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Haematological and Serum Biochemical Profiles of *Heterotis niloticus* (Cuvier, 1829) from Lake Alau, Maiduguri, Nigeria

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ABSTRACT

Heterotis niloticus, a commercially important fish species exploited in Nigerian waters is currently been considered as a candidate for aquaculture. Therefore, hematological parameters of the fish are investigated to assess its health status for sustainable production in Nigeria. Thirty *H. niloticus* weighing 315.2 to 476.5 g were randomly collected from fishers catch. Blood samples were taken from caudal peduncle to assess the White blood cells (WBC), red blood cells (RBC), packed cell volume (PCV), hemoglobin (Hb) and serum biochemical parameters such as Protein, glucose, creatinine, cholesterol, urea and alkaline phosphatase (AP) using standard laboratory techniques. The mean values of RBCs, WBCs, Hb and PCV were 4.71±1.17 $x10^{12}$ l^{-1}, 10.84±4.48 $x10^{9}$ l^{-1}, 12.31±0.80 g dl^{-1} and 41.0±0.04%, respectively while biochemical indices were: protein, 30.57±4.28 g l^{-1}; glucose, 8.51±1.56 mmol l^{-1}; creatinine, 66.00±6.32 µmol l^{-1}; cholesterol, 2.76±0.69 mmol l^{-1}; urea, 3.87±0.30 nmol l^{-1} and AP, 22.29±7.09 U l^{-1}. The haematological and biochemical parameters investigated were within standard range for healthy fish. This study thus, provides baseline information on the physiological status of *Heterotis niloticus* in Lake Alau.

Key words: Haematology, Serum, Fish health, Blood profile, *Heterotis niloticus*, Lake Alau

INTRODUCTION

The African bony tongue, *Heterotis niloticus* (Cuvier, 1829) is a large fish that is widespread in rivers and lake system in many parts of Africa (Moreau, 1982) and especially in Lake Alau. The fish belongs to the family Arapaimidae of the order Osteoglossiformes, and it is monospecific (Adite, 1987). *Heterotis niloticus* is predominantly planktivorous (Olaosebikan and Raji, 2013). However, Adite *et al*. (2005) reported it as an omnivore. The differences in food habits of *H. niloticus* from different habitats suggest a degree of trophic plasticity of this species.

Fish well-being is impacted by pollution, water quality and microorganisms in natural habitat among other factors. They adapt somewhat to adverse conditions by changing their physiological activities. Increasing scientific, political and public attention is therefore being paid to fish welfare, especially as regard the quality of life and state of well-being in commercial production systems (Huntingford *et al*., 2006). Various risks factors to fish welfare (stressful husbandry practices, disease, water quality) have been extensively discussed, but establishing what is acceptable for the fish and how to quantify welfare using relevant operational indicators remains a major challenge (Ashley, 2007).

Hematological parameters are considered important indicators of the fish health status (De Pedro *et al*., 2005). In general, blood profile gives important information on fish nutritional, physiological and health conditions. Hence, the haematological status reflects animal physiological processes. According to Lataretu *et al*. (2012), the environmental conditions of fish, especially water quality, can influence the packed cell volume (PCV), red blood cells count (RBC), erythrocyte count, white blood cells count (WBC) and haemoglobin (Hb). Also, serum *biochemical condition* provides information on state of

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internal organs, electrolytes, proteins as well as nutritional and metabolic parameters (Newman *et al*., 1997).

In tropical fish, normal ranges of various blood parameters have been established by different scientists including Peres *et al*. (2015*) in Solea senegalensis,* Abalaka (2013) in *Clarias gariepinus*, Onyia *et al*. (2013) in *Heterobranchus bidorsalis,* Owolabi (2011) in *Synodontis membranacea,* Adebayo et al. (2007) and Kori-Siakpere *et al*. (2005*)* in *Parachanna obscura,* Hrubec *et al*. (2000) in Oreochromis hybrid, Fagbenro *et al*. (2000) in *Heterotis niloticus* and Bhasker and Rao (1989) in *Chanos chanos*. These scientist's opinion as regards the normality levels of various blood parameters in fish are divergent. Thus, Peres *et al*. (2015) recommended the ranges of 12 – 26% for PCV, 2.8 – 6.0 g dl^{-1} for Hb, 90 - 97% for RBC, 4 – 10% for WBC, 2.6 – 6.3g dl^{-1} for total protein, 1.0 – 2.3 for albumin, 19.0 – 86.0 mg dl^{-1} for glucose, 93–598 U l^{-1} for alkaline phosphatase, 118–605U l^{-1} for aspartate aminotransferase, 0.1 to 0.9 g dl^{-1} for cholesterol, 124 to 202 mmol l^{-1} for sodium and 1.1 to 4.6 mmol l^{-1} for potassium in normal, healthy fish. Kori-Siakpere *et al.* (2005) confirmed the mean blood haemoglobin concentration of 5.70 g dl^{-1}, mean PCV of 19.20 %, mean RBC of 1.67 x 10^{12}/L, mean WBC of 19.07 x 10^3 mm^{-3}, mean total plasma protein of 4.45 g $dl^{-1}$and mean plasma glucose of 67.42 mg dl^{-1}, for a typical healthy fish.

Hrubec *et al*. (2000) reported the range of 1.91 – 2.83 (2.31) x 10^6 l^{-1} for RBC, 27 – 37 (33) % for PCV, 21,559 – 154,690 (75659) μl^{-1} for WBC, 7.0 – 9.8 (8.2) g dl^{-1} for Hb, 557 – 9,873 (1,805) μl^{-1} for neutrophils, 400 – 4,286 (1,520) μl^{-1} for monocytes, 35 – 1,645 (334) μl^{-1} for eosinophils, 4.8 – 7.8 (6.1) g dl^{-1} for plasma protein, 1.3 – 2.6 (1.8) g dl^{-1} for albumin, 0.1 – 0.5 (0.2) mg dl^{-1} for creatinine, 30 – 69 (46) mg dl^{-1} for glucose, 110 – 318 (189) mg dl^{-1} for cholesterol, 15 – 39 (22) U l^{-1} for ALP, 9 – 102 (26) U l^{-1} for AST, 139 – 160 (151) mEq l^{-1} for sodium, 3.5 – 5.4 (4.3) mEq l^{-1} for potassium and 128 – 142 (136) mEq l^{-1} for chloride in Oreochromis hybrid. *Onyia et al. (2013) gave the ranges of* 5.05±0.17 – 5.2±0.26 ×10^{10} l^{-1} for RBC, 6.858.33±828.86 – 6.910±801.46 ×10^9 $l^{-1}$for WBC, 51.93±14.82 – 53.4±10.11 % for PCV, 18.43±4.36 – 53.4±10.11 % for Hb in normal healthy *Heterobranchus bidorsalis* in the Northeast Nigeria.

Furthermore, there are also report of individual variation in the blood parameters of *Heterotis niloticus* from different habitat in the tropics. For instance, RBC is 1.50±0.02 (0.58 – 2.17) 10^{12} l^{-1}, WBC is 57.2±4.9 (53.9 – 58.7) 10^9 l^{-1}, PCV is 28.12±2.98 (13 – 39) %, Hb is 4.46±0.43 (2.2 – 6.2) g dl^{-1}, total protein is 57.0±6.7 (50 – 83) gl^{-1}, glucose is 61.46±5.29 (41.0 – 82.0) mg dl^{-1}, albumin is 4.76±0.83 (0.4 – 7.5) mg dl^{-1}, sodium is 117±4.7 (97 – 139) mM and potassium concentration of 21.7±1.05 (18.3 – 29.9) mM in *H. niloticus* from Southwest Nigeria (Fagbenro *et al*., 2000), while in *H. niloticus* from Southeast Nigeria as reported by Odo *et al*. (2009), total protein is 53.6±5.4 (47 – 78) gl^{-1}, glucose is 57.38±4.17 (46.0 – 79.0) mg dl^{-1}, albumin is 3.87±0.75 (0.3 – 6.9) mg/dl, sodium is 112±3.6 (87 – 127) mM and potassium concentration of 18.45±1.02 (15.3 – 27.6), RBC counts is 1.50±0.02 (0.58 – 2.17) 10^{12} l^{-1}, Hb concentration is 4.06±0.43 (2.2 – 6.2) g dl^{-1}, WBC is 57.2±4.9 (53.9 – 58.7) 10^9 l^{-1} and PCV is 28.12±2.98 (13 – 39) %.

However, there is paucity of information on haematological profile of *Heterotis niloticus* from Lake Alau, Northeast Nigeria. This study therefore aims to establish baseline haematological parameters for *H. niloticus* from Lake Alau, which can be used as reference point in comparative studies and in monitoring

MATERIALS AND METHODS

Haematological parameters

Thirty healthy adult *H. niloticus* (380.61±47.94 g) were collected from fishers' landings in Lake Alau (lat. 11°44 N and long. 13°10 E) for three months. Five (5) ml blood samples of were collected via caudal peduncle puncture from each of the sample using 2ml syringe fitted to 22-gauge hypodermic needle (Stoskopf, 1993). The blood was dispensed into ethylene diamine tetra acetic acid (EDTA).

Red blood cells (RBC) and White blood cells (WBC) counts were estimated using a Neubauerhaematocytometer and Hendricks (1952) diluting fluid for RBC and Shaw (1930) solution for WBC following Hesser (1960). Haemoglobin (Hb) concentrations were estimated using the Sahli-Helligehaemoglobin method as described by Hesser (1960). Packed cell volume (PCV) was estimated using a micro-haematocrit method as described by Hesser (1960). The erythrocyte indices (MCV, MCH and MCHC) were calculated as in Dacie and Lewis (2001):

Mean Corpuscular Volume (MCV) (fL) = $\frac{PCV}{RBC} \times 10$

Mean Corpuscular Haemoglobin (MCH) (pg) = $\frac{Hb}{RBC} \times 10$

Mean Corpuscular Haemoglobin Concentration (MCHC) (g dl^{-1}) = $\frac{Hb}{PCV} \times 100$

Serum biochemistry

Three (3) ml blood was also transferred into a tube containing Lithium Heparin (LH) anticoagulant for plasma biochemical analysis. The plasma obtained by centrifugation from the lithium heparinised samples was stored at 20°C until analyzed. The analytes determined includes glucose, total protein, albumin, cholesterol, sodium, potassium, chloride, bilirubin, creatine, uric acid, alkaline phosphatase (ALP), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) using the methods of Svobododa *et al*. (1991).

Data analysis

Data obtained were subjected to descriptive statistics (means and standard deviations) and One-Way Analysis of Variance (ANOVA) using SPSS 20.0.

RESULTS

Haematological parameters

The range and mean hematological values obtained for *Heterotis niloticus* from the study are as presented in Table 1. The Red Blood Cell counts has a range of 3.40 – 7.00 x 10^{12} L^{-1} and a mean value of 4.71±1.17 x10^{12} l^{-1} while White Blood Cell counts varies between 6.10 and 19.00 x10^9 l^{-1} with a mean value of 10.84±4.48 x10^9 l^{-1}. Pack cell volume range between 36.0 and 46.0 % with a mean value of 41.0±0.04 %.

Table 1. Haematological parameters of *Heterotis niloticus* from Lake Alau

Parameter	Mean (±SD)	Range	References	
			Odo *et al*. (2009)	Fagbenro *et al.* (2000)
RBC ($\times 10^{12} l^{-1}$)	4.71±1.17	3.40 – 7.00	0.58 – 2.17	0.58 – 2.17
WBC ($\times 10^9 l^{-1}$)	10.84±4.48	6.10 – 19.00	53.90 – 58.70	53.90 – 58.70
Hb (g dl^{-1})	12.31±0.80	11.30 – 13.50	2.20 – 6.20	2.20 – 6.20
PCV (%)	41.0±0.04	36.0 – 46.0	13.00 – 39.00	13.00 – 39.00
PLT ($\times 10^9 l^{-1}$)	83.40±6.87	75.00 – 94.00	–	–
Mon (%)	2.50±0.58	2.00 – 3.00	–	–
Lym (%)	50.00±8.25	38.00 – 59.00	–	–
Neut (%)	47.00±8.27	38.00 – 60.00	–	–
Eosin (%)	1.50±0.55	1.00 – 2.00	–	–
MCV (fL)	90.33±16.00	65.70 – 111.80	128 – 304	130 – 310
MCH (pg)	27.13±5.12	19.29 – 35.29	28 – 36	30 – 39
MCHC (g dl^{-1})	30.01±1.43	28.25 – 31.67	0.11 – 18	0.12 – 0.19

Key: RBC - red blood cell, WBC - white blood cell, Hb - haemoglobin, PCV - packed cell volume, PLT- platelets, Mon - monocytes, Lym - lymphocytes, Neut - neutrophils, Eosin – eosinophils, MCHC = Mean corpuscular haemoglobin concentration, MCH = Mean corpuscular haemoglobin, MCV = Mean corpuscular volume

The haemoglobin concentration also varies between 11.30 and 13.50 g dl^{-1} with a mean of 12.31±0.80 g dl^{-1}. Platelets range from 75.00 – 94.00 x10^9 l^{-1} with a mean value of 83.40±6.87 x10^9 l^{-1}. Monocytes ranged between 2.00 – 3.00 %, with the mean value being 2.50±0.58 %. Percent of lymphocytes was found within the range of 38.00 – 59.00 % while neutrocytes level varied from 38.00 to 60.00 %. The eosinophils content of *H. niloticus* ranged between 1.00 – 2.00 % with 1.50±0.55 % mean concentration.

The Mean corpuscular volume ranges between 65.70 – 111.80 fL with a mean value of 90.33±16.00 fL while Mean corpuscular haemoglobin (MCH) varied between 19.29 – 35.29 pg with a mean value of 27.13±5.12 pg. Mean corpuscular haemoglobin concentration (MCHC) ranged from 28.25 to 31.67 g dl^{-1} with 30.01±1.43 g dl^{-1} mean concentration.

Serum biochemistry

Serum biochemistry parameters of *Heterotis niloticus* from Lake Alau is as shown in Table 2. Haemato-biochemical analyses revealed that the total protein content range from 26.00 to 36.00 g l^{-1}; creatinine from 58.00 to 76.00 µmol l^{-1}, blood urea from 3.60 to 4.30 nmol l^{-1}, uric from 18.00 to 21.00 nmol l^{-1} and glucose content from 7.50 to 12.00 mmol l^{-1} serum. The range for the cholesterol, potassium, sodium, albumin, chloride, alanine aminotransaminase, aspartate aminotransaminase and alkaline phosphatase were 2.10 – 3.80 mmol l^{-1}, 3.60 – 6.90 mmol l^{-1}, 112.00 – 120.00 mmol l^{-1}, 12.00 – 14.00 g l^{-1}, 76.00 – 80.00 mmol l^{-1}, 12.00 – 39.00 U l^{-1}, 47.00 – 99.00 U l^{-1} and 11.00 – 32.00 U l^{-1} respectively.

Table 2. Serum biochemistry parameters of *Heterotis niloticus* from Lake Alau

Parameter	Mean (± SD)	Range	References	
			(Odo *et al.*, 2009)	(Fagbenro *et al.,* 2000)
Protein (g l^{-1})	30.57±4.28	26.00 – 36.00	47.00 – 78.00	50.00 – 83.00
Creat (µmol l^{-1})	66.00±6.32	58.00 – 76.00	–	–
Urea (nmol l^{-1})	3.87±0.30	3.60 – 4.30	–	–
Uric (nmol l^{-1})	19.57±1.13	18.00 – 21.00	–	–
Gluc (mmol l^{-1})	8.51±1.56	7.50 – 12.00	46.00 – 79.00	41.00 – 82.00
Chol (mmol l^{-1})	2.76±0.69	2.10 – 3.80	–	–
Potass (mmol l^{-1})	5.07±1.15	3.60 – 6.90	15.30 – 27.60	18.30 – 29.90
Sod (mmol l^{-1})	116.86±3.02	112.00 – 120.00	87.00 – 127.00	97.00 – 139.00
Albumin (g l^{-1})	12.71±0.95	12.00 – 14.00	0.30 – 6.90	0.40 – 7.50
Chloride (mmol l^{-1})	78.57±1.90	76.00 – 80.00	6.40 – 145.00	7.00 –163.00
ALT (U l^{-1})	24.00±10.71	12.00 – 39.00	–	–
AST (U l^{-1})	76.43±18.23	47.00 – 99.00	–	–
AP (U l^{-1})	22.29±7.09	11.00 – 32.00	–	–

Key: Creat - creatinine, Uric -uric acid, Gluc - glucose, Chol- cholesterol, Potass - potassium, Sod - sodium, ALT-alanine aminotransaminase, AST - aspartate aminotransaminase, AP- alkaline phosphatase.

Also, mean values for haematobiochemical components were protein 30.57±4.28 g l^{-1}, creatinine 66.00±6.32 µmol l^{-1}; urea 3.87±0.30 nmol l^{-1}; uric 19.57±1.13 nmol l^{-1}; glucose 8.51±1.56 mmol l^{-1}; cholesterol 2.76±0.69 mmol l^{-1}; potassium 5.07±1.15 mmol l^{-1}; sodium 116.86±3.02 mmol l^{-1}; albumin 12.71±0.95 g l^{-1}; chloride 78.57±1.90 mmol l^{-1}; alanine aminotransaminase 24.00±10.71 U l^{-1}; aspartate aminotransaminase 76.43±18.23 U l^{-1} and alkaline phosphatase 22.29±7.09 U l^{-1}.

DISCUSSION

Haematological profile is an important tool for effective monitoring of physiological and pathological state of a fish (Kohanestani *et al*., 2013). Steinhagen *et al*. (1990) and Fernandes and Mazon (2003), reported that these parameters are closely related to the response of fish to environmental and biological factors. In the present study, the mean value of red blood cells count was significantly higher than values obtained for *Heterotis niloticus* ($1.50 \pm 0.02 \times 10^{12} l^{-1}$) from Southeast (Odo *et al*., 2009) and Southwest Nigeria (Fagbenro *et al*., 2000). However, the RBC values in this study were within the normal range recommended for healthy fish (*Kori-Siakpere et al.,* 2005; Fagbenro *et al*., 2000; Hrubec *et al*., 2000; Bhasker and Rao, 1989).

When compared with other fish species, RBC value in this study was greater than that of *Clarias anguillaris* (2.60±0.45 µL) and *Clarias gariepinus* (3.08±1.23 µL) from Geriyo Lake, Nigeria (Onyia *et al*., 2015). The value was also higher than 0.6 – 3.3 $x10^6$ mm^{-3} recorded for *Parachanna obscura* in four freshwater bodies in South-western, Nigeria (Adebayo *et al*., 2007). The elevated RBC counts and HB concentration in fish are a response to the higher metabolic demand (Satheeshkumar *et al*., 2011) and physiological adaptation to different modes of life (i.e., habits) and ecological habitats (Goel *et al*., 1984). Clark *et al*. (1979) opined that RBC generally shows inter and intra species differences in the same or different environment. Nevertheless, RBC count greater than $1.0\times10^6 mm^3$ is considered high and indicative of high oxygen carrying capacity of the blood (Lenfant and Johansen, 1972).

White blood cells count obtained from this work was in consonance with the recommended range for a typical healthy fish (Kori-Siakpere et al., 2005; Hrubec *et al*., 2000). However, Odo *et al*. (2009) and Fagbenro *et al*. (2000) reported significantly high WBC counts (57.2±4.9 10^9 l^{-1}) for *H. niloticus* in their studies. The fluctuations in WBC values could be as a result of differences in ecological conditions (Goel *et al*., 1984). In reference to other species, WBC counts in this study is higher than 4.01 $x10^3 mm^{-3}$ reported for *P. obscura* (Adebayo *et al*., 2007) and 4.18 ± 0.28 $x10^9$ l^{-1} obtained for *C. gariepinus* (Abalaka, 2013). The value was also higher than the range (2.20 x 10^4 mm^{-3} to 5.0 x 10^4 mm^{-3}) recorded for *Channa striatus*, *Cyprinus carpio*, *Catla catla* and *Labeo rohita* from Palaru-Porunthlaru dam, India (Kandeepan, 2014). According to Douglass and Jane (2010), WBC counts has implication for immune responses and the ability of the animal to fight infection.

The mean haemoglobin fell within the range (5.6–15.8 gdl^{-1}) reported for *Esox lucius* (Mulcahy, 1970) and similar to (11.27±1.26 gdl^{-1}) that of *Parachanna obscura* (Odedeyi, 2013; Adebayo *et al*., 2007). This value is also higher than 4.46 gdl^{-1} recorded for *Synodontis membranacea* (Owolabi, 2011) and 7.92±1.81 gdl^{-1} obtained for *Channa africana* (Akinwumi, 2015). Goel (1984) relates the number of RBC and haemoglobin concentration to the oxygen content of the surrounding water. Devi *et al*., (2004) have reported a decrease of Hb content in fish *Heteroneustes fossillis* due to exposure of paper mill effluents. Therefore, increase in Hb content as compared to 4.06±0.43g dl^{-1} by Odo *et al*. (2009) and 4.46±0.43g dl^{-1} by Fagbenro *et al*. (2000) suggests a healthy condition of *Heterotis niloticus* in Lake Alau.

The mean values of packed cell volume (PCV) obtained from this study were within the range of 22 – 48% (Bhasker and Rao, 1989) and 23 – 43% (Wedemeyer and Yasutake, 1977), for healthy fish. This result was also in consonance with the normal range (20 to 50%) recommended by Pietse *et al.* (1981) and Clark *et al*. (1979). The value obtained for PCV is similar to that of *C. gariepinus* (48.29±7.12 %) from Egbe dam (Akinwumi, 2015) but lower than *C. anguillaris* (66.73±30.93%) and *C. gariepinus* (65.02±18.64%) from Lake Geriyo (Onyia *et al*., 2015). These differences may be due to species-specific hematological characteristics in teleost as reported by Akinrotimi *et al.* (2011). This value is however, higher than the corresponding values (28.12±2.98 %) reported for *Heterotis niloticus* from other ecological zones (Odo *et al*., 2009; Fagbenro *et al*., 2000).

The value obtained for platelets is similar to that of Akinwumi (2015) who reported 94.79±36.09 and 63.73±57.03 for *C. gariepinus* and *P. africana,* respectively. Latif *et al*. (2015) however, reported higher platelet concentration in *Channa marulius* (109.0±14.0 – 216.0±39.28 $\times10^9$ l^{-1}) in River Chenab, Pakistan. The monocytes, lymphocytes, neutrophils and eosinophils results observed in this study showed marginal differences when compared with *Synodontis membranacea* (Owolabi, 2011), *Alburnoides eichwaldii* (Kohanestani *et al*., 2013), *C. gariepinus* (Ipinmoroti, 2015), *Channa striatus, Cyprinus carpio, Labeo rohita,* and *Catla catla* (Kandeepan, 2014) and *Heteropneustes fossilis* (Khanam and Latifa, 2013). The differences may be due to seasonal fluctuations (Mahagen *et al*., 1979), ecological habitats (Goel *et al*., 1984) and species-specific hematological characteristics in teleost (Akinrotimi *et al.*, 2011), rather than poor health status.

The mean corpuscular volume of *Heterotis niloticus* (65.70 – 111.80 fL) in this study did not differ considerably from the values (115 – 183 fL) reported by Hrubec *et al*. (2000) for normal, healthy fish.

This finding is thus in consonance with the findings of Adedeji and Adegbile *(*2011), who respectively report 99.29±2.00 and 116.16 μ^3 mean corpuscular volume in *Clarias gariepinus* and *Chrysichthys nigrodigitatus* from Asejire dam. However, the mean MCV value evident in this study is lower than 187.16±12.79 fL and 191.20±1.74 fL recorded for *H. niloticus* by Odo *et al*. (2009) and Fagbenro *et al*. (2000) respectively. The variance may be a factor of season, age, environmental condition which could influence concentration of haemoglobin in the red blood cell. The range of mean corpuscular haemoglobin (19.29 – 35.29 pg) obtained from this study were similar to findings of Odo *et al*. (2009) and Fagbenro *et al*. (2000). These values, therefore fall within the normal range recommended for healthy fish (Hrubec *et al*., 2000; Terry *et al.,* 2000; Nilza *et al.,* 2003). Mean corpuscular haemoglobin concentration was in conformity with previous reports on *Tilapia species* (Hrubec *et al*., 2000), *C. gariepinus* (Adedeji and Adegbile*,* 2011) but higher than the value obtained in *H. niloticus* (Odo *et al*., 2009; Fagbenro *et al*., 2000). The estimate of MCHC obtained in the present study agrees with that of Goel *et al*. (1984) which indicate a healthy fish.

Serum biochemistry

Jawad *et al*. (2004) opined that serum biochemistry varies from species to species and can be influenced by many biotic and abiotic factors such as water temperature, seasonal pattern, food, age and sex of the fish. However, Goel *et al*. (1984) attributed differences to physiological adaptation and ecological habitats. In this study, total serum protein for *Heterotis niloticus* was in line with the normal range for healthy *H. niloticus* as reported by Odo *et al.* (2009) and Fagbenro *et al.* (2000). This result also coincides with the findings of Abalaka (2013), who reported 32.09±1.79 gl^{-1} and 30.12±1.69 g l^{-1} for total protein in reared and wild *Clarias gariepinus*, respectively. Contrarily, this value was higher than 4.57±0.21 g l^{-1} recorded for *Clarias gariepinus* (Nwabueze and Regha-John, 2015), 11.25 g l^{-1} obtained for *Heteropneustes fossilis* (Acharya and Mohanty, 2014) and 4.38g l^{-1} reported for *Solea senegalensis* (Peres *et al*., 2015). The result was however, comparatively lower than 4.45 g l^{-1} in *P. obscura* (Kori-Siakpere *et al.,* 2005) and 4.8 – 7.8 g l^{-1} in Oreochromis hybrid (Hrubec *et al*., 2000). The divergence in results may be due to species-specific hematological characteristics in teleost (Akinrotimi *et al*., 2011).

Creatinine, a breakdown product in the blood is a more specific indicator of kidney function. The mean creatinine value observed is within the normal range of 100 – 500 µmol l^{-1} as reported by Hrubec *et al*. (2000). It was however, comparatively higher than 49.71±16.15 µmol l^{-1} reported for *Synodontis membranacea* (Owolabi, 2011). The difference could be attributed to varying physiological adaptation and ecological conditions as suggested by Goel *et al*. (1984).

The mean value of urea was moderate and similar to 3.05±0.67 nmol l^{-1} reported for *Synodontis membranacea* by Owolabi (2011) but higher than *Clarias gariepinus* (1.27 ± 0.03 - 2.12 ± 0.09 8.70 nmol l^{-1}) (Nwabueze and Regha-John, 2015). The level of urea is influenced by the state of hydration and very high level usually indicates impaired kidney. Goel *et al*. (1984), posited that varying amounts of blood urea usually reflect the habit of the fish with actively swimming fish having lesser amount of blood urea compared to the less active and sluggish fish. Similarly, Borges *et al*. (2007) ascribed a high blood concentration in fish to be a sign of stress associated with the increase in the cortisol level.

The uric acid level observed in this study is higher than 0.76±0.33 nmol l^{-1} found in *Synodontis membranacea* (Owolabi, 2011). This variation might be attributed to the hot climate in the study area. Adeyemo *et al*. (2003) suggested that temperature changes affect the biochemical blood levels. Glucose level was significantly higher than 4.24±1.74 mmol l^{-1} in *Synodontis membranacea* from Jebba Lake (Owolabi, 2011) and 5.54±0.56 mmol l^{-1} reported for *Clarias gariepinus* in Tiga dam (Abalaka, 2013). The value was however, lower than (61.46 ±5.29 mg dl^{-1}) recorded for *Heterotis niloticus* in River Ogbese (Fagbenro *et al*., 2000), 57.38±4.17 mg dl^{-1} for *H. niloticus* in Anambra River (Odo *et al*., 2009) and 70.83±6.67-82.88±8.76 mmol l^{-1} for *Clarias batrachus* in freshwater pond (Acharya and Mohanty, 2014). The differences may be as a result of varied ecological zones which necessitate different physiological adaptation to modes of life (Goel *et al*., 1984), rather than poor health status. The cholesterol level in this study is consistent with the observations of Owolabi (2011), for *Synodontis* *membranacea* and Nwabueze and Regha-John (2015), for *Clarias gariepinus*. These two authors reported normal range of cholesterol as 1.2 – 21 mmol l^{-1} for healthy fish. Conversely, the mean potassium value from this study is slightly lower when compared to *Heterotis niloticus* (Odo *et al*., 2009; Fagbenro *et al*., 2000), *Synodontis membranacea* (Owolabi, 2011) and *Notopterus notopterus* (Kulkarni, 2015) but higher than the value reported for *Solea senegalensis* (Peres *et al*., 2015).

The mean value for sodium is comparable to the findings of Fagbenro *et al*. (2000), but lower than those reported for *Synodontis membranacea* (Owolabi, 2011) and *Solea senegalensis* (Peres *et al*., 2015), and higher than *Notopterus notopterus* (Kulkarni, 2015). In contrast, the albumin level was found to be higher than the values documented by Fagbenro *et al*. (2000) and Peres *et al*. (2015) but lower than what was reported by Owolabi (2011). Similarly, serum chloride is consistent with mean value (82±1.7 mmol l^{-1}) previously reported for *Heterotis niloticus* (Fagbenro *et al*., 2000) but significantly higher than *Synodontis membranacea* (Owolabi, 2011). The blood AST, ALT and AP which are enzymes mainly located in the liver, heart and bones have their concentrations at variance with the observations of Nwabueze and Regha-John (2015) for *Clarias gariepinus*, Abalaka (2013) for *Clarias gariepinus* and Owolabi (2011) for *Synodontis membranacea.* The differences in most studied parameters could be attributed to variations in ecological zones which necessitate different physiological adaptation to modes of life (Goel *et al*., 1984), rather than poor health status. Bianchi *et al*. (2014) also corroborates that differences in reference intervals among fish are related to interspecific and environmental variations.

Conclusion

The present findings revealed that most haematological and biochemical values obtained were within the normal range reported for *Heterotis niloticus* and other tropical species. There exists interspecies variation in serological parameters such as glucose, albumin, urea and serum chloride, which could be attributed to different climate and habitat conditions rather than poor health status. Hence, the reference intervals obtained in haematological and biochemical parameters from this study could be used as baseline to assess the health status of *H. niloticus* especially from the Northeast Nigeria.

REFERENCES

Abalaka, S.E. (2013). Evaluation of the Haematology and Biochemistry of *Clarias gariepinus* as Biomakers of Environmental Pollution in Tiga dam, Nigeria. *Brazilian Archives of Biology and Technology* 56(3):371-376.

Acharya, G. and Mohanty, P.K. (2014). Comparative haematological and serum biochemical analysis of catfishes *Clarias batrachus* (Linnaeus, 1758) and *Heteropneustes fossilis* (Bloch, 1794) with respect to sex. *Journal of Entomology and Zoology Studies* 2 (6): 191-197.

Adebayo, O.T., Fagbenro, O.A., Ajayi, C.B. and Popoola, O.M. (2007). Normal haematological profile of *Parachanna obscura* as a diagnostic tool in aquaculture. *International Journal of Zoological Research* 3(4): 193–199.

Adedeji, O.B. and Adegbile, A. F. (2011). Comparative Haematological Parameters of the Bagrid Catfish (*Chrysichthys nigrodigitatus)* and the African Catfish (*Clarias Gariepinus*) from Asejire Dam in Southwestern Nigeria. *Journal of Applied Sciences Research* 7(7): 1042-1046.

Adeyemo, O.K., Agbede, S.A., Olaniyan, A.O. and Shoaga, O.A. (2003). The haematological response of *Clarias gariepinus* to changes in acclimation temperature. *African Journal of Biomedical Research*, 6: 105 – 108.

Adite, A. (1987). Donnéespréliminaires sur l'écologie et la production halieutique du complex elagunaire Toho-Ahouangan (English title not available), Benin: Faculté des Sciences Agronomiques, UniversitéNationale du Bénin, 157Pp.

Adite, A., Winemiller K.O., and Fiogbe, E.D. (2005). Ontogenic, seasonal and spatial variation in the diet of *Heterotis niloticus* (Osteoglsssiformes: Osteoglossidae) in the So River and lake Hlan, Benin, West Africa. *Envt. Biol. Fishes.,* 73: 367-378.

Akinrotimi, O.A., Bekibele, D.O and Orokotan O.O. (2011). Select Hematological Values of the African Catfish (Clarias gariepinus) Raised in a Water Recirculating Aquaculture System. *International Journal of Recirculating Aquaculture* 12: 1 – 5.

Akinwumi, F.O. (2015). Hematological Characteristics of Two Teleost Fish in a Tropical Reservoir. *Research in Zoology* 5(1): 16-19.

Ashley, P.J. (2007). Fish welfare: current issues in aquaculture. *Appl. Anim. Behav. Sci.,* 104: 199–235.

Bhasker, B. R. and Rao, S.K. (1989). Influence of environment variables on haematology and compendium of normal haematological ranges of milk fish, *Chanos chanos* (Forskal), brackishwater culture. *Aquaculture* 83: 123-136.

Bianchi, M.B., Jerônimo, G.T., Pádua, S.B., Satake, F., Ishikawa, M.M., Tavares-Dias, M. and Maurício L. Martins, M.L. (2014). The haematological profile of farmed *Sorubim lima*: reference intervals, cell morphology and cytochemistry. *VETERINARSKI ARHIV 84* (6), 677 – 690.

Borges, A., Scotti, L.V., Siqueira, D.R., Zanini, R., Amaral, F., Jurinitz, D.F. and Wassermann, G.F. (2007). Changes in haematological and serum biochemical values in jundiá *Rhamdiaquelen* due to sub-lethal toxicity of cypermethrin. *Chemosphere* 69: 920–926.

Clark, S., Whitmore, D.H. and McMahon R.F. (1979). Consideration of blood parameters of largemouth bass, *Micropterus salmoides J. Fish Biol*., 14: 147-154.

Collazos, M.E., Ortega, E., Bariga, C. and Rodriguez, A.B. (1998). Seasonal variation in haematological parameters of male and female *Tinca tinca*. *Mol. And Cell. Biochem*., 183: 165-168.

Dacie, J.V. and Lewis, S.M. (2001). *Practical Haematology*. 9th Edition. Churchill Livingstone, London, 633Pp.

De Pedro, N., Guijarro, A.I., Lo´Pez-Patin˜O, M.A., Martinez, A., ´Lvarez, R. and Delgado, M.J. (2005). Daily and seasonal variations in haematological and blood biochemical parameters in the tench, *Tinca tinca* Linnaeus, 1758. *Aquat. Res.,* 36: 1185–1196.

Devi, G., Baruah, B.K and Das, M. (2004). Study on the effect of paper mill effluent on Haematological profile of *Heteropneustes Fossilis* (Bloch), *Poll. Res.* 23 (4): 611-614.

Douglass, J.W. and Jane, K.W. (2010). Schalms Veterinary Haematology. John Wiley and Sons, Blackwell Publishing Ltd. 1232 Pp.

Fagbenro, O., Adedire, C.O., Ayotunde, E.O. and Faminu, E.O. (2000). Haematological profile, food composition and enzyme assay in the gut of the African bony-tongue fish, *Heterotis* (*Clupisudis*) *niloticus* (Cuvier 1829) (Osteoglossidae). *Trop. Zool.,* 13: 1-9.

Fernandes, M.N. and Mazon, A.F. (2003). *Environmental pollution and fish gill morphology*. In: *Fish adaptation* (eds. V. AL and B.G. Kapoor), Science Publishers Enfield Press USA, pp. 203 – 231.

Gabriel, U.U., Akinrotimi, O.A. and Eseimokumo, F. (2011). Haematological responses of wild Nile tilapia *Oreochromis niloticus* after acclimation to captivity. *Journal of Biological Science*, 4, 225-30.

Goel, K.A., Mishra, B.P., Gupta, K. and Wadhwa, S. (1984). A comparative Haematological study on a few freshwater Teleost. *Indian J. Fisheries.* 31(1):108-112.

Hendricks, L.J. (1952). Erythrocyte counts and haemoglobin determinations for two species of suckers, genus *Catostomus*, from Colorado, *Copeia* 4: 265-6.

Hesser, E.F. (1960). Methods for routine on fish haematology. *Prog. Fish cult.,* 22:164-171.

Hrubec, T.C., Cardinale, J.L. and Smith, S.A. (2000). Haematology and Plasma Chemistry Reference Intervals for Cultured Tilapia (Oreochromis Hybrid). *Veterinary Clinical Pathology* 29(1): 7 – 12.

Huntingford, F.A., Adams, C.E., Braithwaite, V.A., Kadri, S., Pottinger, T.G., Sandoe, P. and Turnbull, J.F. (2006). Current issues in fish welfare*. J. Fish Biol.,* 68:332–372.

Ipinmoroti, M.O. (2015). Variation in the Blood Constituents of Catfish (*Clarias gariepinus* Burchell 1822) Caught from Different Habitat. *International Journal of Scientific Research in Environmental Sciences* 3(6): 0226-0233.

Jamalzadeh, H.R. and Ghomi, M.R., 2009. Haematological parameters of Caspian salmon *Salmo trutta caspius* associated with age and season. *Marine and Freshwater Behaviour and Physiology*, 42, 81-87.

Jawad, L.A., Al–Mukhtar, M.A. and Ahmed, H.K. (2004). The relationship between haematocrit and some biological parameters of the Indian shad, *Tenualosa ilisha* (Family Clupeidae). *Animal Biodiversity Conservation* 27: 478–483.

Kandeepan, C. (2014). Haematological and Biochemical Parameters on Few Fresh Water South Indian Teleosts. *International Journal of Current Microbiology and Applied Sciences* 3(9): 1015-1022.

Khanam, T. and Latifa, G.A. (2013). Haematological Parameter of *Heteropneustes fossilis* (Shingfish). *Journal of Science Foundation* 11(1): 3 – 10.

Kohanestani, Z.M., Hajimoradloo, A., Ghorbani, R., Yulghi, S., Hoseini, A. and Molaee, M. (2013). Seasonal variations in haematological parameters of *Alburnoides eichwaldii* in Zaringol Stream-Golestan Province, Iran. *World Journal of Fisheries and Marine Sciences* 5: 121-1262.

Kori-Siakpere, O., Ake, J.E.G. and Idoge, E. (2005). Hematological characteristicof the African Snakehead, *Parachanna obscura*. *AFJ Biot.,* 4(6): 527-530.

Kulkarni. R.S. (2015). Haematology of the freshwater fish, *Notopterus notopterus*in relation to Physico-chemical characteristics of the water. *International Letters of Natural Sciences* 40:19-23.

Lane, H.C., 1979. Progressive changes in hematology and tissue water of sexually mature trout, Salmo gairdneri Richardson during the autumn and winter. *Journal of Fish Biology* 15: 425-436.

Lataretu, A., Furnaris, F. and Mitranescu, E. (2012). Haematological profile as stress indictor in fish.Scientific Works. Series C. *Veterinary Medicine* LIX (1): 102-104.

Lenfant, C. and Johansen, K. (1972). Gas exchange in gill, skin and lung breathing. *Respiratory Physiology* 14: 311-318.

Mahagen, C.L., Eurell, T.E., Cannon, M.S. and Grumbles, L.C. (1979). T and B cell analogues from peripheral blood immune channel catfish *Ictalurus punctatus*. *J. Fish Biol*., 14: 31 – 37.

Moreau, J. (1982). Expose synoptique des donnes biologiques sur *Silver Catfish* (Cuvier 1829). FAO Synopsis Peches 131:1-45.

Mulcahy, M.F. (1970). Blood values in the pike, *Esoxlucius*. *J. Fish Biol*., 21: 203-209.

Newman, S. H., Piatt, J. F. and White, J. (1997). Haematological and plasma biochemical reference ranges of Alaskan seabirds: their ecological significance and clinical importance. *Waterbirds* 20(3): 492–504.

Nilza, L.R., Ligia, M.M., Dense, O.S., Rassia, B.P., Celso, V.N., Tania, U.N., Benicio, A.F. and Benedito, P.F. (2003). Haematological and biochemical values for Nile tilapia (*Oreochromis niloticus*) cultured in semi-intensive system. *Acta Scientiarum Biological Science Maringa* 25(2): 385-389.

Nwabueze, A.A. and Regha-John, J. (2015). Seasonal variations in Serological profiles and growth status of farmed and wild *Clarias gariepinus* (Burchell, 1822) obtained from Asaba, Nigeria. *Journal of Agricultural Science and Technology* B 5: 205-215.

Odo, G. E., Nwamba, H. O. and Eyo, J. E. (2009). Aspect of the Biology of *Heterotis niloticus* Cuvier 1829 (Osteoglossiformes: Osteoglossidae) in the Anambra flood River system, Nigeria. *Animal Research International* 6(2): 994 – 1002.

Olaosebikan, B.D. and Raji, A. (2013). *Field Guide to Nigerian Freshwater Fishes* (Revised Edition). National Institute of Freshwater Fisheries Research (NIFFR), New Bussa, Nigeria. 144Pp.

Onyia, L.U., Diyaware, M.Y., Michael, K.G., Musa, M. and Ochokwu, I. J. (2015). Comparison of Haematological Indices, Blood Group and Genotype of *Clarias gariepinus* (Burchell, 1822) and *Clarias anguillaris* (Linneaus, 1758). *Journal of Fisheries and Aquatic Science* 10(5): 392 – 399.

Onyia, L.U., Michael, K.G. and Ekoto, B. (2013). Haematological profile, blood group and genotype of *Heterobranchus bidorsalis. Net Journal of Agricultural Science* 1(2): 69-72.

Owolabi, O.D. (2011). Haematological and serum biochemical profile of the upside-down catfish, *Synodontis membranacea* Geoffroy Saint Hilaire from Jebba Lake, Nigeria. *Comp. Clin. Pathol*., 20: 163-172.

Peres, H., Costas, B., Perez-Jimenez, A., Guerreiro, I.and Oliva-Tele, A. (2015). Reference values for selected haematological and serum biochemical parameters of Senegalese sole (*Solea senegalensis* Kaup, 1858) juveniles under intensive aquaculture conditions. *J. Appl. Ichthyol.,* 31: 65–71.

Satheeshkumar, P., Ananthan, G., Senthil Kumar, D. and Jagadeesan, L. (2011). Haematology and biochemical parameters of different feeding behaviour of teleost fishes from Vellar estuary, India. *Comp Clin Pathol* DOI 10.1007/s00580-011-1259-7.

Shaw, A.F.B. (1930). A direct method for counting the leucocytes, thrombocytes and erythrocytes of bird's blood. *J Path Bact*., 33(2): 833-845.

Steinhagen, D., Kruse, P. and Korting, W. (1990). Some haematological observations on carp *Cyprinus carpio* L., experimentally infected with *Trypanoplasma Borelli* (Laveran and Mesnil, 1901, Protozoa: Kitenoplastida). *J. Fish Dis.,* 14: 157-162.

Stoskopf, M.K. (1993). *Clinical Pathology in Fish Medicine*. WB Saunders Company, New York, USA., 251Pp.

Svobodova, Z., Pravola, D. and Palackova, J. (1991). Unified methods of haematological examination of fish. *Research Inst. of fish culture and Hydrobiology*. Vodnany, Czechoslovakia., 31Pp.

Terry, C., Hrubec, T. C. and Stephen, A. S. (2000). Haematology of fish. *Vet. Clin. Pathol*., 174: 1120-1125.

Wedemeyer, G.A. and Yasutake, W.T. (1977). Clinical methods for the assessment of the effect of environmental stress on fish health. *Technical paper at the US fish and wildlife service*. No.89. Washington, DC, US Dept. of interior, Fish and wildlife service, 180Pp.