ASPECTS OF THE BIOLOGY OF *Heterotis niloticus* CUVIER 1829 (OSTEOGLOSSIFORMES: OSTEOGLOSSIDAE) IN THE ANAMBRA FLOOD RIVER SYSTEM, NIGERIA

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ABSTRACT

Studies on some aspects of the biology of Heterotis niloticus in Anambra river were carried out for 22 months. Analysis of the stomach content of 546 species of H. niloticus in Anambra river established the preponderance of plantivorous crustacean, copepods and cladocera throughout the four maturation stages examined. Seasonal variations occurred in the dietary components of the fish. The length-weights relationship and the relative condition revealed that females had better condition. The mean length and weight were 94.5 ± 60 cm (29 – 167 cm) and 120 ± 21.8g (10 – 250g) respectively. A sex ratio of 1:0.8 (M: F) at Otuocha was more pronounced than at Ogurugu and Nsugbe. Digestive enzyme assays in the different gut regions (oesaphagus, stomach, pyloriccaeca, ileum and rectum) of H. niloticus showed an array of glycosidase (amylase, sucrase, malatase, lactase, cellulase); protease, (pepsin, trypsin, chymotrypsin) and lipases. The pattern of spread and relative activity of the enzymes is consistent with its planktophagous diet. Haematocrit values, haemoglobin concentrations, erythrocyte and leucocytes counts, mean cells haemoglobin concentrations, plasma protein, glucose, albumin and inorganic ion (sodium, chloride, calcium, potassium, magnesium, phosphorus) for H. niloticus were established. Correlations were found between some blood parameters and standard length.

Keywords: *Heterotis niloticus*, Length-weight relationship, Stomach content, Digestive enzymes, Haematology

INTRODUCTION

The freshwaters of the forested region of Nigeria supports large population of the West African Osteoglossid fishes. *Heterotis niloticus* is an important element in the artisanal fishery of the Anambra river basin. The fish is a regular feature in the Anambra river basin and is highly cherished because of its socio-cultural benefits, particularly among the Igbo people of Nigeria. Considerable biological studies have been undertaken and documented on some economically important tropical fish families in Anambra river basin, for instance, Clariidae (Eyo and Mgbenka, 1992; Mgbenka and Eyo, 1992; Ezenwaji and Inyang, 1998), Distochontidae (Nwani, 1998), Clupeidae (Ezenwaji and Offia, 2003) among many others. Studies on aspect of the biology of *Heterotis* are vast (Balogun, 1980; Lawal, 1991; Ugwumba, 1992; Akegbejo-Samsons, 1995; Fagbenro *et al.,* 2000), nevertheless non from the Anambra river basin. To be able to manage a resource of such commercial importance, knowledge of its biology is imperative. The study of dietary habits of fish, based on stomach content analysis, is widely used in fish ecology as an important means of investigating trophic relationships in aquatic communities. The ability of an organism to digest a given material is dependent on the presence of appropriate enzymes. No information is available on the quantitative and qualitative of assays of digestive enzymes in the gut *of H. niloticus* of Anambra river, in contrast to other African freshwater fishes whose digestive enzymes assays have been established (Uys and Hecht, 1987; Olatunde *et al*., 1988; Fagbenro, 1990; Fagbenro *et al.,* 1993; Fagbenro *et al.,* 2000). The use of haematological characteristics in diagnosing the health status of fish under captive rearing is well established. The knowledge of the haematological profile of a fish also indicates its dietary sufficiency and physiological stress. The haematological profile of a few African fish species have been reported (Olatunde *et al*., 1988; Fagbenro, 1990; Fagbenro *et al.,* 1993; Fagbenro *et al.,* 2000). Despite the foregoing, it does appear that no investigation has been conducted on the aspect of biology of *H. niloticus* of Anambra river basin. Thus, this study, which forms part of a larger and on-going investigation, on the fish and fisheries of the river basin, addresses aspects of the biology of the species viz; qualitative and quantitative food composition, occurrence, distribution and relative activities of glycosidases, proteases and lipases in the different gut regions, haematological and serological profiles, age, growth and reproduction.

MATERIALS AND METHODS

Study Area: The Anambra river is about 207.4k m in length and 14014km^2 in area (Awachie, 1976). It rises from the Ankpa hills (ca. 305 – 610m above sea level), flows in southerly direction through a narrow trough that gradually broadens as it courses down. It crosses the Kogi/Anambra States boundary a bit north of Ogurugu, then meanders through Ogurugu

to Otuocha and Nsugbe. From there it flows down to its confluence with the Niger at Onitsha. The basin lies between latitude $6^0 10^1$ and $7^0\ 20^1$, longitude $6^0\ 35^1$ and $7^0 40^1$ east of Niger river into which the Anambra river empties.

There are two main seasons, the dry season October/November – March and the rainy season (April – September / October) approximately corresponding to the dry and flood phases of the hydrological regime (Ezenwaji, 1986).

The vegetation is derived Guinea Savannah. Also the riparian vegetation, ecology and productivity of the river basin have been extensively studied (Awachie and Ezenwaji, 1981). The abundance and distribution of macroinvertebrates in the flood river system has been documented (Eyo and Ekwonye, 1995).

Sampling: Monthly *H. niloticus* were sampled at Ogurugu, Otuocha and Nsugbe stations, along Anambra river for twenty two months with 200 baited hook and line (no.17), baskets traps, seine gill nets of 3 cm stretched mesh in deep waters. The 200 baited hook and line, seine gill nets of 3 cm mesh size set overnight (1800 – 0700 h) in each sampling location were taken as unit efforts, and used to determine the distribution and abundance of the osteoglossid. Total length (TL) to nearest 0.1 cm and body weight to the nearest 0.1 g of each fish species were measured and the sex determined.

Age and Growth: The length-frequency data were grouped into 2-cm TL intervals and the length-based Powell-Wetherall method (Sparre and Venema, 1992) was employed in estimating the asymptotic length ($L\infty$) of the von Bertalanffy growth function from the linear relationship, $L = a + bl$, where L = mean length of the fully recruited fish computed from L upward, a and b being regression constants. The growth coefficient (K) was derived from Ursin (1994) thus: $K = 0.27 \exp(0.038T)$, where T = 27.5C (Ezenwaji, 1982). The age at length zero (to) was estimated from the empirical relationship of Pauly (1979) thus: $\log(-to) = -0.3922 - 0.2752 \log L\infty - 1.038 \log K$. Mean lengths at age were then estimated from the resulting von Bertalanffy growth function. The length growth performance index (ǿ) was calculated according to Pauly and Munro (1984) thus: $ǿ = \text{Log } iK + 2\log L\infty$. The relationship of body weight (W) to TL was determined using the power curve ($W = aTL^b$). Relative condition factor (Kn) was estimated as ($Kn = W/aTL^b$ (Le Cren, 1951).

The length-weight relationships (LWR) were determined for the same species collected at different periods. These different estimates were considered separate 'population'. Fulton condition factor, k, was calculated as: $K = W/L^3 \times 100$. Where W = fish weight (g) and L = Fish length (cm).

Food and Feeding Habits: The stomach of each *H. niloticus* was dissected out and its degree of fullness estimated on 0 – 20 points scale; where 0, 2.5, 5, 10, 15 and 20 points were allotted to empty, trace, quarter-full, half-full, three quarter-full and fully distended stomachs respectively.

Stomach contents were sorted into categories and identified. The contents were further analyzed using relative frequency (RF) and point's method (Hynes, 1950; Hyslop, 1980). In the RF, the frequency of a particular food item in all stomachs was expressed as a percentage of the frequencies of all food items.

For the point's scheme, each stomach was allotted 20 points regardless of the fish size and these were shared amongst the various contents, taking account of their relative proportion by volume. The points gained by each food item in all stomachs examined were computed and expressed as a percentage of the total points of all food items. The point's scheme gave an indication of bulk contribution of each food category to the diet composition. %RF and %PP were then used to determine the index of food significance as follows: IFS = (% RF x % PP) / (Σ % RF x % PP) x 100 (Hyslop, 1980). Food items with IFS $\geq$ 3 % were regarded as primary, $\geq$ 0.1 to < 3 % as secondary, whereas food with < 0.1 % were regarded as incidental. The IFS data were used to compute diet breadth based on Shannon-Wiener function (H) as follows: $H_{(IFS)} = \Sigma (n_i/N) \text{Log}_e (n_i/N)$ (Shannon-Wiener, 1963). Where Ni = IFS of each food item, N = total IFS of all food items. Food richness was defined as the number of food items in the diet with IFS $\geq$ 0.1%.

Digestive Enzyme Assays: Twenty-three adult *H. niloticus* specimens (TL 29-167 cm) were kept unfed for 72 hours inside out door concrete cisterns in order to bring them to a similar physiological state as well as to ensure the emptiness of their entire gut. They were anaesthetized with 0.5 % MS 222 and dissected to remove the entire gut. The gut was later separated into anatomically distinct regions. The different gut regions were pooled and homogenized. The homogenates were then cold centrifuged (4 ^{0}C) at 1200 rpm for 5 minutes. The supernatants were used as crude extracts without further purification. Benedict's qualitative reagents were used for the qualitative assays of glycosidase (Olatunde *et al.*, 1988), while quantitative assays were conducted using the dinitrosalicyclate (DNS) methods (Plummer, 1978). Qualitative and quantitative assays of proteases followed the methods of Balogun and Fisher (1970).

Haematological and Serological Profiles: Twenty three live specimens (TL 32 – 51 cm) capture from the river basin were kept undisturbed in large glass aquaria (120 litre capacity) supplied with filtered and aerated tap water for two weeks of acclimation to laboratory conditions (pH 7.8, dissolved oxygen concentration >6 mg/l, water temperature 26 - 28.5 ^{0}C), prior to blood sampling. During the acclimatization period the fishes were fed 5 % of their body weight with 40.40 % crude protein fish diet (Eyo and Ezechi, 2004) in divided rations, twice daily.

Table 1: Abundance and percentage of occurrence (%FO) of *Heterotis niloticus* in the Anambra flood river system, Nigeria

Location	Forest plain habitat		Grass plain habitat		Marshy habitat		Location
	No	%FO	No	%FO	No	%FO	total
Ogurugu	16(0.8)	71	11(0.5)	68	19(12)	94	46(2.5)
Otuocha	12(0.5)	93	14(0.7)	80	16(0.8)	77	46(2.0)
Nsugbe	18(0.9)	86	19(1.0)	79	12(0.7)	82	49(2.6)
Habitat total	46[a]	32.6	44[a]	31.2	47[a]	33.3	141

Key: *%F0 = percentage frequency of occurrence, a = the figures in the same column or row with the same superscript are not significantly different p=0.05, values in parentheses = weight in kg*

Table 2: The relationship between body weight and total length ($W = a TL^b$) of the *Heterotis niloticus* from the Anambra flood river system, Nigeria

Length range		Sex	N	A	B	r^2	P
Min (cm)	Max (cm)						
59	**142**	**Female**	54	$3.9x10^{-3}$	2.978	0.970	<0.001
39	**150**	**Males**	48	$1.2x10^{-2}$	3.109	0.869	<0.001
98	**292**	**Both sexes**	102	$9.3x10^{-3}$	2.79	0.872	<0.001

Table 3: Sex ratio of *Heterotis niloticus* in the Anambra river basin

Month	Ogurugu			Otuocha			Nsugbe			Anambra river		
	M	F	Sex ratio	M	F	Sex ratio	M	F	Sex ratio	M	F	Sex ratio
January	19	11	1:0.6	21	13	1:0.6	-	-	-	10	26	1:0.7
February	7	2	1:0.3	13	6	1:0.5	-	-	-	15	5	1:0.3
March	-	-	-	5	7	1:1.4	-	-	-	5	7	1:1.4
April	12	13	1:0.6	13	7	1:0.5	-	-	-	34	26	1:0.8
May	23	21	1:0.9	16	19	1:1.2	8	11	1:14	47	51	1:1.1
June	29	11	1:0.4	15	18	1:1.2	20	14	1:0.7	64	43	1:0.7
July	35	26	1:0.7	26	13	1:0.5	-	-	-	11	39	1:0.6
August	24	11	1:0.5	22	20	1:0.9	-	-	-	46	31	1:0.7
September	-	-	-	20	27	1:1.4	8	13	1:1.6	20	40	1:2.0
October	-	-	-	19	29	1:1.5	-	-	-	19	29	1:1.5
November	-	-	-	9	6	1:0.7	-	-	-	9	6	1:0.7
December	32	17	1:0.5	30	4	1:0.1	-	-	-	62	21	1:0.3
Total	181	112	1:0.6	209	169	1:0.8	36	38	1:1.1	342	324	1:0.7

All fish were considered healthy on the basis of their appearance and absence of obvious signs of disease. No sexual selection was made. The fish were caught individually using hand net and anaesthetized with 0.5 % MS 222. Blood was collected from the caudal vein of each fish using heparinized disposable syringes and hypodermic needles. Haematocrit (PCV) was measured after centrifugation at 15000 rpm (MSE Microcentrifuge). Haemaglobin (HB) content, leucocyte count (WBC), erythrocyte count (RBC), total plasma protein, plasma glucose, plasma albumin and plasma ion (Na, CL, Ca, Mg, K, P) concentrations were determined using the methods of Svobodova *et al.* (1991). Blood grouping was performed based on agglutination tests, while the genotype was determined by haemoglobin electrophoresis (Delany and Garratty, 1969).

Data Analysis: Data for corresponding months were pooled together for analysis. Abundance data were analyzed by two-way analysis of variance (ANOVA).Food composition and sex ratio were analyzed by students-test and X^2 test respectively (Bailey, 1994).

Differences were considered significant at 5% level of probability. The methods described by Ogunbiyi and Okon (1976) were used to determine lipase activity both qualitatively and quantitatively. Controls were run simultaneously for all assays. Regression analysis was carried out between the various haematological parameters and standard length. The coefficient of regression (r) was then analyzed for statistical significance by student's t-test (p=0.05).

RESULTS

Distribution and Abundance: The number of *H. niloticus* in the various stations showed no significant difference (P = 0.05). The osteoglossid fish appeared to be evenly distributed, and frequently occurred in all the stations studied. These osteoglossids occur throughout the year but with the peak from June – August (Table 1).

Size Range: The length of *H. niloticus* ranged from 29.00 – 167.00 cm Total Length (mean 94.5 $\pm$ 6.00 cm TL), while the weight ranged from 10.00 – 250.00 g (mean 120 g $\pm$ 21.8 g). Sexes were not different in lengths and weights (p>0.05) (Table 2).

Table 4: Relative importance and occurrence of food items in stomachs of *Heterotis niloticus* fry, fingerling, juveniles and adult in the Anambra river

Diet and fish variables	Stage 1 post fry 10.3 cm	Stage 11 fingerling 17.1 cm	Stage 111 juveniles 25.0 cm	Stage IV adults 31.8 cm
Copepods	38.5	40.0	50.0	50.0
Cladocera	38.0	45.6	49.0	52.0
Ostracoda	30.0	28.5	36.5	38.1
Diatoms	20.1	28.0	38.5	39.6
Protozoan	15.5	-	20.6	27.8
Insect parts	26.1	-	10.5	9.7
Bivalves	20.1	8.6	10.5	13.0
Annelids	21.6	7.1	9.0	8.9
Plant remains	-	10.5	9.7	10.0
Plant detritus	-	8.6	10.4	10.8
Sand	-	7.1	15.5	11.9
Unicellular algae	-	8.0	11.7	12.0
Total no of Fish Examined	60	60	60	71
Number with food	35	41	46	42

Ta**ble 5: Trophic spectrum of the diet for all sizes of *Heterotis niloticus***

Diet	% PP	% RF	IFS
Copepods	18.45	9.70	28.15
Cladocera	18.01	12.69	30.70
Ostracoda	14.06	5.22	19.28
Diatoms	16.61	16.67	33.28
Protozoan	9.40	14.68	24.08
Insect parts	8.90	5.70	14.60
Bivalves	6.01	8.00	14.01
Annelids	2.00	6.01	8.01
Plant remains	7.91	14.92	22.83
Plant detritus	2.46	3.48	5.94
Sand	2.64	2.74	5.38
Unicellular algae	10.46	14.18	24.64

Age and Growth: From the length-based Powell-Wetherall method, L = 36.4 cm Tl (or 340mm TL). Estimated K and t_o were 8 yr^1 and -17 yr^1, respectively.

Sex: The monthly sex ratio ranged from 1:0.1 for Otuocha in December to 1:1.6 for Nsugbe in the month of September, the overall sex ratios of *H. niloticus* in Anambra river ranged from 1:0.3 to 1:1.5 with a modal sex ratio of 1:0.7 in favour of the males (Table 3). The Otuocha and Ogurugu stations showed more pronounced sex ratio similarity than the Nsugbe station.

Food and Feeding Habits: One hundred and sixty four (164) (65.34 %) of the 251 stomachs examined contained 12 different food items (Table 4). Out of the food items isolated with increasing maturity, foods of animal origin were most important in the juvenile's diet than those of plant origin (Table 4). A shift from carnivorous to omnivorous dietary pattern occurred with age (Table 4).

The trophic spectrum (Table 5) of the diet for all sizes of *H. niloticus* indicated that the crustacean (Cladocerans, Copepods and Ostracoda) were more dominant in juvenile's and adult diets. The insect parts were of primary importance as food items fry, juveniles and adult stages respectively. Other food items, plant detritus, plant remains, sand and unicellular algae were of secondary importance. The plantivorous crustacean particularly the copepods and cladocera form the main food throughout the four stages of fish examined. The food items were mostly available during the dry season (Table 6).

Qualitative food composition was higher in the dry than in the wet season (Table 7). Copepods, ostracods, chironomid larva, plant remains and sand were significantly more in the dry than in the wet season. The converse was true for the cladocera, insect parts, bivalves, protozoan and unicellular algae. The occurrence of other food items was not different between the seasons. Food richness and diet breath were dependent on season.

Digestive Enzyme: Enzymes detected in the different regions of *H. niloticus* gut, their distribution and activity varied along the gut length. Significant quantities of glycosidase were detected in the oesophagus, stomach, pyloric caeca, and duodenum. Cellulase activity was recorded only in the pyloric caeca (Table 8). The protein hydrolyzing enzymes found in the stomach are pepsin-like while those in the pyloric caeca are alkaline proteases, possibly trypsin and /or chymotrypsin. Lipase activity occurred along the entire gut length with peaks in the pyloric caeca and duodenum (Table 8). Generally, no enzyme activity occurred in the rectum.

Haematological and Serological Profiles: The mean values for the blood parameters are presented in Table 9. The linear regression analysis of the blood parameters as functions of total length gave the following relationships: PCV (%) = 9.56 + 0.83 TL (cm), r=0.187, p = 0.05; RBC ($10^{12/l}$) = 0.18 + 0.05 TL (cm), r = 0.007, p = 0.05; Plasma Na (nM) = 7.64 + 0.19 TL (cm), r = 0.285, p = 0.05 and MCHC (g/dl) =1.769 x 10^{-3} + 8.24 x 10^{-6} TL(CM); r = -0.143, P = 0.05. The results of the serological studies (Table 10)

Tables 6: The monthly IFS of *Heterotis niloticus* in Anambra river

Diet and Fish variables	N	D	J	F	M	A	M	J	J	A	S	O
Copepods	2.16	0.40	0.20	0.01	-	11	0.30	-	2.01	0.01	-	0.29
Cladocera	2.10	0.40	-	0.69	0.61	-	-	0.1	0.3	-	-	11.4
Ostracoda	0.34	0.13	-	0.31	0.09	-	-	0.5	-	-	-	0.32
Diatoms	0.6	0.19	0.1	1.79	-	8.70	0.1	0.3	-	35.22	0.31	1.10
Protozoa	0.31	0.17	0.21	-	-	-	-	-	0.61		0.78	0.86
Insect parts	0.86	0.10	-	-	-	-	-	-	-	0.01	0.05	0.18
Bivalves	1.10	0.31	0.25	0.53	0.31	-	-	-	-	1.11	-	0.86
Annelids	0.27	0.20	-	-	-	0.01	-	0.4	-	3.75	-	-
Plant remains	0.40	0.37	0.09	0.01	0.91	2.0	-	0.6	-	-	-	2.02
Plant detritus	1.12	0.61	0.55	0.61	0.2	-	-	-	-	0.03	-	1.62
Sand	0.36	0.54	0.40	-	-	-	-	-	0.3	10.06	30.0	-
Unicellular algae	0.17	0.08	0.33	-	-	-	-	0.8	-	-	-	0.18
Food richness	12	12	8	7	5	4	2	6	4	7	4	10
Diet breath	1.72	1.20	1.50	1.63	1.47	1.80	1.0	0.79	1.51	1.37	1.35	1.79

Table 7: Seasonal variation in IFS of *Heterotis niloticus* in Anambra river

Diet and Fish variables	Dry	Wet	P
Copepods	3.01	-	<0.05
Cladocera	1.71	-	
Ostracoda	3.62	0.01	
Diatoms	2.91	0.10	<0.05
Protozoa	0.71	-	
Insect parts	0.88	0.03	
Bivalves	0.07	-	
Annelids	0.09	-	
Plant remains	17.81	0.08	<0.05
Plant detritus	3.61	-	
Sand	24.08	0.16	
Unicellular algae	0.09	-	
Food richness	13	5	
Diet breadth	1.86	1.03	

showed a similar anti-gene reaction to that observed in human blood. The predominant blood group of *H. niloticus* is O+ (90%), while the genotypes are AA (51%) and AS (49%).

DISCUSSION

The abundance of *H. niloticus* in Anambra river may be influenced, to variable extent, by number of factors, including food availability, short life span, high natural mortality and environment. Abundant foods may also permit rapid growth and high recruitment. Early sexual maturity and all year round breeding in fishes are generally survival strategies and adaptations aimed at perpetuating the species in response to high fishing and/or natural mortality. The survivors prey on the rich variety of food available in the river; they grow very fast and become recruited into the fishery. It seems probable that it is in this way that large numbers of *H. niloticus* are maintained in the Anambra river. While a fairly good knowledge of the breeding biology of *H. niloticus* is beginning to emerge in Nigerian lentic and lotic habitats, we still need as Marshall (1993) noted for *Limnothrissa miodon*, to ascertain the environmental factors determining reproductive success, the effect of fishing on the sexually mature individuals and the relationship between stock and recruitment. Furthermore, knowledge of other demographic characteristics such as (growth and mortality) of *H. niloticus* is also important in order to gain an overall understanding of factors determining its abundance in the Anambra River.

Fish growth is determined by the combined effects of food quality and quantity. Analysis of food composition in stomach of *H. niloticus* from the Anambra river basin showed a predominant microphagous diet plus insect larvae. Coupled with the possession of numerous densely-packed gill rakers (developed into fine sieves), this suggests a filter-feeding habit. Brief accounts of the dietary habit of *H. niloticus* in Epe Lagoon (Balogun, 1980), Badagry creek (Lawal, 1991), Eleyele Reservoir, Oba Dam (Ugwumba, 1992) and coastal wetlands of southwest Nigeria (Akegbejo-Samsons, 1995) confirmed *H. niloticus* as a micro ore. The inclusion of sand grains was possibly an accidental ingestion along with insect larvae, annelids, prawns and bivalves, while the high occurrence and prominence of detritus (Tables 4, 5, 6) suggest frequent bottom feeding on benthic invertebrates, which dominated the diet in the river habitat. It was evident that *H. niloticus* was strictly a planktonic microphage in the lentic habitats, while it adopted a mud-eating microphagous habit in the river. Ecologically, these habits seem to be common and characteristic of osteoglossid fish species (Akintunde, 1977). This adaptiveness to the natural diet is responsible for the success of *H. niloticus* in the various habitats. *H. niloticus* exhibit, wide plasticity in their feeding, primarily consuming a combination of two or more of crustaceans, insects, plankton and plant detritus, depending on availability and abundance of these foods the main food throughout the three stages of fish that were examined. Changes observed in food composition and feeding habits of fish in relation to the size or age of fish are biological phenomenon, which are common in many tropical fish species (Hellwell, 1972). Bhatt (1972) observed similar trend

Table 8: Summary of qualitative and quantitative assays of digestive enzymes in the gut of *Heterotis niloticus*

Digestive enzymes	Oesophagus	Stomach	Pyloric caeca	Duodenum	Ileum	Rectum	SE
GYCOSIDASES[1]							
A-amylase	7.42	8.04	192.5	165.9	87.3	ND	2.69
Sucrase	ND	11.6	16.0	32.6	29.0	ND	0.58
Maltase	ND	42.7	49.1	40.6	48.0	ND	1.08
Lactase	ND	26.2	34.1	37.0	31.2	ND	0.64
Cellulose	ND	ND	21.8	ND	ND	ND	-
PROTEASES[2]	ND	125.8	240.8	262.0	102.7	ND	3.29
LIPASE	ND	40.5	287.4	243.0	110.4	ND	3.67

ND=not detected; [1] mg glucose/min/mg protein at 37 ^{0}C; [2] change in optical density at 595nm/hr/mg of L-tyrosine/hr at 37^{0}C; 3 =mill equivalents of fatty acids /mg protein/hr @ 37^{0}C; SE = standard error

Table 9: Haematological characteristics of *Heterotis niloticus* in Anambra river

Haematological parameter	Mean (±SD)	Range
Total length (TL) (cm)	30.22 (0.92)	30.4-39.5
Body weight (Wt) (g)	419.40 (31.17)	300.8-610.1
Erythrocyte (RBC) (10 $^{12/1}$)	1.50 (0.02)	0.58-2.17
Leucocytes count (WBC)(10 9/1)	57.2(4.9)	53.9-58.7
Haematocrit (PCV) (%)	28.12 (2.98)	13-39
Hemoglobin concentration (Hb) (g/dl)	4.06 (0.43)	2.2-6.2
Erythrocyte sedimentation rate (%)	31.16(7.84)	11-80
MCV (mean corpuscular volume) (11)	187.16 (12.79)	128-304
MCH (mean corpuscular haemoglobin) pg	19.27 (1.28)	28-36
MCHC (mean corpuscular haemoglobin concentration) (g/dl)	0.14 (0.01)	0.11-18
Plasma protein (g/l)	53.6 (5.4)	47-78
Plasma glucose (mg/dl)	57.38(4.17)	46-79.0
Plasma albumin (mg/g)	3.87 (.75)	0.3-6.9
Na (mM)	112 (3.6)	87-127
Cl (mM)	76 (1.07)	6.4-145
K (mM)	18.45 (1.02)	15.3-27.6
Mg (mM)	7.23(0.46)	5.4-9.2
P (mM)	521.23(49.10)	196.2-682.1
Ca (mM)	0.87(0.12)	0.54-1.12

Table 10: Percentage occurrence of serological characteristics in *Heterotis niloticus*

Blood group	
A	-
B	-
AB	-
O+	91
O-	9
Genotype	
AA	-
AS	51
SS	49
Agglutinations test	
+ve	-
-ve	100

in India catfish, *Mystus seeghala* (Sykes) and *Mystus vittatus* (Block) respectively. Fagade and Olaniyan (1973) noted similar occurrence in the most African shad, *Ethmalosa fimbriata* (Bow dish). However, the dominance of plantivorous crustacean was established in the study irrespective of the additional food items that emerged later.

Except for the occurrence of amylase in the oesophagus, Akintunde (1985) observed a similar general pattern of digestive enzyme distribution in *Sarotherodon galilaeus* Linnaeus 1758. Worthy of note is the occurrence of enzyme secretion in the oesaphagus of *H. niloticus* (Table 8) which is rare, having been reported in only a few fish species (Kawai and Ikeda, 1971). The variety of glycosidase indicates the ability of *H. niloticus* to digest a wide range of carbohydrate food components. Cellulase activity was recorded only in the pyloric caeca and its origin is attributed to gut micro flora ingested along with the detritus which featured prominently in the diet (Table 8). Detritus-inhabiting microflora (which produces microbial cellulase) imparts the ability to digest cellulose to their host animals (Chow and Halver, 1980).

The relatively high activity levels of proteases, particularly in the pyloric caeca and duodenum (Table 8), were not surprising in view of the large proportion of protein components (mainly zooplankton) in the diet (Table 8). Pepsin would hardly be expected to occur in the two distal gut regions since it is active only in strongly acid media

found in the stomach. Lipase distribution and activity along the entire gut (Table 8) was also reported in *Clarias isheriensis* Sydenham, 1980 (Fagbenro, 1990). From the foregoing, it is evident that *H. niloticus* is enzymatically well equipped to digest the carbohydrate, protein and lipid components of its diet.

Generally, the ranges of the blood parameters determined for *H. niloticus* (Table 9) are similar to those reported for Africa fresh water catfish species, except for those of erythrocyte count (RBC) and haematocrit (PCV) which are higher in *H. niloticus.* The mean haematocrit value of *H. niloticus* is comparable to those of African clariid catfishes, *C. isheriensis* (Kori-Siakpere, 1985). *C. gariepinus* Burchell, 1822 and *Heterobranchus longifilis* Valenciennes, 1840 (Erondu *et al.,* 1993). The mean RBC value for *H. niloticus* was lower than those reported for *Heterobranchus bidorsalis* (Erondu *et al.,* 1993; Fagbenro *et al.*, 1993) but comparable or slightly higher than the values reported for other catfish species *C. isherensis*, *C. gariepinus* and *Chrysichthys nigrodigitatus* (Kori-Siakere, 1985; Erondu *et al.,* 1993). Except for *H. bidorsalis,* the mean leucocytes count (WBC) value of *H. niloticus* is higher than those reported for freshwater fishes by Erondu *et al.* (1993).

The high values of erythrocyte count and haemoglobin concentration (Table 9) reflect a high oxygen carrying capacity of the blood which is consistent with the correlation of haemaglobin concentration and fish activity. As suggested by Lenfant and Johansen (1972), haemaglobin concentration is higher in the fishes capable of aerial respiration. *H. niloticus* can tolerate very low values of dissolved oxygen because it is able to undertake aerial respiration via the air-bladder (D'Aubenton 1955).Thus the high Hb values in *H. niloticus* are indicative of its air-breathing character and high activity. The results of the serological studies (Table 10) showed similar anti-gene reaction to that observed in human blood. The predominant blood group of *H. niloticus* is O+ (90%). While the genotypes are AA (51%) and AS (49%). These may suggest the use of *H. niloticus* as animal model for medical sciences research involving humans.

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