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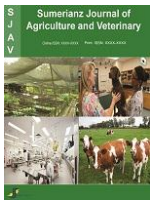

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Physical and Physiological Status of *Clarias Gariepinus* (Burchell, 1822) From Lake Alau Maiduguri Nigeria

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Abstract

Clarias gariepinus is undoubtedly a fish of high economic interest in Nigeria. Due to its wide acceptability as food fish, there is a need to monitor the health conditions of the fish in culture and capture environment to guarantee its sustainable production. This study therefore, investigates the physical and heamatological profile of C. *gariepinus*, captured from Lake Alau. Water and fish samples were collected monthly for three months. Water samples were analysed for nitrate, Dissolved Oxygen (DO) and temperature following standard procedures. Samples of C. *gariepinus* (n=30) were obtained from fishermen catches. Standard Length (SL) and Body Weight (BW) were measured. Length-Weight Relationships and condition factor were also calculated. Red Blood Cells (RBC, $10^{12}l^{-1}$), Packed Cell Volume (PCV, %), Protein (g l^{-1}) and Albumin (g l^{-1}) were determined following standard methods. Data were analysed using descriptive and inferential statistics. Mean values obtained for Nitrate (1.05±0.77 mgl^{-1}), DO (6.40±0.36 mgl^{-1}) and temperature (24.37±0.30 ^{o}C) were optimum. The SL and BW ranged from 28.2 to 34.5 cm and 210.0 to 350.0 g, respectively. C. *gariepinus* in Lake Alau exhibit negative allometric growth (1.73), while Condition factor (0.96±0.14) indicates suitability of the environment for this species. RBC, PCV, protein and albumin were 5.92±2.91, 0.35±0.08, 35.14±5.82 and 13.02±2.06, respectively. The haematological profile of C. *gariepinus* in Lake Alau as documented was optimum and compared well with species from other water bodies.

Keywords: African catfish; Condition factor; Haematology; Lake alau; Water quality.

1. Introduction

African catfish *Clarias gariepinus* is a popular freshwater fish in Nigeria due to its rich flesh, good taste, and its high nutritional value. According to Williams, *et al.* [1], fish producers ranked African catfish as the most preferred species in Nigeria due to high market demand and fast growth rate. *Clarias gariepinus* is omnivorous species, prefers to inhabit swamp, lakes, canal, streams, ponds and rivers. However, its natural population is decreasing gradually due to improper management, changes in physicochemical conditions of water and influence of anthropogenic activities around aquatic environment [2]. In this regard, length-weight relationships and fish blood studies provide facts that are cornerstone in the environmental monitoring and toxicological research that indicate the physiological and pathological change in fishery management [3, 4].

Length-weight data represent basic parameters for monitoring fish population, as it provides important information concerning the structures and function of population. In fishes, condition factor also provides information on the physiological state of the fish in relation to its welfare [5]. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live [6]. Also, blood is a very good medium of assessing health status of animals, and the use of haematological techniques is gaining importance for toxicological research, environmental monitoring and assessment of fish health conditions [7]. Blood composition is usually altered during disease or malnutrition condition [8]. The knowledge of haematological profile of a fish also indicates its dietary sufficiency and physiological response to environmental stress [9, 10].

Fish are closely associated with the aquatic environment and the blood will reveal conditions within the body of the fish long before there is any visible sign of disease [11]. Blaxall and Daisley [12], have reported the possibility of using haematocrit and haemoglobin values as tools for checking anaemic condition in aquaculture and fishery management. Serum protein, urea, uric acid, cholesterol and glucose concentrations are accepted as indicators of nutritional status [13], while white blood cell is useful as indicator of diseased condition or extent of infection as elevated values are obtained in abnormal conditions [14]. Blood glucose and PCV as well as electrolyte balance are considered to be valuable tools for the identification of secondary stress condition in fish [15].

Some of the recent works on *Clarias gariepinus* in Nigeria inland waters include those of Akinwumi [16] in Egbe dam, Ipinmoroti [17] in Lake Asejire, Nwabueze and Regha-John [18] in Ona Lake, Onyia, *et al.* [19] in Lake Geriyo and Abalaka [20] in Tiga dam. However, there is, at present, dearth of information on the haematiological profile of the species in Lake Alau, Nigeria. This study therefore, investigates the physical and physiological status of *Clarias gariepinus* in Lake Alau, Nigeria.

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2. Materials and Methods

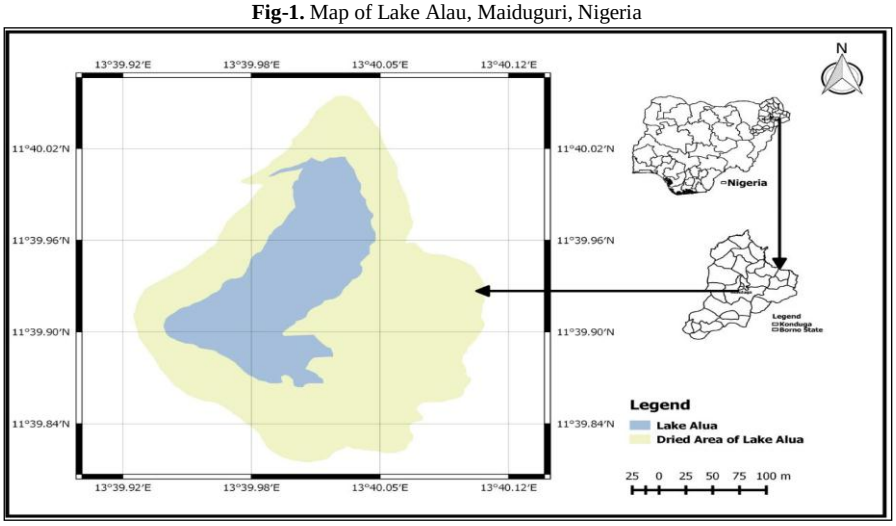
2.1. Study Area

Lake Alau is located between Latitude 11°39'84"–11°40'02"N and Longitude 13°39'92"–13°40'12" E of Borno state, Nigeria (Fig. 1). The reservoir covers about 56km^2 with mean maximum depth of 9 meters. The area occupies an undulating terrain with the highest altitude of about 354m above sea level [21]. The reservoir was formed primarily for the provision of potable water for the Maiduguri Metropolis as well as to irrigate over 8,000ha of farmlands within and around the reservoir basin [22]. Also, the reservoir contributes immensely to the fisheries of the north-eastern region of the country.

2.2. Collection of Fish and Water Samples

Thirty live specimens (280.00±52.91g) of *Clarias gariepinus* were obtained bimonthly for three months (September – November, 2018) from artisanal fishermen's catch. These samples were transported in oxygenated open tanks to the laboratory within 2hours of capture to the Wet laboratory, National Institute for Freshwater Fisheries Research, Maiduguri Zonal Office for further analysis.

Fig-1. Map of Lake Alau, Maiduguri, Nigeria



Also, water samples from the Lake were collected bimonthly for analysis in the laboratory. The parameters analysed include water temperature, pH, dissolved oxygen, total alkalinity, conductivity, turbidity, nitrate and nitrite concentrations. Temperature was measured *insitu* with mercury in–glass, pH and conductivity with a multi-meter water checker (Intelligent, Model AD 33915), while dissolved oxygen, total alkalinity, turbidity, nitrate and nitrite were analysed following the standard procedure [23].

2.3. Weight-Length Relationship and Relative Condition Factor

Length and Weight of all samples collected were measured and weighed in fresh condition following Olanrewaju, *et al.* [5]. These data were used to find the relative condition factor [24] and the weight-length relationship (WLR), making use of Equation 1:

$$W = a \cdot Lt^b \quad (1)$$

Where W stands for total weight in grams, Lt for total length in centimeters and **a** and **b** are constants. Both these constants were estimated by a linear regression of Equation 2 transformed:

$$W = \log a + b \times \log L \quad (2)$$

2.4. Haematological Analysis

Blood sample of about 5ml blood was collected from each fish sample within 24 h after capture by severing the caudal peduncle following Ajani, *et al.* [10]. Thereafter, the samples were taken to the Analytical Laboratory, University of Maiduguri Teaching Hospital for haematological analysis. Haemoglobin (Hb) concentration was determined by the cyanmethaemoglobin method [25] while the packed cell volume and the albumin was determined using the Bromocresol green method as described by Peters, *et al.* [26]. The red and white blood cell counts were determined using Neubauer Chamber. Total protein was determined according to the procedure described by Stoskopf [27]. Urea was determined by Urease method and creatinine by Folin-Wu filtrate methods as described by Connors, *et al.* [28]. Alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase and cholesterol were determined by spectrophotometric method. Preparations were made for the determination of differential leukocyte count, albumin, conjugated and total bilirubin, bicarbonate and plasma ion (Na, Cl, K) concentrations using the methods of Svobodova, *et al.* [29].

2.5. Statistical Analysis

Data was analyzed using SPSS software package. For the LWR data, the level of significance of 'r' was estimated and the value of 'b' was tested using the Student's t-test ($p<0.05$). The relative condition factor (Kn) was

tested with the standard Kn = 1.00, by Student's t-test ($p<0.05$). The haematological and water parameters data were presented as mean±standard deviation (SD)

3. Results and Discussion

Table 1 presents data on the physic-chemical parameters of Lake Alau. Dissolved oxygen, pH and temperature have a mean value of 6.40±0.36mgl^{-1}, 8.35±0.12 and 24.37±0.30^{o}C, respectively. Also, mean values for alkalinity, conductivity and turbidity were 72.80±3.55mgl^{-1}, 114.07±2.71µScm^{-}1, and 20.67±4.81FTU respectively. Mean nitrate value as obtained was 1.05±0.77mgl^{-1} while nitrite value was 0.06±0.02mgl^{-1}. The present results indicate that the physico-chemical characteristics of Lake Alau water were within the standard recommended values for fish health and wellbeing [30-32].

Table-1. Physico-chemical concentration of water samples from Lake Alau and comparison with standard regulatory values

Water parameters	Mean±SD	Standard limits		
		[30]	[31]	[32]
Dissolved oxygen (mgl^{-1})	6.40±0.36	5.00 – 10.00	>1.0	>5.0
Temperature (^{o}C)	24.37±0.30	25.0 – 32.0	20.0 – 35.0	25.0 – 32.0
pH	8.35±0.12	6.5 – 8.5	5.0 – 9.0	6.5 – 8.5
Alkalinity (mgl^{-1})	72.80±3.55	50.0 – 300.0	10.0 – 400.0	<500.0
Conductivity (µScm^{-1})	114.07±2.71	50.0 – 500.0	20.0 – 1500	500.0
Turbidity (FTU)	20.67±4.81	–	1.0 – 150.0	500.0
Nitrate (mgl^{-1})	1.05±0.77	0.10 – 3.00	20.0	<90.0
Nitrite (mgl^{-1})	0.06±0.02	0.0 – 0.5	–	3.0

The weight-length distribution and relative condition factor (Kn) of *Clarias gariepinus* samples used in this study are presented in Table 2. The total length ranged between 32.20cm and 38.50cm with a mean of 35.06±2.42cm and standard length varied between 28.20cm and 34.50cm with a corresponding mean of 31.38±2.58cm. The specimens weigh between 210.00 g and 350.00g (280.00±52.91g). This shows that the species used for the study were relatively matured and they can be categorized as adult suitable for consumption. The fish sizes of *Clarias gariepinus* in this study were within ranges classified as adult by Ipinmoroti [17], and Acharya and Mohanty [33] in their studies.

The Kn value (0.96±0.14) was not different from 1.00, according to the *t*-test analysis. Badejo and Oriyomi [34], reported a similar result with a condition factor of 0.6±0.000 for *Clarias gariepinus* in Erinle Reservoir, Ede, Nigeria. Several other authors such as Kalu, *et al.* [35]; Offem, *et al.* [36] and Egbal, *et al.* [37], equally reported similar findings with variation in the number of species observed.

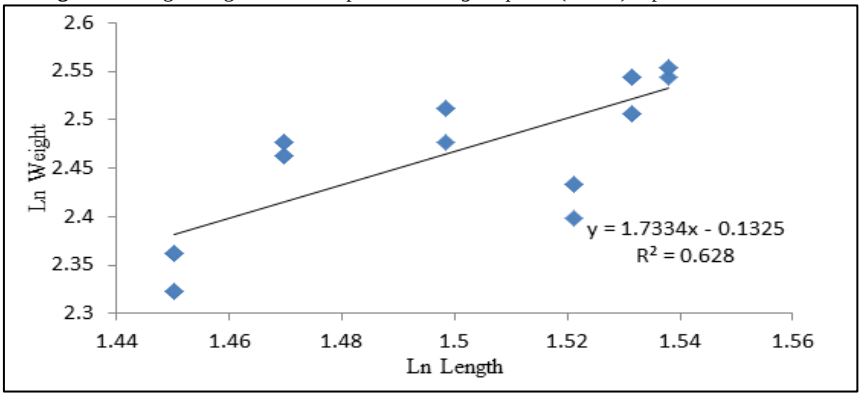
Table-2. Weight and Length distribution of *Clarias gariepinus* captured from Lake Alau, Maiduguri

Parameter	Mean±SD	Range	
		Minimum	Maximum
Weight (g)	280.00±52.91	210.00	350.00
Standard length (cm)	31.38±2.58	28.20	34.50
Total length (cm)	35.06±2.42	32.20	38.50
Kn	0.96±0.14	0.68	1.17

Legend: *SD* standard deviation, *Kn* condition factor

The weight-length relationship, values of determination coefficients (r^2) and corresponding equation are demonstrated in Figure 2. The equation that describes this relationship is LogW = Log-0.132+1.733 Log SL, given that the obtained value for the slope '*b*' of the weight-length relationship was significantly lower than 3.0 (Student test, $p < 0.05$), indicating a negative allometric growth. Alhough, Allen [38] suggested that the value of 'b' in an ideal fish is 3, that is, it should agree with the cube law' ($W = aL^3$). Joadder [39], however attributed variation in 'b' value to species variation, difference in environmental factors, sex variation etc. This result coincides with the findings of Olanrewaju, *et al.* [4], who observed 2.829 (negative allometric) in *Raiamas senegalensis* from Lake, Alau.

Figure-2. Weight-length relationships in *Clarias gariepinus* (n = 30) captured in Lake Alau



Also, negative allometric growth of *Clarias species* in Nigerian lakes and reservoirs have been well documented by various studies including [35, 36, 40]. This finding is also consistent with the work of Koffi, *et al.* [41] and Egbal, *et al.* [37] who reported negative allometric growth in *Clarias species* in El-Girba reservoir, Sudan and Aby lagoon Côte d'Ivoire, respectively.

The results of haematological profile of *Clarias gariepinus* are as presented in Table 3. The minimum and maximum observed Red Blood Cells of the analysed *Clarias gariepinus* specimens were 3.40 and 9.20 10^{12} l^{-1} with a corresponding mean of 5.92±2.91 10^{12} l^{-1}. However, the RBC value in this study is comparatively higher than 2.60±0.45 10^{6} µl and 3.0833±1.23 10^{6} µl reported by Onyia, *et al.* [19] for *C. gariepinus* and *Clarias angularias* in Lake Gariyo. The White Blood Cells ranged from 20.20 – 26.90 10^{9} l^{-1} while the haemoglobin varied from 8.90 – 16.40 g dl^{-1}. Also, the mean WBC value (22.50±2.78 10^{9} l^{-1}) in this study was lower than those of *Clarias gariepinus* (41.1±11.048 10^{3}µl), *Heterotis niloticus* (57.2±4.90 10^{9}/l) and *Channa africana* (37.03±9.13 10^{9}gdl^{-1}) as reported by Erhunmwunse and Ainerua [42], Fagbenro, *et al.* [9] and Akinwumi [16], respectively. In contrast, the hemoglobin concentration (12.76±3.29 g dl^{-1}) was higher as compared to those reported by Erhunmwunse and Ainerua [42], Acharya and Mohanty [33] and Akinwumi [16] for *C. gariepinus*, *C. batrachus* and *C. gariepinus*, respectively.

The minimum Packed Cell Volume was 0.24 %, while the maximum was 0.45 % with overall mean of 0.35±0.08 %. The Platelets ranged from 89.00 – 118.00g, with a mean value of 99.00±12.16 (10^{9} l^{-1}). Monocytes varied from 2.00 to 4.00 %, and the mean value was 2.80±0.83 %. Lymphocytes ranged from 50.00 to 74.00 % while the heterophils varied between 23.00 and 46.00 %. The mean values of lymphocytes and heterophils were 60.80±8.58 and 34.40±9.07 %. However, Erhunmwunse and Ainerua [42] reports higher PCV but lower Platelets, Monocytes and Lymphocyte in *Clarias gariepinus*.

Table-3. Haematological profile of *Clarias gariepinus* captured from Lake Alau, Maiduguri

Parameter	Mean±SD	Range	
		Minimum	Maximum
RBC (×$10^{12}$$l^{-1}$)	5.92±2.91	3.40	9.20
WBC (×$10^{9}$$l^{-1}$)	22.50±2.78	20.20	26.90
Hb (g dl^{-1})	12.76±3.29	8.90	16.40
PCV (%)	0.35±0.08	0.24	0.45
PLT (×$10^{9}$$l^{-1}$)	99.00±12.16	89.00	118.00
Mon (%)	2.80±0.83	2.00	4.00
Lym (%)	60.80±8.58	50.00	74.00
Heterophils (%)	34.40±9.07	23.00	46.00

RBC red blood cells, *WBC* white blood cells, *HB* heamoglobin, *PCV* packed cell volume, *PLT* platelet, *Mon* monocyte, *Lym* lymphocyte

The results of plasma biochemical indices of *Clarias gariepinus* are summarized in Table 4. A total of 13 biochemical indices were measured and their range intervals (minimum and maximum) and mean values were recorded. Total protein ranged from 27.00 g to 40.90g l^{-1}, creatinine varied from 6.00 cm to 30.00 µmol l^{-1} and urea varied between 30.5 and 36.0 nmol l^{-1}. The mean values of total protein, creatinine and urea were 35.14±5.82 g l^{-1}, 20.60±9.09 µmol $l^{-1}$and 2.22±0.57 nmol l^{-1}, respectively. These values were much higher than value reported for *Clarias gariepinus* by Ajani, *et al.* [10]. The total and conjugated bilirubin values range between 0.50 – 1.30 µmol l^{-1} and 0.20 to 1.00 mmol l^{-1}, with mean values of 1.00±0.30 µmol l^{-1} and 0.56±0.30mmol l^{-1} respectively. In contrast, Goel, *et al.* [43] reports higher bilirubin concentrations for *Mystus tengara, Heteropneustes fossilis, Labeo bata, Labeo ciirsa, Notopterus notopterus, Mastacemblus pancalus* and *Channa punctatus.*

The cholesterol and albumin values varied between 4.00 to 7.00 mmol l^{-1} and 10.00 to 15.00 g l^{-1} with the overall mean of 5.06±1.19 mmol $l^{-1}$and 13.02±2.06 g l^{-1}, respectively. The result agrees with the findings of Nwabueze and Regha-John[17] who recorded 3.01±0.09 g dl^{-1} (Albumin) and 14.47±1.86 mmol l^{-1} (Cholesterol) for *Clarias gariepinus* from Ona Lake in Delta state, Nigeria.

Table-4. Plasma Biochemical Indices of *Clarias gariepinus* population in Lake Alau

Parameter	Mean±SD	Range	
		Minimum	Maximum
Protein (g l^{-1})	35.14±5.82	27.00	40.90
Creat (µmol l^{-1})	20.60±9.09	6.00	30.00
Urea (nmol l^{-1})	2.22±0.57	1.50	2.90
T. Bil (µmol l^{-1})	1.00±0.30	0.50	1.30
C. Bil (mmol l^{-1})	0.56±0.30	0.20	1.00
Chol (mmol l^{-1})	5.06±1.19	4.00	7.00
Potass (mmol l^{-1})	6.26±1.02	4.65	7.33
Sod (mmol l^{-1})	113.80±6.97	107.00	123.00
Albumin (g l^{-1})	13.02±2.06	10.00	15.00
Chloride (mmol l^{-1})	70.84±6.51	62.30	76.90
ALT (U l^{-1})	23.88±7.03	14.70	32.60
AST(U l^{-1})	199.62±81.21	88.20	308.40
AP (U l^{-1})	11.60±4.92	8.00	20.00

Creat creatinine, *T. Bil* total bilirubin, *C. Bil* conjugated bilirubin, *Chol* cholesterol, *Potass* potassium, *Sod* sodium, *ALT* alanine aminotransaminase, *AST* aspartate aminotransaminase, *AP* alkaline phosphatase

Potassium varied from 4.65 to 7.33 mmol l^{-1}, sodium ranges between 107.00 – 123.00 mmol l^{-1} while chloride swings from 62.30 to 76.90mmol l^{-1}. Mean potassium, sodium and chloride values were 6.26±1.02, 113.80±6.97 and 70.84±6.51 mmol l^{-1}, respectively. This observation was in tandem with the findings of Owolabi [44] and Fagbenro, *et al.* [9]. The alanine aminotransaminase (ALT), aspartate aminotransaminase (AST) and alkaline phosphatase (AP) concentrations ranges between 14.70 – 32.6, 88.20 – 308.4 and 8.00 – 20.00 U l^{-1}, respectively. Also, the overall mean values obtained for ALT, AST and AP were 23.88±7.03, 199.62±81.21 and 11.60±4.92 U l^{-1}, respectively. These findings show little disparity with the results obtained by Ajani, *et al.* [10] for *Clarias gariepinus*, Abalaka [20] for *C. gariepinus* and Owolabi [44] for *Synodontis membranacea*.

Results of the correlation coefficient matrix between the various haematological parameters studied are presented in Table 5. Red blood cells showed strong significant positive correlation with heamoglobin (r =0.976, $p<0.01$) and packed cell volume (r = 0.947, $p<0.05$), but lymphocyte had strong significant inverse correlation with heterophils (r = -0.894, $p<0.05$). However, significant positive interactions were observed between heamoglobin and packed cell volume (r = 0.990, $p<0.01$).

Table-5. Pearson correlation coefficient among the haematological indices of *Clarias gariepinus*

	rbc	**wbc**	**hb**	**pcv**	**plt**	**mon**	**lym**	**hetrol**
rbc	1	-0.169	0.976**	0.947*	0.055	-0.408	0.018	-0.290
wbc		1	-0.355	-0.397	-0.651	0.601	-0.674	0.473
hb			1	0.990**	0.195	-0.575	0.150	-0.393
pcv				1	0.309	-0.666	0.114	-0.353
plt					1	-0.589	-0.096	0.258
mon						1	-0.285	0.441
lym							1	-0.894*
hetrol								1

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed). *rbc* red blood cells, *wbc* white blood cells, *hb* haemoglobin, *pcv* packed cell volume, *plt* platelet, *mon* monocyte, *lym* lymphocyte, *hetrol* heterophils

Pearson's correlation (Table 6) indicated significant physiological interaction between plasma biochemical parameters. Alanine aminotransaminase showed significant positive correlation with bicarbonate (r = 0.901, $p>0.05$), but a significant inverse correlation with conjugated bilirubin (-0.938, $p>0.05$). Also, significant positive interactions was observed between albumin and total protein (r = -0.954, $p<0.05$) while bicarbonate show negative relationships with urea (r = -0.933, $p<0.05$). Conjugated bilirubin correlated significantly with bicarbonate (r = -0.985, *p<0.01*) and urea (r = 0.888, *p<0.05*). Aspartate aminotransaminase showed a significant and positive relationship with potassium (r = 0.970, *p<0.01*). Similar findings were obtained by Olanrewaju [45] for *Parachanna obscura* in Eleyele Reservoir, Ibadan, Nigeria.

Table-6. Correlation matrix between the plasma biochemical indices of *Clarias gariepinus*

	Alt	**tbil**	**alb**	**creat**	**ast**	**cbil**	**sod**	**potass**	**chlo**	**HCO_3**	**urea**	**chol**	**ap**	**tp**
alt	1	-0.567	0.063	-0.531	0.489	-0.938*	0.570	0.519	-0.194	0.901*	-0.870	-0.217	-0.278	-0.217
tbil		1	-0.271	0.788	0.251	0.465	-0.860	0.162	0.518	-0.474	0.434	-0.007	0.659	-0.037
alb			1	0.268	0.380	0.180	0.462	0.354	-0.242	-0.322	0.410	0.826	-0.791	0.954*
creat				1	0.322	0.650	-0.718	0.150	0.651	-0.712	0.593	0.257	0.057	0.495
ast					1	-0.435	0.087	0.970**	0.007	0.296	-0.183	0.352	-0.016	0.286
cbil						1	-0.533	-0.523	0.331	-0.985**	0.888*	0.282	-0.030	0.453
sod							1	0.242	-0.821	0.476	-0.266	0.399	-0.541	0.212
potass								1	-0.221	0.384	-0.195	0.420	0.043	0.228
cl									1	-0.287	-0.039	-0.523	0.079	-0.081
HCO_3										1	-0.933*	-0.422	0.096	-0.583
urea											1	0.660	-0.032	0.634
chol												1	-0.363	0.835
ap													1	-0.685
tp														1

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed). *creat* creatinine, *tbil*total bilirubin, *cbil*conjugated bilirubin, *chol* cholesterol, *potass* potassium, *sod* sodium, *alt* alanine aminotransaminase, *ast* aspartate aminotransaminase, *ap* alkaline phosphatase, tp total protein, *cl* chloride, *HCO_3* bicarbonate, *alb* albumin

4. Conclusion

The findings from the study infer that the values obtained for physic-chemical parameters of Lake Alau water were within desirable limits for aquatic life. The study also revealed a good state of growth, well-being and blood profile for the species, which is significant to continuous production of the species in the area. The knowledge of length-weight relationship and hematological parameters of the fish obtained from this study will therefore; help to monitor changes in the health status of the fish from time to time.

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