aJava

Asian Journal of Animal and Veterinary Advances

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Asian Journal of Animal and Veterinary Advances

ISSN 1683-9919
DOI: 10.3923/ajava.2022.98.104

CrossMark

Research Article

Assessment of Haematology and Proximate Composition of *Clarias gariepinus* (Burchell, 1822) Population Groups for Genetic Improvements

[1]U.A. Mikaheel, [1]L.A. Argungu, [2]W.A. Hassan, [3]H. Jibrin, [1]T. Mamman and [1]S.A. Sadiq

[1]Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto, Nigeria
[2]Department of Animal Science, Usmanu Danfodiyo University, Sokoto, Nigeria
[3]Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, Nigeria

Abstract

Background and Objective: *Clarias gariepinus* with the common name "African catfish" is one of the most important tropical catfish species for aquaculture in Nigeria. It is widely cultured in Nigeria. However, one of the major difficulties being faced in most fish hatcheries and production farms is infectious diseases. Therefore, this research was conducted on the haematology and proximate composition of three population groups of *C. gariepinus* to identify a hardier population group that can be recommended for such genetic modifications. **Materials and Methods:** The haematology and proximate analyses of *Clarias gariepinus* were carried out on these ecotypes for the wild and cultured systems. An automated blood analyser was used for the haematological analysis, while the proximate analyses were carried out following the standard laboratory protocol of the National Institute of Freshwater Fisheries Research, New Bussa. **Results:** The results revealed variations in the blood composition of the *C. gariepinus* population groups studied and both the environmental and genetic references indicated that population group A (wild) is superior to the other two population groups B and C (pooled cross and Dutch) having a highest significant mean value of Mean Corpuscular Haemoglobin Concentration (MCHC) alongside other parameters and was therefore recommended for the improvement of the cultured stocks. **Conclusion:** This research concludes that there is variation in the blood composition of the *C. gariepinus* P. Groups studied and both the environmental and genetic references indicated that the P. Group A is superior to the other two. P. Groups B and C had the highest significant mean value of Mean Corpuscular Haemoglobin Concentration (MCHC).

Key words: *Clarias gariepinus*, haematology, proximates, population genetics, river rima, wild, cultured

Citation: Mikaheel, U.A., L.A. Argungu, W.A. Hassan, H. Jibrin, T. Mamman and S.A. Sadiq, 2022. Assessment of haematology and proximate composition of *Clarias gariepinus* (Burchell, 1822) population groups for genetic improvements. Asian J. Anim. Vet. Adv., 17: 98-104.

Corresponding Author: U.A. Mikaheel, Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto, Nigeria Tel: +2348189304930

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Clarias gariepinus (Burchell, 1822) with the common name “African catfish” is one of the most important tropical catfish species for aquaculture in Nigeria. It is widely cultured in Nigeria and many tropical and subtropical regions of the world[1]. It constitutes one of the largest groups of farmed freshwater fishes in Nigeria. The rapid increase in aquaculture production in recent years in Nigeria has come from the increasing intensified culture systems for this commercially potent species. However, one of the major difficulties being faced in most fish hatcheries and production farms is infectious diseases. Fish immune response systems are not so well developed as those of mammals[2]. Several claims of selective breeding for disease resistance to specific pathogens in farm fish have little evidence in quantitative genetic control for such characters[3]. Furthermore, attempts to improve farm fish’s resistance to certain diseases by selective breeding have not been highly successful[2]. Seasonal variation and uncontrollable environmental conditions influence the immunity and resistance of fish more than the genetic inherence of the fish both in the wild aquatic environment and under culture conditions[2]. In a reflection on the difficulties posed by the various traditional genetic approaches to improve farm fish’s genetic disease resistance, the modern genetics of gene transfer may offer a more direct solution to this problem. Therefore, this research was conducted on the haematology and proximate composition of three population groups of *C. gariepinus* to identify a hardier *C. gariepinus* population group that can be recommended for such genetic modification. Population group A is a representative sample of the indigenous wild gene pool of *C. gariepinus* from the most exploited river Rima, Sokoto, the population group C was a pure line of the most commonly cultured strain of cultured *Clarias gariepinus* in Sokoto, while population group B has a shared genetic pedigree with the earlier mentioned population groups[4]. As such an improved breed of *C. gariepinus* bred with adequate knowledge of genetic potency for disease resistance is expectedly envisaged to be resistant enough and possess ontogenetic disease resistance alleles for subsequent progenies. The proximate analysis is a test of the end quality of what the fish may be in terms of nutritional value after the improvement.

Clarias gariepinus is well distributed in Nigeria and across Africa, spreading from the Nile through West Africa, Algeria and to Southern Africa. They are also found in Asia Minor, Israel, Syria and the Southern part of Turkey.

Phenotypically, *C. gariepinus* is a non-scaled fish, its dorsal and anal fins are extended, with strong pectoral fins. Spines are either serrated or not serrated at all as described by Oyebola *et al.*[5]. Clariidae is elongated, it has four pairs of barbells. this family is equipped with a suprabranchial organ, continuous from the folds of the second and fourth branchial arch and this equips the fishes of this family with the accessory breathing organ to breathe with atmospheric oxygen, for some time, outside the water[6]. They are also known as “walking catfish” because of their ability to crawl several metres on land using their pectoral spines[6].

The genus *Clarias* consists of 35 valid species and is the third most diverse catfish genus in Africa. Onyekwelu *et al.*[6] identified six subgenera in this genus: *Anguilloclarias*, *Brevicephaloides*, *Clarias*, *Clarioides*, *Dinotopteroides* and *Platycephaloides*. The subgenus *Clarias* includes only two valid species: *C. gariepinus* (Burchell, 1822) and *C. anguillaris*[7], the former being of greater economic importance, as it is the most cultured catfish in Africa and the third most cultured catfish species in the world[8].

The head is large, depressed equipped with a thick bony skull bigger than the rest of the body in growing *C. gariepinus* but has a considerable proportional head to body size in the advanced growth stage of the fish species[9]. The mouth is large and sub-terminal equipped with vomerine teeth[10]. In *C. gariepinus*, respiratory gaseous exchange takes place in the gill filaments[6]. The main constraint facing the culture of *C. gariepinus* is the low survival during the larval and fingerling stages[11] leading to insufficient amounts of quality catfish seed. High mortality rates occur among larval stages of *C. gariepinus*[11]. therefore, there is the need for aquaculture stocks improvement for resistance to fry/fingerlings common hatchery diseases. Genetic improvement of the stock will profer the best solution to the foregoing problem, therefore, there is the need for the assessment of haematology and proximate composition of *Clarias gariepinus* (Burchell, 1822) population groups from river Rima for genetic improvements of the local aquaculture stocks.

MATERIALS AND METHODS

Study area: This research was conducted in Usmanu Danfodiyo University, Sokoto, located on 130°7′38.9″N and 5°12′19.0E within Sokoto. Sokoto is in the savannah agro-ecological zone (latitude 13°0027.0″N and longitude 5°15′05.6″E), about 350 m above the sea level. The study was carried out in the Fish Biology Laboratory of the Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto, between May and November, 2017, because rainfall establishes between mid May to early June and peaks in August. The climate is semi-arid with rainfall of between

550 and 700 mm. The dry season starts from mid October, to late April[12]. Sokoto receives an average annual temperature of 30.26°C and average annual relative humidity of 48.54%[12].

Fish sample collection: Live samples of *C. gariepinus* were collected from the river Rima (population group A), Kwalkwalawa area and two other selected fish farms (population groups B and C). The collected samples were taken to the laboratory for blood sample collection and tissue samples for haematological and proximate analysis respectively.

Experimental procedure: Blood samples measuring 1.5 mL each were collected from the caudal peduncle as described by Ibiyo *et al.*[13]. The blood samples of the fish collected from each population group were taken to a commercial laboratory and subjected to haematological analysis to determine the following parameters, using an automated haematological analysing machine (Haematology analyser, Genesis AH6000) for haematological analyses. White Blood Cell (WBC), Red Blood Cell (RBC), Packed Cell Volume (HCT/PCV), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentrate (MCHC), Mean Cell Volume (MCV) while 100 g each of oven-dried fish tissue samples from the three population groups were taken to the Central Laboratory of the National Institute of Freshwater Fisheries Research, (NIFFR), New-Bussa for proximate analyses. The proximate analyses were done following NIFFR Central Laboratory Protocols.

Statistical analyses: Data was exported into SPSS version 20 (IBM SPSS) for descriptive analysis. Analyses were done based on population groups for haematological parameters and the proximate composition of the different fish population groups. Means comparison and separation were by (DNMRT).

RESULTS

Haematology of the three *C. gariepinus* population groups: Table 1 presents the results of the measured haematological parameters. It was only the mean cell volume (MCV) and Mean Corpuscular Haemoglobin Cells (MCHC), that revealed a true between ecotype significant ($p<0.05$) variation. The mean cell volume (MCV) of the population group A (109.73±1.33) fL was significantly lower ($p<0.05$) than the two cultured population groups B and C. Population group B (123.13±1.87 fL), was significantly the same ($p>0.05$) as (118.40±3.31 fL) recorded by population group C. The Mean Corpuscular Haemoglobin Cells (MCHC) recorded by the wild population group was 29.58±0.49 g dL^{-1}, which was significantly ($p<0.05$) the highest value than those recorded by the two cultured population groups. Population group B recorded the lowest significant MCHC of 25.43±1.11 g dL^{-1}, while population group C recorded 27.73±0.77ab g dL^{-1}, with an intermediate significant ($p<0.05$) difference between the other two population groups. However, The White Blood Cell (WBC), Red Blood Cell (RBC), Haemoglobin (HGB), MCH and HCT volumes were not significantly different ($p>0.05$) across the three fish population groups.

Table 1: Comparative Haematology of the three fish population groups

Sample sources	P. Group A		P. Group B		P. Group C	
Parameters	Mean±SE	SD	Mean±SE	SD	Mean±SE	SD
WBC (10^9 L^{-1})	68.07±4.14^a	8.30	57.86±15.74^a	31.47	54.22±13.20^a	26.41
RBC (10^{12} L^{-1})	2.96±0.11^a	0.21	2.66±0.58^a	1.14	2.55±0.39^a	0.77
HGB (g dL^{-1})	9.63±0.48^a	0.96	8.13±1.64^a	3.29	8.35±1.26^a	2.52
MCHC (g dL^{-1})	29.58±0.49^a	0.97	25.43±1.11^b	2.22	27.73±0.77^{ab}	1.55
MCH (pg)	32.40±0.50^a	1.00	31.25±0.96^a	1.91	32.78±0.39^a	0.77
MCV (fL)	109.73±1.33^b	2.65	123.13±1.87^a	3.73	118.40±3.31^a	6.63
HCT/PCV (%)	32.48±1.42^a	2.84	32.93±7.25^a	14.50	30.50±5.35^a	10.69

Means in rows with same letters are not significantly different ($p>0.05$), P. Group: Population group, WBC: White blood cell, RBC: Red blood cell, HGB: Haemoglobin, HTC/PCV: Haematocrit/packed cell volume, MCH: Mean corpuscular haemoglobin, MCHC: Mean corpuscular haemoglobin concentrate and (MCHC): Mean cell volume (MCV)

Table 2: Proximate analysis of the *C. gariepinus* population groups

Groups	Moisture	Fat	Protein	Crude fibre	Ash	NFE
P. Group A	6.09±0.24^a	24.09±0.24^b	62.90±0.02^b	0.61±0.01	5.19±0.13	1.14±0.17^a
P. Group B	5.18±0.08^b	25.13±0.15^a	63.15±0.13^{ab}	0.57±0.02	5.16±0.01	0.82±0.06^{ab}
P. Group C	4.26±0.01^c	25.72±0.60^a	63.38±0.03^a	0.65±0.32	5.41±0.01	0.55±0.01^b

Mean in columns with the same superscripts are not significantly different ($p>0.05$), P. Group: Population group and NFE: Nitrogen free extracts

Proximate composition of the three *C. gariepinus* population groups: Table 2 presents the result of the proximate composition of the three fish population groups. It was observed that the protein and NFE constituents of the population groups vary across the population groups, with the P. Group C being the significantly ($p<0.05$) highest mean value 63.38$\pm$0.03 than the other two P. Groups studied. The fat content was significantly different between the ecotypes, with the P. Group C having the highest value than the other two P. Groups. Here the wild P. Group were found to be inferior to the other two P. Groups.

DISCUSSION

The mean cell volume (MCV) which varied only between the ecotypes is also an indication that variations do exist among the P. Groups studied. Though the WBC which is major immune response blood cell are similar across the P. Groups, one cannot outrightly deny the fact that haemoglobin is also an important component of blood that helps in the absorption of iron which is essential for cellular respiration and thus has a critical role to play in the fight against infections. There are different types of environmental factors that can impair the normal physiological processes of fish and thus compromise their health. if allowed to exceed certain limits, inverse relationships between environmental factors and fish disease are commonly reported in aquaculture[14]. The aquatic habitat of fish is the principal component of the environment that influences fish's health. the most critical water quality conditions that are readily influenced by biological activity and therefore of primary concern in aquaculture, include dissolved oxygen (DO), un-ionized ammonia, nitrite, carbon dioxide and pH tolerable and lethal concentrations for many of these constituents have been documented for many species of fish[15]. Some physico-chemical water quality parameters that are not alterable by biological activities, such as alkalinity, hardness, salinity, temperature and turbidity may also affect fish’s health, especially if they are not within tolerable ranges. Different fish species may vary considerably in terms of specific tolerance limits for various water quality parameters[16]. In addition to these natural components which deteriorate water quality, there is are different natural and synthetic chemicals that may compromise water quality and consequently affect the health of fish. Haematological parameters have been widely used in the clinical diagnosis of diseases and pathogens of both humans, animals and fish[13,17]. The application of haematological analyses is valuable also in the study of fish biology and nutrition for the monitoring of fish health, diseases, nutrient utilization and stress[17]. Morphologically, the cells identified in the blood of cichlids include, erythrocytes, thrombocytes, neutrophils, eosinophils, basophils, lymphocytes and monocytes[13]. Lymphocytes are the most numerous cells comprising the leucocytes which function in the production of antibodies and chemical substances involved in defence against infections[18]. An increase in white blood cell (leucopenia) as observed in the fish is attributed to an increase in production of leucocytes in the spleen[19,20].

The result of the haematological analyses as presented in Table 1 above revealed not much variation among the *C. gariepinus* population groups studied. All the seven parameters analysed fell within the same mean value range which makes it difficult to think of any genetic variation as to the production of such blood cells. Meanwhile, Omitoyin *et al.*[19] reported the PCV 15.00, HB 15.00, RBC 2.60, MCV 57.69, MCHC 33.33 WBC of 11.500 when fed *C. gariepinus* with poultry litter. Sotulo and Faturoti,[21] reported that reduction of PCV, Hb and MCV values could be attributed to the toxins or anti-nutrient factor in the fish feed ingredient[22]. Results of these authors followed a conducted research while this current research seeks to establish a default condition of the *C. gariepinus* population groups. However, two of the parameters measured were found to be significantly different, one of which exhibited a between Population group variation and the other varied across the fish population groups. Meanwhile, Periayah *et al.*[23] found out that there was an inverse correlation between the Mean Cell Volume (MCV) and the number of circulating Red Blood Cells (RBC). Adedeji *et al.*[24] while working on different freshwater species from Asejire dam, to set a standard value for the haematological parameter, reported RBC of 3.03 and MCV of 99.58 for *C. gariepinus.* This result revealed a lower RBC for the three fish population groups and generally high MCV across the population groups. This may be due to geographical location or distance between the experimental locations from the authors cited above. It is worthy of note that as much as hereditarily genetic as the composition of blood is, the physico-chemical, nutritional and other environmental factors of the fish’s habitat could influence the expression of such characteristics that may be observed at a certain time of a year or season to a great extent.

Also, of all the haematological indices studied, only the Mean Corpuscular Haemoglobin Concentration (MCHC) exhibited variations across the three fish population groups pointing to the superiority of population group A (wild fish P. group). This is an indication that the wild population group A has more resistance to depletion in dissolved oxygen than the cultured Population groups B and C. While the P. Group B is also superior to C about this gene-environment controlled character. Mikaheel *et al.*[25] described ecotype-based variations in electrophoretic dissipation of the blood serum of wild (river Rima) and cultured *C. gariepinus* from Sokoto metropolis. These authors noticed a clear variation in the protein banding pattern between the ecotypes and Toth *et al.*[26] stated that electrophoretic banding pattern can directly be linked to the gene encoding the protein. The variation here in the blood composition as a function of protein transcription could be said to be in line with the findings of these authors. The mean cell volume (MCV) which varied only between the ecotypes is also an indication that variations do exist among the P. Groups studied. Though the WBC which is major immune response blood cell are similar across the P. Groups, one cannot outrightly deny the fact that haemoglobin is also an important component of blood that helps in the absorption of iron which is essential for cellular respiration and thus has a critical role to play in the fight against infections.

Fish provide varying nutritional qualities based on the species or seasons[27,28]. It's however, important to note that the varying seasons dictate the water quality parameters of the fish's habitat. This habitat may also have varying physico-chemical parameters based on the location and the biotic habitats of the water body. Either wild or culture Ecotype system has an important role to play in the constituent solution of aquatic habitat. Moisture, dry matter, protein, lipids, vitamins and minerals are the most important components that act as sources of nutritive value of fish products[18]. The moisture content also varies across the group, while thinking of assertions that varying moisture content can result from exposure time to drying facility, intensity of drying (temperature) and the average initial moisture content of the fish. The latter assertion agreed with Aberoumad and Pourshafi[29] who reported that a good indication of relative energy, protein and lipid composition of flesh could be derived from its moisture content. Fish meat has low lipids and higher water than beef or chicken to a significant level[30]. The total lipid and ash content of fish is greatly affected by an increase in weight or length of the fish may also change with the season habitats and feed fed to the fish[1,31]. Although documented reports from different parts of the world indicate that seasonal variations may be responsible for differences in haematology and the proximate compositions of different animals including fish, fish being cold-blooded is more affected by those changes. Essentially, this study has established a default condition of *C. gariepinus* population groups from the wild and culture conspecifics from the research area. This will serve as baseline genetic information and a filled knowledge gap that can be applied to further research on the genetic resources of the species. Knowledge about obtainable strains of *C. gariepinus* within the research area and how this information gathered about the strains may influence outcomes of further research, not only in fish genetics and breeding but also, in other fields of fisheries sciences, fish biology, fish biotechnology, fish nutrition, fish post-harvest technology, conservation sciences, biodiversity and fish population dynamics.

CONCLUSION

There is variation in the blood composition of the *C. gariepinus* P. Groups studied and both the environmental and genetic references indicated that the P. Group A is superior to the other two P. Groups B and C by recording the highest significant mean value of Mean Corpuscular Haemoglobin Concentration (MCHC) and this is considered as one of the characteristics that aid the biological absorption of iron for dissolved oxygen utilization. This research, therefore, recommends that the P. Group A (wild) can be selected based on MCHC over the P. Groups B and C for genetic improvements for disease-resistant farm fish.

SIGNIFICANCE STATEMENT

Many hatcheries folded up at a point in time or quit operation due to high mortality of *C. gariepinus* at fry stages, which can be averted through genetically guided intraspecific selective breeding of wild and cultured *C. gariepinus.* The findings of this research will serve as baseline genetic information for successful selection based breeding programs and for further genetic research on the fisheries of River Rima and other water bodies with related characteristics.

ACKNOWLEDGMENT

Sincere gratitude to Late Prof. J.K. Ipinjolu, he was the major backbone of this research but has passed away as at the time of compiling this manuscript. He was a father, teacher, supervisor, mentor, lecturer and role model to me and many others. He was indeed a rare gem in our midst we never knew we could lose so soon. I pray that his gentle soul continues to rest in peace.

REFERENCES

1. Solomon, R.J. and A.R. Oluchi, 2018. Proximate analysis and nutritional value of African catfish (*Clarias gariepinus*) fed with local (*Telferia occidentals* and *Moringa olefera*) and industrial feed (Coppens). J. Fish. Livest. Prod., Vol. 6. 10.4172/2332-2608.1000267.
2. Laimeheriwa, B.M., 2018. The genetic research methods and its role in aquaculture on Indonesia. Oceanogr. Fish. Open Access J., Vol. 8. 10.19080/OFOAJ.2018.08.555738.
3. Rahman, M.A., A. Arshad, K. Marimuthu, R. Ara and S.M.N. Amin, 2013. Inter-specific hybridization and its potential for aquaculture of fin fishes. Asian J. Anim. Vet. Adv., 8: 139-153.
4. Wyckmans, M., A. Herrel and D. Adriaens, 2011. Analysis of ontogenetic changes in head shape and diet in a catfish with moderately enlarged jaw adductors (*Clariallabes melas*). Belg. J. Zool., 141: 11-20.
5. Oyebola, O.O., B.O. Omitoyin, A.E. Salako, E.K. Ajani and M.O. Awodiran, 2013. Genetic and biochemical differentiation of pectoral spine variants in *Clarias gariepinus*. Int. J. Mod. Biol. Res., 1: 8-14.
6. Onyekwelu, I., C.C. Anyadike, N.I. Ossai, O.A. Nwoke and E.L. Ndulue, 2020. Interrelationship between some morphometric parameters and bodyweight of tank-based cultured African catfish (*Clarias gariepinus* burchell, 1822). Aquacult. Fish., 6: 628-633.
7. Agbebi, O.T., D.E. Ilaboya and A.O. Adebambo, 2013. Preliminary characterization of genetic strains in clariid species, *Clarias gariepinus* and *Heterobranchus bidorsalis* using microsatellite markers. Afr. J. Biotechnol., 12: 364-369.
8. Garibaldi, L., 2012. The FAO global capture production database: A six-decade effort to catch the trend. Mar. Policy, 36: 760-768.
9. Alexandrova, U., A. Kotelnikov, S. Kotelnikova, A. Firsova and A. Kuzov, 2021. Early ontogeny of Clarias gariepinus and its features under artificial cultivation at different temperature conditions. IOP Conf. Ser.: Earth Environ. Sci., https://doi.org/10.1088/1755-1315/937/3/032035.
10. Olaosebikan, B.D. and A. Raji, 1998. Field Guide to Nigerian Freshwater Fishes. Federal College of Freshwater Fisheries Technology, New Bussa, Niger State, Nigeria, Pages: 106.
11. Orina, P.S., J. Rasowo, E. Oyoo-Okoth, S. Musa, J.M. Munguti and H. Charo-Karisa, 2016. Combined effects of photoperiod and temperature on growth and survival of African catfish (*Clarias gariepinus*, Burchell 1822) larvae under laboratory conditions. J. Appl. Aquacult., 28: 17-25.
12. Argungu, L.A., U.A. Mikaheel, H. Jibrin and F.M. Abdullahi, 2021. Determination of morphometric and meristic characters of African snakehead, *Parachana obscura* (Gunthers, 1861) in River Rima, Sokoto, Nigeria. Int. J. Fish. Aquat. Stud., 9: 309-312.
13. Ibiyo, L.M.O., R.M.O. Kayode, A. Oresegun, O. Mogaji and F.O. Joshua, 2018. Evaluation of clupeids and danish fish meal based diets on the growth of African catfish, *Clarias gariepinus* fingerlings. Arch. Food Nutr. Sci., 2: 31-37.
14. Odedeyi, D.O., 2007. Survival and growth of hybrid (Female *Clarias gariepinus* (B) and male *Heterobranchus longifilis* (Val.) fingerlings: Effect of broodstock sizes. Am. Eur. J. Sci. Res., 2: 19-23.
15. Makori, A.J., P.O. Abuom, R. Kapiyo, D.N. Anyona and G.O. Dida, 2017. Effects of water physico-chemical parameters on tilapia (*Oreochromis niloticus*) growth in earthen ponds in Teso North Sub-County, Busia County. Fish. Aqua. Sci., 20: 1-10.
16. Aparicio, S., J. Chapman, E. Stupka, N. Putnam and J.M. Chia *et al.*, 2002. Whole-genome shotgun assembly and analysis of the genome of *Fugu rubripes.* Science, 297: 1301-1310.
17. Ayoola, S.O., 2011. Acute toxicity and histopathology of Nile Tilapia (*Oreochromis niloticus*) fingerlings exposed to aqueous and ethanolic extracts of *Euphorbia poissonii* leaves. New Clues Sci., 1: 55-68.
18. Omoniyi, I., A.O. Agbon and S.A. Sodunke, 2002. Effect of lethal and sub-lethal concentrations of tobacco (*Nicotiana tobaccum*) leaf dust extract on weight and hematological changes in *Clarias gariepinus* (Burchell). J. Appl. Sci. Environ. Manage., 6: 37-41.
19. Omitoyin, B.O., E.K. Ajani and O.A. Fajimi, 2006. Toxicity of gramaxone (paraquat) to juvenile African catfish, *Clarias gariepinus* (Burchell, 1822). Am. Eur. J. Agric. Environ. Sci., 1: 26-30.
20. Ayoola, S.O. and I.A. Maduekwe, 2012. Biochemical and haematological response of *Clarias gariepinus* (Burchell, 1822) juveniles fed with diet containing *Mytilus edulis* shell at varying level. J. Fish. Aquat. Sci., 7: 468-474.
21. Sotolu, A.O. and E.O. Faturoti, 2009. Growth performance and haematology of *Clarias gariepinus* (Burchell, 1822) fed varying inclusions of *Leucaena leucocephala* seed meal based-diets. Revista UDO Agriccola, 9: 979-985.
22. Omitoyin, B.O., 2006. Haematological changes in the blood of *Clarias gariepinus* (Burchell 1822) juveniles fed poultry litter. Livest. Res. Rural Dev., Vol. 18.
23. Periayah, M.H., A.S. Halim and A.Z.M. Saad, 2017. Mechanism action of platelets and crucial blood coagulation pathways in hemostasis. Int. J. Hematol. Oncol. Stem Cell Res., 11: 319-327.
24. Adedeji, O.B., V.O. Taiwo and S.A. Agbede, 2000. Comparative haematology of five Nigerian freshwater fish species. Nig. Vet. J., 21: 75-84.
25. Mikaheel, U.A., J.K. Ipinjolu, L.A. Argungu, W.A. Hassan and M.Y. Abubakar, 2019. Evaluation of wild and cultured African mud catfish (*Clarias gariepinus*, Burchell, 1822) from water bodies around Sokoto metropolis. using SDS-PAGE. J. Agric. Environ., 15: 141-147.

26. Toth, E.E., S.K. Brem and G. Erdos, 2009. "Virtual inquiry": Teaching molecular aspects of evolutionary biology through computer-based inquiry. Evol.: Educ. Outreach, 2: 679-687.
27. Rasul, M.G., I. Jahan, C. Yuan, M.S.I. Sarkar, M.A.J. Bapary, M.A. Baten and A.K.M.A. Shah, 2021. Seasonal variation of nutritional constituents in fish of South Asian Countries: A review. Fundam. Appl. Agric., 6: 193-209.
28. Dani, J.A., D. Ji and F.M. Zhou, 2001. Synaptic plasticity and nicotine addiction. Neuron, 31: 349-352.
29. Aberoumad, A. and K. Pourshafi, 2010. Chemical and proximate composition properties of different fish species obtained from Iran. World J. Fish Mar. Sci., 2: 237-239.
30. Nestel, P.J., 2000. Fish oil and cardiovascular disease: Lipids and arterial function. Am. J. Clin. Nutr., 71: 228S-231S.
31. El-Marakby, H.I., 2006. Effect of dietary sources and levels of lipids ongrowth performance and feed utilization of fry Nile Tilapia, *Oreochromis niloticus* (L.) (Teleostei: Perciformes). J. Fish. Aquat. Sci., 1: 117-125.