benue is the main tributary of the Niger River. It rises in the Adamawa Plateau of central Cameroon, flows west across central Nigeria, and joins the Niger 483 km from the coast. River Benue's width varies from about 488 to 976 m, is 1,370 km long and its navigable length is more than 965 km during the wet season [9].

Sample collection

The method described by [10] was adapted. A total number of 50 specimens were purchased from fish sellers at Wadata market in Makurdi. The samples purchased were transported in an ice-chest with ice cubes (to reduce posthumous digestion of the stomach contents).

Morphomeric measurements for length-weight relationship (LWR)

The Total length (TL) from the tip of the snout to the end of the caudal fin and standard length (SL) from the tip of the snout to the base of the caudal fin of each specimen was measured in centimetres' (cm) using a measuring board. The body weights were measured in grammes (g) using a digital weighing balance (Metlar model L2211). This was read to the nearest 0.1 gramme. These parameters were used to obtain data on the Length-Weight Relationship (LWR) and Condition factor (K) using the equations below:

Length-weight relationship (LWR)

The LWR of the fishes was calculated using the equation

$W = aL^b$

Where W = the observed total weights of the fishes,

L = the observed standard lengths,

A and b are constants, b is the slope usually between 2 and 4 and a is the intercept on the length axis. The logarithmic transformation of the equation above gives a straight-line relationship.

LogW = Log a + bLog L

When Log10 W is plotted against Log10 L, the regression coefficient is b, and log a is the intercept on the Y axis.

Condition factor (K)

The condition factor (K) was computed from the equation:

Where, K is the condition factor,

W is the total weight of the fish and

L, is the standard length of each specimen.

Sex determination

Sex determination was carried using methods described by Muhammad et al. [11]. The specimens were dissected using a pair of dissecting scissors. This was done from the anal opening to the part of the body below the operculum to expose the gonads for sex identification. In the young males, testes were thin, thread-like with very small projections, whitish in colour and extend to about 1/3 of the abdominal cavity. In adult males, the testes were creamy in colour with very conspicuous granules. The young females had thin, pink to white tubular structures occupying about 1/5 of the abdominal cavity. In adult females, that were about to spawn eggs were readily iscernable in the ovaries which increased in size and filled most of the abdominal cavity.

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Stomach content analysis

The stomachs of the dissected fishes were removed and immediately preserved in 4% formalin in sterile bottles for subsequent food items examination and analysis. Food items were awarded points based on the volumes they were judged to have occupied. The stomachs were awarded 0, ¼, ½, ¾, or full according to their fullness as described by Ogbe et al. [8]. Each stomach sample was then opened and the content emptied in a petri dish. Some food items such as grains and insect parts were identified with the naked eye, while others were identified with the aid of a microscope. Slide preparation were made and examined under the light microscope using the X10 and X40 objectives. The stomach contents were analysed using:

Frequency of occurrence method

Point method.

Data analysis

Fisat II (Fish Stock Assessment Tools of the World Fish Centre) was used to determine the regression relationship between Standard length and weight for both species studied following Ogbe et al, (2008) formula: LogW = Loga + bLogL.

Results

Length-weight relationship (LWR), Mean condition factor (K) and morphometric measurements of *Hydrocynus forskalii* and *Alestes nurse* from lower river benue

The length-weight relationship of *Hydrocynus forskalii* and *Alestes nurse* in Lower River Benue, Nigeria during the period of study is presented in (figures 2 and 3). The b-value of *Hydrocynus forskalii* (2.60) reveals negative allomerism while the b-value of *Alestes nurse* (2.73) reveals negative allomerism. Both had positive correlation (R^2= 0.6893 and R^2= 0.9143). The mean condition factor (K) for *Hydrocynus forskalis* and *Alestes nurse* are presented in (table 1). The mean condition factor (K) for *Hydrocynus forskalis* is 1.38±0.07 while *Alestes nurse* had mean condition factor (K) of 1.26±0.02 there is no statistical difference between the condition value (K) of both species (P>0.05). A total of 100 samples were measured for morphometric parameters. The ranges showed variations of these parameters between both species as *Hydrocynus forskalis* had total length of (33.53±0.76), standard length (27.57±0.71), weight (521.30±30.43) and Gut Length (146.59±2.82) while *Alestes nurse* had total length of (33.41±0.67), standard length (32.74±4.99), weight (487.64±26.46) and Gut Length (149.14±3.14). There is no statistical difference between the measured morphometric parameters of both species (P>0.05).

Figure 1: Map of Makurdi Showing the Sampling Sites.

Frequency of occurrence and degree of stomach fullness of items ingested by *Hydrocynus forskalis* and *Alestes nurse* from lower river benue

The frequency of occurrence (%) of items ingested by *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue during the period of study is presented in (Table 2). Four (4) different items ranging from plants to Detritus materials were ingested by both species. This included Plant materials, Fish Parts, Plankton, Detritus and unidentified materials. Percentage variation of items ingested by *Hydrocynus forskalis* (Table 2) recorded detritus as the highest (100%), followed by plant materials (83.78%), Plankton (51.35%) with Fish Parts having the least (43.24%) while *Alestes nurse* had also detritus as the highest (95.00%), followed by plant materials (80.00%), Plankton

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(50.00%) with Fish Parts having the least (42.50%). Relative percentage of occurrence of food composition of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue is presented on (Table 3). *Hydrocynus forskalis* has Plant materials (68.79%), Fish Parts (10.83%), Plankton (20.38%) while *Alestes nurse* has Plant materials (61.79%)), Fish Parts (15.45%), Plankton (22.76%). (Figure 4) depicts the degree of stomach fullness of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue throughout the period of study. *Hydrocynus forskalis* degree of fullness of gut examined had 13 degree both for full and quarter full, 11 for half full and 2 for empty while *Alestes nurse* degree of fullness of gut examined had 15 degrees for quarter full, 14 for half full and 11-degree fullness.

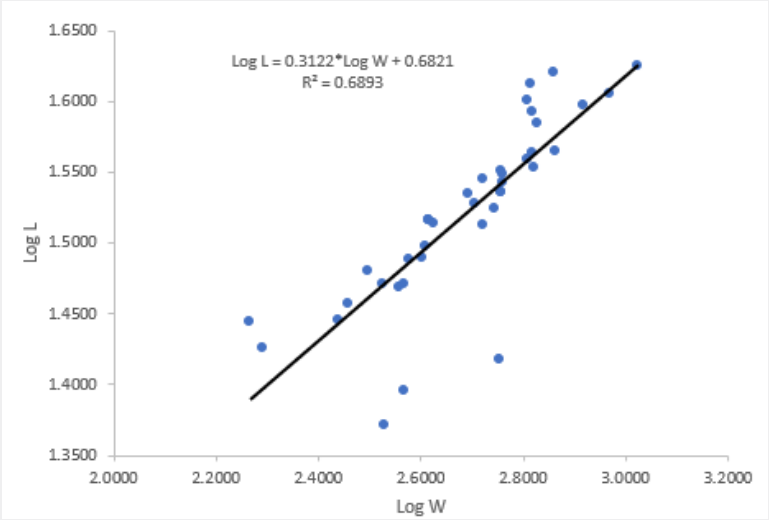

Figure 2: Length-Weight relationship of *Hydrocynus forskalis* from Lower River Benue.

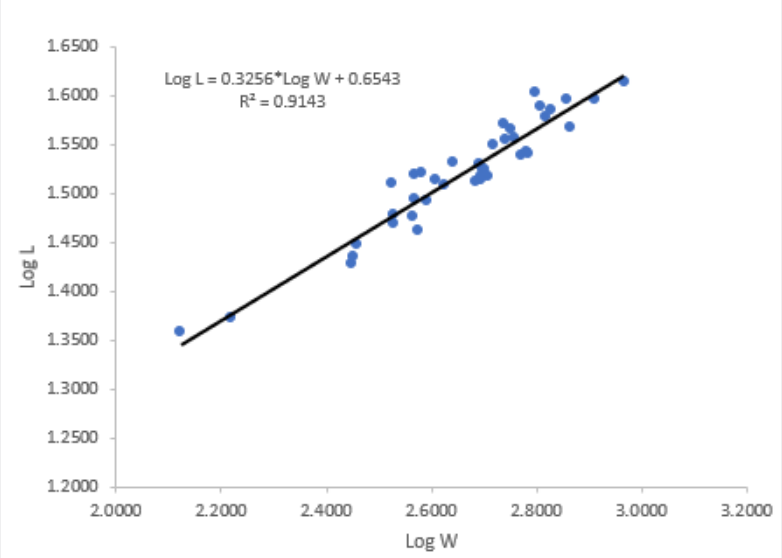

Figure 3: Length-Weight relationship of *Alestes nurse* from Lower River Benue.

Table 1: Mean morphometric characteristics of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue.

Species	Total Length	Standard Length	Total Body Weight	Gut Length	Condition Factor
Hydrocynus forskalis	33.53±0.76[a]	27.57±0.71[a]	521.30±30.43[a]	146.59±2.82[a]	1.38±0.07[a]
Alestes nurse	33.41±0.67[a]	32.74±4.99[a]	487.64±26.46[a]	149.14±3.14[a]	1.26±0.02[a]
P-Value	0.91	0.31	0.41	0.55	0.12

Mean in the same column with different superscripts differ significantly

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Table 2: Frequency of occurrence of food items in *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue.

Species	Plant materials	Fish Parts	Plankton	Detritus	Empty	Total
Hydrocynus forskalis	31 (83.78%)	16 (43.24%)	19 (51.35%)	37 (100%)	2	39
Alestes nurse	32 (80.00%)	17 (42.50%)	20 (50.00%)	38 (95.00%)	0	40

Values in parentheses represent the percentage of guts with food items within fish species

Table 3: Relative percentage of occurrence of food items in *Hydrocynus forskalis* and *Alestes nurse* fromLower River Benue.

Species	Plant materials	Fish Parts	Plankton	Total
Hydrocynus forskalis	108 (68.79%)	17 (10.83%)	32 (20.38%)	157 (100%)
Alestes nurse	76 (61.79%)	19 (15.45%)	28 (22.76%)	123 (100%)

Values in parentheses represent the percentage of food items within total food items in a fish species

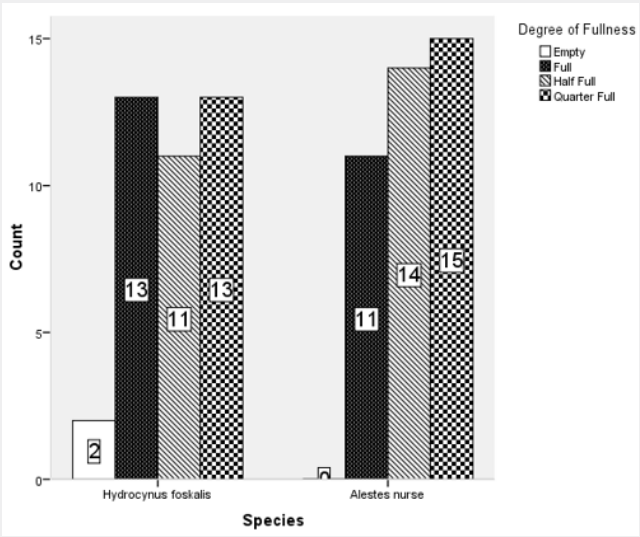

Figure 4: Degree of fullness of gut of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue.

Discussion

Length and weight are two basic parameters widely used in the study of fish biology. In fisheries science, the role of Length Weight Relationship (LWR) is an integral component to which size is more biologically relevant since ecological and physiological factors largely depend on size [12]. Moreover, LWR in fish allow comparison of life history that undergoes morphological changes [13]. Fishes grow in life and weight of fish increases as a function of length [14]. Length-weight relationship predicts the growth pattern of fish. If the value is equal to 3 it is known as isometric growth and less than or greater than 3 are known as either negative or positive allometric growths. The concept of LWR is further employed in the estimation of fish condition factor (CF) and providing information on growth type [15]. Alternatively, CF serves as an indicator of fish general well-being based on the assumption that a heavier fish of a given length is in a better condition [16]. Both species had b-values of 2.60 and 2.73, respectively. This shows that the both exhibited negative allometric growth. This is in line with the findings of Fafioye and Oluajo [17], Offem et al. [18] and Lawal et al. [19] but contrary to the findings of Yem et al. [20]. This could be due to location difference, period of sampling, sizes caught and number of samples used amongst other factors.

Correlation coefficient value (R2) of both species showed positive correlation between the length and weight, which indicated a homogenous population. This is in line with the findings of Konan et al. [21]. This could be due to the conducive nature of the river in terms of adequate physico-chemical parameters, availability of food, shelter amongst others for the survival of the species. Length-length relationship is a vital component of fish because it also shows the growth of fish. Condition factor (K) is very important because it shows the well-being of an organism in its immediate environment; whether it is conducive for survival or not. Ogbe et al. [8] reported that condition factor can be used to assess the well-being of fish. The mean condition factor (K) for *Hydrocynus forskalis* is 1.38±0.07 while *Alestes nurse* had mean condition factor (K) of 1.26±0.02. This means that the fishes are all

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doing well. When K-value is equal to 1 and above it indicated that the fish is doing well in the water body as reported by Thomas et al. [22]. This shows that the environment is good for the survival of the species in the river. The findings of this study are contrary to the works of Dada and Araoye [23] reported K - value of less than 1. This could be due to predation, breeding season, competition for food, pollution and size of fish amongst other factors. Araoye [23] reported that low condition factor was recorded when environment condition was poor, there was spawning pressure on females. Atobatele and Ugwumba [24] did report that low condition factor could be due to reduced availability of food and prey items. River Benue is a favourable environment for the survival of both Hydrocynus forskalis and Alestes nurse. In addition, their high number and medium sizes observed show that the fisheries are still developing.

Morphometric and meristic measurements, whether in the raw form, ratio and residual values are key parameters used to establish the identity of fish, evaluate racial relationship between them, and also used to segregate species of fish. According to Carpenter et al. [25], morphometric analysis helps to understand the relationship between body parts of an animal. Ogbe et al. [8] used 54 morphometric characteristics to discriminate among four fish species using raw, ratio and residual values. Four of such characteristics were used to validate the presence *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue.

Mean weight of *Hydrocynus forskalis* were higher than that of *Alestes nurse*, which did not differ significantly ($p>0.05$). This finding is similar with Ogbe et al. [8] but on the contrary, Atobatele and Ugwumba [24] did report bigger weights in *Alestes nurse* than *Hydrocynus forskalis*, which contradicts this study. The disparity could be due to ecological differences, seasonality, size caught and the time of sampling, effect of physico-chemical parameters amongst other factors. The study has also shown that most of the samples collected fall within the range of small to average sizes. Food is a very vital in the life living organisms because all life processes depend on it. Food and feeding habit of fish, apart from its relevance in aquaculture and optimization of fish yield, also helps to describe habitat types, ecological productivity and environmental heterogeneity. Four (4) major items were eaten as food by both *Hydrocynus forskalis* and *Alestes*. These ranged from Plant materials, Fish Parts, Plankton, Detritus and unidentified materials. This is in line with the findings of Asuquo [26] and Yem et al. [20] where they examined the stomach contents of C. *nigrodigitatus* in Cross River Estuary and Kainji Lake respectively. Similarly, Lawal et al. [19] reported food organisms for the species to consist of phytoplankton, crustaceans, mollusks, plant materials and fish parts. Offem et al. [18] also reported 8 major groups of food item - fish, insects, crustaceans, mollusc, worms, rotifers, plant materials, and detritus as food of C. *nigrodigitatus*. Also, Inyang and Ezenwaji [9] similarly reported the species to have fed on both plant and animal materials with the animal materials component being dominant. This was not in agreement with Dada and Araoye [23]. This could be as a result of unspecialized mode of feeding by the fish. Welcomme [27] did report that unspecialized feeders eat insects, zooplankton, detritus and plant matter according to their abundance. Overall, Detritus was most preferred, followed by Plant materials and lastly Fish Parts. The results observed in this study as well as previous studies confirm that *H. forskalii* is a piscivorous species. Mhlanga [28] reported that adult *H. vittatus* in Lake Kariba are predominantly piscivorous on the families Clupeidae, Cichlidae, and Characidae and sometimes on Clariidae, with invertebrates constituting a very small part of the diet. This suggests that for this fish prey captured depends to some extent on what is available. Alestes nurse is an omnivorous species that feeds on various food items present within its ecosystem. Saliu [29] reported the diet of *Brycinus nurse* (Pisces: Characidae) from Asa reservoir in Ilorin, Nigeria, to be omnivorous with a vast array of food items consumed including 9 families (flagellates, bivalves, copepods, branchiopods, ephemeropterans, arachnids, cyprinids, chlorophytes and higher plants), comprising 10 genera and 10 species. In the Jamieson River (Niger Delta, Nigeria), Brycinus longipinnis fed on allochthonous food items on the water surface and the substratum, and the primary food items consumed by the species were insects mainly Hymenoptera (tailor ants) and Coleoptera [29]. Other insects, immature aquatic insects, aquatic macrophytes, algae, and detritus were supplementary diets and accounted for less than 10% of the species diet.

Frequency of stomach fullness is a key that can be used to determine the feeding intensity of fish in the aquatic environment. The low percentage of empty stomach and high percentage of stomach with food of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue suggests that there was abundance of food throughout the period of study. This could be due to the availability of the diverse or wide variety of food items the river. This agrees with the findings of Yem et al. [18]. The degree of stomach fullness determines the feeding category as well as feeding intensity of fish. Ogbeibu and Ezeunara [30] did report that ecological conditions governed by seasonal diversity of food could affect the feeding habits, feeding intensity and diets of fish. On a general note, the results of the fullness method of stomach contents analysis revealed that there was high degree of feeding intensity due to the fact that percentage of full stomach was more than that of empty stomach. Ogbeibu and Ezeunara [30] reported that even at species level, fish in the same genus sometimes has different feeding intensity or category.

Conclusion

Length-weight relationship showed negative allometric growth for both species. Condition factor (K) of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue were within the favourable range. Length-length relationship showed strong relationship between these parameters. Morphometric parameters were used to validate the identity of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue. Correlation coefficient showed

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positive relationship among these parameters. Four major items were eaten by *Hydrocynus forskalis* and *Alestes* nurse from Lower River Benue, which included Plant materials, Fish Parts, Plankton and Detritus. Stomach fullness index of *Hydrocynus forskalis* and *Alestes nurse* from Lower River Benue showed high feeding intensity. *Alestes nurse* an omnivore. This is also supported by gut length to body length ratios.

Recommendation

- Morphometric parameters, especially those with strong correlations should be used to identify *Hydrocynus forskalis* and *Alestes nurse*.
- More study should be done on the population structure to ascertain if there are sizes bigger than the ones reported in this study.
- *Hydrocynus forskalis* and *Alestes nurse* from the river has aquaculture potential, therefore culture trials should be carried out.
- Plant and animal components should constitute the diet of *Hydrocynus forskalis* and *Alestes nurse.*
- In view of the importance of stomach content analysis, studies should be extended to other native fish species so as to provide the scientific information for their management.

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