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Temporal Changes in Gut Contents, Morphometry and Digestive Enzymes of *Hepsetus odoe* (Bloch, 1794) in Eleyele Lake, Ibadan, Nigeria

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Abstract: An in-depth information on diet and nutrient utilization of *Hepsetus odoe* is fundamental for its sustainable management, especially through aquaculture. This study, therefore carried out to assess the gut content, morphometry, and digestive enzymes of *H. odoe* in Eleyele Lake, Nigeria. One hundred and fourteen (114) samples of *H. odoe* were randomly collected from fishers' catch for seven months covering wet and dry seasons. There are 49 big (21–27cm) and 65 small (12–20cm) fish sizes in the sample. Stomach content and digestive enzymes were analysed using standard methods, while gut length (GL) and gut weight (GW) were measured following standard procedures. Diatom dominated the diet and more full stomach were observed in big size female during wet (41.82%) and dry (30.51%) seasons. The mean Gut Repletion Index ranged from 23.72% (dry season) to 26.67% (wet season), and Zihler's index revealed significant difference ($p>0.05$) between seasons. The mean condition factor obtained between the sizes and sexes in both seasons ranges from 0.58±0.00 to 0.78±0.04. The gastrointestinal structure of *H. odoe* show no significant difference ($p<0.05$) between males and females during both seasons. The significant highest levels of pepsin activity were observed in big size female during wet season. Generally, seasonal variations affected gut content, morphometry, and digestive enzyme parameters of *H. odoe* across sexes and sizes.

1. Introduction

The African pike *Hepsetus odoe* is a popular endemic freshwater fish in Nigeria and belonged to the family Hepsetidae of order Characiformes (Figure 1). The fish is highly sourced and cherished as a very important component in the diet among riparian communities due to its tasteful flesh and nutritional values (Kareem *et al*., 2016). Thus, it is a highly demanding and important source of rich protein potential to the riverine people in many parts of Nigeria. In artisanal fishery, *H. odoe* is

extracted and commercialized by local fishermen and contributing to the economy of the fishing communities. The fish therefore makes significant contribution to the nation's GDP as emphasized by Ashimolowo *et al*., (2022).

Figure 1. African Pike, *Hepsetus odoe*

African pike is a desirable species that can play an important role to fulfill the demand of the local consumption through pond culture. However, knowledge on gut content and digestive enzymes is important to evaluate the commercial potentiality of its stock, culture, and management. The research study of the food and feeding habits of freshwater fish species is the subject of ongoing research, which constitutes the basis for the development of such a successful management program for fishing and fish farming. Fish gut content analysis provides an important insight into feeding patterns given details on different kinds of food present in the stomach and quantitative assessment of feeding habits as an important aspect of fisheries management (N'Da *et al*., 2023). However, basic studies on the morphology of fish digestive tract and metabolism play a key role in diet formulation and digestion.

Gut morphology and digestive enzymes of fish is essential for assessing the nutritional function of each digestive organ and the nutritional physiology of the species. Caruso *et al*., (2009) also stated that, nutrient utilization by fish is a direct function of the morphology of its gastro-intestinal tract. Digestive enzyme activity varies within species, and influenced by biotic (size, age, origin) and abiotic (temperature, season, food) parameters (Oladimeji *et al*., 2020). Hidalgo *et al*., (2011) revealed that the age and/or stage of development significantly influences the digestive enzyme activity in different fish species. This can be used as a basis to develop feed formulation suitable for different sizes of fishes, so that optimal nutritional values and cost-effectiveness can be obtained.

The previous studies documented on *Hepsetus odoe* in Eleyele lake include evaluating the sex ratio, gonadosomatic index, diet composition and fecundity (Kareem *et al*., 2015), growth patterns and condition factor (Kareem *et al*., 2016), length-weight relationship, condition factor and fecundity (Akponine and Ayoade, 2012; Nasri *et al*., 2021), food and feeding habits (Ayoade *et al*., 2018). Other studies from across Nigeria include allometry and condition factors of *Hepsetus odoe* in Ogbomosho reservoir (Adedokun *et al*., 2013), and the diet compositions of *Hepsetus odoe* in Ikose/Iluju reservoir (Adedokun and Fawole, 2015). However, there is a dearth of information on the gut morphometry and digestive enzymes of this fish especially in Eleyele lake.

Hence, this study was conducted to investigate the variations in gut content, morphometry, and digestive enzymes of *H. odoe* in Eleyele Lake, based on sex and seasons. The results of this study will provide valuable information about fish digestive physiology as concern different sexes and seasons of the year. The study will support aquacultural efforts of *Hepsetus odoe* by ensuring a feed formula that will enhance the domestication of this fish in the future.

2. Methodology

2.1 Study area

Eleyele Lake is a modified natural wetland located between Latitude $7^0$25'0" – $7^0$26'15" N and Longitude $3^0$50'45" – $3^0$52'15" E in Ibadan, Southwest Nigeria (Figure 2). It is the second largest Lake in Oyo State, Nigeria, covering an estimated area of about 546 Km^2 including the catchment (Kareem *et al*., 2016). The construction of the dam was started in 1939 and completed in 1942 to impound water of Ona River for supply of portable water to Ibadan people and environs. The dam is however playing an important role in food security within Eleyele town and environs by providing fresh fishes to people.

2.2 Fish Sampling

The study was conducted from December 2019 through June 2020. Live fish sample (n = 114) were collected from landing site for two seasons: 59 samples during dry season (December 2019 – February 2020) and 55 samples during wet season (April – June 2020). The samples after collection were transported in an ice-packed box to the laboratory for further analysis. In the laboratory, fish obtained were categorized into two sizes: small size (12.0–20.0 cm) and big size (21.0–27.0 cm). Total and standard lengths were measured to the nearest centimeters and then further studies were carried out. The sex of fish was determined by macroscopic examination of the gonads after dissection.

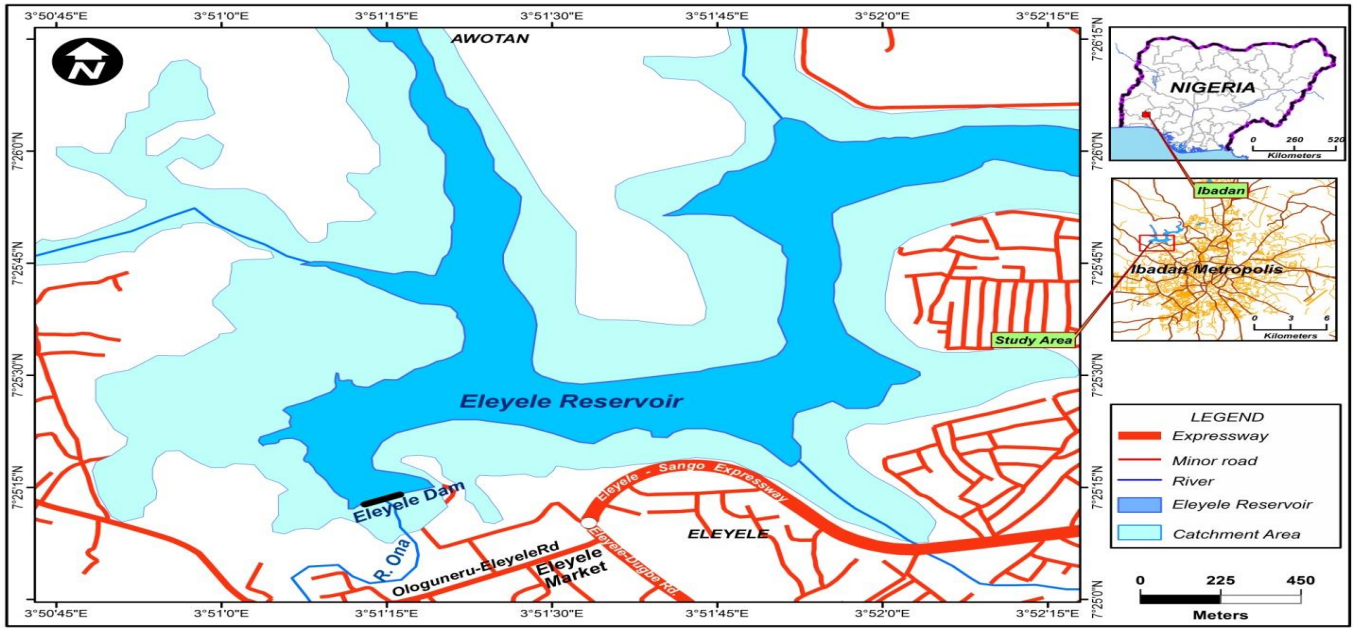

Figure 2. Map of Eleyele Lake

2.3 Diet Analysis

The fish was dissected, and the gut taken out for diet analysis. The state of fullness of each stomach was recorded and expressed as empty, half-full and full. The food composition in each gut was determined using numerical and occurrence method as described by Hyslop (1980). Gut repletion index (GRI) was also calculated following the Ekpo *et al*. (2014) formula:

$$\text{GRI} = \frac{Number\ of\ non{-}empty\ gut}{Total\ number\ of\ gut\ examined}\ x\ 100$$

2.4 Gut Morphometry

Gut length (GL) and weight (GW) were measured to the nearest of 0.01 g and 0.1 cm with an electronic weighing balance (Scout Pro SPU202, AB-204) and meter rule, respectively. These guts morphometric characters were used to calculate the relative gut length, relative gut mass and Zihler's index (ZI). Fish condition factor (CF) was also calculated using Pauly (1984) formula.

$$\text{RLG} = \frac{Length\ of\ the\ gut\ (cm)}{Total\ length\ of\ the\ body\ (cm)}$$

$$\text{RLM} = \frac{Weigth\ of\ the\ gut\ (g)}{Total\ weigth\ of\ the\ body\ (g)}$$

ZI = gut length (mm) x [10 x (body mass $(g)^{1/3}$)]$^{-1}$

CF = Fulton's condition factor (K) = body mass (g) x [length $(cm)^3$]$^{-1}$ x 100

2.5 Histopathology and Digestive Enzymes Analysis

The appropriately labeled samples were brought to the laboratory and subjected to the procedures of fixation, dehydration, clearing, embedding, sectioning, floating, mounting, and staining with routine Hematoxylin and Eosin stains as described by Hopwood (1996). The prepared slides were examined using Olympus microscope camera. The pathological changes observed were described accordingly based on histological structure of the tissues. For digestive enzyme analysis, the guts after emptying their contents were put into phosphate buffered saline, homogenized physically and the homogenates centrifuged at 1200 rpm for 30 minutes. The supernatants were used as crude enzyme extracts without further purification. Digestive enzymes activities of each sample were analysed in triplicate using spectrophotometry in the Analytical laboratory of the department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria. The qualitative determination of glycosidases (carbohydrates), proteases and lipases followed the methods of Olatunde *et al*. (1988) and Ogunbiyi and Okon (1976), respectively.

2.6 Statistical Analysis

Data obtained from the study were subjected to descriptive statistics (mean and standard deviation). The analysis correlates the ratio of gut length to total length and condition factor, the ratio of gut weight to body weight and condition factor, gut length to body mass and condition factor for morphometry and all enzymes' variables were also analyzed with condition factor and subjected to the Statistical Programming for the Social Science (SPSS version 25).

3.0 Results

3.1 Diet and Gut morphometry

Three degrees of fullness were recorded in the study and these include full, half full and empty (**Figure 3**). In wet season, big female revealed fuller (12.73%) and half full (29.09%) stomach, while empty stomach was pronounced in big (5.45%) and small size (7.27%) male *Hepsetus odoe*. **Figure 4** show that big female had highest full (3.39%), half full (27.12%) and empty (11.86%) stomachs in dry season. However, empty (8.47%) stomach was more in small male *H. odoe* during dry season. The prevalence of food items in the guts of big and small sizes of male and female *H. odoe* in wet season is presented in **Table 1**. Six prey categories with an unidentified material were found in female, especially big size had higher frequency of occurrence in diatom (15.09%), insect part (12.26%), daphnia (10.38%), protozoa (10.38%), insect (7.55%) and fish parts (3.77%). However, diatom (6.60%) and daphnia (4.72%) were the most occurred food items in big male *H. odoe*. Similar trends were followed in the percentage numerical abundance. **Table 2** presents the frequency of occurrence and percentage numerical abundance of various categories of food items according to size classes and sex during the dry season. Unlike wet season, seven prey items were discerned in dry season. The dominant food items in both male and female of the two sizes include diatom, insect part, daphnia and rotifera. Diatom is most appeared in big size female (14.58%), followed by small size male (10.42%), big size male (8.33%) and small size female (7.29%). However, the least occurred (1.04%) food items are insect in small size female, rotifera in small size male and unidentified material in big size female. Meanwhile, insect, fish part and unidentified material were conspicuously absent in big size female, small size male and male of both sizes, respectively. The seasonal variations of Gut Repletion Index (GRI) of *H. odoe* are presented in **Figure 5**. It is evident that, no significant difference ($p>0.05$) exists in GRI between seasons.

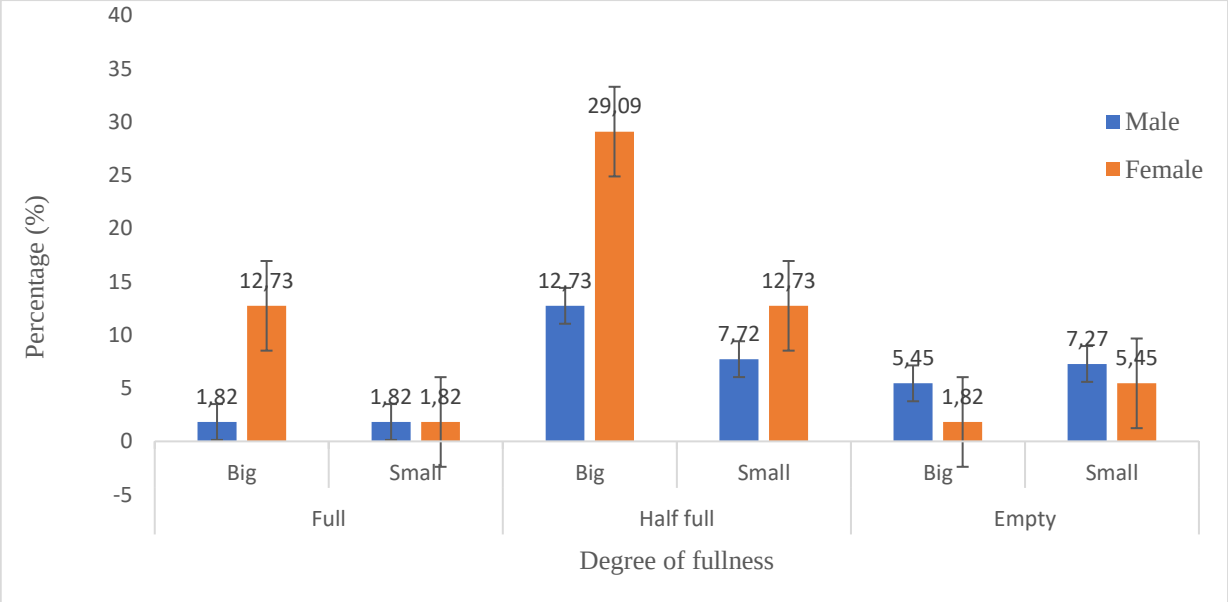

Figure 3. Index of fullness of male and female *Hepsetus odoe* in wet season

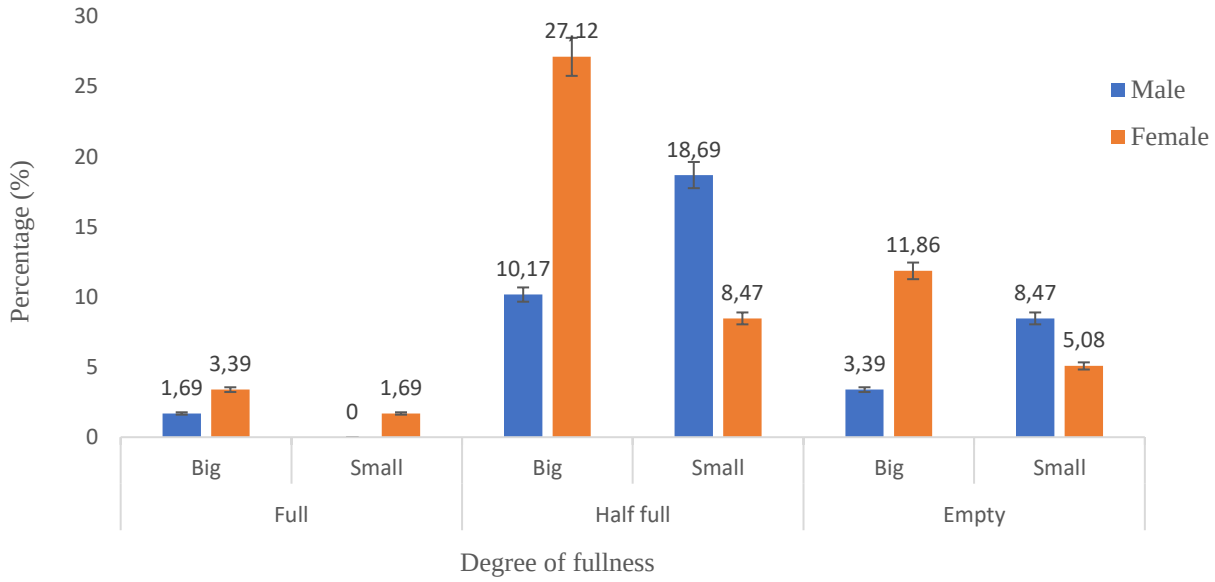

Figure 4. Index of fullness of male and female *Hepsetus odoe* in dry season

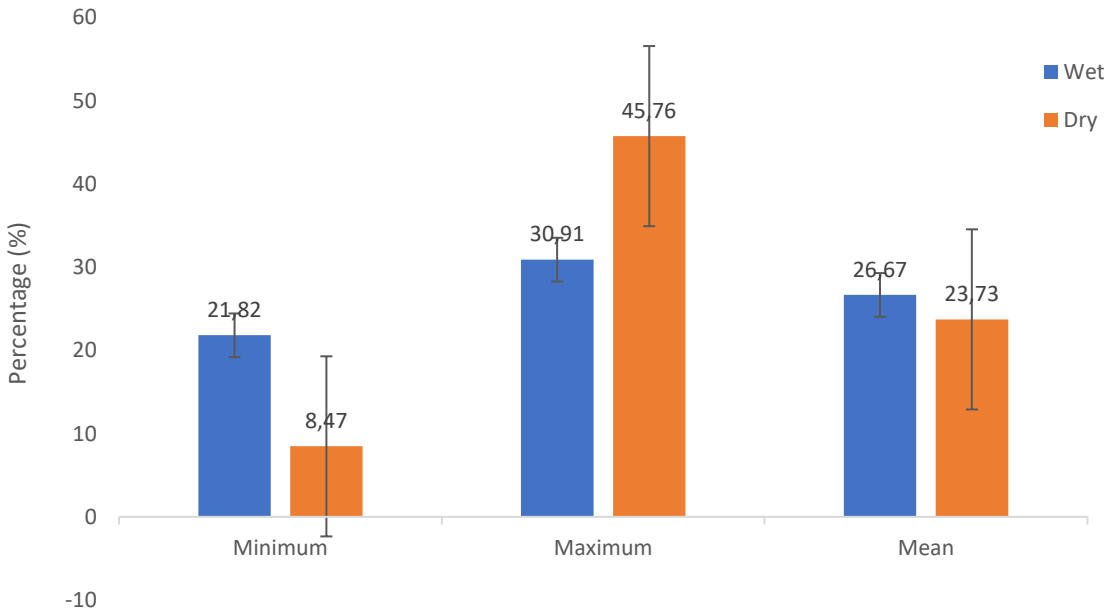

Figure 5. Gut Repletion Index of *Hepsetus odoe* during wet and dry seasons

The GRI value obtained in wet season was comparatively higher (26.67±4.57 %) than 23.73±19.55 % in dry season. The seasonal relative length of the gut (RLG), relative gut mass (RGM) and Zihler's index (ZI) of *H. odoe* were presented in **Table 3.** The results indicated that during wet season the RGL in big (0.64±0.03 cm) and small (0.64±0.03 cm) size female *H. odoe* was equal, but that of big size male (0.62±0.13 cm) was higher than the small (0.57±0.00 cm) size. However, there was no significant different ($p>0.05$) between sex. Also, the wet season values obtained for RGM shows that the guts of small size male (2.33±0.00 g) and female (0.60±0.65 g) were slightly heavier

Table 1. Diet composition of male and female *Hepsetus odoe* in wet season

Food items	Frequency of Occurrence								Numerical Method							
	Male				Female				Male				Female			
	B		S		B		S		B		S		B		S	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Diatom	7	6.60	4	3.77	16	15.09	4	3.77	12	2.06	5	4.95	52	21.48	13	5.37
Insect	1	0.94	1	0.94	8	7.55	4	3.77	1	0.41	1	0.41	11	4.54	9	3.71
Insect part	2	1.89	2	1.89	13	12.26	4	3.77	3	1.23	6	2.47	36	14.87	9	3,71
Daphnia	5	4.72	2	1.89	11	10.38	1	0.94	8	3.30	6	2.47	18	7.43	8	3.30
Protozoa	2	1.89	-	-	11	10.38	1	0.94	5	2.06	-	-	16	6.61	1	0.41
Fish part	-	-	-	-	4	3.77	1	0.94	-	-	-	-	15	6.19	5	2.06
Unidentified material	-	-	-	-	1	0.94	1	0.94	-	-	-	-	1	0.41	1	0.41

B: Big, S: Small, N: Number, %: Percentage

Table 2. Diet composition of male and female *Hepsetus odoe* in dry season

Food items	Frequency of Occurrence								Numerical Method							
	Male				Female				Male				Female			
	B		S		B		S		B		S		B		S	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Diatom	8	8.33	10	10.42	14	14.58	7	7.29	21	10.88	30	15.54	46	23.83	21	10.88
Insect	2	2.08	4	4.17	-	-	1	1.04	3	1.55	4	2.07	-	-	1	0.5
Insect part	5	5.21	4	4.17	7	7.29	2	2.08	7	3.63	5	2.59	10	5.18	2	1.04
Daphnia	3	3.13	3	3.13	3	3.13	2	2.08	4	2.07	5	2.59	5	2.59	4	2.07
Rotifera	3	3.13	1	1.04	3	3.13	-	-	3	1.55	1	0.52	3	1.55	-	-
Euglonephyta	2	2.08	2	2.08	2	2.08	2	2.08	3	1.55	2	1.04	2	1.04	2	1.04
Fish part	2	2.08	-	-	3	3.13	-	-	2	1.04	-	-	6	3.11	-	-
Unidentified materials	-	-	-	-	1	1.04	-	--	-	-	-	-	1	0.52	-	-

B: Big, S: Small, N: Number, %: Percentage

Table 3. Gut morphometry parameters of male and female *H. odoe* during wet and dry seasons

	Wet					
	Male		Female		Pearson	
Parameters	Big	Small	Big	Small	correlation	P-value
RGL (cm)	0.62±0.13	0.57±0.00	0.64±0.03	0.64±0.03	0.52	0.21
RGM (g)	0.19±0.07	2.33±0.00	0.45±0.50	0.60±0.65	0.52	0.21
ZI	0.34±0.11	0.78±0.00	0.38±0.22	0.52±0.08	0.71	0.01*
			Dry			
RGL (cm)	1.29±1.63	0.96±0.00	1.15±0.22	1.07±0.13	0.61	0.11
RGM (g)	2.67±0.85	1.53±0.00	1.43±2.31	2.79±0.37	-0.38	0.39
ZI	0.59±0.09	0.73±0.00	0.68±0.05	1.30±0.05	0.49	0.25

RLG: Relative length of the gut, RGM: Relative gut mass, ZI: Zihler's index, * Significant @ 5% level (p>0.05)

than that of big size male (0.19±0.07g) and female (0.45±0.50 g), respectively. Similarly, the small size male had higher ZI value (0.78±0.00) compared to big size (0.34±0.11), while big and small size female had 0.38±0.22 and 0.52±0.08, respectively. There exist positive correlation and significant difference (p<0.05) between both sizes and sex.

In dry season, the RGL of big size male was comparatively higher (1.29±1.63 cm) than 1.15±0.22 cm of big size female of *H. odoe*. However, small size female (1.07±0.13 cm) had higher value than small size male (0.96±0.00 cm) but no significant different (p>0.05) **(Table 3).** Both sizes of male and female *H. odoe* had the same trend of RGM in dry season. The data in **Table 3** indicated no significant difference (p>0.05) in Zihler's index of male and female *H. odoe*. However, the big size male *H. odoe* had superior ZI value (0.73±0.00) than big size female (0.68±0.05). Whereas the small size female shows higher value (1.30±0.05) compare to male of the same size (0.59±0.09).

3.2 Condition factor

Figure 6 shows the seasonal condition factor (CF) of male and female *H. odoe* in Eleyele lake. The CF values obtained for big size male (0.78±0.04) were same in wet and dry season, while big (0.74±0.09) and small size female (0.69±0.03) were highest in wet season. Further, the big size male (0.78±0.04) had better CF than big size female (0.71±0.05 – 0.74±0.09), but small size female (0.68±0.05) is fair better than small size male (0.58±0.00 – 0.67±0.00).

3.3 Gastro-intestinal Structure and Digestive enzymes

The gastrointestinal structures of *H. odoe* during wet and dry season presented in **Table 4**, show that there is no significant difference (p>0.05) between males and females. In wet season, the big size male had the highest villi width (319.64±65.11) and cryptal depth (674.68±83.16) and width (189.36±99.96), while villi height (1462.09±537.88) and villi width (173.23±24.66) were more pronounced in small size female. However, in dry season, only villi width (211.83±100.86) surpassed in big size male but higher villi height (1740.43±384.43), villi width (152.87±14.48) and

muscle thickness (230.20±0.30) revealed in small size female. The digestive enzyme activities of male and female *H. odoe* during wet and dry season is given in **Table 5**. In wet season, the values obtained for female samples were higher than the males except Sucrase (0.66±0.00) and Maltase (1.27±0.00) which were higher in small size males.

However, the values obtained for all investigated parameters were not statistically significant ($p>0.05$) between sexes, except pepsin. While in dry season, highest chymotrypsin activities were recorded in both big (0.42±0.14) and small (2.95±0.00) size male samples. Similarly, the α-amylase, maltase and lipase activities were non-significantly higher in females than in males.

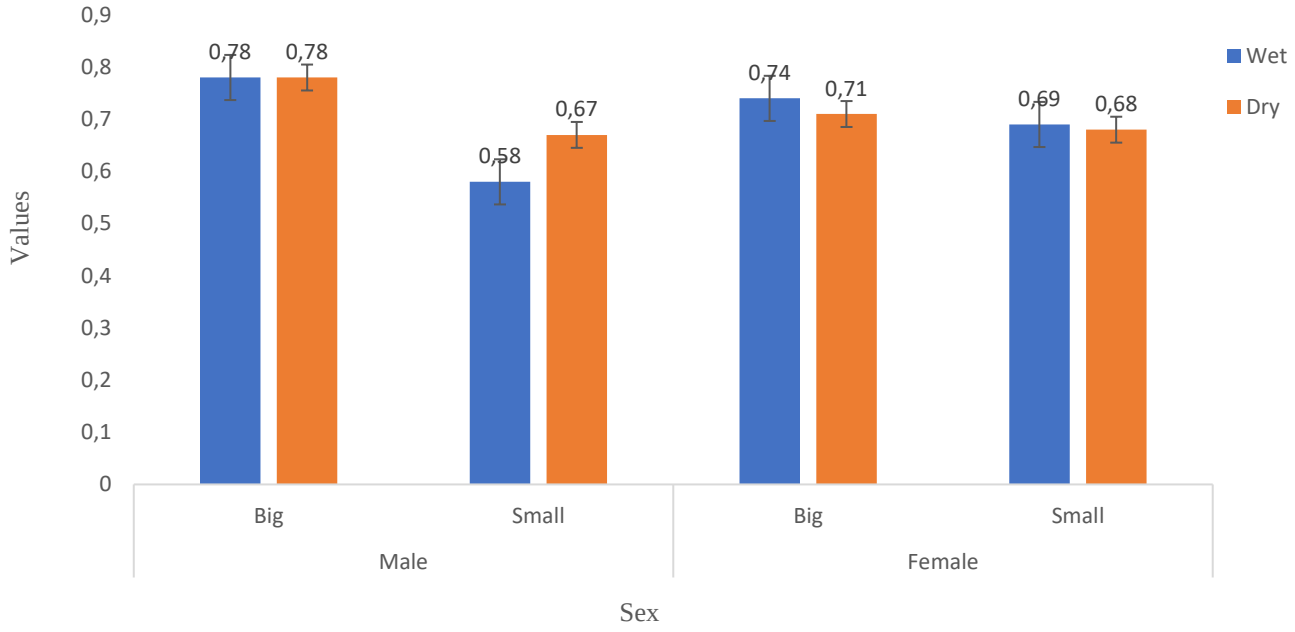

Figure 6. Condition factor of male and female *H. odoe* during wet and dry seasons

4.0 Discussion

4.1 Diet and Gut morphometry

Information on fish diet, gut morphology and digestive enzymes provide hints on the species nutritional requirements and role in diet formulation under culture environment. The sex and seasonality related with feeding as discerned in the present study is supported by variations in the degree of stomach fullness in both sizes of *Hepsetus odoe*. The big and small size female *H. odoe* exhibited highest full and half-full stomach compared to male of both sizes during wet and dry season. The female high feeding intensity in this study could be attributed to metabolism through hormonal activity, resulting in reproduction. This assertion is in line with the report of Kareem *et al*. (2019) who suggest that feeding intensity could either be linked to spawning activities and/or food availability. Panday *et al*. (2023) also submitted that the feeding intensity of a fish is related to its stage of maturity, reproductive state, and availability of food items in the environment.

Table 4. Gastrointestinal structure of male and female *H. odoe* during wet and dry season

Parameters	Wet				Pearson correlation	P-value
	Male		Female			
	Big	Small	Big	Small		
VH	1423.73±328.33	1269.63±0.00	1488.82±296.52	1462.09±537.88	0.54	0.20
VW	319.64±65.11	144.98±0.00	174.60±42.59	173.23±24.66	-0.56	0.30
CD	674.68±83.16	756.66±0.00	573.72±150.89	742.47±198.41	0.50	0.28
CW	189.36±99.96	126.63±0.00	115.25±29.86	121.84±7.92	-0.32	0.41
MT	163.87±58.12	239.68±0.00	257.56±27.20	228.37±38.95	-0.54	0.20
			Dry			
VH	1574.70±139.41	1370.12±142.15	1791.11±334.05	1740.43±384.43	0.83	0.13
VW	211.83±100.86	134.56±14.74	147.70±24.96	152.87±14.48	0.76	0.24
CD	471.97±56.65	983.05±320.16	701.79±184.03	835.23±250.41	-0.78	0.21
CW	128.81±20.15	130.69±5.73	139.68±18.31	117.24±18.59	0.89	0.07
MT	230.04±113.02	220.38±27.15	236.06±52.41	230.20±0.30	0.82	0.15

VH: Villi height, VW: Villi width, CD: Cryptal depth, CW: Cryptal width, MT: Muscle thickness

Table 5. Digestive enzyme of male and female *H. odoe* during wet and dry season

Parameters	Wet				Pearson correlation	P-value
	Male		Female			
	Big	Small	Big	Small		
α-amylase	0.10±0.00	0.35±0.00	0.49±0.24	0.39±0.05	0.60	0.10
Sucrase	0.13±0.14	0.66±0.00	0.26±0.19	0.11±0.09	-0.63	0.06
Maltase	0.12±0.02	1.27±0.00	0.67±0.99	0.33±0.40	-0.55	0.17
Chymotrypsin	0.15±0.15	0.10±0.00	0.47±0.73	0.28±0.09	-0.52	0.17
Pepsin	0.29±0.36	0.19±0.00	0.71±0.67	0.50±0.06	0.68	0.03*
Lipase	26.69±4.28	11.26±0.00	26.58±6.71	19.62±0.00	0.76	0.05
			Dry			
α-amylase	1.11±0.39	1.13±0.00	1.23±0.55	1.34±0.54	0.57	0.19
Sucrase	0.88±0.62	0.25±0.00	0.84±0.79	0.57±0.34	-0.51	0.24
Maltase	0.16±0.05	0.12±0.00	0.39±0.28	0.38±0.23	0.66	0.14
Chymotrypsin	0.42±0.14	2.95±0.00	0.24±0.14	0.55±0.44	0.59	0.16
Pepsin	0.69±0.56	0.26±0.00	0.40±0.43	1.25±0.99	-0.45	0.27
Lipase	24.43±0.24	24.42±0.00	31.56±0.71	30.91±5.34	-0.69	0.09

* Significant @ 5% level (p>0.05)

The examination of the gut contents of *H. odoe* in this study show prevalence of eight food items including diatom, insect part, daphnia, protozoa, rotifera insect, fish parts and Euglonephyta. Rotifera and Euglonephyta were however not found during wet season while protozoa were absent in dry season. The dominant food items recorded in this study were similar to those observed in *H. odoe* by Ayoade *et al.,* (2018), Kareem *et al*., (2015) and Abdul *et al.,* (2016) in Eleyele lake and Ogun State coastal estuary, respectively. The species of fish consumed are not identify in this study due to the extent of digestion already taken place, and this is also supported by Ayoade *et al.,* (2018) in their study. Further, the fish part and other varieties of food items as found in this study portray *H. odoe* as piscivores and opportunistic feeder. In support to this finding, Ayoade *et al.,* (2018) and Kareem *et al*., (2015) found *H. odoe* from Eleyele lake to be piscivorous and opportunistic feeder. Further, the high occurrence and abundance of food items found in large size *H. odoe* in this study was similar to the observation of Kareem *et al.* (2015) and Adedokun and Fawole (2015). The gut repletion index (GRI), which is the intense feeding activity due to the abundance of food consumed by fish was slightly higher in wet season than dry season in the current study. This is an indication of low feeding activity and it contradict the findings of Abdul *et al.* (2016) who observed 100 % GRI value in *H. odoe* from Ogun State coastal estuary, Nigeria. According to Ullah *et al*. (2023), the seasonal diversity of food items is influenced by food habits, diet and feeding intensity of fish.

Data on gut function and its efficiency is one of the keys to successful commercial production of fish species. Therefore, relative gut length (RGL), relative gut mass (RGM) and Zihler index (ZI) were explored as potential indices to identify feeding habits of fish based on their gut length. The RGL (0.57±0.00 – 1.29±1.63) of *H. odoe* across sex and seasons as obtained in this study, fall within the carnivorous mode of feeding as indicated by Rust (1995). Akponine and Ayoade (2012) also found similar RGL of 1.68 (big size) and 0.07 (small size) in *H. odoe* from Eleyele lake. Meanwhile, slight changes of dietary habit as found in this study show the lowest RGL value in both sizes and sexes as an indication of carni-omnivorous habit. Similar observation has been reported in many freshwater fishes by Saikia *et al.* (2015) and Koundal *et al.* (2013). The RGM values was slightly higher in big size male (2.67) and small size female (2.78) in dry season, and vice versa in wet season. Generally, the results suggest that both sexes and sizes of *H. odoe* feed on similar food items in the lake as corroborated by Karasov and Douglas (2013). This finding was same as Akponine and Ayoade (2012), who reported low RGM value of 1.61 for female, 0.66 (male), big size (1.68) and small size (0.07) *H. odoe* in Eleyele lake. Kareem *et al*. (2015) however observed RGM value ranged between 0.64 and 15.54 for *H. odoe* in the same waterbody. According to Lloret and Planes (2003), relative gut mass is an indication of feeding condition, and species which utilize active diet have heavier guts as compared to starved. Thus, the low RGM value in this study could be attributed to low feeding activity and breeding season of the fish species. Similarly, the Zihler's index in the present study indicated that both sizes and sexes fell under the category of low body mass which classified as carnivorous (Kramer and Bryant, 1995).

4.2 Condition factor

The average condition factor (CF) obtained in this study between the sizes and the sexes across seasons ranges from 0.58±0.00 (small size male) to 0.78±0.042 (big size male). However, LeCren (1951) established that good growth condition is deduced when $K_n \geq 1$, while the organism is in poor growth condition compared to an average individual with the same length when $K_n < 1$. This is an indication that regardless of the sizes, sexes and seasons, *H. odoe* in Eleyele Lake show poor condition which could be attributed to poor environmental condition. Other factors that contributed to poor growth condition aside pollution include spawning period, shortage of food supply, disease/parasitism, poor physiological state of the fish and fishing pressure (Karim *et al*., 2016). Akponine and Ayoade (2012) and Oso *et al*., (2011), reported similar low CF in *H. odoe* from Eleyele Lake and Ado-Ekiti Reservoir, respectively. Kareem *et al*., (2016) however obtained high CF for male (1.23) and female (1.24) *H. odoe* in Eleyele Lake, Ibadan. Also, the findings of Adedokun *et al*. (2013), who recorded mean condition factor of 1.58 for *H. odoe* from Ogbomosho reservoir contradict the present results.

4.3 Gastro-intestinal structure and Digestive enzymes

Morphology of small intestine is considered as the main indicator of normal gut histology, and any alterations in intestinal morphology may affect nutrient metabolizability and performance (Laudadio *et al*., 2012). Wang and Peng, (2008) noted that the villi and crypts of the absorptive epithelium play an important role in the final stage of nutrient digestion and assimilation. The increase of villi height in this present study was similar to the intestine of a typical predator and a predator-facultative benthophage such as pike (*Esox Lucius*) and burbot (*Lota lota*) as stated by Nasruddin *et al*., (2014). This result coincides with the finding of Adejonwo *et al*., (2020) who observed increase in villi height in African catfish fed mushroom stalk meal supplemented diets. Also, the higher cryptal depth and width in big sizes of both sexes in the current study indicates efficient digestibility and absorption in the ingested feed as highlighted by Zhou *et al*. (2010). Tengjaroenkul *et al*., (2000) elucidate that the distribution and intensity of intestinal enzyme activity along the gut varies with feeding habits and intestinal morphology. The rate at which fish digest their food is of primary importance in determining feeding rates, frequency, and ration size (Borlongan *et al*., 2002). Umalatha *et al*., (2016) also noted that the best digestive capacity of the fish occurs during the early stage of their development. In the current study, there was high level of amylase in small sizes of both sexes compare to the big sizes during both seasons. This could be because of starch digestion and glucose absorption which occurs mainly in the part of the intestine of small size of both sexes during wet and dry season. These findings show a similar trend in amylase activity reported in *Sarotherodon galilaeus* (Akintunde, 1984). However, most reports on α-amylase in fishes conclude that herbivorous or omnivorous fishes have higher α-amylase activities than carnivorous fishes (Horn *et al*., 2006).

Pancreatic secretions such as trypsin and chymotrypsin play an important role in protein digestion (Lazo *et al*., 2007). The present study reveals no significant variation of chymotrypsin activity of the intestine between different sizes and sexes, which is in tandem with the findings of Umalatha

et al. (2016). Also, the higher chymotrypsin value recorded in small size male during dry season could be attributed to high temperature which has been reported to increase the metabolic rate of living organisms as noted by Wootton (1984). Zambonino-Infante *et al*. (2007) referred that optimum energy allocation is affected in such a situation, and the energetic balance is redirected to maintenance rather than growth. The maltase value in small size male *H. odoe* during the wet season was higher than the values recorded in both sizes of female and big size of male in this current study. This is an indication that complete utilization of starch occurs mostly in small size male *H. odoe*. This observation is in line with the findings of Clark *et al*., (1984) who reported demonstrated substantial activity of maltase in the whole gut extracts of Dover sole, *Solea solea*. The high sucrase, pepsin and lipase activities found in both sizes and sexes in the current study, suggested the consumption of protein- and fat-rich food items by this species.

Conclusion

The study identified six major diets utilized by *H. odoe*, which classified it as carnivores and opportunistic feeder. The big size of both sexes shows high numerical food abundance but no significant variations in gut repletion index between seasons. The slight changes in the dietary habit as reflected in gut parameters of both sizes and sexes of *H. odoe* in Eleyele Lake indicate carni-omnivorous feeding habit. The condition factors of both sizes and sexes in both seasons is less than 1, which confirm poor growth condition in the Lake. The gastrointestinal structure of the fish made clear an intestine of a typical predator and a predator-facultative benthophage. Generally, *H. odoe* show proper digestion of carbohydrate, protein- and fat-rich food items but these attributes did not manifest in their growth performance indices. This study thus suggests regular monitoring and amelioration of anthropogenic disturbances in the Lake basin.

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